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Enculturing brains through patterned practices

Andreas Roepstorff[a,b,*], Jörg Niewöhner[c], Stefan Beck[d]

[a] Department of Social Anthropology, University of Aarhus, Ethnography and Social Anthropology, Nordre Ringgade1, 8000 Aarhus, Denmark

[b] Center of Functionally Integrative Neuroscience, University of Aarhus, Aarhus University Hospital, Aarhus Sygehus, Nørrebrogade 44, 8000 Aarhus, Denmark

[c] Laboratory: Social Anthropology & Life Sciences, Institute of European Ethnology, Humboldt University Berlin, Mohrenstr. 41, 10117 Berlin, Germany

[d] Institute of European Ethnology, Humboldt University Berlin, Mohrenstr. 41, 10117 Berlin, Germany

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ABSTRACT

Recent findings in neuroscience have shown differential patterns in brain activity in response to similar stimuli and activities across cultural and social differences. This calls for a framework to understand how such differences may come to be implemented in brains and neurons. Based on strands of research in social anthropology, we argue that human practices are characterized by particular patterns, and that participating in these patterns orders how people perceive and act in particular group- and context-specific ways. This then leads to a particular patterning of neuronal processes that may be detected using e.g. brain imaging methods. We illustrate this through (a) a classical example of phoneme perception (b) recent work on performance in experimental game play. We then discuss these findings in the light of predictive models of brain function. We argue that a 'culture as patterned practices' approach obviates a rigid nature-culture distinction, avoids the problems involved in conceptualizing 'culture' as a homogenous grouping variable, and suggests that participating as a competent participant in particular practices may affect both the subjective (first person) experience and (third person) objective measures of behavior and brain activity.

1. Introduction

Understanding the effects of culture on the brain appears to be the newest trend in social cognitive neuroscience (Chiao, 2009; Han & Northoff, 2008; Henrich, Heine, & Norenzayan, in press; Vogeley & Roepstorff, 2009). In interesting ways, this has reopened old questions about cognitive universals versus cultural relativism (Roepstorff, in press). For more than a century, anthropology as a scientific discipline has been concerned with understanding culture. However, anthropologists have hardly been present in the current trend to culturalize neuroscience (see, however, Duque, Juan, Turner, Lewis, & Egan, 2009, for a notable exception). One reason is that within anthropology, the idea of culture as an analytical concept has been heavily, and we believe rightly, criticized (Kuper, 1999; Roepstorff & Bubandt, 2003). This criticism can be applied also to many uses of 'culture' in the cognitive neurosciences. However, we believe that the anthropological research tradition has more to offer to this discussion than an effective but not very constructive critique. In this article, we outline how a 'patterned practice' approach may be useful for this debate.

The dominant concept of culture in current neuroscientific research is that of culture as a latent variable. Typical research designs compare, for example, collectivistic with individualistic societies (Tang et al., 2010). This is problematic because a long line of anthropological research has shown that culture as a label for assumedly homogeneous populations is often meaningless, not least because of significant intra-cultural variation. What is more, the increasingly global movement of people, commodities and information has created new heterogeneous groups that do not fit the old labels (e.g. Appadurai, 1997; Ong & Collier, 2005). Instead, it has been proposed to replace the broad and overly encompassing concept of culture with the more specific, middle-range concept of patterned practice (Bourdieu, 1977; Roepstorff & Bubandt, 2003). Everyday life is continuously ordered into more or less stable patterns that are specific to particular types of situations, defining preferences, predispositions, and expectations for actors (Alexander, 1988; Parsons & Shils, 2001). These patterns present regularities that arise from everyday practices while at the same time shaping them. Patterns appear to be emergent phenomena that are currently not sufficiently explained by its constitutive factors, i.e. individual behavior or intersubjectivity (Daston, 2002; Niewöhner & Kontopodis, 2010).

We argue that the concept of patterned practice can be key in unpacking 'effects of culture on the brain'. The concept of patterned

* Corresponding author at: Department of Social Anthropology, University of Aarhus, Ethnography and Social Anthropology, Nordre Ringgade1, 8000 Aarhus, Denmark. Tel.: +45 8942 4674, mobile: +45 2636 2772.

E-mail addresses: andreas.roepstorff@hum.au.dk (A. Roepstorff), joerg.niewoehner@staff.hu-berlin.de (J. Niewöhner), stefan.beck@rz.hu-berlin.de (S. Beck).

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practice groups people by establishing through empirical work that participants interact, thereby actualizing concrete, shared material-discursive environments. This takes up the basic insight that any action is embedded in three heuristically different "environments" — normative orders, social dynamics and material conditions (Parsons, 1937) where actors are confronted with the challenge to interactively with others interpret, understand, and strategize in concrete situations to solve practical problems (Alexander, 1988). The concept of patterned practices in domain-specific material-discursive environments stresses that actors participate in particular ways of doing things in these joint activities, for example praying regularly in particular ways (Schjodt, Stodkilde-Jorgensen, Geertz, & Roepstorff, 2008; Schjoedt, Stodkilde-Jorgensen, Geertz, & Roepstorff, 2009) or spending hours listening to and producing music (Vuust, Ostergaard, Pallesen, Bailey, & Roepstorff, 2009; Vuust & Roepstorff, 2008). A patterned practice approach assumes that regular, patterned activities shape the human mind and body through embodiment, and internalization. Vice versa, enacting practices shape and re-shape norms, processes, institutions, and forms of sociality. Culture gets under the skin and skull, if you will, and it is remade gradually through collective instances of actualization (Beck, 2007; Niewöhner, Kehl, & Beck, 2008).

