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TOWARDS A NEUROSEMIOTICS OF FRIENDSHIP

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Introduction: Why friendship?

The aim of this chapter is to get a sense of what a neurosemiotics of friendship might look like, investigating the difference between a semiotics of friendship and a neurosemiotics of friendship based upon neuroscientific research. The key premise has been lucidly articulated by Jorna (2009: 2831), who wrote: "Humans, whether they are conceived of as information processing systems or as neurological systems, are signals, signs and symbols using systems themselves. Therefore, neurosemiotics, largely, is also about ourselves." Insofar as friendship molds much of our lives, across ages and scenarios, then its study should not escape the purview of this nascent field.

Still, why use friendship as a case? What *is* friendship? Is it a real relation in the social world (like relations of family, class, or institutional roles)? Is it a human phenomenon involving subjective experience? Or is it a "construct" used in fields such as network research and social cognitive neuroscience, where such constructs are seen either as a hypothesized cause for certain patterns of behavior, or as a way to operationalize abstract notions, like friendship? These three characterizations are not disjunctive and they may all be adequate, depending upon context. Indeed, there are even more ways of characterizing friendship, drawing on insights from anthropology, history, philosophy, social psychology, and ethology, to name just some fields.

Friendship, in its everyday sense, designates a special social bond between two or more persons. Such a link has essentially relational and semiosic characteristics that are (neuro)biologically grounded and embedded in cultural and social matrices of norms, ideals, habits, ways of living, and ways of thinking and communicating. This richness foregrounds a broad variety of approaches relevant for illustrating the epistemic benefits of neurosemiotics. Although the term "friendship" has multiple meanings – a common one being *a voluntary relationship of mutual liking, trust, and support between the agents involved* – and is studied by many disciplines, it is fruitful to use the social relationship of friendship as a lens to better understand the social and semiotic nature of the self, thus emphasizing an important aspect of all social and psychic phenomena – namely, that they can be understood as mutually constituting each other (there can be no normal psyche without a social structuring environment and vice versa) within a set of neurobiological constraints and enablements. There is a subjective phenomenology particular to the human psyche, but it is embedded and enculturated within a social matrix that also needs to be accounted for (indicating the existence of a sociocultural phenomenology transcending the purely subjective, such as social norms, organizational habits, and institutions).

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Similarly, the psyche is embodied in a human organism where (measurable and unmeasurable) brain processes are only a part of its total material biology. If it is true that neurosemiotics is largely about ourselves (as Jorna states in the opening quote), to understand ourselves is also to understand how we are placed in a sociosemiotic grid of "other selves," interacting with semiosic fluxes through our bodies (including our brains), in a cultural matrix codetermining who we are. If a friend can be seen as another social self (Aristotle's famous suggestion),[1] friendship is a good place to investigate social cognition and its neurosemiotics.

It is not purely coincidental that a seminal paper on neurosemiotics (Favareau, 2001) analyzed the then newly discovered mirror neurons and their role in empathy and the general emergence of intersubjectivity. What applies in general for the neurosemiotics of intersubjectivity is particularly crucial for the interplay between self and other in friendship. Favareau (2001: 86–87) argued that

> to equate the "self" as coterminous with biological proprioception, with the first-person perspective, or with a node in a social matrix is to impoverish the conception of "self" by several significant orders – for the self to *be* a self must be all of these recursively at once and more. The full "self" as we understand it in our daily lives is a dynamically determined self at every moment and the relations of which it is inextricably a part (itself, other, language) are likewise dynamically and perpetually co-construed. It is therefore as much a product of social interaction as of neurotransmission, for both the interpersonal and extrapersonal aspects of this self are deeply rooted in a massively non-linear, re-entrant ecology of signs.

As we will see below, the contemporary neuroscience of friendship lends itself, when interpreted neurosemiotically, to add a new dimension to Aristotle's notion of the friend as another self.

The theoretical framework for the following analysis, apart from Peircean semiotics (Peirce, 1931–1958; Stjernfelt, 2014), is a perspectival realist (Giere, 1999) philosophy of interdisciplinarity that acknowledges the irreducible complexity of the models and perspectives offered by the natural, human, and social sciences upon friendship phenomena in their evolutionary, biological, historical, psychological, social, political, and philosophical (including ethical) aspects (Caine, 2009; Hruschka, 2010; Digeser, 2016). There is not yet any single integrative theory of friendship, but many attempts have been made to trace friendship's evolutionary prehistory and culture-dependent universality, as well as the plurality of ways in which it can be enacted. Neurosemiotics is an important part of this territory of investigative attempts to map friendship phenomena in the real world.

