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The Love of Neuroscience: A Sociological Account

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Abstract

I make a contribution to the sociology of epistemologies by examining the neuroscience literature on love from 2000 to 2016. I find that researchers make consequential assumptions concerning the production or generation of love, its temporality, its individual character, and appropriate control conditions. Next, I consider how to account for these assumptions' being common in the literature. More generally, I'm interested in the ways in which epistemic communities construe, conceive of, and publicly represent and work with their objects of inquiry—and what's thereby assumed about them and about the world. I argue that these implicit or explicit assumptions are a distinct type of *explanandum*, whose distinctiveness sociology hasn't adequately appreciated and taken advantage of. I think it should and I hope it will.

Keywords

neuroscience, neural correlates, love, knowledge, science, sociology of epistemologies, assumptions

And yet I wish but for the thing I have

(*Romeo and Juliet*, act II, scene ii)

INTRODUCTION

The neuroscience of love "is a growing field of research, which only recently has become the topic of intensive and rigorous scientific empirical investigations." It aims to identify "the specific cortico-subcortical neural network as well as the central and peripheral electro-physiological indices of love" (Cacioppo et al. 2012b:12). Neuroscientists of love argue that "a rigorous neuroscientific approach integrated with other disciplines such as social psychology has the potential to answer age-old questions as to the mechanism underlying

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and function of love. Love, termed pair-bonding in nonhuman mammalian species, has an evolutionary base; has a distinctive neurobiological substrate; and in humans manifests as a combination of physical sensations and feelings that is in response to certain stimuli or events" (Cacioppo and Cacioppo 2016:109).

In order for neuroscientists' experiments to work as intended, participants need to be in love and they need to experience love while their brains are being scanned. In order to look for the neural correlates of love, neuroscientists need a concept or definition of love, so that *its* correlates can be looked for. They may not need a precise definition or concept, such as a list of necessary and sufficient conditions, but they at least need a rough one.[1] This is because neuroscientists wish to develop a scientific theory of love—not a scientific theory of liking someone a lot or being sexually attracted to them. They wish to explain love, or at least something like love—not to explain friendship or something like friendship. But where is this concept or definition of love to be gotten from? How can its conceptualization be rigorous and scientific, so that "rigorous scientific empirical investigations" can rely on it? How should the boundary between love and non-love be drawn, so that brain scans are about what they're meant to be about?

Neuroscience is a latecomer to a crowded scene here. Countless people have puzzled over what love is (and isn't) and how to know what love is (and isn't). They include, for example, Plato's *Symposium* and *Lysis* (although they don't discuss "love," but "*erōs*" and "*philia*," and translation is part of the problem), and Aquinas's distinction between *amicitia, amor, caritas*, and *dilectio*. Countless arguments have claimed to individuate love; individuate a certain number of types of love; distinguish love from Christian *agapē* and from Buddhist *mettā*; and distinguish love from attraction, from friendship, from the conjunction of attraction and friendship, from liking, and from infatuation or "limerence." Countless psychologists have developed questionnaires and scales to measure the different types of love, "love styles," "dimensions of the prototype of love," and "models of the nature of love" (Aron and Aron 2012; Aron and Westbay 1996; Fehr and Russell 1991; Hendrick, Hendrick, and Dicke 1998; Sternberg and Grajek 1984), so they now have 33 different measures of "passionate love" (Hatfield, Bensman, and Rapson 2012). From Plato to Hatfield, every concept, definition, or construct has been objected to for one reason or another, partly because there's no agreement about what makes one concept, definition, or construct better than another, or what it'd be to get it right.

If you're a neuroscientist who studies love, this might be a terrible state of conceptual affairs and a major methodological challenge. If you're a social scientist who studies neuroscientists who study love, though, this is a terrific empirical opportunity. Neuroscientists' conceptual choices, whatever they are, won't be neutral. Whatever they are, they will have taken sides in long-standing philosophical and social scientific debates about love, what it is, and what it's not. They will have made assumptions about the nature of love, loving, lover and beloved, and the social context in which love exists. This applies to both its conceptualization and its attendant operationalization. In this regard, love exemplifies a more general problem in contemporary brain science. Neuroscientists have conducted experiments about the neural correlates or underpinnings of many phenomena that the social sciences and humanities have long tried to put their finger on, such as morality, spirituality, religion, trust, empathy, sympathy, gratitude, compassion, creativity, beauty, and art. In trying to experimentally get at these things, their properties, and how they work, neuroscientists can't avoid making conceptual choices and assumptions.

Sociologists neither commend nor condemn these choices that neuroscientists must make, but exploit them for their own descriptive and explanatory aims. How the objects of inquiry of neuroscience are construed and measured is valuable data for sociology, and in particular

for the sociology of epistemologies. What neuroscience thereby assumes about its objects and the social world is valuable data for sociology, and in particular for the sociology of epistemologies. This is the project to empirically investigate, not knowledge, beliefs, ideas, understandings, and theories, but rather their epistemological bases. And this is the project to which I'm making a contribution in this paper. My tactic: I identify and dissect neuroscientists of love's choices and assumptions, as they conceptualize and operationalize their objects. Or, more precisely, as they publicly present—and do things with—conceptualized and operationalized objects in ways that are acceptable to their scientific and non-scientific audiences.

The paper is organized as follows. The next two sections introduce the sociology of epistemologies, the neuroscience of love, my data, and my approach. Then, I present my findings about the love of neuroscience, what it assumes, and how to explain these assumptions' being common in the literature. The last two sections discuss my account's contributions and where to go from here. Sociologists can fruitfully investigate epistemologies in diverse settings and using diverse methods. One small but important part of that project focuses on scientists' objects of inquiry. Another small but important part of that project focuses on assumptions.

SOCIOLOGY OF EPISTEMOLOGIES

In philosophy, epistemology asks what knowledge is, under what conditions you can be said to have knowledge, what steps should be taken to obtain knowledge, and how knowledge claims should be assessed. In sociology, epistemology has normative uses, but it can also be an empirical research subject. The sociology of epistemologies (SoE) investigates the epistemological bases of people's ideas, beliefs, and understandings, and societies' norms, practices, and institutions (ordinary people and institutions, of which scientists and science are a special part). It investigates the practical criteria for something's counting as knowledge in society *S* or field *F*; what the objects of knowledge claims are, that is, that which knowledge claims are about; how knowledge claims are given support and validated; what's accepted as evidence; and what's taken to be knowable in the first place. In *S* or *F*, what makes true things true? What makes obviously true things obviously true? What makes laughable things laughable? And how does this get practically sorted out?

SoE asks how epistemologies vary across time and place, and what accounts for these variations. It asks how assumptions about knowledge, cognition, their objects, and their methods vary. It doesn't ask which epistemological approaches are better and worse, more and less likely to produce doxastic goods. As Whooley (2013:247) puts it, "epistemological issues and debates are not confined to the rarefied air of academic philosophy, but rather are practical issues that people must negotiate in social life. They are ripe for sociological analysis. Whereas the conceit of philosophers investigating epistemology is to find a universal grounding for the justification of knowledge, sociologists can bring their empirical sensibility to delineate how these epistemological issues get sorted in practice."

SoE is an empirical project. It's an old-new empirical project, which builds on three scholarly traditions. First, SoE builds on the traditional sociology of knowledge and the more recent sociology of ideas (Bourdieu 1984; Camic and Gross 2001; Camic, Gross, and Lamont 2011; Eyal et al. 2010; Gouldner 1970). However, SoE singles out and concentrates on epistemologies. Not only do social actors have diverging beliefs, ideas, and understandings, make diverging knowledge claims, and use diverging methods, but also their epistemologies might be systematically different. Actors might explicitly or implicitly disagree about what counts as truth, what counts as unintelligibility or nonsense, and whether

knowledge can ever be objective. Groups and organizations might differently establish what a knowledge claim is, how you should go about validating it, what counts as evidence, what counts as good evidence, and what counts as sufficient evidence that something is the case. Epistemologies are often tacit, since ordinary people (evidently and fortunately) aren't epistemologists and know nothing about epistemology. Still, tacit epistemologies have discursive and practical manifestations.

Second, while SoE needn't be about science, scientists, and scientific knowledge, it builds on key themes about epistemology in science and technology studies (STS) and the sociology of science, including the construction of scientific objects. Especially important is Knorr Cetina's (1999:3, 2005:67–68) approach, which distinguishes between "the construction of knowledge" and "the construction of the machineries of knowledge construction." You have scientific claims on one hand, and, on the other, the epistemological machinery and assumptions with which and upon which scientific claims are built. Sociologists of scientific knowledge have had much to say about the former, given their claim that "the very content of scientific knowledge is amenable to sociological analysis" (Fuchs 1992:35). Yet, whether explicitly described in these terms or not, many works are about both: both the "content" of scientific proposition *p* and the epistemological assumptions that make *p* count as a scientific proposition and as a proposition at all. Further, STS has investigated standard epistemological issues such as what counts as evidence and "the meaning of data" (Collins 1998; Pinch 1985a, 1985b). It has also investigated what factors shape scientists' methodological and epistemological dispositions (not only their beliefs and theories) (Rosental 2003; Stepan 1986).