The overarching claim of this paper is thus: Patterns of practice at the level of social interaction correlate in relevant ways with neural and psychophysical patterns, and in the same way that social practice forms patterns, large-scale brain signals as well as other psychophysical signals generated during particular task performances can be analyzed to expose significant patterning (Kahnt, Heinzle, Park, & Haynes, 2010). This leads to a specific approach: employ social patterns of practice instead of an abstract notion of culture to inform experimental design and participant recruitment.

2. Alternating sounds and experienced patterns

To illustrate what we mean by patterned practices and why the anthropological research tradition may add to the understanding of them, we turn to one of the most striking patterned practices that humans undertake: speaking. From high-level pragmatics, such as figuring out when something is meant to be ironic, to low-level phoneme perception, such as being able to hear as distinctively different two sounds in vowel or consonant space, engaging in linguistic practices relies on an ability to pick up, act on, and generate very fine discriminations. These patterns are in the world, embedded in the practice of talking together.

By being participants in those practices, by learning to speak in the first place, or by later learning another language, these patterns come to be recognized. As people master the language, their brains become able to pick up these highly specific patterns, somehow get meaning from them, and produce them with their embodied vocal apparatus. This patterning, of minds, brains and bodies, is certainly not a trivial process. Even for a young child, whose life is almost entirely about learning, and who is equipped with a brain conceivably at the peak of plasticity, it takes years of constant practice. This is not done in isolation, the child is not only immersed in an environment of structured practices but also usually surrounded by others, parents, siblings, care-takers who help and correct the process. To older people, as those of us struggling to speak a non-native language know painfully well, getting it just right is almost impossible. Once one masters such processes, they appear to run automatically, to have become second nature (Bourdieu, 1990). However, when this is not mastered, the complexity of it becomes apparent.

One remarkable analysis of this, at the level of phoneme perception, was given by Franz Boas[1] in 1889 in a short article "On Alternating Sounds" (Boas, 1889). At the turn of the 19th Century, many researchers in the burgeoning disciplines of anthropology and linguistics were occupied with establishing relations between heredity and environment (Brinton, 1898), also in an evolutionary perspective,[2] and the differentiation of languages were used as a key case. A central issue was the apparent discovery of "alternating sounds" in certain so-called primitive languages (Brinton, 1888). A number of linguists, who went out to describe some of the newly discovered native languages, e.g. in the Americas, came back and reported that the native subjects were apparently not able to maintain phoneme constancy. As one perplexed researcher, Dr. Behrendt working with the Chapanec, stated it: "No other language has left me in doubt as this one. The same person pronounces the same word differently, and when his attention is called to it, will insist that it is the same". Another researcher, Father Montoya, describing the Guarani, claimed that "there is in this language a constant changing of letters for which no sufficient rules can be given" (quoted from Brinton, 1888). These and other findings allowed Brinton in an influential paper to conclude that "the phonetic elements of primitive speech [as deduced through the native American languages] probably had no fixedness" (Brinton, 1888, p. 218).

Now enters Franz Boas. Through inspiration from Helmholtz, he was fully up-to-date on developments in psychophysics, and he used recent findings in sensory discrimination across various modalities (touch, vision, smell, hearing) to argue that "new sensation is apperceived by means of similar sensations that form part of our knowledge…[not that] such sensations are not recognized in their individuality, but they are classified according to their similarity, and the classifications are made according to known sensations" (Boas, 1889, p. 50). This principle, transferred to phonetic discrimination, would suggest that previous phonetic classifications, such as those present in one's native language, could affect how sounds in a different language were heard. Equipped with this hypothesis, he went through transcriptions of the many Inuit dialects that were being done at that time by researchers across the Arctic. This showed that (a) these transcriptions were affected by the nationality of the linguist and (b) that even the same observer (in this case Boas himself) would on different occasions spell the same word differently. Furthermore, the spelling could change over time, as he became better able to pick up particular sounds in the new language that did not exist in those languages he was already familiar with.

This lead him to conclude that: "I think.…it is clear that all such misspellings are due to wrong apperception, which is due to the phonetic system of our native language. For this reason,

1 Franz Boas was a Jewish-German and Jewish-American intellectual, and a key figure in defining anthropology at the turn of the 19th Century. Born in Minden, Germany in 1858, he graduated in Physics from Kiel University in 1881 with a thesis on the optical properties of water. Through an interest in geography, he left for North America to conduct what today would be known as ethnographic fieldwork among Inuits in Baffin Island Canada. After his habilitation at Berlin University in 1886, he emigrated to the US in 1887, first as an assistant editor of Science magazine, but he soon became involved in defining the newly emerging discipline of anthropology both in museums and academic institutions. From 1899 he was professor of anthropology at Columbia University, he designed the first Ph.D. program in the discipline in the US and influenced a whole generation of anthropologists in the US and in Europe. He died in 1942, according to the anthropology legend at the Columbia University Faculty Club, in the arms of Claude Levi–Srauss, the French hero-to-be of anthropology in the second half of the 20th century. A researcher who took to the extremes the idea that culture could be thought of as a stable, structured set of differences.