Neuroscience needs semiotics

The meaning of "a semiotics of *X*" is exemplified by "a semiotics of ideology" – that is, the use of concepts, theories, and perspectives from semiotics to understand ideology as a real-world phenomenon. It comprises: (1) *the academic collective* as a social-institutional network of researchers gathering around the study of ideology; (2) *the epistemic object*, namely, ideology as constituted specifically through a semiotic perspective being applied to investigate it; and (3) *the real object* – for instance, the various political and religious ideologies existing throughout the history of human societies. To become a subject matter of investigation, a real object must be mediated to constitute an epistemic object, and this can happen in various ways through the application of different theoretical and methodological perspectives from different disciplines (Køppe, 2012). Thus, the epistemic object of ideology as a semiotic phenomenon is not identical to (but may share similarities with) the epistemic object of ideology as seen through the perspectives of sociology, political science, or anthropology, among other fields. The similarity between dimensions (1), (2), and (3), and the Peircean distinction between interpretants, representamens, and dynamical objects, will not escape the attention of a semiotically sensitive reader.[2] Thus, a semiotics of *X* involves *X* as a real dynamic object studied through the tools of semiotics, thereby constituting *X* as a semiotic phenomenon allowing investigators to ask specific questions and pursue their inquiry. If *X* is living processes as investigated within biology, a semiotics of *X* is the field of biosemiotics (Favareau, 2010a). This field is dependent upon research already done within standard biology, but biosemiotic approaches help by putting the material mechanisms of living systems as discovered by biologists into a broader perspective of signs, meaning, and communicative function, and also help to explain why biology has long been perfused with information and signal metaphors (Emmeche & Hoffmeyer, 1991) by actually taking these metaphors seriously and developing them into genuine biosemiotic concepts. In this sense, biosemiotics helps us to expand biology to better grasp communication in nature. Similarly, neurosemiotics helps us to expand the understanding achieved by the neurosciences.

But what is it that neurosemiotics (Leewen et al., 1992; Ivanov, 1993; Nöth, 2000; Jorna, 2009; Favareau, 2001, 2010a, 2010b) can offer specifically?[3] As we will see with the case of friendship, it can offer two things, both needed for better interpretations of the findings of neuroscience. First, neurosemiotics uses the tools of semiotics to study the forms of sign action underlying neurobiological processes and mechanisms as a basis for the emergence of cognitive, volitional, and emotional behavior as well as intentionality, functioning as an interdisciplinary bridge between semiotics and neuroscience in general. It emulates: (1) an academic interfield connecting semiotics with cognitive neuroscience; and (2) a special approach constituting an epistemic object of neurosemiosic processes; pointing to (3) real existing but hitherto undiscovered or unexplained phenomena that are thus brought under scrutiny. Second, it also offers a critical subjecting of neuroscientific findings to semiotic analysis: A scientific neuroscience research paper (a sign of knowledge) is a complex proposition with a predicate and a subject, stating true (or probably true, or false) claims about the properties of something – for example, "friendship has a neural correlate,"(Güroğlu et al., 2008). Seen as such (namely, as a dicisign[4] or an argument), a research report can be analyzed semiotically by analyzing how this complex dicisign refers, what subsigns it consists of, the role of models and diagrams in it, its inferential structure, what (scientific, philosophical, cultural) discursive universes it involves, and the role of errors and uncertainties in its empirical grounding, among several other aspects. In this second sense, neurosemiotics parallels the philosophy of (neuro)science, but uses semiotic instead of philosophical methods.

A semiotics of friendship

Because a semiotics of *X* must take *X*'s potentials for and enactments of sign exchanges and interpretation as a focal point of analysis, a semiotics of friendship must analyze such a relation from the perspective of *semiosis* – that is, sign generation, representation, sign action and interpretation, and their processual roles in the interactive relations of two or more friends as they are located in a social web. If we focus on friendship between humans – knowing that some non-human animals can also relate in ways that best can be described as friendship (Denworth, 2020) – this situatedness in a social web involves markers or identity indices like age, gender, class, ethnicity, race, culture, and language. Being triadic relational structures in the Peircean sense, semiosic processes (where some signs stand for something to somebody or just some third instance) involve the mediation of qualities, existants, and general thoughts (or feelings, reactions, and concepts). It seems obvious that friendship – when seen as a communicative relationship between two or more human beings knowing each other well, having a reciprocal trust in each other, and a positive affective preference for each other for reasons that may be clear or obscure (or both) to those involved – is a social semiotic relation that by hypostatic abstraction (Peirce, 1958) has become a potential object of reflection for the agents involved, and a source of change of and by themselves. It is not a simple rule-based and purely instrumental relation (like my relation to my greengrocer when I buy broccoli); rather, it is a mutually valued, shared, and personal relation beyond mere economic, nutritional or other survival-related necessities. Friendship is similar to semiosis, as it is communicational, embodied, and depends upon a register of biolinguistic capacities that need to be in action and working before we can see it unfolding. One can even give a definition of friendship (Emmeche, 2014), emphasizing its relational triadicity as it is governed not just by the two friends but also by social norms.[5]

All these aspects need not involve the perspective of neuroscience, even though friendship is unfolding (psychologically, socially, culturally) within a set of neurobiological constraints and enablements, which is why a neurodegenerative disease can have the sad effect of ultimately ending a friendship (Rorty, 1993). One can analyze classic and modern conceptions of friendship from a semiotic perspective, give a semiotic definition of the relationship, and investigate the sign actions of its dynamisms (in formation, maintenance, and termination) quite independently of any focus on its neurobiological mechanisms, constraints or enablements. However, a neurosemiotics of friendship will have to draw upon insights about its neurobiology on some dimensional scale. Let us turn to our main example.

A neurosemiotics of friendship

There have been few, albeit quite remarkable, examples of research on friendship in the neurosciences (Brent et al., 2014; Chavez & Wagner, 2020; Denworth, 2020; Güroğlu et al., 2008; Wang et al., 2016; Woods et al., 2020). Recasting this work in a semiotic perspective may help shape our ideas of neurosemiotics as a nascent field of research.