Third, SoE builds on research about truth, objectivity, fact, and styles of thought, which has looked at these erstwhile sacrosanct concepts from the perspectives of sociology, history, and historical epistemology (Bourdieu 2001; Canguilhem 1955; Chang 2004; Daston and Galison 2007; Foucault 1969; Hacking 2002; Kuhn 1970; Shapin 1994; Somers 1995; Sturm 2011).[2] In this spirit, SoE squarely establishes epistemologies as its main *explananda*. It specifies what they are, their features, dimensions, and methodological obstacles. How should you go about accounting for groups' and organizations' epistemologies? How does it differ from accounting for their knowledge claims, understandings, ideas, and beliefs? How does it differ from accounting for scientific communities', professions', or organizational fields' methodological tendencies, such as tools and techniques that become prevalent, and then go out of fashion?

Despite these genealogies, only recently has SoE been recognized as a collective project and distinct body of work. Few people have used the expression "sociology of epistemologies." There is no review paper about it. Its boundaries are fuzzy. Indeed, they are being performatively delineated in this very paper (Austin 1962). Either way, the way I understand SoE, many sociological studies have made contributions to it. Their empirical settings are diverse: medicine, sexuality, and psychiatry (Epstein 2007; Waidzunas and Epstein 2015; Whooley 2010, 2013, 2014), the German *Stasi* (Glaeser 2011), technological accidents (Downer 2011; Vaughan 1996), poverty knowledge (Rodríguez-Muñiz 2015), policymaking and evaluation (Breslau 1997), and the uses of measurement, quantification, and statistics (Espeland and Sauder 2007, 2016; Igo 2007; Schweber 2006). The most frequent empirical setting, though, is the epistemologies of social and natural science communities (Abbott 1990, 2001a, 2001b, 2016; Abend 2006; Au 2017; Keim 2016; Knorr Cetina 1999, 2011; Lamont 2009; Mallard, Lamont, and Guetzkow 2009; Steinmetz 2005a, 2005b, 2013), including their causal claims (Abend, Petre, and Sauder 2013; Vaidyanathan et al. 2016).[3]

Just like "the sociology of knowledge has set itself the task of solving the problem of the social conditioning of knowledge," the sociology of epistemologies has set itself the task of

solving the problem of the social conditioning of epistemologies (Mannheim 1954:237, 1971; Merton 1945:379–80). You find them in discursive understandings, but also built into practices, things, and bodily dispositions. Epistemologies shape people's and organizations' interactions with the social world; their artifacts, tools, and narratives; and their habits, routines, and rituals. People and organizations have understandings about the social world. They also have mental and material machineries with which to understand it. Both have an impact on the character of societies and social life.

Epistemologies encompass many issues, so an empirical study about epistemologies might raise many kinds of questions. In this paper I raise a specific one. I'm interested in the nature of the objects about which scientific claims are made. I'm interested in the ways in which epistemic communities construe, conceive of, and publicly represent and work with these objects; how they're demarcated; and what's thereby assumed about them and about the world. If you make claims about *X*, what's *X* like? How can you pick out *X* and tell *X* from non-*X*? What are the essential, defining properties of *X*? How do you know what the essential, defining properties of *X* are?

WAYS OF LOVE-MAKING

Let's turn to love—that is, the study of love via the study of the brain. This is a strategic empirical choice on my part. I didn't choose the neuroscience literature on love because it's representative or typical of any kind of neuroscientific research. Much to the contrary. To begin with, the field is smaller than its public visibility might suggest. Many magazines, newspapers, and blogs love to talk about love and love to talk about neuroscience. No wonder they also love to talk about the neuroscience of love. Trade books, conferences, and presentations about this subject seem to be doing well, too—such as *The New Science of Love, Wired for Love, The Brain in Love*, and many others.[4] Helen Fisher's 2008 TED talk, "The Brain in Love," has more than 4,800,000 views (as of August 2017). There are also stories, art, and films about the brain in love, such as the 2012 documentary, *The Love Competition*, directed by Brent Hoff. The film is about "the world's first ever 'love competition,'" held at the Stanford Center for Cognitive and Neurobiological Imaging. "Seven contestants had five minutes in an fMRI machine to love someone 'as hard as they can.'"[5] The machine determined who loved the hardest and hence won the competition.

The neuroscience of love's public visibility is a mixed blessing, because it opens the way for the criticism that it's not serious research, but pop neuroscience. Harsher critics speak of neuro-bunk, neurobonkers, neurobollocks, or brain porn (Hasler 2012; Heinemann 2012; Satel and Lilienfeld 2013). Even John Oliver, host of "Last Week Tonight," lambasted "Dr. Love"—that's neuroscientist Paul Zak—on these grounds. Whatever comedians' views are, the scientific community's views aren't encouraging either: the neuroscience of love has lower status than other, more traditional research areas.

As far as my arguments are concerned, the point is that neuroscience research on love is in many senses an outlier. But my aim isn't to provide a representative or generalizable account about the neuroscience of social-psychological phenomena, or social, cognitive, and affective phenomena. I'm interested in neuroscientists' epistemologies, assumptions, and objects of inquiry per se, and as a means to develop SoE. For this purpose, the neuroscience of love is a suitable choice, precisely because the concept of love is tricky and love as an object of inquiry is tricky. Therefore, the neural correlates of love are more sociologically promising than, say, the neural correlates of visual perception or disgust.

How a given scientific object or construct comes to be is a crucial sociological and historical issue. What social interactions and processes led to the love of neuroscience

becoming what it is and what it is presented as? Knowing is a collective activity, especially in natural science, but it's also a diachronic process. How do objects change over time, especially as experiments and lab meetings are conducted, experiments don't work, other labs start publishing on the same issue, and so on? These questions should consider both the backstage and frontstage of science. Ethnographers have profitably explored the backstage and observed how science is actually done and what scientists actually think—as opposed to stylized presentations in journal articles, talks, and grant proposals. However, in this paper I concentrate precisely on stylized presentations and their epistemological assumptions. This paper isn't about scientists' true beliefs and actual experiments and lab meetings, but formal scientific discourse (Bourdieu 2001; Gilbert and Mulkay 1984), which reflects what communities publicly take to be acceptable or good epistemologies. That's the sort of epistemologies that make it into high-status social loci (e.g., high-status journals), are considered characteristic of epistemically virtuous persons and organizations, and won't raise eyebrows or be deemed insane (Fleck 1979). Needless to add, backstage and frontstage inquiries are complementary. SoE needs both.

My data are published neuroscientific works. I collected and analyzed works whose central topic is love and the brain; the neural correlates, basis, or substrates of love; or the relationship between brain activity and love or love-like phenomena. To be included, an article had to be published between 2000 and 2016 and in English. Experiments often search for the neural correlates or underpinnings of love, or of one type of love, using fMRI. However, there are various variations on the theme: experiments may use different techniques, designs, and paradigms. I included both experimental studies and reviews. I excluded works that were primarily based on traditional social-psychological approaches and methods (as opposed to neuroscientific), primarily about oxytocin, primarily about the evolution of love, and primarily about mate choice and attachment in nonhuman animals. Applying these exclusion criteria was for the most part straightforward, but occasionally I had to make a hard judgment call.

I ended up analyzing 58 works: 35 studies and 23 reviews (see appendix). I didn't intend this to be a sample, but the whole population of neuroscientific works that met my criteria, so I performed many searches of many kinds to locate them (last searches performed in August 2016). I'm afraid exhaustiveness is an aim that reality tends to fall short of—be it in data collection or elsewhere.

THE LOVE OF NEUROSCIENCE

How do neuroscientists go about investigating the neural correlates or substrates of love? To get us started, consider two pioneering studies: Bartels and Zeki's "The Neural Basis of Romantic Love" (2000) and "The Neural Correlates of Maternal and Romantic Love" (2004). These studies have been very influential in the field and are still frequently cited: according to a Google Scholar search (August 2017), the former has about 1,045 and the latter about 1,425 citations.

In "The Neural Basis of Romantic Love," Bartels and Zeki (2000:3829) look at what's generally seen as the paradigmatic kind of love. They "wanted to chart the neural correlates of this affective state [romantic love] when it is generated by a visual input which is emotionally neutral to an external observer." To do this, they recruited 17 subjects "who professed to be 'truly, deeply and madly in love.'"[6] The researchers didn't take these professions or self-reports at face value, however. Subjects "were selected by means of short written statements describing how much they were in love and by an interview" (cf. Fisher, Aron, and Brown 2005:59).