2 If this sounds familiar, it suggests that it may be time to revisit those discussions to avoid entering into discursive blind alleys that were discovered and partly mapped out more than 100 years ago.

I maintain, that there is no such phenomenon as synthetic or alternating sounds, and that their occurrence is in no way a sign of primitiveness of the speech in which they are said to occur; that alternating sounds are in reality alternating apperceptions of one and the same sounds'' (p. 52). Boas then, highly systematically, went on to examine two implications of this, (a) whether various sounds, which resemble one known sound may be considered the same, although they are really different ('sound blindness', by analogy with colour blindness a failure to hear different sounds as different), and (b) whether persons, who allegedly speaks an alternating sounds language, would perceive as alternating sounds in German or English, languages that by definition were not primitive and hence should not contain "alternating sounds". Based on single subject findings, which counted as evidence 100 years ago, he found support of the hypothesis in both cases and he therefore concluded that "alternating apperception" may be involved both in "alternating sounds" and in "sound blindness".

We have gone at some length to detail Boas' argument because it demonstrates quite clearly key principles in an anthropological research approach and in ethnographic methods that we will use in Section 3 to relate to current neuroscientific research on gaming behavior. *The neuroscience of experimental game play* relates to current neuroscientific research on gaming behavior. Boas argued that the process of classifying sounds in particular ways is a result of having been exposed previously to that particular classification pattern. From the 'inside' of this patterned practice, i.e. if one knows the language, the perceived sounds fall into these categories. If one does not know the language, one may either miss out on important distinctions, or, alternatively, perceive as different two instances that from the point of view of the speaker were meant to be the same.[3] For a researcher, participating in practices through so-called participant observation, in Boas' case very concretely learning to speak the language, is one way to develop sensitivity to the structuring categories of the patterns of practice. This sensitivity can then be brought into the analysis of the data in selecting the categories that structure the research questions.

Arguably one of the best and most influential studies of encultured brains, conducted by Risto Näätänen and colleagues in Finland, explored a phenomenon similar to the sound blindness described by Boas as part of the alternating apperception complex. The authors used a mismatch-negativity (MMN) paradigm. Briefly, these paradigms present subjects with unattended sounds in particular repeated patterns. Through decades of research, Näätänen and colleagues have shown that the primary auditory cortex is highly sensitive to changes in predictable patterns and that, once a pattern has been established, one may detect a characteristic EEG and MEG signature, e.g. to pitch differences or to the presentation of temporally unanticipated sounds (Naatanen, Astikainen, Ruusuvirta, & Huotilainen, 2010; Naatanen, Tervaniemi, Sussman, Paavilainen, & Winkler, 2001). The study in (Naatanen et al., 1997) utilized the fact that although the Finnish and Estonian languages are very closely related, Estonian vowel space has an additional vowel, /õ/, not found in Finnish. The authors therefore presented to speakers of Finnish and Estonian as deviants a prototype of this sound, along with vowels that existed in both languages (/o/ and /ö/), and a sound that was not a prototypical vowel (located between /e/ and /ö/). They found that whereas to the Estonians, /õ/, /ö/ and /o/ elicited similar MMN responses, the Finns showed much less MMN response when presented with /õ/ relative to the Finnish prototypical vowels /ö/ and /o/. This demonstrated that when an acoustic deviant is presented, a vowel prototype in the native language elicits a larger MMN than could be explained by the acoustic properties alone. Judged by MEG, this differential activation by a prototypical phoneme in the native language was in particular caused by an activity in the left primary auditory cortex. Similar findings have since been found also between other languages (e.g. Hindi and English Sharma & Dorman, 2000) and also mediated by more complex patterns of discrimination, such as that found between Korean and Russian, where a $[d]/[t]$ consonant discrimination exists in both languages, but only in Russian this differentiates between different words (Kazanina, Phillips, & Idsardi, 2006).

This line of research demonstrates how brains may become patterned by participating in practices structured in particular ways. In the cases here discussed, the differences in patterning, exposure to different languages with different structures of the phonetic space, may co-locate with differences in culture in the sense that 'Finns' appear to have one type of brain while 'Estonians' appear to have a different type of brain. Indeed, differences in early auditory processing has been used in a highly problematic attempt to define a particular "Japanese" brain (see discussion in Vogeley & Roepstorff, 2009). However, such generalizations running wild shows precisely why "culture" in itself may rarely be a suitable variable for research, neither in anthropology nor in neuroscience.

The MMN response appears a highly robust finding, supported by long lines of research, and this can also be found to discriminate differentially between groups that are not defined by linguistic or cultural criteria. Vuust and colleagues compared how experienced jazz musicians and non-musicians reacted to unanticipated deviations in rhythmic presentations. They found that brains of musicians reacted with a much larger MMN response to deviations in rhythmic structure than did rhythmically inept subjects. This difference was, like in the original Estonian/Finnish comparison, larger in the left hemisphere. Notably, it was even more pronounced when comparing subtle, but musically meaningful deviations that did not violate the basic meter of the presented stimuli (Vuust et al., 2009, 2005). These deviations, technically regrouping of subdivisions, are, however, key elements in mediating communication when jazz musicians improvise (Vuust & Roepstorff, 2008), and they were specifically selected as stimulus material because they, at least since the classic Miles David Quartet recordings, have come to form a key category that mediates communication when jazz musicians perform.