We will focus upon an excellent study within cognitive social neuroscience by Carolyn Parkinson, Adam M. Kleinbaum, and Thalia Wheatley, which seems to indicate that friends often have some similarities at the neural level. First, let's remind ourselves about the social science notion of *homophily*, introduced by Paul Lazersfeld in the 1950s. This term denotes the tendency for people to have (non-negative) ties with people who are similar to themselves in socially significant ways. Much social science research has indicated that similarity seems to breed connection, and this pattern influences network ties of many types, including marriage, friendship, work, advice, support, information transfer, exchange, co-membership, and other types of relationship. The result is that people's personal networks are homogeneous with regard to many sociodemographic, behavioral, and intrapersonal characteristics (McPherson et al., 2001). The hypothesis investigated by Parkinson and Wheatley (from neuroscience) and Kleinbaum (from social network research) was that homophily – especially when manifested as friendship, but also more generally as closeness in a social network – can be detected at the neural level among people; that it might be shown that friends actually "click"' even at the neural level, not just on a social and emotional level. So if friends might be said to have an instant rapport with each other (in the sense of a close and harmonious relationship in which they understand each other's feelings or ideas and communicate well), this form of relatedness has a neural signature. Operationalizing friendship (to be discussed below) so as to be a measurable construct, seen as a relation in a social network, and using the scanning technique of functional magnetic resonance imaging (fMRI) on a concrete population of university students, the three researchers found that "[s]imilar neural responses predict friendship," to quote the title of their paper (Parkinson et al., 2018: 1). From a neurosemiotic perspective, the study is especially interesting both for what it reveals and for what it leaves unanswered, as we shall see. Their abstract, quoted here, will serve as our point of departure:

> Human social networks are overwhelmingly homophilous: individuals tend to befriend others who are similar to them in terms of a range of physical attributes (e.g., age, gender). Do similarities among friends reflect deeper similarities in how we perceive, interpret, and respond to the world? To test whether friendship, and more generally, social network proximity, is associated with increased similarity of real-time mental responding, we used functional magnetic resonance imaging to scan subjects' brains during free viewing of naturalistic movies. Here we show evidence for neural homophily: neural responses when viewing audiovisual movies are exceptionally similar among friends, and that similarity

> decreases with increasing distance in a real-world social network. These results suggest that we are exceptionally similar to our friends in how we perceive and respond to the world around us, which has implications for interpersonal influence and attraction.
>
> *(Parkinson et al., 2018: 1)*

So Parkinson et al. (2018) claim to have revealed a new aspect of friendship (and homophily more generally) called *neural homophily*, meaning that some neurological phenomena are more similar between friends than between nonrelated persons. It concerns the activity patterns of different brain regions when persons are exposed to (i.e., perceive and interpret) some meaningful stimuli. In the study these were 14 video clips covering a range of topics and genres such as comedy clips, documentaries, and debates. The clips were selected so that they would likely be unfamiliar to the subjects, effectively constraining the subjects' thoughts and attention to minimize mind wandering, and to evoke meaningful variability in responses, because different subjects attend to different aspects and have different cognitive as well as emotional reactions to them (i.e., they interpret content differently).

The subjects used for the first part of the study were a cohort of 279 first-year university students in a graduate program at Dartmouth's Tuck School of Business. All participants filled out a survey (administered in November of the students' first academic year) to characterize their internal social network. Forty-two students, who were interested in participating in the subsequent neuroimaging part of the study, did so in February.[6] A survey question read:

> Consider the people with whom you like to spend your free time. Since you arrived at [institution name], who are the classmates you have been with most often for informal social activities, such as going out to lunch, dinner, drinks, films, visiting one another's homes, and so on?

Classmates' names were supplied as listed in columns, with one column corresponding to each section of students in the graduate program. The subjects could indicate any number of social ties, and had no time limit for responding to this question. The survey only inquired about students' interactions with other members of their academic cohort, not individuals outside their group of classmates. Thus, a social network analysis could be made, mapping the nodes (students) and the edges (their ties) of the network. Friendship was operationalized as a mutually reported tie – that is, having two students both indicating a positive response to the abovementioned question (basically a checked box for the name in the survey's column of classmate's names). In network terms, an undirected edge would connect two actors only if both nominated the other "as a friend," as the scientists say, which may be friends but could also be just those with whom you will have spent some free time.[7] The protocol also allowed mapping social distance, operationalized as the smallest number of intermediaries or mutual social ties required to connect two individuals in the network. Demographic data about each subject's gender, ethnic identity, and country of citizenship were obtained from the school's register to control for mere demographic similarities.

In the subsequent fMRI study, the 42 students viewed the same series of video clips on various topics (music, politics, food, sport, science, comedy, satire) ranging in length from 88 seconds to more than five minutes and chosen, as mentioned, to evoke a range of different emotions. As participants watched the clips, the scanner recorded the responses of what in the analysis would be compartmentalized into 80 separate regions of their brains (for each hemisphere, 34 cortical areas and six subcortical structures). Then the researchers compared the responses of each student with the responses of every other student. The 42 students paired up in 42·41/2 = 861 distinct ways, and some of these dyads would classify as friends [social distance = 1] (because of mutual nomination in the survey), others as friends of friends [distance = 2], and so on, up to a category of distance 4 or more.

