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How Collective Representations Can Change the Structure of the Brain

Abstract: *Culture not only influences human psychology and perceptions of self, others and reality, it also, in certain contexts, influences the quality and degree of consciousness itself. If the brain gives shape to consciousness, then we would expect culture to have a corresponding impact on the functional anatomy and microstructure of the brain. The concept of ‘collective representations’, as developed by Durkheim, refers to the often crucial components of human life that have meaningful existence only because we agree that they do — such as customs, money, religion, cosmology, language, games, laws, power structures and artistic genres. We present recent imaging research which illuminates the feedback relationship between these two types of representation — the collective and the cortical — and which demonstrates that collective representations can have well-defined cortical representations.*

Introduction

It is now well established that human ‘common sense’ — that motley jumble of assumptions and beliefs that we accept as self-evident truths impervious to critical examination (Bourdieu, 1972) — varies from one culture to another, often in quite grotesque ways. Human perceptions of self, others, kin, foreigners and reality at large, are equally variable. In the New World, for example, there are widespread beliefs

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that animals are humans wearing animal suits, and that when a person dons a ritual animal mask, that person is transformed into an animal (Viveiros de Castro, 1998). Butchering animals for food fails to dispel such beliefs — apparently, animal disguise is more than surface appearance: it transforms the body all the way through. There is plenty of evidence that comparable beliefs were at one time also common in Europe — from witchcraft, vampire and were-wolf pandemics to the talking animals and animal transformations in traditional fairy tales (Knight, 1991). Even in the supposedly rational world of science, there are persistent difficulties in defining the nature of human personhood (Henshilwood and Marean, 2003; cf. *JCS*, 2007), which cannot be entirely dissociated from the idiosyncrasies of Western culture (Whitehead, 2006; this volume).

The structural complexity of enculturated human societies is also known, at least in certain contexts, to shape the quality and degree of conscious experience itself — for example, Erika Bourguignon (1973), from an examination of almost five-hundred human societies, showed that spiritual experience is inversely correlated with structural complexity. In the simplest and most egalitarian societies, OBEs (out-of-body experiences) tend to be frequent, conscious, voluntary and accessible to most people who desire them. In ritual trance participants regularly leave their bodies in order to negotiate, on behalf of their community, with spiritual beings or even the High God himself (Katz, 1982). In contrast, in more stratified societies and nation states such as Haiti or Brazil, ‘possession trance’ is the norm — alien entities ‘ride’ their chosen human hosts, controlling them like marionettes without intrinsic consciousness or will. In the ‘monophasic’ and materialistic West (Laughlin *et al.*, 1992), spiritual experiences of a life-transforming kind (James, 1902; Hardy, 1979) occur only once or twice in a lifetime, in some sixty percent of the population (Hay and Morisy, 1978). These extraordinary disparities in experience, perception and belief would seem to be the necessary correlates of the equally extraordinary benefits of culture.

Humans are unusually social animals. Our ability to communicate and to co-ordinate our efforts in very large numbers, together with our manual dexterity, ingenuity and extensive repertoire of socially-transmitted skills, has led to our dominance as a species. Individual survival is crucially dependent on social competence and cultural conformity — together with the suggestibility that this requires. Even our basic perceptions are coloured profoundly by our social experience. The salience of a visual percept is likely to be determined by its

meaning for the individual — a meaning construed within a network of socially constructed meanings.

The concept of ‘collective representations’, as developed by Durkheim (1912/1995), refers to the often crucial components of human life that have meaningful existence only because we agree that they do — such as customs, money, religion, cosmology, language, games, laws, power structures and artistic genres. Such representations, which have objective and measurable existence in the world, have (in Durkheim’s conception) a moral force. They are constraining for social actors, they are the product of cooperation, they require adherence without prior examination, and they determine paths of social action (cf. Knight, this volume). They are not generally found in other animal species, so far as we know, and must be internalized in the form of shared procedural and semantic memories, which enable effective social interaction and contribute to our identities as social persons. While they must be consistent with the constraints of individual psychology and brain function, collective representations are highly variable across cultures and clearly possess a certain autonomy. Nevertheless, within a given culture they provide an indispensable framework for all meaningful actions, including those required for survival. In doing so, they frequently render cultures mutually unintelligible and provide fuel for enduring conflicts.