Clearly, professional musicians engage in very different practices to most of us. Hours are spent practicing and playing, entraining the body, the senses and the mind. They perform highly structured practices, and in these, particular patterns of rhythmic anticipation and generation appear as communicational devices, both in the performance and in the neuronal signatures that they may elicit (Vuust & Roepstorff, 2008; Vuust, Roepstorff, Wallentin, Mouridsen, & Ostergaard, 2006). However, only by bending the concept of culture to the level where it no longer becomes meaningful, can one talk of them as belonging to a 'specific' culture. Here, much more selectivity is afforded by the concept of patterned practices in the domain-specific material-discursive environments musicians are participants in: the concept points to embodied practices, the competent manipulation of material artifacts (i.e. instruments, notational systems), the highly specific social institutions or settings (i.e. orchestras, jam sessions) they take place in etc.

3. The neuroscience of experimental game play

In this section, we extend the above argument about the importance of systems of classification from language and music to higher-level cognitive functions, specifically behavior in experimental game play. We argue that recent influential studies at the

3 These ideas were later systematized by the Russian linguist Trubetskoy into the idea of a phonological sieve (Trubetzkoy, 1939, quoted in Buckingham & Yule, 1987).

intersection of experimental economics and neuroscience can be re-interpreted from an anthropological perspective to show that peoples' performances in experimental games are not merely a matter of cultural learning and group membership but are highly dependent on the everyday participation in specific patterns of practice. Participating in patterns of practice mediates between culture and innate human capacities. Patterns of practice thus coordinate neural networks in action and facilitate learning and adaptation as a process extending from the individual brain to sociality and material-discursive environments.

Research in neuroeconomics during the last decade has shown experimental game play to correlate with brain activity. One of the first studies on the neural correlates of trust and reciprocity (McCabe, Houser, Ryan, Smith, & Trouard, 2001) used a two player game for cash rewards that pitched research subjects against either a human or a computer opponent. After pooling subjects on the basis of a behavioral analysis into two groups (cooperative only against human opponents and not cooperative at all), an analysis of the brain scans revealed a pattern of activations mainly in the prefrontal cortex for the first group when cooperating with persons. The second group showed no significant differences in brain scans between the two conditions. Notably, one of the strongest activations when cooperating appeared in the medial prefrontal cortex near an area also implicated in 'theory-of-mind' like tasks (Gallagher, Jack, Roepstorff, & Frith, 2002). While analytically crude, this study nevertheless shows that opting for a collaborative strategy appears to carry particular neuronal signatures.

Many more studies have pursued this approach and confirmed and elaborated on the results. Most of them have been implicitly or explicitly underpinned by the idea of *homo oeconomicus*, i.e. an individual that uses rational choice to maximise personal benefit in experimental games (but see discussion in Petersen, Roepstorff, & Serritzlew, 2009).[4] This notion of homo oeconomicus carries certain assumptions into the experimental studies and their interpretation that have come under increasing scrutiny. By way of re-reading this critique from an anthropological point of view, we are suggesting a different perspective on the role of neural networks in human interaction and learning.

Experimental game studies have tended to presume that the decision-making process is an economic affair, i.e. a matter of using cognitive capacity to select the best strategy in an economic exchange situation. Entering homo oeconomicus into 'person games' that attempts to simulate social exchange processes problematizes this assumption. McCabe et al. already showed that trust begins to matter in two person constellations. An imaging study using the ultimatum game by Sanfey et al. two years later revealed differences in BOLD signals correlate with the perceived fairness of offers within an ultimatum game in brain areas involved in attaining emotional goals (Sanfey, Rilling, Aronson, Nystrom, & Cohen, 2003). Subjects received offers from humans and from computer opponents that would present them with a fair or unfair share of a known sum. Accepting the offer led to a payout of the money, rejecting it would leave both players empty handed. All fair offers were accepted, but a significant proportion of unfair offers were rejected with a large inter-subject variability (from 0%–100% rejection rate). The brain scans demonstrated for unfair offers from a human opponent a significant difference in the BOLD signal in right dorsolateral prefrontal cortex and anterior insula. The authors conclude that ultimatum games require participants to pursue emotional and cognitive goals and that this dual demand is also reflected in brain activity.

Experimental games with more than one person simulate social situations. Navigating these social situations is not merely a matter of rational choice and cognitive skill. It involves a range of human individual and interactive capacities, the recruitment of which during performances in games is reflected in neural activity. Importantly, human behavior in these experimental games is extraordinarily sensitive to the social context, which is simulated through experimental conditions. A study by Tania Singer and her colleagues studied brain responses to the acquired moral status of faces (Singer, Kiebel, Winston, Dolan, & Frith, 2004). Research subjects played several rounds of a Prisoner's Dilemma game with fair or unfair confederates presented through facial photographs, before being scanned while making gender judgments of their opponents' faces on the basis of the known photographs. In line with the group's predictions, cooperative subject faces' "social behavioral status" affected "automatic" emotional processes leading to cooperators being judged more likeable than a neutral face and vice versa for defectors. The activation found in the response to cooperator faces (e.g. in amygdala, striatum including putamen and nucleus accumbens, lateral orbitofrontal cortex, insula, fusiform gyrus, and STS) are highly consistent with general models of social cognition. Elegantly, Singer introduced a non-intentional condition, where research subjects were told that confederates had a choice with respect to their own strategy or they did not and merely reproduced a pre-given plan. Neural responses turned out to be most robust for intentional, cooperative agents and less so for unintentional agents. This study also indicates "that rapid learning regarding the moral status of others is expressed in altered neural activity within a system associated with social cognition" (ibid.: 653).