The results were quite remarkable. The neural responses of friend pairs were significantly more alike than those of non-friend pairs in terms of the calculated inter-subject time series correlations. For each of the 861 unique dyads, the Pearson correlation between the time series of fMRI responses (Figure 18.1) was computed for each of the 80 brain regions. The neural response similarity within each student dyad was summarized as a single variable; so for each dyad, a weighted average of normalized neural response similarities was computed, with the contribution of each brain region weighted by its average volume in the sample of fMRI subjects. It was shown that, overall, the more similar their neural responses, the shorter the distance between them in the social network. In statistical terms, for each one-unit increase in overall neural similarity, the odds that two people were friends increased by 47 percent. Even when the researchers controlled for the demographic (non-neural) similarities of people in each of the 861 pairs (features such as age, gender, and nationality), the correlation between neural response and position in the social network remained. Thus, neural similarity provided additional predictive power, above and beyond similarity in terms of the observed demographic variables, as seen when the "full model" was compared with a model that did not include neural similarity.

The authors further examined whether certain brain regions were driving the observed relationship. Broad regions of the ventral and dorsal striatum were thus detected, including the right nucleus accumbens, the bilateral caudate nucleus, the left putamen, the right amygdala, the right superior parietal lobule, and the left inferior parietal cortex (Parkinson et al., 2018: 1–14).[8] These are not delimited to the regions known to process social information, as Wheatly commented to a science journalist: "It was all over the brain, sensory regions, memory, language … You couldn't say here's the social brain network that is responsible for friendship. It was that friends' brains are remarkably similar across huge swathes of areas" (Denworth, 2020: 292). Yet the correlation was especially strong in areas related to shared perspective-taking, visual and auditory attention, and affective processing. Wheatly commented:

> Friends are literally seeing and hearing the world more similarly than people who are friends of friends and friends of friends of friends. It's coming down to the level of how you're processing sights and sounds. Given a music video, if you and I find some parts of the melody or some part of the visuals particularly engaging, then we're going to tune our eyes and ears to those parts.
>
> *(Denworth, 2020: 292)*[9]

The researchers also tested whether it was possible to predict friendship status based on similarity of the fMRI response time series across brain regions. The use of the word "prediction" here (and in the paper's title) should, of course, be taken with caution. When a journalist phrased the findings thus: "Parkinson and her colleagues also found that the brain responses alone could do a pretty good job of predicting whether two people were friends, mere acquaintances or total strangers" (Kaplan, 2018), "predicting" in this statistical sense used by the researchers means first training a machine learning algorithm to recognize patterns of neural similarities associated with four social distance categories (1, 2, 3, and 4+) from a subset of the total dataset from the dyads, and then to check whether this classifier program can "guess better" in the sense of deviating significantly from classifying completely randomly when exposed to data outside the training set. As mentioned, the 861 dyads were divided into four categories of social distance: "friends" defines a distance of 1 (N = 63); "a friend of a friend" implies a distance of 2 (N = 286); "a friend of a friend of a friend" entails a distance of 3 (N = 412); and the last category was dyads with a distance of 4 or more (N = 100). If the algorithm was making random guesses about a dyad's social distance, it would guess right 25 percent of the time.[10] But the classifier trained on the brain responses correctly identified friends 48 percent of the time (meaning there was close to a 50–50 chance of hitting a right answer if asked whether those in a particular dyad were friends – so much for statistical "prediction").[11] It also correctly classified