So, subjects were truly, deeply, and madly in love. In the experiment, "visual inputs" were used to "elicit" or "generate" love in them:

> During the scan each subject viewed coloured pictures of the faces of four people on a neutral background: their boy- or girlfriend and three friends of same sex as their loved partner. All four were of similar age, and the duration of friendships (4.3 ± 5.2 years, median 3 years) was not shorter than the one of the loving relationships (2.4 ± 1.7 years, median 2.3 years). . . . Subjects were instructed to view the pictures, to think of the viewed person and to relax. (Bartels and Zeki 2000:3829–30; see also Scheele et al. 2013)

Bartels and Zeki's (2000:3832) arguments rely on a "comparison of brain activity elicited when subjects viewed pictures of their friends with that produced when they viewed pictures of their loved partner." Methodologically, the stimuli are pictures, and the neural correlates of subjects' reactions to these stimuli are the neural correlates of romantic love. What do Bartels and Zeki find? Their conclusions are bold: "[b]y showing that a unique set of interconnected areas becomes active when humans view the face of someone who elicits a unique and characteristic set of emotions, we have shown that underlying one of the richest experiences of mankind is a functionally specialised system of the brain."

In "The Neural Correlates of Maternal and Romantic Love," Bartels and Zeki's strategy is similar: they elicited maternal love very much like they had elicited romantic love before. This time subjects were 20 English mothers:

> Each provided photographs of their own child . . . , of another child of the same age . . . with whom they had been acquainted for about the same length of time . . . , of their best friend . . . , and of another person they were acquainted with. . . . Like in our previous study on romantic love (Bartels and Zeki 2000), the volunteers were instructed to simply view the pictures and to relax. Since subjects reported after the scan . . . that their emotions were less intense during the last cycle of photopresentations, the last repeat was omitted from analysis.

Like their 2000 article, Bartels and Zeki's (2004:1156–57) key inferences were based on "[a]ctivations revealed when mothers viewed their own child versus an age and familiarity matched acquainted child." Maternal love seems less problematic than romantic love; mother-child love doesn't face the same challenges that boyfriend-girlfriend love does. Either way, in both cases love had to be generated or produced. Like romantic love, maternal love is generated or produced in the lab, so that its brain substrates be sought.

Bartels and Zeki's approach is typical in the literature. Table 1 presents six neuroscience studies that try to get at love in a comparable manner, using comparable stimuli. In these and many other studies, subjects viewed "pictures of a 'loved person'" and pictures of non-loved persons, such as "famous people" and "unknown people." This isn't a small detail: "Selection of an appropriate control condition [is] critical if one is to draw the appropriate conclusions from the observed activation. . . . That is, it is assumed that the only difference between the experimental and control trials is the factor of interest . . . and that the mathematical subtraction of the responses it generates will isolate those, and only those, areas specifically involved in that process" (Armony and Han 2013:144). Take "Reward and Motivation Systems: A Brain Mapping Study of Early-stage Intense Romantic Love in Chinese Participants," by Xu and colleagues (2011:249). Like Bartels and Zeki, Xu and colleagues were after "activations specific to the beloved." Unlike Bartels and Zeki, however, Xu and colleagues didn't

Table 1. Love Stimuli.

Authors	Year	Title	Stimuli
Acevedo et al.	2012	Neural correlates of long-term intense romantic love	Ten women and 7 men married an average of 21.4 years underwent fMRI while viewing facial images of their partner. Control images included a highly familiar acquaintance; a close, long-term friend; and a low-familiar person. Effects specific to the intensely loved, long-term partner were found. . . . As predicted, individuals reporting intense, long-term romantic love showed neural activity in response to images of their partners (vs various controls) in mesolimbic, dopamine-rich regions important for reward-processing and motivation. (pp. 145, 153)
Başar et al.	2008	Brain oscillations evoked by the face of a loved person	Pictures of a "loved person" were presented to female subjects and the elicited responses were compared with responses to pictures showing faces of a "known and appreciated person" or an "unknown person" during EEG recordings (n = 20 females). (p. 105)
Kida et al.	2014	I love my grandkid! An NIRS study of grandmaternal love in Japan	[W]e used NIRS [near-infrared spectroscopy] to examine cortical regions involved in grandmaternal love by measuring oxy-Hb concentration changes in the APFC [anterior prefrontal cortex] of grandmothers who were viewing video clips of their grandchild with a neutral expression or a smile, in comparison with that when viewing video clips of an unfamiliar child having the same expression. (p. 132)
Takahashi et al.	2015	Imaging the passionate stage of romantic love by dopamine dynamics	During a first visit to the laboratory, some 2 weeks prior to scanning, each subject provided 8 picture portraits of their partner, taken from different angles, and a similar number of portraits of other friends of the same sex as their partner, whom they had known for equivalent periods but toward whom they had neutral feelings. (p. 2)
Vico et al.	2010	Affective processing of loved faces	Subjects viewed black-and-white photographs of faces that belonged to one of five categories: loved ones, famous people, unknown people, babies, and neutral faces from the Eckman and Friesen system. Subcategories of loved faces included romantic partner, parents, siblings, second-degree relatives, and friends. . . . Faces of loved ones elicited larger autonomic (skin conductance and heart rate), electromyographic (zygomatic activity), and ERP (P3 and LPP) responses than all other faces. (pp. 2894, 2899)
Xu et al.	2011	Reward and motivation systems: a brain mapping study of early-stage intense romantic love in Chinese participants	Before scanning, participants provided a photograph of their romantic partner (Positive Stimulus) and a familiar acquaintance (Neutral Stimulus) the same sex as their partner and for whom they had no romantic feelings. . . . Participants (a) viewed the photo of the romantic partner (positive stimulus) for 30 s, (b) carried out the count-back task for 40 s (countback1), (c) viewed the photograph of their familiar acquaintance (neutral stimulus) for 30 s, and (d) carried out the count-back task for 20 s (countback2). (pp. 251, 252)

compare the brain activation elicited by pictures of the beloved to pictures of "friends," but to pictures of "familiar acquaintances." Other labs used neither friends nor familiar acquaintances, but "faces of a 'known and appreciated person'" (Başar et al. 2008:105).

My last example is Beauregard and colleagues' (2009) "The Neural Basis of Unconditional Love." This article is atypical: it doesn't investigate romantic or maternal love but "unconditional love." Which is said to be a different "type" or "kind" of love, "also called unlimited love or 'Agape' love." Beauregard and colleagues' subjects aren't typical either, but people "with a very high capacity for unconditional love": assistants in l'Arche communities.[7] Stimuli aren't photographs of subjects' beloved partners or children, but "individuals (children and adults) with intellectual disabilities" (Beauregard et al. 2009:94). Despite these particularities, Beauregard and colleagues partake of the assumption that love is the sort of thing that can be generated or produced.

In fact, they make a more radical assumption in this respect: "Participants were scanned during a control condition and an experimental condition. In the control condition, participants were instructed to simply look at a series of pictures depicting individuals with intellectual disabilities. In the experimental condition, participants were instructed to feel unconditional love towards the individuals depicted in a series of similar pictures" (Beauregard et al. 2009:93). They refer to the former, the control task, as PV (passive viewing), and to the latter, the experimental task, as UL (unconditional love). Beauregard and colleagues (2009:94) explain in the methods section: "In the UL blocks [of pictures], participants were instructed to self-generate a feeling of unconditional love toward the individuals depicted in the pictures. Therefore, the UL task involved both a cognitive component (self-generation) and an emotional-experiential component (feeling)."

Typically, love is generated by stimuli, but this is an unintentional response, caused by the researchers' experimental task. By contrast, Beauregard and colleagues think that, at least in the case of "unconditional love," the photograph-viewing approach isn't enough. Subjects' viewing a suitable photograph must be coupled with their "self-generating . . . a feeling of unconditional love." The authors (2009:95) describe subjects' self-generation of unconditional love as follows: "All participants reported feeling unconditional love in both the UL condition and the PV condition. . . . During the interview conducted at the end of the scanning session, participants did not report feelings other than unconditional love during the control and experimental conditions. At the end of the experiment, several participants told the experimenters that the UL task was relatively easy to do."

Setting aside methodological worries about these self-reports (as well as worries about the quantifier "several"), Beauregard and colleagues refer to unconditional love as a "task" that is "relatively easy to do." It's as if generating love were a voluntary activity. Indeed, it's as if it were like solving a chess endgame puzzle, which several subjects happened to find easy. Despite its unusual research design, this study still exemplifies the assumption I now zero in on.

PRODUCING LOVE

Neuroscientists of love try to grasp and understand love; that's one object of inquiry whose character and characteristics they are after. In carrying out this project, they typically make an assumption—or, more precisely, a set of assumptions—that I call "production of love" (PoL). It comprises three dimensions: generation, temporality, and individualism. One additional assumption has to do with the experiments' control or baseline.