The experiment thus shows that altering the experimental conditions so that the task remains the same, but the social context changes, has a significant effect on participants' neural responses. This points to the high-level context sensitivity of human, and neural, responses, and it allows, and requires, to abandon a simple behaviorist stimulus-response conceptualization of the social cognition brain imaging experiment. Instead, a differential understanding of the experimental situation, which may be manipulated via the *script* that provides the experimental subject with the context of the stimuli, can become the defining variable. This effectiveness of this script may, then, be validated by asking subjects to *report* on their behavior (Jack & Roepstorff, 2002).

Before we move to a discussion of our last example, we link these findings back to Boas' *alternating sound* case. This suggested that taking part in particular practices, i.e. learning and speaking a language, alters the participants' auditory capacities and their system of sound classification. If the system of classification which the research subjects use (the first person system) differs from the system which the scientific observer uses (third person system), misinterpretations may arise. The imaging studies of economic exchanges, which we have discussed so far make a similar point for the higher-level phenomena. Firstly, the social context, albeit simulated in experimental situations, matters. Participating in a particular practice, e.g. a Prisoner's Dilemma game, alters research subjects' system of classification. Faces are recognized differently. Secondly, these alterations are reflected in different neural activity. Stated more generally: engaging in social interaction alters my view of others, which in turn corresponds with altered neural activity.

The contrast of the intentional and unintentional condition showed that these alterations are highly sensitive to changes in the experimental conditions, i.e. the simulated social contexts. Boas'

[4] The notion of the individual underlying homo oeconomicus is not an invention of economics, or any other scientific discipline for that matter. Rather it is a hallmark of Western modernity. As anthropologist Marshall Sahlins (1996) points out, the figure of the isolated individual searching for salvation through reason can be traced back to the roots of Christianity. It is deeply embedded in Western cosmology and largely implicit in much of modern philosophy, economics, evolutionary theory and clinical medicine.

second point, the difference between systems of classification from 'the inside' and from 'the outside', did not seem to concern Singer et al. The paper appears to take for granted that research subjects share with the researchers the characteristics relevant for the experiment: they see money as a neutral means of exchange that they value, they distinguish in similar ways between cooperators and defectors, they are used to apply the moral evaluative order dominant in market-based exchange systems etc. In the following section we present a study that has deliberately created a situation, where experimenters and subjects differ in relevant ways. This creates a problem for traditional experimental economics and neuroscience but at the same time, it presents a rich opportunity for novel research.

A group of researchers around the anthropologist Joseph Henrich conducted a major cross-cultural study of preferences and behavior in experimental game play in fifteen small-scale societies. Henrich et al. (2005) set out from the observation that most studies are conducted in large-scale, modern market societies with university student study populations. This selection bias may have contributed significantly to the high consistency in findings across study populations, which has many economists convinced that so many people performing similarly in experiments has to be an indicator of an underlying universal human capacity. The obvious alternative interpretation received little attention until recently but concerns us here with a view to Boas' observations: university student experimental participants are actually pretty "WEIRD", i.e. Western, Educated, Industrialized, Rich and Democratic. As such they are outliers with respect to the entire spectrum of homo sapiens' decision-making capacities and preferences, yet they match perfectly the experimenters (Henrich et al., in press). Henrich and his colleagues took seriously this latter interpretation and conducted three different experimental games (ultimatum game: UG, dictator game: DG, public goods game: PGG) in fifteen small-scale societies across the globe, including slash-and-burn and foraging horticulturalists, agro-pastoralists, semi-nomadic, transhumant as well as nomadic groups. They compared the results to each other and to the established body of results from Western student populations. The findings reveal substantially more behavioral variability across groups then previously shown (Henrich et al., 2005). Obviously, the consistency produced in previous findings had more to do with selection bias than with a universal human characteristic.

More important for the argument in this paper is the explanation offered for the patterning of this newly found variance. The researchers not only conducted the experimental games in the respective societies, but also gathered data on socio-economic structure as well as ethnographic data on patterns of everyday life. This allowed them to explore whether differences in economic organization and the structure of social interactions could explain the variance across societies. This revealed a significant correlation between offers in the ultimatum game and a complex index including measures of payoff to cooperation, market integration, anonymity, privacy and sociopolitical complexity in the respective societies. However, individual economic and demographic variables turned out to be inconsistent and largely insignificant predictors of game behavior within and across groups. Sex, age, wealth, market exposure, formal education or language competence did not consistently explain substantial portions of variance in behavior when measured as individual variables. The research group therefore concluded that "[t]he fact that group-level measures of economic and social structure statistically explain much of the between-group variance in experimental play suggests that there may be a relationship between game behavior and patterns of daily life in these places" (ibid.: 811).