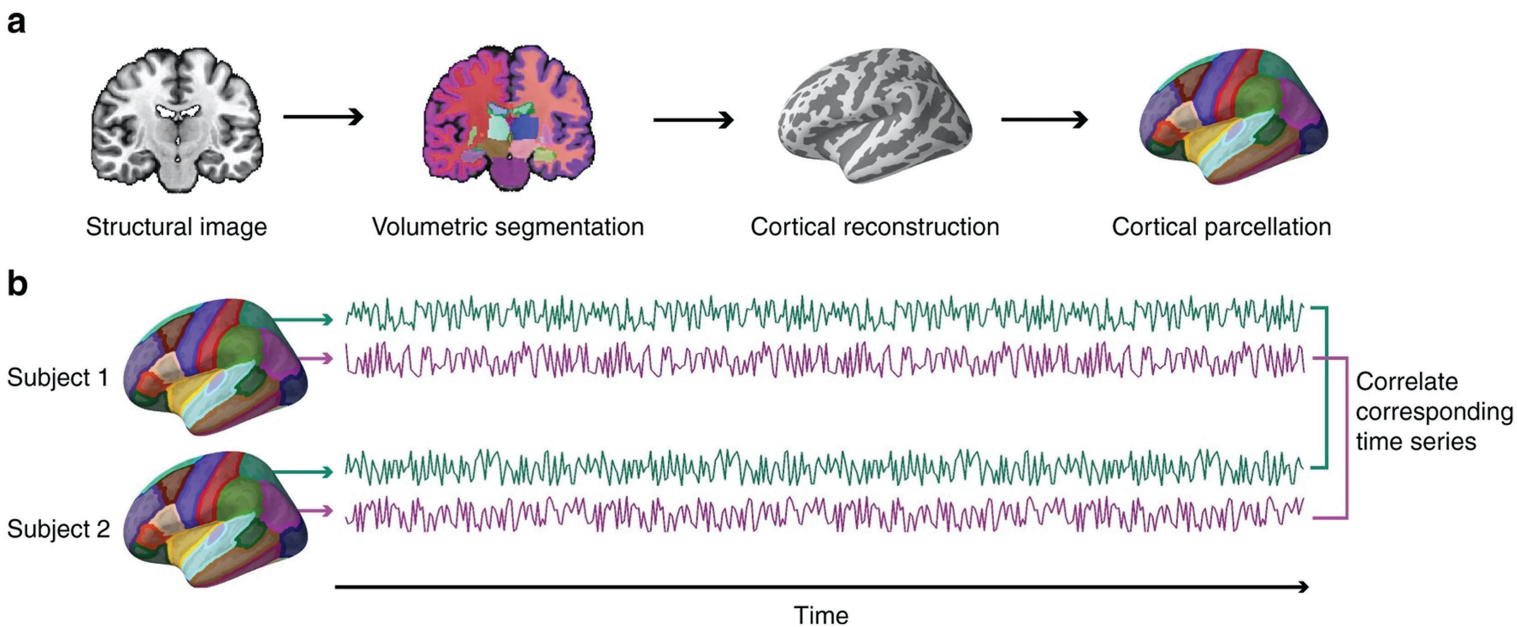

Figure 18.1 Computing inter-subject time series correlations

A. 80 anatomical regions of interest (ROIs) were derived for each individual; segmentation of cerebral cortex, subcortical white matter, and deep gray matter volumetric structures (signified by color in the image) was performed on the high-resolution scan of each individual's brain volume. Next, a cortical surface model was reconstructed and parcellated into anatomical units, here signified by different colors in the cortical parcellation scheme on the far right. B. For each individual, the average response time series within each ROI was extracted during video viewing. The correlation between time series extracted from each pair of corresponding ROIs was computed for each unique pair of subjects. For details see Parkinson et al. (2018). Credit: Creative Commons Attribution 4.0 International License. See e-book for a full-color version of this figure.

distance 2 relationships 39 percent of the time, distance 3 relationships 31 percent of the time, and distance 4 relationships 47 percent of the time, according to the study (Figure 18.2). When the algorithm guessed wrong, it was usually only off by one category.[12]

Disregarding our reservations about the meaning of "prediction," it is indeed remarkable that one can use time series correlations between any two brains perceiving the same material to indicate the likelihood that the persons involved are friends – or *could be* friends, as there was no deeper understanding involved about the actual nature of these mutually sympathetic nominations (liking to spend free time with another person).[13] If this study should be expanded (from being about potential friendship to become a neurosemiotics of realized friendship), more focus on the specific nature of the involved relationships would be needed. Standard analyses of social distance would not suffice and must be supplied with investigations of the qualitative sociology and psychology of the actual relationships. An interesting procedure would then be to first investigate the nature of the relationships involved and how they might be differentiated, eventually inspired by the classic trichotomy between friends of utility, friends of pleasure, and very good or best friends – which is empirically feasible (cf. Anderson & Fowers, 2020) – and then perform a similar analysis to see where "neural homophily" would be most salient. A hypothesis would be that there is no special neural homophily or similarity among friends of utility, but that there is so for friends of pleasure, while for very good friends the degree of similarity is more difficult, if not impossible, to guess (this group may also cover more distinct types of relationships) but it might take an intermediate position. A similar conjecture could be posed for the trichotomy of social, familiar, and communicating friendships (Little, 1993).

But what about the causality behind the correlation between social distance and brain patterns? "Do we become friends with people who respond to the environment similarly, or do we come to respond to the world similarly to our friends?" asked the researchers, and immediately admitted that "we cannot ascertain, based on these results alone, whether neural response similarity is a cause or consequence of friendship" (Parkinson et al., 2018: 1–14).[14] They plan to continue their research with follow-up studies in a longitudinal setting, to monitor whether, for instance, a group of students naturally gravitate towards those who see the world the same way as they do or if they become neurally more similar once they share experiences with their friends (Denworth, 2020). Another study has shown that neural similarity also correlated with social proximity for brains in the absence of external stimuli.[15]

A way to interpret a high degree of neural similarity in the time series of two persons' brains is to see this as an example of neural synchrony (Hasson, 2012). As cognitive neuroscientist Mathew Lieberman phrased it, the study is "one of only a handful of neural synchrony studies to use machine learning algorithms, such that neural synchrony is actually being used to predict something about the people whose brains are synchronized," the only difference being that while other studies predicted experiences and memories, Parkinson et al. (2018) "predicted aspects of the social structure of a large novel group from the similarity of their neural responses" (Lieberman, 2018: 371–372).

The neurosemiotics of opacity in data-intensive brain research

While using the term "predict" with care, however, a neurosemiotics of friendship should also ask: Who is doing the predicting? Is it the researchers or the algorithm trained on the data set? What kind of knowledge is achieved through this laborious exercise? Can we imagine the possibility of unpacking the classifier algorithm (which in this and many similar studies via machine learning becomes almost blackboxed)[16] and from its structure extract an understandable lesson or some explicit knowledge that would help us, as humans, not only to classify dyads to social distance categories more or less successfully (if we have a big and reliable dataset and good machine learning tools), but actually *know* in the explanatory sense about the detailed workings of neural homophily, and gain some sort of deeper understanding of the neurosemiotic mechanisms involved?

Compare such a statement as "I know a friendship when I see one but cannot tell you how I know this" when uttered by (a) a layperson, (b) a psychotherapist, and (c) a research group with a classifier algorithm à la Parkinson et al. (2018). We would only think of (a) and (b)'s utterances as scientific if their knowing how to identify friendship were accompanied by some general explanatory principles related to how they got this skill and what friendship is within some theoretical perspective; but we tend to think that (c)'s utterance is more scientific when it is based upon elaborate empirical research, including semi-automated inductive reasoning on brain scan data, including pattern recognition by machine learning. Yet, in all three cases, it may be more accurate to say that something is distinguished (or "predicted") and in this sense is "known," rather than seeing the knowledge attained as explanatory. The classifier algorithm used by Parkinson offers in itself no explanation of its skills of distinguishing social distance categories.