Generation. Love is construed as something capable of being generated, elicited, or produced. The point of showing pictures to subjects is to generate love in them, right there and

then, in order to observe its neural correlates. Even a study whose stimuli are subliminal primes conceives of love as a reaction to a stimulus (Ortigue et al. 2007).

I highlight neither that love can be generated or produced in the lab, by experimenters, nor that it can be generated or produced by visual stimuli such as photographs of subjects' loved ones. These are two debatable methodological questions. Rather, the assumption I highlight is that love is the sort of thing that can be generated or produced at all. For instance, if the experimenter brings a boa constrictor to the scanner room, subjects are likely to get scared: that would be fear and that fear would have been produced by the stimulus. Likewise, to produce the experience of seeing red, the experimenter may show them blood or strawberries. In this respect, neuroscientists' PoL renders love comparable to fear, sensory perception, localized physical pain, or sexual desire (more on this subsequently). They are all reactions to stimuli. Even if there are kinds of love (say, "passionate love," "companionate love," and "compassionate love"), PoL applies across the board. All of them can be generated by the appropriate stimuli.

Temporality. Love can be represented or modeled as a discrete, temporally circumscribed event. Or, to be more accurate, it can be represented or modeled as a series of discrete, temporally circumscribed events. This is a temporal sequence that comprises two or three successive, causally connected stages. At t_1 an individual is shown a visual stimulus (though the stimulus needn't be visual). As a result, at t_2 certain changes occur in her, in her brain and elsewhere. Her brain is often described as carrying out particular tasks that are not consciously available, such as processing, computing, implementing, recognizing, understanding, and deciding. Sometimes there's also t_3: the individual's reactions, such as behavioral responses or subjective experiences, which are the causal consequences of t_2. According to this sequence, the love-event begins at a specific point in time and has a specific and short extension. Brain activation is measured to find the correlates of *that*. What happens during this interval contrasts with the state of the brain before the stimulus (t_0) and after the behavioral responses or subjective experiences (t_4).

Neuroscientists' idea isn't that a person's love really consists of just that one event. Indeed, some studies are specifically about "long-term pair-bonds," that is, "long-term happily married, sexually monogamous individuals reporting intense love for their partner" (Acevedo et al. 2012:145). Rather, love consists of a set or series of events. But these are similar in the relevant respects to the one produced and observed in the lab. What's more, love-events can be grasped one at a time, and then the data can be added up, statistical analyses can be performed, and so on. These events' nature—including their neural nature—isn't a function of their belonging to one process, narrative, or life, except in the limited sense that the same body is their carrier. Put another way, what's thereby assumed is the analytical independence and detachability of these discrete instances. Alternatively, love may be described as a more-or-less durable state in which an individual is; the experimental stimuli are simply triggers, which cause subjects to manifest, activate, or make visible what's already and more-or-less permanently there in them. You may also say that the stimuli aren't producing love, but a love-manifestation or a love-reaction. I'm uncertain about the distinctiveness of this view, but in any case the distinction between love as a non-activated state and an activated state still depends on the PoL assumptions under scrutiny.

Individualism. Neuroscience-of-love studies assume that love is an individual-level property. It's a property or attribute of a person, just as her height, a judgment she uttered, how many times she flew to Montevideo last year, or whether she's experiencing disgust right now. This isn't merely a methodological thesis, but an ontological one. This means love is unlike collective or structural properties, such as there existing certain norms, institutions, or grammar rules. It's unlike population density, mortality rate, and other demographic

measures. Moreover, love is the property of an individual as opposed to a dyad (or as opposed to a larger group or entity). It's not essentially a relational property either. It's triggered by your beloved person or object, and in this sense they are necessary. But they still cause it in you, just like a boa constrictor may cause fear in you. Thus, neuroscience can observe love by producing it one individual at a time; in fact, one instance at a time.

Subtraction. As a cognitive neuroscience textbook explains, "The idea behind cognitive subtraction is that, by comparing the activity of the brain in a task that utilizes a particular cognitive component . . . to the activity of the brain in a baseline task that does not, it is possible to infer which regions are specialized for this particular cognitive component. . . . [A] comparison between two or more tasks or conditions is always needed." For instance, if "both experimental and baseline tasks involve [e.g.] visual processing . . . a subtraction should cancel this out" (Ward 2015:57). Yet, on what grounds should the baseline task be selected?

This is a tough methodological question for many neuroscientific studies. Looking at the neuroscience of love in particular, you have to distinguish love from non-love. You have to do it in such a way that "the only difference between the experimental and control trials is the factor of interest" (Armony and Han 2013:144): subjects' experiencing love. Here three concrete questions arise. First, does seeing the face of a boyfriend vis-à-vis seeing the face of an appreciated person get at the same phenomenon as seeing the face of a boyfriend vis-à-vis seeing the face of a familiar acquaintance? If it doesn't, what's the best way to go? Second, you have to control for potential confounds, say, the photographed person's gender, age, ethnicity, length of relationship, facial expression, and "physical attractiveness." What should and shouldn't be controlled for? Third, what's the relationship between love-relations and friendship-relations, or appreciation-relations, or acquaintance-relations? For example, do love-feelings encompass friendship-feelings? More generally, what's love minus the love component? How should you draw this boundary, so you can get at the neural substrates of love?

However neuroscientists of love answer these questions in their studies, they will contain useful data for the sociologist. Sociologists aren't in the business of evaluating these answers, let alone evaluating the logic of the subtraction method, pure insertion, or linearity. Instead, they're in the business of observing what assumptions about love and loving are thereby made. And then giving an account of their characteristics, functions, and uses. And then asking why successful assumptions might have succeeded. All of which are empirical sociological questions. So, this paper makes no claims as to whether neuroscientists' assumptions really are plausible, reasonable, parsimonious, beautiful, elegant, useful, fecund, or likely to help them discover the truth; or rather implausible, unreasonable, weird, contrived, useless, philosophically confused, ugly, barren, or crazy.

EXPLANATION

In the preceding two sections I sketched the PoL set of assumptions. It's admittedly a rough sketch, which skips over nuances, disagreements, and differences between types of love. Still, it shows that the love of neuroscience is a particular kind of love. It's been construed in particular ways and, whether deliberately or not, particular assumptions were made in the process. The next question is why these assumptions are common in the neuroscience-of-love literature; how to explain their adoption, success, and plausibility within and outside the scientific community.

A compelling explanation will comprise many factors. One has to do with the experimental method, which constrains what can be asked and how. There are logical constraints and practical constraints, for example, subjects need to go home, or, more likely, to their dorms.

I'd like to consider two other parts of the explanation. I won't demonstrate that my hypotheses are true, but only that they're worthy of further consideration and empirical corroboration.[8]

Evolution

The theoretical framework of the neuroscience of love is evolutionary. It's particularly shaped by (a simple version of) evolutionary psychology, its aims, and its style of thought. PoL stems from this evolutionary framework and an analogy it invites, along with a common conception of science, what issues it addresses, and how it addresses them.

According to this conception, science approaches the world analytically. It takes up one phenomenon or factor at a time, *ceteris paribus*. It tries to discern elementary constituents, particles, and forces. And it tries to discern general patterns and laws. So, love can and should be stripped of its cultural surface or coating (the poems, flowers, movies, Valentine's Day, marriage institutions, divorce norms, and differences across cultures and over time), so as to isolate its core or essence. This is a "disentangling manoeuver," which should "peel off" the cultural stuff and reveal the essence of love to science (McDowell 1998:201). It's a universal core to boot, love itself, despite divergent epiphenomenal manifestations (Jankowiak and Fischer 1992).

But how to get at it? Evolutionary theory suggests a dual premise that frames much of the neuroscience literature. First, love is analogous to or continuous with reproductive behaviors and underlying physiological processes in humans. Second, love is analogous to or continuous with other mammalian and avian behaviors and underlying physiological processes (cf. Waidzunas and Epstein 2015:20). The current search for the neural and hormonal underpinnings of love is what such evolutionary analogy or continuum calls for. In turn, it provides evidence needed by the evolutionary account. As an influential early article, "Love: An Emergent Property of the Mammalian Autonomic Nervous System," argues:

> Love, as a neurophysiological construct, not only promotes reproduction, but it also provides a pair-bond to promote safety in the challenging environment. Within this adaptive context, love may have evolved functionally as a temporal shortcut to bypass the slow, often tedious, and potentially unsuccessful processes of communication and social engagement to foster physical proximity and to promote intimacy and reproductive behaviors. (Porges 1998:858; see also Carter 1998; Crews 1998; Griskevicius, Haselton, and Ackerman 2015)

More specifically, the argument is that "love evolved to serve several functions: Displaying reproductively relevant resources; Providing sexual access; Signaling sexual fidelity; Promoting relationship exclusivity through mate-guarding; Displaying commitment; Promoting actions that lead to successful reproductive outcomes; Providing signals of parental investment" (Buss 2006:66). The sexual functions and commitment/attachment functions may be analytically and biologically separable, they may engage distinct "systems," but their joint contribution to evolutionary fitness is evident. Even more, love contributed to the evolution of "social intelligence": "romantic love is an adaptation—a commitment device—that facilitated long-term pair-bonding, which in turn (along with alloparenting) helped advance the evolution of the high levels of social intelligence that characterize our species" (Fletcher et al. 2015:31).