How do these findings relate to Boas' alternating sounds? Interpreting the performance in experimental games when experimenters and research subjects lead totally different lives, i.e. have potentially little common ground from which to interpret the world, is similar to Boas' inside and outside perspective on systems of classification. The experimenters in the Henrich study set up a two person experimental game. We know that research subjects are highly sensitive to this set-up, specifically to the social context, which the set-up simulates. Conducting their games in small-scale societies, Henrich et al. face the problem that they cannot assume that participants read the situation the way they themselves do. The experimenters simply do not know how their research subjects understand the social situation that is presented to them. This understanding, however, has an effect on behavior as well as neural activity. This understanding determines to a significant extent how people perform in the experimental game and it is crucial in interpreting the findings. What is more, participants from small scale societies might rightly assume that they will reencounter co-participants later, outside of the game situation; and they might well bring *to* the game knowledge of their social status, standing etc. acquired beforehand. From their point of view, the "game-situation" might be nothing more (but no less!) than an event – however exceptional – in an ongoing social exchange that will have real consequences.

Thus it is paramount to find out how research subjects approach the experimental game and what they bring to it. This is a question not just of method but also of theoretical perspective. First on method: To gauge whether research subjects have done what the experimenters thought they would be doing in the experiment, many researchers conduct validating check-ups through post-experiment or post-scan interviews (Jack & Roepstorff, 2002). The focus here is mainly on understanding the tasks at hand. Henrich et al. go a large step further, because they cannot assume that their participants share even some of the basic assumptions built into the games. They collect socio-economic and ethnographic data in the host societies and this raises a number of important points: (1) Group level data best explains behavioral variance. (2) Individual factors, such as sex, wealth or age explain little. (3) Beyond group membership, it is particular patterns of practice in participants' daily lives that are used in analogy to make sense of the game and perform accordingly. For example, one of the groups, the Orma of South America, associates the public goods games (PGG) with their local game of *harambee*. This is a phenomenon where Orma families contribute to a public fund relative to their own means if the group as a whole decides to pursue a public good such as building a road. The methodological point here is straightforward: if there is any reason to believe that participants' daily lives may differ significantly from experimenters assumptions, it is important to collect detailed, ethnographic data on these lives. Knowing the relevant patterns of practice may then form the basis for interpreting individual behavior in games.

The theoretical point is more important and less straightforward. It concerns the core concept of culture, the crucial question how culture – e.g. in the form of tacit assumptions – enters experimental games to affect individual behavior and how that relates to neural activity. Henrich proposes two non-exclusive possibilities how patterns of daily life affect individual behavior in games: (1) "different social, cultural, and physical environments foster the development of differing generalized behavioral dispositions", i.e. specific groups of people may be more altruistic than others, and (2) the experimental games cue highly context-specific behavioral rules. Both possibilities are congruent with coevolution theory, i.e. the idea that genes and culture are intertwined informational systems exposed to dual evolutionary forces. The argument is that humans "should be equipped with learning mechanisms designed to accurately and efficiently acquire the motivations and preferences applicable to the local set of culturally evolved social equilibria (institutions)" (Henrich et al., 2005, p. 812).

There are several problems with this interpretation and we suggest here an alternative reading with a relevance for neuroscientific research. Henrich's interpretation portrays culture as a system of beliefs and values that are all shared by a particular group.

Thus group characteristics, i.e. culture, through "cultural learning" either inscribe themselves as general traits in the individual or they do so as domain-specific rules (Tomasello, Malinda, Josep, Tanya, & Henrike, 2005). If that were entirely correct, one could use group membership as a proxy for behavior. Characterizing the group from which one recruits automatically reveals everything relevant about the individual. This raises two related problems: firstly, it is difficult to know whether the group that one has identified is actually homogeneous with respect to the behavioral parameters to be tested. Henrich et al. show that individual characteristics such as age, sex or wealth explain little variance in their study populations. In other instances (i.e. other research questions asked, other study populations, where relevant subgroups exist) gender or age effects may be relevant or groups may be socially stratified in relevant ways. Secondly, Boas' analysis suggests that it is not abstract group membership per se but speaking the language – competent performance –, which entrains the particular system of classification. It is taking part in a particular pattern of practice that drives how subjects perform in experimental games and it is taking part in such patterns that inscribes itself into neural patterns. Thus we suggest to treat the common concept of culture with much care in the neurosciences and instead use patterns of practice as a more specific denominator. In addition, that way it is much clearer how participants are approaching experimental situations.