It is widely assumed that the brain shapes our conscious experiences (and perhaps even more widely assumed — with less justification — that the brain ‘creates’ consciousness). It is also known that the brain is in turn shaped by experience (one feature of brain development, for example, being characterized as ‘survival of the useful’: Changeux, 1985; Edelman, 1987; 1992). So, to the extent that collective representations shape the nature and contents of consciousness, we would expect that these cultural constructs would also shape the functional anatomy and microstructure of the brain. The aim of this article is to examine some of the evidence for cultural influence on the brain, in the expectation that this will contribute to the empirical bases on which consciousness studies may be grounded.

During the last two decades, the scope of functional studies of the human brain has dramatically expanded. This has been driven by the development of non-invasive techniques, such as functional magnetic resonance imaging (fMRI: Turner *et al.*, 1998) and magnetoencephalography (MEG), which have enabled much more precise measurements to be made of brain activity during carefully controlled tasks. A special feature of these techniques is that they can be used repeatedly with the same subjects, thus allowing longitudinal studies of

development and learning. It is also now possible to study reasonably-sized samples of normal populations, given the proliferation of MRI scanners largely dedicated to brain research.

This invites questions concerning the extent to which social and cultural forces shape not only our psyches and experience of the world, but also our brain organization. We need to examine the interplay between the propensities and constraints intrinsic to the brains with which we are born and the enormous amount of learning and accommodating which we do throughout our lives.

For the sake of definiteness, we will consider only a subset of the wide range of such questions.

1. Is it useful to partition the human brain into ‘social’ and ‘non-social’ components?
2. Could ‘collective representations’ have their own brain representations?
 - a. If so, is it likely that these have distinct brain localizations?
 - b. Given that repetition is a common feature of training, what are the effects of repetitive practice on cortical organization and cortical volume?
 - c. Are the long-term brain changes associated with skill acquisition dependent on the means by which that skill is acquired?
 - d. What is the role of emotion in mapping a collective representation into the brain?
3. How do these internalized maps in turn support and develop collective representations?

In this article we will address these questions in turn, from the perspective of functional brain mapping.

1. Is It Useful to Partition the Human Brain into ‘Social’ and ‘Non-Social’ Components?

The growing literature of social cognitive neuroscience describes what has come to be called the ‘social brain’ (Brothers, 1990, 1997; Adolphs, 1999, 2003). By this is meant that network of brain areas most involved in negotiating social action, which includes the amygdala (evaluating facial expression), the medial prefrontal cortex (a ‘theory-of-mind’ area, representing other people’s beliefs and intentions), the left frontal operculum and anterior cingulate cortex (integrating goals with

behaviour) and the fusiform gyri and superior temporal gyri (activated by socially important visual stimuli such as faces) (see Figure 1, colour section at the end of this book). According to Adolphs, social cognition is marked and distinguishable from other types of cognition by its emotional quality. In his view social 'behaviour' is intimately associated with the 'processing of emotions'.

But this view is hard to sustain in the face of brain lesion data (Damasio, 1994) which shows that the old compartmentalization of 'reason' and 'emotion' is largely conventional. We do not have space here to present a historical, comparative linguistic, or cross-cultural account of 'reason–emotion' terminology, but Damasio showed that rationality is dependent on emotion, and suggested that rational decision making requires options to be tagged with 'somatic markers' — or representations of embodied states that will result from alternative decisions. These allow us to evaluate potential choices in terms of pleasure–pain or nice–nasty. For us to plan effectively, to decide on courses of action, even to move a limb, requires motivation, and the motivational system of brain regions includes areas traditionally associated with emotion, areas rich in dopaminergic and serotonergic synaptic connections (Damasio, 1994; Seymour *et al.*, 2004). It is of course possible to argue differences — for example, emotion by definition is always conscious (otherwise we merely have an autonomic state), whereas a great deal of processing that might be considered 'rational' takes place unconsciously (Frith & Frith, 2007: *passim*). However, at a neuroscientific level, the concept of 'reason' is very far from being clearly established.