This is a picture that many evolutionary psychologists have argued for. It comes in a theoretical lexicon purged of uniquely human features, such as language and culture:

"attraction," "pair bonding," "parental investment," "attachment," and "mate retention" (Buss 2006; Campbell and Ellis 2005; Young 2003). These expressions apply to human and nonhuman animals alike, so they're amenable to the investigations of evolutionary psychology and neuroscience. They have a good conceptual fit with their arguments. You need to figure out neither if the distinction between "the four loves"—*agapē, philiā, storgē*, and *erōs*—is valid and universal (Lewis 1960), nor if Ovid, Capellanus, and Jean de Meun were talking about the same thing as Neruda (Singer 2009a, 2009b). Nor do you need to figure out if the English word "love" can be translated into all human languages, so experimenters anywhere can recruit subjects who are in love in the same sense that Romeo and Juliet were in love, and ask them questions about love in that sense. These activities require the interpretation of meanings, along with the cultural understandings and practices that make linguistic expressions intelligible. But a science of love would rather restrict itself to objective observation and measurement. For interpretation is a messy, unscientific business. Plus, meaning and language specificities would tell against the universality of love's essence (cf. Xu et al. 2011, 2012).

Eventually, the analogical framing facilitates a transition from claims about attraction, pair bonding, parental investment, attachment, and mate retention to claims about love. This is a necessary argumentative step insofar as your article, book, talk, or grant proposal's *explanandum* is said to be love—not just attraction, pair bonding, parental investment, attachment, and mate retention. Love's "building blocks" and "evolutionary antecedents" must become actual love. Animal models' behavior must be connected to humans' behavior. Then, all this scientific research can be weaved into a single narrative.[9]

You may highlight that "biological anthropologists and neuroscientists are already dissecting the chemical ingredients of love, from the basic sex drive to romantic love" (Frazzetto 2010:25). You may examine the neural similarities and dissimilarities between love and desire, thereby assuming their conceptual and methodological commensurability (Diamond and Dickenson 2012). As it turns out, they share a "brain network," "which reinforces several studies emphasizing the similarities between love and desire" (Cacioppo et al. 2012a:1052). You may explicitly represent the continuum, too: "love, a cross-cultural universal, is a developed form of [the] attraction system" (Fisher et al. 2005). And maybe put "love" in quotes to stress the point: "Biologically, to 'fall in love' is the first step in pair formation" (Esch and Stefano 2005:176). Or you may simply put love, "long-term pair bonds," and "enduring attachments between sexual partners" side by side, without spelling out the implicit premise: "Although love is the source of a large variety of emotions and feelings and celebrated in all human cultures by countless works of art, as yet surprisingly little is known about the neurobiological underpinnings of long-term pair bonds (i.e., enduring attachments between sexual partners) in humans" (Scheele et al. 2013:1).

The neuropeptide oxytocin has been helpful to these arguments, due to its versatile relevance to many human and nonhuman phenomena: it "trigger[s] or modulat[es] a full range of physiological functions and emotions: happiness, attraction, love, affection, and hatred after stress" (Viero et al. 2010:150; see also Zak 2012). Indeed, here the continuum or analogy may come into full view:

> To dissect the anatomy and chemistry of love, scientists needed a biological equivalent of the Rosetta stone. Just as the actual stone helped linguists to decipher an archaic language by comparison to a known one, animal models are helping biologists draw parallels between ancient physiology and contemporary behaviours. . . . If we accept selective social bonds, parenting and mate protection as proxies for love in humans, research in animals supports the hypothesis that oxytocin and vasopressin interact to

> allow the dynamic behavioural states and behaviours necessary for love. (Carter and Porges 2013:14)

The neuroscience of love thus becomes conceptually compatible with research about the neural correlates of arousal or attraction, with research about the role of oxytocin and vasopressin, and with research about "other mammalian species displaying monogamous life strategies," such as the prairie vole (Lieberwirth and Wang 2014, 2016:8; Wang et al. 2013). Love can be placed on the same theoretical plane as more docile and tractable concepts, such as arousal, lust, desire, attachment, pair bonding, mate choice, mate attraction, or mate retention. Falling in love is a more evolutionarily recent and complex form of attraction and mate choice; remaining in love is a more evolutionarily recent and complex form of bonding, attachment, and mate retention. Both falling in love and remaining in love increase offspring survival. Love can be placed in the same methodological category as those more docile and tractable concepts—where the question of what exactly neural correlates are neural correlates of doesn't arise in the same tricky fashion.

We're now in a position to see why the PoL assumptions are at home in the neuroscience of love. As far as I know, nobody doubts that sexual arousal can be produced or elicited in the lab. It's just that kind of thing. You can elicit it by showing subjects "sexual stimuli" or "erotic stimuli," such as "attractive opposite-sex nudes in modeling poses" (Hamann et al. 2004:415) or "photographs of nude boys and men" (Schiffer et al. 2008:24). Then, you can examine the brain activation patterns that correlate with arousal (Fisher et al. 2002; Gillath and Canterberry 2012; Sylva et al. 2013). Much like it allows conceptual transitions in the theoretical narrative, the aforementioned analogy or continuum allows love to be the kind of thing that can be produced—in terms of both ontology and methodology. An arousal-instance is that which follows a sexual stimulus (pictures of naked models); a love-instance is that which follows a love stimulus (pictures of partners or children). Neuroscientists' experimental methods befit both phenomena. And the nature of the object—love—seems to come across as plausible to the relevant audiences.

Choices and Decisions

PoL is common in the neuroscience literature on love. A reasonable inference is that these assumptions and conception of love seem plausible to neuroscientists themselves and to their scientific and non-scientific audiences: journal referees, funding agencies, or the media. PoL seems plausible (not crazy), so neuroscientists' experiments and claims about love are seen as being about love (not about something else).[10] What accounts for this (roughly speaking) cultural fact? I think one causal factor might be a widespread understanding of people as decision-makers or choosers, which is taken to apply to much of their behavior and life, or even to the whole of it.

Its bare bones are as follows. In the beginning and at bottom, there are individual organisms. Individuals' lives can be represented as bodies moving about and encountering stimuli, to which they have positive or negative reactions, about which they make positive and negative judgments, and which present them with action choices. The stimuli are of all kinds: a predator, an attractive woman at a bar, a train hurtling down the tracks toward five workers, or five brands of *alfajor* in the grocery store. The choices may be whether to approach or avoid, marry him, break up with him, move to the suburbs, commit a crime, commit suicide, light up a cigarette, raise your left arm, or turn the knob to open the door. These are things individuals decide to do, whether or not they are conscious of the causes or drivers of their choices, and whether or not they are conscious of the fact that they are making choices.

Every individual makes hundreds of little judgments and choices every day, which in turn shape the initial conditions of her next judgment and choice—like nodes in a tree structure diagram. That she could have done otherwise becomes a thin requirement, ever closer to the absence of logical necessity. But it suffices to represent and narrate her life as a succession of independent events and interactions with external objects, including people. In addition, a society's repertoire or menu of actions (what there is for a person to do) isn't specific to it. Actions' intelligibility isn't problematic or socially accomplished. Individuals encounter stimuli, have options before them, and perform actions in particular situations or "environments" (Perrin and Lee 2007)—all of which is already intelligible to them and to the external observer.

This understanding of social life leads to the individualist assumption mentioned previously. Love is an individual-level property: a person has it (whether what she has is a feeling, experience, or state isn't decisive here). Other people enter the picture only because love has "intentionality," in the sense that phenomenologists and philosophers of mind use that word. It requires an object; it must be directed at something, such as your boyfriend, father, daughter, God, or pet. Yet, it remains essentially individual, centered on the subject, not relational. Again, I don't assess the reasonableness of this assumption, but point out that it amounts to taking sides in an old controversy in social theory. For example, relational views would argue that the neuroscience of love gets off on the wrong ontological foot. For "the meaning of an action arises from its relations to other actions—both temporally, as a successor and a forerunner in coherent sequences of social events, and structurally, as a vertex in a synchronic ensemble of actions. Beneath this lies a more profound assumption that actions, not actors, are the primitives of the social process. The substratum of social life is interaction, not biological individuals who act" (Abbott 2007:7; see also Aspers 2010; Blumer 1969; Emirbayer 1997; Latour 2005).