Patterns of practice can be elicited through ethnographic research very much in the same way that Henrich et al. have done. Such an approach reveals, for example, the patterns of economic exchange not as an abstract, universalistic system but as a concrete social practice in everyday life. Anthropological literature abounds with findings that the economic model of universal exchangeability, which is the characteristic doxa for market driven economies, is a rather exotic outlier of human economic practices (Gregory, 1997). In many societies studied by anthropologists, there exist hermetically insulated "spheres of exchange" (Ferguson, 1992) or strictly separated, socially often exclusive "transactional orders" (Bloch & Parry, 1989) where different types of things circulate, subjected to different normative orders. And there exist subtle social processes – again subject to careful moral evaluation – through which assets from one transactional order might be converted to another (Bohannan, 1955; Carsten, 1989). What counts as "fair" or is assumed to be "rational" accordingly is rather diverse. However, careful analysis reveals that these "separate spheres of exchange", which are characterized by specifically patterned economic practices and moral evaluation schemes, are existent in market economies also (Woolsey Biggart, 2001; Zelizer, 1996). It would only be prudent then, e.g. not to universalize – what most participants in market economies believe – that "market relations should be calculating and rational, and personal relations should not" (Woolsey Biggart, 2001, 475) and to use this assumption as a tacit condition for game experiments. Instead, a careful analysis of practiced transactional orders is necessary to interpret what study participants "bring into" these experiments.

This conceptual shift from culture to patterned practices has three further implications:

(1) Relevant patterns of practice exist in any society. If one is interested, for instance, in the brain signals underlying object-centered joint action, one may compare surgeons that are busy all day cooperatively manipulating bodies with non-surgeons.[5] The notion of patterned practice thus gets around having to recruit "exotic" groups from far-away places, while at the same time unpacking the black box that culture has been.

(2) Patterns of practice suggest an understanding of agency as distributed, very much in line with the work on distributed cognition or cognition in the wild (Hutchins, 1995). Patterns of practice are neither social structures out there that are learned by the individual, nor are they produced by human cognitive individuals. Patterns of practice arise from the continuous interaction of human actors, material artefacts, social and formal institutions, rituals, norms and beliefs (Roepstorff, 2008).

(3) Patterns of practice constantly engage neural networks. Coevolution theory portrays a very clean separation of culture and genes that bypasses the person and where *cultural learning* is envisaged largely as information exchange where abstract cultural models, somehow, inscribe themselves in the individual. A patterned practice approach, on the other hand, explores a process of what one might call *networks-in-action* whereby individual patterns of resonance may be established between neural networks and patterns of practice. Neural networks in action are thus networks that extend in relevant ways in social interaction. How these extensions work, i.e. how brains communicate and humans interact, is mediated by patterns of practice.

4. Patterned practices and neural networks-in-action

Understanding the entanglement of patterned practices and neural mechanisms is a key challenge that provides some of the most interesting and potentially fruitful possibilities for future research. Recently a number of positions in theoretical neuroscience have explored how the ability to form predictions may be a key issue in human brain function (reviewed in Bar, 2009, and exemplified in other contributions to that special issue). Although this approach is not in itself novel, the interest in a *Bayesian brain* seems to form an emerging framework for brain functioning.

One influential formulation of this explores the brain as a hierarchically organized generative learning device, which attempts to mine its sensory inputs based on expectations and prior established models of causes in the environment. Arguably, this may explain both modular segregation of brain processes and the functional integration into larger subsystems (Friston, 2003, 2005). This framework is currently examined across a wide range of perceptual and cognitive phenomena (Frith, 2007; Hohwy, Roepstorff, & Friston, 2008; Vuust et al., 2009). In the current empirical investigation of such models, a key indicator is a 'prediction error', i.e. a mismatch between the expected events and those actually occurring. One instance of such prediction error is the mismatch negativity (MMN), found by Näätänen et al. in Estonian subjects to a deviant sound that only in Estonians mapped onto the vowel classification system. Similarly, the failure of the Finnish subjects to produce a similar MMN points to the lack of a prior model for that particular vowel sound, and hence not the same reason to identify that as a significantly different event, as indexed by the MMN.

The patterned practice approach is highly compatible with these findings. From the inside of a practice, certain models of expectancy come to be established, and the patterns, which over time emerge from these practices, guide perception as well as action. They may even be formulated explicitly, by observers or practitioners, as logics and structures of that practice (Bourdieu, 1990). However, at the level of human actions, the patterns of practice approach does not stop at identifying significant breaks in individual expectancies. It asks how these practices *construct* particular realities — realities that are shared between people physically, socially and mentally through interaction. Interacting with other people is not only about mismatching predictions. Human interaction is also about exchanging expectancies, systems of classification and modes of understanding. This is frequently employed in cognitive experiments (Jack & Roepstorff, 2002), e.g. when Singer et al. (2004) told their experimental subjects

5 If the lack of a control group is an issue for the particular research question, one may induce a particular pattern of practice experimentally (Casasanto, 2008).

that particular confederates where not acting out of free will but only according to a pre-given plan. Such framing of the stimulus is not based on prior experiences but on a high level exchange of a model of understanding (a 'top–top interaction', see Roepstorff, 2004; Roepstorff & Frith, 2004), and it does not seem to rely on 'mismatch' and prediction errors, but rather on establishing a match or a resonant pattern between individuals. The neural signature of such process appears highly dependent on the perceived relations between the people in the interactions. Trust and perceived charisma may e.g. evoke a downregulation of frontal executive areas during such interactions, (Schjoedt, Stodkilde-Jorgensen, Geertz, Lund, & Roepstorff, 2010), perhaps as a lowering of epistemic vigilance (Sperber et al., in press).