Furthermore, with rare exceptions, all human action takes place in a social context, and even when alone we are often performing to an unconscious gallery of significant others whom our brains handily represent (sometimes referred to as 'theatre of mind': Whitehead, 2001). The situation of the subject of an fMRI brain-scanning experiment, lying in a scanner performing some computer-controlled task, is extraordinarily social (cf. Roepstorff, 2001). One might almost say that it is ritualized — the experimenter is temporarily given complete and formal control over the subject's actions, the outcome of which, in terms of publishable experimental results, may not be known until months later, and may indeed never be known if the experiment turned out to be a failure. In order for the subject to feel comfortable enough in the unfamiliar, confined and very noisy space of the scanner bore, they must be put at ease and reassured by the radiographer, using well-rehearsed social skills. This has aspects of an initiation, a rite of passage.

But the argument can be taken further. During infancy we go through a process of learning to use our senses in close and continual partnership with caregivers, especially our mothers (cf. Gratier and Trevarthen, this volume). What is important and salient, whether visual, auditory, gustatory, tactile or olfactory, is defined jointly in this relationship (Trevarthen, 2001), and so it can be fairly claimed that much of our brains dealing even with perception are structured by social experience (see Chiao *et al.*, this volume). This claim becomes even stronger if one takes the view, following Gregory (1997) and Friston (2003), that in perception our sensory cortex acts as a comparator, most active when the thin stream of neuronal impulses representing the outside world does not match the model that deeper brain areas create and project to the early sensory areas. It is this model of the outside world which starts to be formed through mother-child social interaction, giving value, meaning and indeed words to shared experiences. If the 'early' areas of the brain that deal with perception are thus socially tuned, how much more so are likely to be those areas which deal more obviously with decisions, mirroring others' actions and control of action? Indeed, it is not easy to imagine brain areas that are not partly structured by early childhood social experience. Perhaps some parietal areas, concerned with spatial relationships and the transformation of eye-centred co-ordinates to head-centred and body-centred co-ordinates, may develop without such social influence.

Our capacities as social animals, which are very likely to be innate (Trevarthen, 2001), and some of which are shared with other species, enable us to participate in interactions that are repeated, systematic, structured, indeed often ritualized. Interactions such as inter-subjective mother-infant communication, classroom learning, family festivals, religious and secular rituals and formal meals have the properties needed to structure our neuronal networks, through the mechanisms of Hebbian learning,¹ which include synaptic potentiation and dendritic sprouting.

Thus the distinction made by Adolphs and his rapidly growing following, between the 'social brain' — thought of as a special network of specific areas — and the rest of the brain, is probably unhelpful.

[1] Donald Hebb (1949) postulated that neurones connect themselves together to form 'engrams' (otherwise known as 'neural nets') by a process that has been loosely paraphrased as *cells that fire together, wire together*. That is, where one neurone (A) repeatedly and persistently stimulates another (B), structural or metabolic change occurs such that the efficiency of A in stimulating B is increased. The process is known as 'Hebbian learning'.

2. Could 'Collective Representations' Have Their Own Brain Representations?

The question arises: how are collective representations stored and organized in the human brain? During the processes of education, social conditioning and maturation they are likely to be mapped in some way onto biologically predetermined cortical areas.