This understanding of social life leads to the discreteness and analytical independence or detachability assumption mentioned previously as well. Here there are instructive parallels between the science of love and the science of morality. In *The Sovereignty of Good*, Iris Murdoch (2001:37) argued that "[t]he moral life . . . is something that goes on continually, not something that is switched off in between the occurrence of explicit moral choices. What happens in between such choices is indeed what is crucial." Murdoch lamented moral philosophy's focus on these choices, instead of on what was crucial. Similarly, the object of inquiry of much moral neuroscience and psychology is individual moral judgment. Conclusions about morality are drawn from moral judgment data. These moral judgments are discrete events; they are structurally analogous to disgust or empathy reactions, and to capuchin monkeys' and chimpanzees' "inequity-averse" and rats' "empathically-motivated" responses to stimuli, too (Bartal, Decety, and Mason 2011; Brosnan 2013; Brosnan and de Waal 2003).

Both the discrete morality-events and the discrete love-events are by nature capable of being generated or produced, and their neural substrates can be apprehended at that specific time interval. In fact, both are products of a more general human "capacity" or set of capacities. This is the aforementioned capacity to distinguish what should be approached (e.g., fruit) from what should be avoided (e.g., feces), which manifests itself as reactions to stimuli, such as positively or negatively valenced emotions, and pro- or con-attitudes. Again, love and morality are analogous to fear, disgust, desire, and attachment—even if superficially more complex and more diverse. Like the individualist assumption, the discreteness assumption entails non-trivial epistemological and ontological commitments. For instance, these commitments are at odds with views of social life as irreducibly processual, in which time and temporality are essential to action and being (Abbott 2016; Glaeser 2005,

2011; Rosa 2005). From this perspective, the starting point of today's sciences of love and morality—discrete actions, behaviors, or judgments—is empirically and conceptually misguided.

To be sure, I'm just proposing a hypothesis, which empirical research may confirm or disconfirm. How frequent are love choices and romantic decision-making in science, and in other social and cultural domains (Curtis 2006; Fisher 2004, 2010; Gottlieb 2010; Joel, MacDonald, and Plaks 2013; Oyer 2014)? How frequently are concepts of choice, decision, decision-maker, and decision-making used to understand and represent love (Ansari and Klinenberg 2015; Illouz 2012; Swidler 2001)? Do they really render PoL plausible and help explain its success?

DISCUSSION

We've looked at the PoL assumptions; we've looked at an aspect of the conceptualization and operationalization of love in neuroscientific research.[11] My account illustrates one way sociological research about epistemologies might go. But why is this undertaking worthwhile? I'll now show why the construction of the object can be a fruitful focus, why assumptions can be a fruitful focus, and how they can make special contributions to SoE.

Scientists' claims and theories must be about something. This something—object, entity, thing, phenomenon—must be identified or individuated. This something must be brought into existence conceptually. Thus, sociologists end up having social classes, networks, and socioeconomic status; historians have revolutions, crises, and periods; anthropologists have cultures, religions, and cults; economists have economies and preferences; and psychologists have many kinds of constructs. These things come into being and become amenable to scientific investigation through processes of construction of the object (Bourdieu et al. 1973; Passeron 1991). They require demarcation or boundary work. Without some boundary between revolutions and non-revolutions, you can't develop a theory of revolutions. Boundaries are also drawn between social science concepts and commonsense, folk, and journalistic concepts (Gieryn 1999; Lamont and Molnár 2002). Concepts must be placed in more encompassing theories and conceptual networks, which emphasize some aspects of reality and deemphasize others (Longino 2013). And concepts must be operationalized, so they reach empirical reality. All of which are interactive, back-and-forth processes: objects aren't fixed at the beginning, but are construed over time, used for empirical research, revised, presented in papers and talks, and so on.

The neuroscience of love exemplifies how neuroscience might establish relationships between two kinds of things. On the one hand, there are brain events, things that happen in a brain, such as particular axons getting depolarized, action potentials arriving at presynaptic terminals, or vesicles releasing neurotransmitters—which taken together are referred to as the "activation of" or "increased activity in" particular brain areas, networks, or circuitry. On the other hand, there are social, cognitive, and affective phenomena, such as deductive reasoning, problem solving, memory, object recognition, counterfactual thinking, action understanding, art experience, aesthetic judgment, moral judgment, financial decision-making, trusting a stranger, helping a stranger, or feeling sympathy or empathy. These phenomena are hypothesized to have neural correlates, substrates, or underpinnings, which neuroscientists try to discover. Or, which is the same, neuroscientists try to discover the brain areas, networks, or circuitry that subserve, are involved, implicated, play a role, support, are responsible for, or are recruited by particular social, cognitive, and affective phenomena. Establishing such correlations may be an epistemic end in itself, but it's often a means to more ambitious epistemic ends.

The former side of the correlation—the brain and neuroimaging side—involves significant methodological and technical difficulties, some of which can't be solved at present, but one day likely will. Scientists' ability to observe, image, measure, represent, and model brain activity will no doubt continue to develop; and so will scientists' ability to causally manipulate it to test their theories (e.g., via transcranial magnetic stimulation and transcranial direct current stimulation). The latter side of the correlation involves another kind of significant difficulties, conceptual ones, which neither technological development nor empirical progress can solve (Bennett and Hacker 2003; Pardo and Patterson 2013, 2016). I argue that these conceptual difficulties open up empirical opportunities and sociological vistas into neuroscience, its conceptual choices, epistemological commitments, assumptions, their impact on neuroscientific knowledge, and the impact of neuroscientific knowledge on the real social world. To show why, my argument has four steps.

(I) Pictures of boyfriends, girlfriends, and children can be neuroscientists' stimuli, but think also of images of artworks or "masterpieces of Classical and Renaissance sculpture" (Di Dio, Macaluso, and Rizzolatti 2007; Vessel, Starr, and Rubin 2012), "religious and nonreligious propositions" (Harris et al. 2009), and stories about fat men who might be pushed off bridges. Neuroscientists can scan subjects' brains all right, but what are the resulting neural correlates neural correlates of (Abend 2017)? What kind of argument can show that they are in fact getting at love, art, religion, and morality, respectively? For neuroscientists don't set out to develop a theory of viewing photographs of boyfriends and girlfriends, but a theory of love; not a neuroscientific account of pushing fat people off bridges, but a neuroscientific account of morality; not an account of people's saying or believing they intend to *F*, but an account of people's actually intending to *F*. As pointed out previously, this conceptual issue has immediate methodological implications for experiments and particularly for the selection of control conditions.

Therefore, these neuroscientists are forced to ask: what it is for a person to really be in love (as opposed to being sexually attracted to someone, or liking someone a lot); what it is for something to be a work of art (as opposed to a urinal); what it is for an action to be a moral action and for a judgment to be a moral judgment; and what it is for a person to truly have the intention to do something (as opposed to her merely saying that she intends to do that). Only then can they go ahead and seek to discover the neural correlates of being in love (not of sexual attraction or of liking a lot), experiencing art (not of looking at objects), making a moral judgment, and true intention. Naturally, there are more and less reasonable answers to these questions; some of them are perfectly fine to design and run an experiment. Yet, these are precisely the kinds of questions philosophers have been discussing and disagreeing about for millennia, and about which, hence, there are large literatures. Which are precisely the discussions, disagreements, and literatures that neuroscience's approach is sometimes said to have surpassed. Experimental science isn't philosophy (heaven forbid!), but this philosophical stuff is a prerequisite for the science to get off the ground.

(II) My point isn't methodological but conceptual. Methodologically, there are better and worse ways of designing experimental paradigms and measuring social phenomena; better and worse constructs; more and less clever tasks and stimuli; some experiments have more external and ecological validity than others. It might be too costly (or impossible) that the stimuli be the real artworks, or the real boyfriends and girlfriends, or real fat men. So you have to make do with showing images of artworks to your subjects, even if viewing the real thing may make a difference, and even if viewing the real thing is arguably constitutive of the experience of art. This is true, but corrigible, at least in principle. Plus, it applies to all of science, whose methods are always imperfect and perfectible. Scientists are of course but

finite human beings, whose time and resources are of course finite, so they have good reason to undertake doable investigations and address tractable problems.

Instead, I'm making a conceptual point, which SoE investigations can benefit from. Imagine a neuroscience group (call it "LoveLab") that sets out to conceptualize love, moral judgment, the experience of art, beauty, religious experience, intention, trust, empathy, or sympathy. What should the lab director and her collaborators do in practice? Should they consult the best works on the subject in philosophy, the best works on the subject in neuroscience, the best works on the subject in social science, their intuitions, their friends, their fellow neuroscientists, the *Oxford English Dictionary* (or the *Duden*, or a Pirahã dictionary), or something else?