The affinities between 'predictive brain' models and a patterned practice approach may not be merely metaphorical. At different levels, they frame the link between action and perception as a continuous process of resonance, where networks-in-action order the coordination of input and output and networks-in-action form and unfold in practice. These develop in the interaction between current events and context-dependent, higher-level models, developed over time, which frame these events based on prior experiences. When these processes occur in human interaction, that is, coordinated in more than one brain, people may through sharing practices, be they linguistic or non-linguistic, come to construct common worlds (Tylen, Weed, Wallentin, Roepstorff, & Frith, 2010). If we are to understand how such processes, that are key instances of social interaction and cognition, are implemented in neural systems, it may not be enough to understand how *mismatches* are generated and propagated. It appears equally important to understand how *matches* – with classifications and expectations – may propagate and resonate both inside brains (Grossberg, 2007) and in the interaction between people (Roepstorff, 2008; Tylen, Wallentin, & Roepstorff, 2009) embedded in a material world (Clark, 2006).

It is in highlighting this element of co-constructing and co-constructed common worlds, that a patterned practice approach to social interaction may help to ask new questions of the neurosciences. Anthropology and related disciplines have a long trajectory of demonstrating how people are able to exchange and co-create worlds that are at the same time material, semantic, and symbolic. Through their actions, people establish resonances between practices in the world and dynamics in the brain. Figuring out the intricate details in these processes seems to require a framework of analysis that does not automatically parse the world into two separate domains of nature and culture (Latour, 1993). A patterned practice approach appears to obviate this distinction (Ingold, 2003), and it demands not only an understanding in the mismatches between predictions and events, but also in how in interaction matching may allow for rapid co-constructions of novel practices and realities both in minds, brains and worlds (Konvalinka, Vuust, Roepstorff, & Frith, in press). At a neural level, it may be a matter of understanding not only segregation and integration (Friston, 2002), but also how in human interaction – through patterned practices and neural dynamics – plasticity and stability go hand in hand (Grossberg, 2009).

5. Conclusion

Social and cultural anthropology have for some time abandoned culture as an analytically meaningful concept and moved to 'patterns of practice' instead. The concept of patterns of practice proposes that human group life orders itself into specific and semi-stable patterns of inter-action, i.e. practices. Practices are shaped by material conditions, social dynamics and normative orders. We have shown through reinterpretations of existing studies in anthropology, linguistics and experimental economics that patterns of practice shape phoneme spaces, i.e. the specific perception of language and music, as well as performance in experimental game play, i.e. the attainment of higher cognitive and emotional goals. As these functions have recently been shown to have neural correlates, we suggest that the anthropological concept of patterns of practice can usefully inform the neuroscientific study of social behavior. In concluding, we reiterate four aspects of patterns of practice as a novel approach to thinking about brain function.

1. The notion of practice mediates between micro- and macro-level phenomena. In the social sciences and anthropology it has proved an empirically as well as conceptually useful middle-range level of analysis that connects actors to structures. We argue that it can do the same in the social neurosciences. Most theoretical frameworks and experimental designs attempt to short-circuit the micro level of brain activity with the macro concept of culture. We have shown in this paper that this approach has serious limitations. Patterns of practice are shaped by neural networks as well as belief systems and normative orders. They thus sit in between micro and macro levels of analysis and enable us to investigate the relative contributions of neural, individual and cultural factors to specific practices.
2. The shift from culture to patterns of practice mirrors in important ways the shift from individual to distributed or embodied cognition (Hutchins, 1991; Wilson, 2002). Neural networks are no longer investigated purely as individual entities. Rather they are studied in action. The programmatic research question now is: how do neural networks shape practices and how do these practices shape neural networks. This marks an important conceptual shift from systems to systems-in-action or processes. Also, it redirects attention from "action" – understood as single, purposeful behaviors – to the analysis of structured (patterned), maintained relations between embodied minds and their social, material and discursive "environments". This perspective explicitly includes intentional as well as non-intentional "non-actions" like passivity or composure, as well as practices which are characterized by "actively suspended intentionality" (e.g. trance inducing practices, intoxication) to achieve extra ordinary body–mind states.
3. Social neuroscience can draw on significant resources in anthropology and the social sciences more generally when pursuing such an approach to the study of social behavior. On the one hand, studies within the paradigm of interactionism have built up considerable expertise in how patterns of social order emerge from and are reproduced by the continuous, reflexive interaction of human actors in specific material-discursive environments. On the other hand, structuralism and other schools of thought such as sociological systems theory have emphasized how particular social orders provide the all-important context for individual behavior and social interaction. Performance theories or ethnomethodology argue that individuals mobilize negotiated frames of reference for moment-by-moment social and cognitive action, e.g. in experimental games, and that these frames are to a significant degree shaped by material conditions as well as normative orders.
4. Pragmatically, the shift from culture to patterns of practice opens up a novel research programme within Western societies. While conducting work amongst remote peoples remains relevant, many important questions can also be investigated at home as long as ethnographic and other social scientific methods are used to identify meaningful patterns of practice. This can be done in collaboration with practitioners (Vestergaard-Poulsen et al., 2009; Vuust et al., 2005), to design experimental paradigms that operationalizes relevant features in the particular practice.

5. A patterns of practice approach highlights that people often co-construct a common world. This may help to ask new questions of the neurosciences, in particular the extent to which people in interaction, through *matches* to expectancy and systems of classifications, may evoke resonance between brains and bodies and/or learn and share neurally implemented modes of understanding.

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