Very few of the socially defined entities coming under the heading of collective representations have been the object of neuroscientific study, even by the older technique of carefully identifying cognitive deficits resulting from acquired brain lesions. However, there has been a substantial amount of work on one such area central to human social life; that is, language. Loss of various components of language resulting from stroke has been of interest in neurology and neuroscience since the time of Pierre Broca (1824–80). Electrophysiological studies, and more recently neuroimaging studies, have added greatly to our understanding of the degree and specificity of localization of language in our brains. It is now clear that comprehension of language normally requires intact left-hemisphere parietotemporal areas, and its articulation requires mediolateral prefrontal areas, also in the left hemisphere. What is striking is that this cortical specialization for language is close to universal, even for the deaf, as we will see later.

This example makes it at least plausible that most collective representations (CRs) have some form of brain representation — that in the course of the socialization processes of childhood, which result in these over-learned concepts and procedures, sets of cortical areas become specialized for each such CR. It is now widely accepted that discrete brain areas have clearly defined computational roles — for instance, the visual area V5 is active only when a visual object is moving, or appears to be moving. This makes it also plausible that, for a given CR, brain representations will have much in common across individuals.

a. What experimental evidence exists showing that CRs have specific localized representation in human brain?

One way to answer this question is to perform brain mapping experiments on a reasonably large number of subjects (typically twelve or more, to give adequate statistical power) using experimental protocols involving specifically culturally-learned tasks. If there is appreciable spatial overlap in the individual brain responses to the tasks, it is fair to conclude that the CR involved has a local representation in human brain. I will outline three studies from the vast and rapidly growing

literature of imaging neuroscience. These fall under the headings of reading, motor skill learning and learning a second language.

A pioneering study (Neville *et al.*, 1998) was performed at the USA's National Institutes of Health (NIH) between 1993 and 1995, comparing brain areas involved in reading English sentences and American Sign Language (ASL) sentences, presented a word at a time. These tasks were contrasted with control tasks consisting of unpronounceable nonsense words and meaningless signs, respectively. Three groups of subjects performed the reading tasks: normally-hearing volunteers, congenitally deaf students from a university for the deaf and hearing subjects born to deaf parents — native hearing signers whose first language was ASL. All were competent at reading English, while the normally-hearing volunteers were completely unable to interpret ASL. The subjects were scanned in a prototype 4 T MRI scanner which had already provided convincing data for simple sensory and motor tasks. There were four findings relevant to the present discussion: firstly, across the hearing subjects there was good spatial consistency for brain areas involved in reading English — the already well-characterized left-hemisphere language areas; secondly, the deaf subjects used only a small subset of these traditional language areas for reading English; thirdly, the same deaf subjects used the traditional language areas when reading ASL, together with extensive corresponding right-hemisphere areas; and fourthly, the native hearing signers used areas similar to the deaf subjects for reading ASL. We may thus conclude that although our genetic inheritance clearly does not entail English reading ability in the way that it entails walking ability, there are cortical areas common to normal brains that are innately suitable for performing this task when mastered using the usual channels of phonology and orthography.

b. Given that repetition is a common feature of training, what are the effects of repetitive practice on cortical organization and cortical volume?

A second relevant study (Karni *et al.*, 1995) was also performed at NIH, which used the unique opportunity offered by functional MRI to follow changes in brain organization over time. Here the volunteer subjects undertook to learn a particular sequence of finger-to-thumb tapping, practising at speed for ten minutes per day for four weeks. This regime reliably results in considerable increases in speed and accuracy, closely analogous to the effect of five-finger exercises on the piano. While precisely sequenced finger tapping itself does not

represent a traditional cultural skill it is not likely to be inherited from our primate ancestors, and in obeying a formal convention established by agreement between the experimenters and subjects it can be classed as a collective representation. Each week the subjects were scanned, while performing both the specific sequence that they were practising and a control sequence which they did not practice, at a speed slow enough that no mistakes were made in tapping either sequence. They were also tested outside the scanner for performance rate and accuracy. When the data were analysed it was clear that in all seven subjects taking part, the area of cortex in the primary motor hand area representing the trained sequence of finger tapping had increased, relative to the area representing the unpractised sequence, over the study period of four weeks. Furthermore, even after an additional eight weeks, during which the subjects had no further practice but the skill level remained high, the area of cortex representing the trained task continued to be larger than for the untrained task, suggesting that a permanent change had taken place (see Figure 2, colour section at the end of this book).