Suppose this lab ends up collectively settling on a certain conceptualization, and they go on to carry out their experiments. But another neuroscientist (call him "Satoshi") reads their studies and finds them unsatisfactory. LoveLab says that love is L_1, and stimulus S_1 can elicit it. Satoshi protests that love is really L_2, S_1 didn't elicit that, so the experiment didn't get at the neural correlates of love at all. Similarly, LoveLab says morality is M_1, but Satoshi protests that morality is really M_2, so the experiments' subjects didn't make moral judgments. LoveLab says conditions C_1, C_2, and C_3 need to obtain for something to count as empathy, whereas Satoshi says that only C_2 is necessary, and what they call "empathy" is in fact sympathy (Jorland and Thirioux 2008; Stueber 2006; Wispé 1986). At this point, the question becomes how to adjudicate these disagreements, what kinds of considerations are relevant, and who should be the judge.[12]

(III) This is a hard problem not only for the neuroscience of social-psychological phenomena, but for many empirical sciences and in particular for the social sciences: what their objects should look like, where their concepts should come from, and what it is to get them right. I'm not asking what to do about this problem and whether it challenges neuroscientists' research program in these areas. Rather, I view it as a sociological opportunity: it can be exploited to examine neuroscientists' assumptions and epistemological commitments.

Sociologists examine neuroscientists' conceptualization- and operationalization-choices, and how they actually come up with concepts, constructs, tasks, and stimuli. How these concepts end up looking in the pages of scientific journals, but also what happened in the lab, at conferences, and elsewhere such that they ended up looking that way—and what changes happened along the way. What reasons are given as to why these concepts end up looking that way? What reasons are given if someone protests that they should have been conceptualized differently (in lab meetings, talks, referee reports, or published commentaries)?

Moreover, concepts exist in conceptual frameworks or networks. I discussed love-concepts based on analogies between love and mammalian attraction and attachment behaviors. Likewise, morality-concepts might be based on analogies between morality and the social and moral emotions. These analogies may or may not be forceful, useful, or defensible. In either case, they aren't empirical claims, but conceptual orientations. They are calls to attend to particular things, use particular schemes, and carry out particular research programs. Saying that *A* is similar or analogous to *B* is an elliptical way of saying that *A* is similar or analogous to *B* in terms of *X* (its weight), in terms of *Y* (when it began to exist), or in terms of *Z* (the letter of the Hebrew alphabet with which its name begins). To determine if anything is similar to anything else, you first need to specify: similarity with respect to what (among a logically infinite number of possibilities); and how similar counts as similar (since logically no two things are identical). Scientific conceptualizations play up certain aspects of things and play down others; they emphasize certain analogies and continuities and deemphasize others. What a field takes its object of inquiry to be comparable (and incomparable)

to and commensurate (and incommensurate) with has substantive and methodological consequences. These choices sociologists can also exploit.

In sum, sociologists can account for the assumptions that are manifest in or built into neuroscientists' objects, concepts, methodological tools, and practical applications. This includes what love, morality, empathy, art, creativity, religion, or spirituality are taken to be, how they can be apprehended or known, how they differ from other things, and what analogies are relevant and irrelevant.

(IV) The empirical study of neuroscientists' objects comprises two aspects. One is objects' backstage construction—which refers to lab meetings, email and mobile phone conversations, offices, experiments, material tools and instruments, papers' and grant proposals' drafts (along with lab directors' comments in the margins), blind alleys, errors, and Archimedean bathtubs. The other is objects' frontstage construction—which refers to published scientific articles, newspaper and magazine articles, trade books, talks and lectures, finished grant proposals, and labs' and researchers' websites. The former calls for ethnographic research: observing, hanging out with, and recording the quotidian lives of the natives. The latter calls for content analysis methods, and the rhetorical analysis of public performances and communications.

Neuroscience labs select concepts and operationalize them, come up with experimental paradigms and tasks, perform experiments, and write papers and grant applications. Since this is collective and interactive work, ethnographers may observe how conceptual disagreements surface and how they are solved in practice. These discussions won't be philosophical, but will be guided by the practical tasks at hand: design studies that are doable and work, get articles published, get grants. Besides conceptual disagreements, ethnographers may also observe meta-disagreements about the criteria to adjudicate conceptual disagreements.

These revealing backstage events have a revealing frontstage counterpart—which analyzing public communications, from *Nature* and *Science* articles to TED talks, can reveal. Sociologists should pay most attention to articles' and presentations' two key moments: first, the transition from ideas to stimuli and measures (usually early on); second, the transition from experimental results to conclusions and implications (usually toward the end). For instance, at some point morality becomes a stimulus that elicits judgments (utterances or more likely finger movements). At a later point, neuroimaging results become claims about morality, theoretical and practical implications, and public policy recommendations.

CONCLUSION

In this paper I've examined the neuroscience-of-love literature from a sociology-of-epistemologies perspective. I've shown that this literature makes consequential assumptions concerning the production or generation of love, its temporality, its individual character, and appropriate control conditions (what doesn't produce love; what love is not). These findings are a contribution to the sociology of epistemologies (SoE), which is a family member of three more established fields: sociology of knowledge, sociology of ideas, and sociology of science/STS. It draws and builds on them. However, its perspective and potential are unique, because it specifically singles out and concentrates on epistemologies, objects of inquiry, and assumptions. To conclude, I consider more carefully how assumptions work, and I show that they're of special significance for the contemporary descendants of Durkheim's *Elementary Forms*, Marx and Engels' *German Ideology*, Mannheim's *Ideology and Utopia*, and Fleck's *Genesis and Development of a Scientific Fact*.

Scientific research is necessarily based on assumptions of many kinds. They may have to do with epistemology, ontology, logic, human nature, probability theory, or technical equipment and materials. They range from the metaphysically fancy (you aren't a brain-in-a-vat; there are laws of nature) to the methodologically pragmatic (the error term is normally distributed; people are rational). Because of this diversity, few things are true of all of them. Some assumptions are consciously made and argued for, some aren't (Kuhn 1970). Some are widely shared, some aren't (Gouldner 1970). Some are more reasonable than others. Some turn out to be more fruitful than others. Some are closer to linguistics' presuppositions or implicatures than others. Some have larger effects on scientific theories than others. Some are closely connected to empirical facts, some aren't. Sociologists' job is to describe and explain the diverse assumptions that underlie or are built into scientific practices, objects, and methodological tools, and the processes through which objects and methodological tools come into being and change.

There's no lack of scholarship on assumptions in both science and everyday life. Is there anything new to say about them? I argue that there's one distinctive feature of assumptions as *explananda*, whose distinctiveness sociologists haven't adequately appreciated, taken advantage of, and put to use.

Compare scientists' assumptions to their truth-claims. It's controversial in philosophy and social science if reality can be a cause of scientists' purportedly true beliefs about it. Yet, for the sake of argument, assume that that's the case. Astronomers believe the earth revolves around the sun partly because the earth does revolve around the sun, just like one cause of my belief that there is a computer screen before my eyes right now is that there really is a computer screen before my eyes right now. True beliefs are partly caused by their truth-makers. Similarly, you may argue for an inference to best explanation: the best explanation of its seeming to me that I have a screen before my eyes is that there's in fact one there, along with my not having taken LSD earlier today.

However, this sort of explanation doesn't work for scientists' assumptions. That's not what assumptions are about or do; they have another function or point. Epistemological assumptions aren't about the world itself, but how to know it, what kind of knowledge is possible, what it is to have knowledge, what's evidence for it, and what's evidence *tout court*. Where to look at the world from, how to look at it, how to talk about it, and what kinds of similarities and differences matter and hence should be used. Take the cognitive practices of a scientific community, or, for that matter, any group, organization, or person. Epistemological assumptions aren't its empirical accounts, but their prolegomena, preliminaries, starting points, bases, or auxiliary equipment: that which makes knowledge and knowing possible. They don't constitute knowledge but "machineries of knowledge construction" (Knorr Cetina 1999:3).

By the same token, ontological assumptions aren't descriptions of what exists in the world—for example, there are such-and-such elementary particles, states of matter, physical constants, social classes, economies, cultures, species, or races, which have such-and-such properties. That'd be science itself. Rather, they address a different level: what it is for something to count as part of the world, what's a kind of thing, and how to individuate or pick out a thing—for example, an elementary particle, species, race, or person.

Assumptions can be based on and informed by empirical reality in many ways. However, precisely because they are assumptions, they can't be wholly determined by what the world is like. Roughly speaking, they can't be true in the way propositions can. Their very nature is such that they must be to some extent up to us.[13] This "up to us" might be cashed out as referring to three things: individuals, individual scientists, or labs; scientific, cultural, or organizational fields; or that which everybody takes for granted in a community or society

("the taken-for-granted"). In any of these cases, the explanation of assumptions' success, prevalence, plausibility, adoption, or acceptance can sidestep some of the troubles that beset the explanation of truth-claims and factual beliefs. They don't need to take sides in philosophical debates about truth—unlike explanations of the success of the belief that the earth revolves around the sun or the success of the belief that Montevideo is the capital of Uruguay.