Of course, the neuroscientists cannot just look at the unprocessed fMRI scanning outputs and point out the locations where two persons' curves (indicating blood flow peaks) are similar enough in time response to count for something that can "predict" anything like friendship. The prediction is highly mediated by algorithms that achieve a form of tacit knowledge, akin to the skill a trained physician has in distinguishing freckles from skin cancer spots. The doctor has learned to do this by training and observing hundreds of cases, and receiving guidance from a skilled expert. Such a tacit knowledge is not explicit, but a cognitive capacity we have when we somehow "know more than we can tell" (Polanyi, 1983: 4). Polanyi's examples of this kind of knowledge include not just technicians' and doctors' ability to correctly diagnose diseases based upon perceptual clues, but also everyday skills such as face recognition – "we usually cannot tell how we recognize a face we know" (Polanyi, 1983: 4). In general, there exist many tasks whose execution we can understand intuitively, even though we cannot verbalize the rules or procedures behind them, and even if we can get machines to learn these tasks, we still do not posit an adequate theory of the social and cognitive processes.

Can the neuroscientist acquire the same kind of skill as the classifier algorithm? Here, a neurosemiotics of friendship involves a semiotics of pattern recognition and statistical prediction via artificial intelligence. The physician may do a good job distinguishing freckles from potentially dangerous spots, but dermatology cannot be just an intuitive skill in classifying skin. It is a science including an explicit biological understanding of the differences between normal and dangerous skin change processes. Likewise, social cognitive neuroscience needs more than pattern recognition of unexplained similarities between people's brains. It needs a transparent theory (not opaque models) of the mechanisms of neural homophily, and this theory may need to couple several levels of description, one for the perceptions of friendship among the agents involved, one about the social structure within which the friendship unfolds, and one about the neural mechanisms "underlying" social cognition and emotion (where a better metaphor than "underlie" may be to see the neural mechanisms as just forming one component of the total brain–psyche–culture system).[17]

Polanyi's appraisal of the role of tacit knowledge in science went along with his insistence on a personal aspect of scientific knowledge and understanding that in no way questioned the authority of a scientist's expertise. Yet who is the authoritative epistemic agent regarding the finding of neural homophily in Parkinson et al. (2018) if parts of the justification of this discovery (the data and their analysis) are epistemically opaque? Humphreys (2009) analyzed the *essential epistemic opacity* of a computational process (leading from an abstract model underlying a simulation to the output) relative to a researcher X. He defined such a process as being "essentially epistemically opaque to X if and only if it is impossible, given the nature of X, for X to know all of the epistemically relevant elements of the process" (Humphreys, 2009: 618). He later expanded the analysis to include *representational opacity* related to machine learning tools like deep neural networks, which perform successfully but whose underlying predictive principles are not fully understood (Humphreys, 2020). The numerical functions between the input values and a probability distribution over the classification types are so complex that interpreting and understanding these functions can be beyond the reach of humans.

A representation is opaque when it is non-transparent, and a *transparent* one presumes that the state of the system is represented "in a way that is open to explicit scrutiny, analysis, interpretation, and understanding by humans and transitions between those states are represented by rules that have similar transparent properties" (Humphreys, 2020: 19). No clear rules of how to come from a degree of neural similarity to friendship status could be offered by Parkinson's group. The central representation in their paper – summing up the data analysis (including the computed time series similarities of the 68880 dyad brain regions recorded) – is a confusion matrix (Figure 18.2), indicating the capacity of the constructed machine learning model to predict social distance based on neural similarities. It summarizes the results of the classifier algorithm (a support-vector network) after being trained on the dataset, but it can hardly be called transparent in the sense just stated.

So, while the epistemic authority is with the person in the case of tacit knowledge of a skilled expert in skin disease diagnosis, in the case of predictive classification of social distance in epistemic opaque computer assisted research, the authority of that "knowledge" is not personal, but technosocially distributed – that is, bound to wider communities of expertise and their computational technologies.

Related to the causality question is a question about what video contents were particularly significant in bringing friends' brains into synchrony or neural similarity? A reviewer of the paper suggested that some movies might be more diagnostic of dyad friendship than others, and asked "to see the overall model performance, prediction accuracy, or rank for individual movies." In their answer, Parkinson's group analyzed the data corresponding to each video clip separately and published these as a supplement. As seen in their Supplementary Table 3, only four of the 14 clips (two comedic videos, one soccer match clip, and a clip called "An Astronaut's View of Earth") provoked a separate neural similarity measure that was statistically significant (either at $p < .05$, $p < .01$, or $p < .001$), while this applied to all the 14 clips compared for both gender and nationality and to none of the