This simple experiment demonstrated unequivocally that our brains are reorganized by repetitive motor practice, and that some of the reorganization takes place in the primary motor area, among the neurons that send commands directly to the motor neurons in the spine that drive our muscles. The important point here is that repetitive motor practice is a very common feature of the culturally defined skills that make up our collective representations. Thus this experiment constitutes a simple demonstration of the way that a cultural practice can develop a localized representation in our brains.

The final study showing the localization of a learned skill addresses the anatomical changes in the brain associated with the learning of a second language (Mechelli *et al.*, 2004). Generally this has been thought to involve purely functional changes in the brain, without necessarily implying further structural changes. Mechelli and colleagues used a sophisticated method (Voxel-Based Morphometry, VBM) for comparing the grey-matter density of individuals' brains (Ashburner and Friston, 2000; Good *et al.*, 2003), and took advantage of the wide range of language abilities found in a London population of English and Italians, to whom they gave high quality MRI scans² (Deichmann *et al.*, 2002). They showed that learning a second language increases the density of grey matter in the left inferior parietal cortex — the region known informally as Wernicke's area — and that the degree of structural reorganization in this region depends on the proficiency

[2] Most MRI laboratories cannot perform scans of the requisite contrast-to-noise ratio.

attained and the age at acquisition. While these effects could result from a genetic predisposition to increased density in this area, it is far more likely that they represent a structural reorganization induced by experience, because early bilinguals acquire a second language through social experience rather than as a result of a genetic predisposition. This inferior parietal region corresponds exactly to an area that has been shown by functional imaging to become activated during verbal-fluency tasks. It is unlikely that this increase in grey-matter density corresponds to a greater number of neurones, since these are not known to multiply after gestation, but it could arise from increased dendritic sprouting or axonal arborization.

This study lends weight to the suggestion made in a number of earlier studies (Schlaug *et al.*, 1995; Schneider *et al.*, 2002) that brain anatomical differences found between musicians and non-musicians may also arise from the extensive repetitive practice required to develop musical skill, rather than from innate differences predisposing them to become musicians. Another study, showing increases in occipital grey matter during the three month course of learning the cultural skill of juggling (Draganski *et al.*, 2004), also points in this direction.

c. Are the long-term brain changes associated with skill acquisition dependent on the means by which that skill is acquired?

Here we return to the study of reading in deaf subjects. For these individuals, the phonological channel for acquiring language is absent, and they also learned English at school — significantly later than normal hearing children and long after their language areas had adapted to the use of ASL. The result is a significantly different and more restricted set of areas for reading English. It should be emphasized that these subjects, university students, are fully competent in this skill. Furthermore, their brains, when applied to what is for them the more natural task of reading ASL, employ the same language areas as hearing subjects, even though it may well be the case that their auditory cortices are considerably reorganized, lacking the normal input.

Two important implications of this finding are, firstly, that more than one set of brain areas may encode a particular skill and, secondly, the brain areas used depend on the learning conditions (see also Sandak *et al.*, 2004). This may have relevance to educational strategies.

d. What is the role of emotion in mapping collective representations into the brain?

It is now well established that we remember items and events that have greater salience for us. Salience can come about by means of directed attention, perceptual intensity, perceived threat or emotional impact. An example of the role of emotion in memory is provided by a series of experiments (Strange, Hurlmann and Dolan, 2003) in which subjects were presented with neutral and emotion-laden words. The emotional words were better remembered than neutral words, and had the interesting effect of impairing memory for neutral words presented just before them. Emotional words characteristically activate the amygdala, a medial temporal brain organelle that appears to be particularly concerned with the emotion of fear, and lies immediately anterior to the hippocampus, another structure known to be crucial in the formation of memory for events.