Sociologists can then ask why assumptions *A* and *B* become prevalent, work, and are successful in a given community, field, or society, whereas assumptions *C* and *D* aren't or aren't anymore. While these assumptions normally remain implicit, whenever they're explicitly discussed *A* and *B* seem plausible to people, whereas *C* and *D* seem outlandish, aren't taken seriously, don't pass the straight face test, or don't fly. These outcomes can be explained in the usual ways. Relevant causal factors may comprise scientific disciplines' institutional, material, and political circumstances, as well as the socio-demographic and cultural attributes of the people who construe objects of inquiry. They may comprise, too, the natural languages scientists happen to speak and express their claims in (English, Mandarin, Pirahã), the tools and technologies they have at their disposal, and the conceptual networks concepts are embedded in and consequently constrained by.

There's another consequence of scientific communities' embeddedness in organizations, cultures, and linguistic communities. Imagine a psychologist, neuroscientist, or anthropologist who began their paper or talk with a crazy construal of the object—for example, she might begin by defining "love" as the state of thinking about four-legged animals that bark, or "morality" as the capacity to evaluate pieces of furniture with a flat top and one or more legs. That just won't fly. The reason why it won't is telling: here craziness is a function of the semantic and cultural meanings of the words "love" and "morality" in contemporary U.S. society and U.S. English. Even where ordinary people's intuitions or commonsense aren't decisive, there are still cultural understandings to which scientists' conceptualizations are accountable—for example, colleagues in your discipline who are not specialists, colleagues in other disciplines, university administrators, funding agencies, science writers, and even undergraduate students and TED audiences. Whatever it assumes, your concept of love and morality must make sense to them. Your concept must come across as plausible, sensible, reasonable. Thus, at least some scholarly concepts and assumptions have to pass non-scholarly plausibility tests.[14]

SoE draws on sociological work on plausibility: plausibility judgments, intuitions, schemes, and structures (Berger 1967, 1969, 1992; Harvey 1981; Shapin 1994; Steinmetz 2005b). For instance, you could argue (though this isn't uncontroversial) that the plausibility of scientists' assumptions is similar to the plausibility of religious beliefs and different from the plausibility of scientists' empirical claims. To use a simple example, a psychologist may say that "people have a tendency to Φ" without better evidence than the tendencies of her neighbors, family, and students in Boston, Massachusetts. Plausibility does affect what statements and generalizations she can get away with, but these claims can, in principle, be checked against survey or census data. By contrast, some assumptions are untestable, because they aren't empirical. They may be more or less useful, more or less generative, more or less elegant, more or less parsimonious. But these are themselves claims that can be sociologically accounted for: scientists' claims about usefulness, generativity, elegance, and parsimony. If you take examples not as neat as mine, things get even more fun: how about physicists' and cosmologists' claims that are both empirical and untestable?

Epistemological, ontological, methodological, and other kinds of assumptions shape knowledge in multiple ways, big and small: its character, production, formulation, presentation, reception, uses, and what there is to be known in the first place. They constitute one important mechanism through which knowledge is shaped by the conditions under which it's

produced, and hence they recast the old problem of the "social conditioning of knowledge" in a novel manner. By foregrounding this distinct type of *explanandum*, we can break new ground in our sociological understanding of knowledge, ideas, and science.

Of course, neuroscientists' assumptions about love may strike us as plausible. So may strike us their assumptions about morality, empathy, trust, art, aesthetics, spirituality, and religion. They may strike some of us as plausible anyway. Which is precisely my point. We are part of the audiences in the eyes of whom conceptions of love must fly—where "we" doesn't refer to specialists in neuroscience, but to radio and TV hosts, politicians and policymakers, science writers, *New York Times* readers, university administrators, and pharmaceutical industry executives in the United States and Europe. However, plausibility judgments and consensuses don't allow for the same causal arguments that truth and truth-claims purportedly do, that is, that reality may partly cause beliefs about it. And the observation that something seems plausible or makes intuitive sense to a particular group of people is just where sociologists' explanatory work begins.

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NOTES

1. Neuroscientists might not need a precise definition or conceptualization of object *X*. They might not need it for the research to get going, or they might not need it at all. Instead, a prototype will do; a rough, in-the-ballpark, provisional conceptualization or definition will do. But they'd still be saying *roughly* what's the thing they're investigating, eliciting, making claims about, or offering a theory of. Even if you don't state the necessary and sufficient conditions for *X* to be a religious experience or a creative action, you have to have some criteria in place, such that my brushing my teeth this morning isn't one.
2. Some of these works pursue normative lines of argument. Some draw philosophical conclusions, for example, that there are no such things as truth and objectivity. Some advance methodological, reflexive arguments about their own epistemological assumptions and the aims of social science (Ashmore 1989; Bourdieu 1984, 1997, 2001; Bourdieu, Chamboredon, and Passeron 1973; Clifford and Marcus 1986; Gouldner 1970). What's sociology of epistemologies' stance on these issues? Does it have to have one any more than other sociological subfields? These questions merit more careful consideration than I can give them here.
3. Sociologists' empirical research on epistemology may address ontology, too. Philosophers' question is what entities the social world contains. Sociologists' question is what entities the social world is taken to contain. What counts as a person (Evans 2016)? What kinds of things are there? What kinds of people are there, say, children, the poor, the mentally ill, or people with disabilities (Hacking 2007; Navon and Eyal 2016; Schnittker 2017)? What kind of thing is a corporation, American business, a social

class, society, or Fuenteovejuna? Do they have beliefs and interests, do things, and have things done to them (Abend 2014; Glaeser 2011; Rodríguez-Muñiz 2015)? Are nonhuman animals moral agents and hence morally blameworthy (Berman 1994; Hyde 1916)? Empirical ontology has gotten less attention in sociology than in anthropology and science and technology studies, where an "ontological turn" is said to have occurred (Johnson 1988; Law and Lien 2013; Mol 2002; Woolgar and Lezaun 2015).

4. Amen (2009); Fletcher et al. (2013); Horstman (2012); Johnson (2013); Lewis, Amini, and Lannon (2000); Praver (2011); Sukel (2012); Tatkin (2011); Walsh (2016); Young and Alexander (2012).
5. https://aeon.co/videos/contestants-have-five-minutes-in-an-fmri-to-love-someone-as-hard-as-they-can.
6. Acevedo and colleagues (2012:146) asked potential subjects, "Are you still madly in love with your long-term partner?" Ortigue and colleagues (2007:1220) recruited subjects "on the basis of advertisements indicating that experimenters were seeking individuals who were currently intensively in love."
7. "L'Arche communities . . . are places where those with intellectual disabilities, called core members, and those who share life with them, called assistants, live together. This special population was selected on the basis that one of the most important criteria to become an assistant is the capacity to love unconditionally" (Beauregard et al. 2009:94; see also Beauregard and Paquette 2006).
8. While I focus on macro-factors (cultural, organizational, historical, historical-epistemological), micro-processes are significant as well (social psychological, interactional). While I focus on science, things are cognized in diverse ways in social, political, and organizational life, consequential assumptions are made, but only some of them end up working and succeeding.
9. The analogical framing and its attendant challenges aren't specific to love at all. Few topics have been more central to human animals than the analogies between human and nonhuman animals. Many scientific research programs, even entire fields, have been and are based on them. Disputes about other species' thought have been staples of our species' thought (Penn, Holyoak, and Povinelli 2008). Not to mention language and morality (Bekoff and Pierce 2009; Crane 2015; Putnam, Neiman, and Schloss 2014; Rowlands 2012; Tomasello 2016). A recurrent character in these disputes argues that they're irresolvable, because they're merely semantic.
10. My evidence for this is indirect and far from decisive; future experimental and survey research may prove me wrong.
11. My arguments are in one sense broader and in another sense narrower. Broader, because many disciplines confront similar conceptual problems regarding the construction of the object, such that measurements of it can be gotten, and claims about it can be made—including most social science. Narrower, because few neuroscience projects force researchers to get their hands as conceptually dirty as love does.
12. If these disagreements can't be adjudicated, LoveLab and Satoshi will both publish articles about the neural substrates of "love," but they could be talking about very different things. Normal science aims at progress, so this sort of skepticism or relativism would be disastrous.
13. "To some extent" is deliberately vague. Exactly to what extent and how are difficult questions. I don't know that I know how to answer them.
14. But what scholarly concepts don't have to pass non-scholarly plausibility tests, despite referring to social life? What's technical and esoteric enough to avoid them, like mathematicians' irrational number and philosophers' possible world?

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