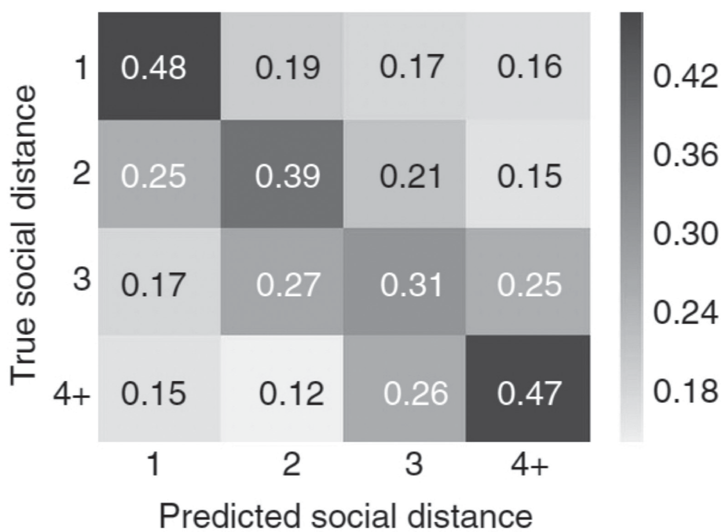

Figure 18.2 Prediction accuracy of classifiers able to predict friendship

Confusion matrix summarizing prediction accuracy of four-way classifiers trained to predict friendship or further distance between members of dyads in their social network based on patterns of neural similarity. Numbers and grey tones indicate how often the classifier predicted that dyads belonged to each social distance category (from Parkinson, et al., 2018; see their 'Methods' for further details). See e-book for a full-color version of this figure.

clips for ethnicity, handedness, or age. These results are difficult to interpret and received no further comments by the group.

However, their research is ongoing and Parkinson's group is determined to shed more light on the causality question. Neurosemiotics can help interpret the results of such lines of research and frame them as forms of knowledge that at once widens the epistemic authority to collective agency (interdisciplinary teams of experts) and make explicit the epistemic costs related to such styles of inquiry in the form of new kinds of scientific uncertainty and epistemic and representational opacity.

Concluding remarks on a friendly critique of common neurosense

To summarize the open questions of the study, substantial additional knowledge (about the way specific areas of the brain process visual and auditory stimuli and bind them together with the subject's previous individual or shared experience to a coherent interpretive response) is needed before we can begin to glimpse the fragments of a neurosemiotic theory of neural homophily that would provide us with explicit and transparent knowledge about the workings of friendship and its *sunaisthesis*, its seeing-together (Flakne, 2005).

Neurosemiotics helped us raise questions concerning the truth status of the research paper as a dicisign predicating neural similarity (and its predicting power) about a subject ("friendship" and, more general, "distance in a social network"). As a complex dicisign, the meaning of the research paper is not reducible to its title and the total argument it communicates helps to contextualize and moderate the simple proposition that "similar neural responses predict friendship." A neurosemiotic analysis contributes to make clear that the title could as well have been the less fancy but more accurate proposition "machine learning algorithms found associations between neural response similarity and preferences for socializing together among a set of first year university students." This clarification may seem commonsensical to the scientists involved, but would impact the way their message is understood by science communicators and the wider public. It may be needed to bring common sense in line with a popular "neurosense" to prevent its interpretation from degrading into nonsense claims. Why did the scientists not choose a more accurate heading? Perhaps this can be explained at the level of some overall social semiotic mechanisms of contemporary science, how it is funded, and the competition for publicity.

Finally, let us not forget the ethical aspect of neurosemiotics. Susan Petrilli and Augusto Ponzio (2010) maintain that human beings, endowed with a capacity of care for semiosis, are also "semioethic animals," with an obligation to reflect upon the conditions for responsible living in open societies. If, in the future, the propositional dicisign "similar neural responses predict friendship" can be proven to be true with more accuracy, several uses and misuses of this knowledge can be imagined, because such a dicisign is tied to instrumental techniques that not only can measure similarity of neural responses, but also could be deployed to control subjects based upon neural profiling information. So if there is reality behind Lieberman's suggestion that perhaps "companies will one day put together teams for projects based on getting the right balance of neural similarity and dissimilarity to optimize team performance and satisfaction" (Lieberman, 2018: 371–372), such a future may look scary from a wider political perspective and make it urgent, when developing a neurosemiotic perspective on the social realm of human beings, to also raise concerns about the ethical challenges to open and friendly societies raised by this brave new world.

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Notes

1 In Aristotle's *Nicomachean Ethics* and his other writings on virtues and the art of living well, friendship played a major role. While he may have understood the notions of self and other quite differently from modern conceptions and contemporary individualistic psychology (Fowers & Anderson, 2018; Stern-Gillet, 1995: Chs 1 and 2), his take on friendship still inspires present-day research.

2 However, to spell out in detail a theory of science (and the dynamics of researchers, their ways of representing and intervening, and the nature so investigated) based on Peirce's semiotics is beyond the scope of this chapter.

3 For this question, an analogy to general fields like biology or linguistics may help. Also in them we find hyphenated or combined designations of specialized research areas – for example, neurobiology and evolutionary biology, neurolinguistics and historical linguistics. They both signify: (1) more or less well-defined institutional subdisciplines (often with their own journals, congresses, associations, research departments, and so on); (2) the specific topics dealt with (e.g., evolutionary or historical change, and neurological or linguistic mechanisms); and (3) the real-world phenomena that are highlighted by these approaches. Such hyphenated fields of research can have a more or less interdisciplinary character. The existence of neurobiology as a subfield does not sever it from the rest of biology or the general study of biological principles and mechanisms. A subfield like neurolinguistics, studying structures and processes in the human brain that underlie grammar and language communication, connects the two broad fields of biology and linguistics.

4 Peirce stated that, "In regard to its relation to its signified interpretant, a sign is either a Rheme, a Dicent, or an Argument. This corresponds to the old division Term, Proposition, & Argument, modified so as to be applicable to signs generally." (*Letters to Lady Welby*, MS [R] L463); Stjernfelt (2014); www.commens.org/dictionary/term/dicisign.