Cultures appear to employ all of these forms of salience in structured contexts in order to impress collective representations into participants' brains. Particularly in ritual, where performative genres are often artfully combined (Turner and Turner, 1985) to give powerful and emotional experiences, participants may obtain a sense of ontological certainty regarding the collective representations that they internalize. In Western cultures, where rituals (defined as formal structures of social action disproportionate to survival outcomes) are not so obvious outside explicitly religious occasions, they are still plentiful (Goffman, 1982) and provide, often without our conscious awareness, continual reinforcement of the apparently stable cognitive features that define a culture and a way of life.

3. How Do These Internalized Maps In Turn Support and Develop Collective Representations?

It can be argued that our brains are primarily devices for generating temporal sequences of actions that have survival value — which of course includes all forms of meaningful action, such as language. Our brains contain networks for maintaining percepts of the actions of others — the mirror system (Rizzolati *et al.*, 1996; Iacoboni *et al.*, 1999) — and areas that are involved with representing the beliefs and intentions of others — the mentalizing areas (Baron-Cohen *et al.*, 1985; Frith and Frith, 2003; see also Whitehead, this volume). It is reasonable to hypothesize that the internalized maps of collective representations interact with these areas, and with areas associated with emotion such as the amygdalae, in the generation of socially appropriate actions.

These actions, such as teaching, officiating in ritual, collective singing, taking part in court proceedings and so on, will establish and reinforce the society's collective representations for all participants. Initiation of these socially appropriate actions will also confirm for the individual the unique ontological status of his or her own society's customs and language.

This perspective offers the possibility of a relatively stable feedback relationship between the collective representations, which are objective entities, 'out there', and the brain activities which maintain and are maintained by them, and by which — through the collective action of many brains — they are formed and conditioned. The challenge now is to seek regularities within our species which transcend cultural differences and which will allow us to generalize more confidently regarding these emergent entities. Very careful cross-cultural analysis, deeply informed by anthropology, will be required to classify collective representations in such a way that nuances of meaning are not destroyed, and like is properly compared with like. Mary Douglas, in her classification of types of culture along the axes of 'grid' and 'group' (Douglas, 1973), may have provided us with a suitable basis for this classification of collective representations. A great deal remains to be done. Unfortunately, serious anthropologists have ventured little into this research area, and the arena has been largely left free for social cognitive neuroscientists such as Sperber and Hirschfeld (2004)³ and evolutionary psychologists such as Pinker,⁴ who depend on an outmoded concept of modular brain organization⁴ that is not consistent with recent experimental findings.

Summary

We have tried to emphasize the contingent nature of much of our experience as social actors — which must qualify the way that we perceive ourselves, each other and the world — as we refer to a

[3] Sperber may be more commonly regarded as a cognitive anthropologist, but has moved over the years to the fringe of anthropology, and certainly does not speak for the majority of cultural or social anthropologists.

[4] It is not the idea of modularity that we regard as outmoded, but the evolutionary psychological conception of this — the notions that there are very many modules, that modules are generally evolved innate structures, and that brain function is primarily the result of combinatorial activation of them. A more sophisticated conception of modules (e.g. Karmiloff-Smith, 1995) is that they arise during development as a result of the interaction of innately sketched-out pathways and their terminating areas with repeated experience that produces Hebbian learning. This modifies the pathways to some extent, and alters the number and density of synaptic connections. So, for instance, a cortical region specialized for reading musical notation can be developed (see Stewart *et al.*, 2003).

collectively defined system of concepts, rules, beliefs and even physical structures in order to give meaning to our actions and find meaning in each others' actions. Durkheim characterized this system by the term 'collective representations'. In neuropsychology the term 'representation' has become commonplace for the action of the brain in forming material counterparts for mental processes, and so it is attractive to consider the relationship between these two types of representation: the collective and the cortical. We think it is well demonstrated that some collective representations can have well-defined cortical representations. In order to avoid ethnocentricity it is incumbent on the research communities of brain science and anthropology to collaborate in joint projects which can tease out the particular and the universal.

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