5 Thus, what Peirce observed about a person's thoughts – that "a person is not absolutely an individual. His thoughts are what he is 'saying to himself', that is, is saying to that other self that is just coming into life in the flow of time" ("What Pragmatism is," Peirce, 1958: Vol. 5, para. 421) – becomes even more accentuated considering the thinking of friends (Emmeche, 2017), and the dialogic aspect of science and philosophy.

6 The information given in this section is both from Parkinson et al. (2018) and brief interviews with the researchers given in Kaplan (2018), Knapton (2018), and especially Denworth (2020).

7 Note that the very notion of a friend differs from its operationalization in the social network survey. A mutual nomination here is not necessarily the same as a realized tie of friendship – that is, some of the dyads could be friends only potentially, in the sense of classmates one has been with most often for lunch, for example.

8 Compare the findings of Güroğlu et al. (2008: 903–910), whose results "revealed, among others, three regions of particular interest as selectively more strongly activated when subjects interacted with their friends than with other peers and celebrities: the amygdala and hippocampus, the nucleus accumbens, and the ventromedial prefrontal cortex."

9 Such findings add new meaning to Aristotle's notion of shared perception, *sunaisthesis*, and his comment that "a man also ought [*dei*] to share-his-friend's-consciousness of his existence [*sunaisthanesthai hoti estin*]" (Flakne, 2005: 37–63).

10 Given that the data were imbalanced across social distance categories, "data resampling and folding procedures were used to create a series of balanced data folds such that all dyads were included in the analyses" (Parkinson et al., 2018).

11 Parkinson et al. (2018) stated that "the classifier tended to predict the correct social distances for dyads in all distance categories at rates above the accuracy level that would be expected based on chance alone (i.e., 25% correct), with an overall classification accuracy of 41.25%." However, one can question whether "percentage of correct answers" is a good criterion for quality when the distribution of the four classes is so unequal: If you guess with the same probability distribution as the data, the percentage of correct guesses is given by: $(63^2 + 286^2 + 412^2 + 100^2) / 861^2 = 35.8\%$, and if you consequently guess "distance 3" (the most frequent category) you will get 412/861 = 47.9 percent correct classifications. Seen in this light, 41 percent is not very convincing. I thank Henrik Nielsen for his helpful comments on this.

12 A part of the neurosemiotics (in sense no. 2 indicated above) would be occupied with correcting misinterpretations of neuroscience in social and popular media that easily appear when news reporters try to make sense of scientists' findings. Thus, a news feature about Parkinson et al. (2018) stated that: "The team also found that MRI response similarities could be used to predict not only if a pair were friends but also the social distance between the two" (Knapton, 2018); this phrasing suggests that the researchers could predict the degree of closeness between real (not just potential) "friends" (rather than predicting the dyad's belonging to one of the four social distance categories), thus alluding to the possibility of distinguishing by these methods between different kinds of friendship – an aspect that was clearly not involved here. Sometimes journalists might just have seen a press release about a study (for this study: see Dartmouth College, 2018) or spoken a few words with the scientists, so misunderstandings are not surprising, but in this case the quoted phrasing is

taken directly from the press release itself (where a better phrasing could have been "predict not only if a pair were friends but also the social distance between the any non-friend pair").

13 The researchers did not access the specific character of the 63 "friendship" (social distance 1) relations within the subgroup of 42 students who mutually reported that they spend time together, and thus cannot say anything beyond that definition of friendship. I thank Carolyn Parkinson (pers. communication) for pointing out that looking at gradations of interpersonal closeness among the dyads identified as "friends" based on that survey would likely require a much bigger sample size in order to have sufficient statistical power. Hopefully further research will allow them to be able to say more in the future.

14 Their paper acknowledges that a large body of research demonstrates that people in our immediate environment influence how we think, feel, and behave, but does not cite work specifically relevant for friendship. There are several relevant philosophical accounts of friendship – friends as mirroring their selves; or having a receptivity to being drawn by the friend and by her understanding of this, or being a plural agent with joint cares, a joint evaluative perspective, a pattern of interpersonally connected emotions, desires, judgments, and shared actions – see Helm (2017) for an overview. Friendship and its various processes, including collaboration between scientists or artists, is relevant for understanding embodied and embedded aspects of cognition (Emmeche, 2017).

15 Studying a group of people in a remote Korean village, Parkinson's team showed that neural similarity in individuals' resting-state brain activity could also predict proximity in their social network, even when controlling for demographic characteristics and self-reported personality traits (Hyon et al. 2020). They suggested that such patterns of brain activity during rest encode latent similarities of how people think and behave associated with friendship. However, a similar study on girls from a day and boarding school in the United Kingdom showed no evidence of a similar correlation (McNapp et al., 2020).

16 As Varoquaux and Thirion (2014) comment, "for progress in neuroscience, black-box prediction engines do not suffice as the key to understanding brain function lies in the properties of the signal used for prediction." Addressing another set of learning algorithms Tanaka et al. (2019) asked: "Are we simply replacing one complex system (a biological circuit) with another (a deep network), without understanding either?" These challenges are also neurosemiotic – that is, they connect a better multi-scale understanding of the brain's neural mechanisms (conceptualized computationally or semiotically) with the higher-order patterns of functional action. Similar questions are also raised in other fields of biology (Baker et al., 2018).

17 It is difficult to tell how to get to such a theory based on the kinds of data in study by Parkinson et al. (2018), but it may not be altogether impossible – cf. the patent by Li M. Fu (1991).

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