JUNGLES AND COMPUTERS: NEURONAL GROUP SELECTION AND THE EPIDEMIOLOGY OF REPRESENTATIONS

HARVEY WHITEHOUSE

The Queen's University of Belfast

Sperber argues that humans are susceptible to certain representations and not others as a result of genetically specified mental devices, and that this helps to explain the global recurrence of certain cultural concepts. Nevertheless, Sperber argues that other representations, to which we have no innate susceptibility, may become widespread for sociological reasons. Against the notion of genetic 'programming', I argue that all mental processes are socially constructed. Based on a synthesis of recent theories in neurology, artificial intelligence, psychology and anthropology, I argue for an integrated cross-disciplinary theory of cultural transmission.

In his Malinowski Memorial Lecture, Sperber (1985) claimed that culture consists of widely transmitted representations. The question which an 'epidemiology of representations' seeks to answer, he argued, is why some representations are widespread, and thus part of culture, whereas others are not (and are therefore either not transmitted or are extremely localized).

Numerous nineteenth-century scholars addressed the question of how and why representations become widespread in human populations. This was clearly the principal problem for approaches such as diffusionism, but it was also high on the agendas of our most cherished intellectual ancestors, such as Durkheim, Marx and Weber. Their approaches to the problem were determinedly sociological, focusing on the formal interrelations between categories of representations. Consider, for example, Weber's notion of an 'elective affinity' between certain types of representations, most famously deployed in his discussion of the emergence of a 'spirit of capitalism' (Weber 1930). Marx likewise proposed a sociological theory of why only certain types of representations become widespread. For Marx, aspects of the process were analogous to natural selection, in which the 'fitness' of materially useless representations was a function of their compliance with production relations (Marx 1954: 791-2). Durkheim's most enduring contribution to social anthropology was his theory of the 'elementary forms' of religion, and this too involved the postulation of causal connexions between formal categories of representations. The issue of why particular types of representations become widespread was not very comprehensively addressed by structural-functionalists (see Fortes 1980: 197), but in recent years the topic has resurfaced in many guises. Witness the spate of ethnographies this decade focusing on the historical formation and

J. Roy. anthrop. Inst. (N.S.) **2**, 99-116

spread of material culture (Thomas 1991), ritual prerogatives (Harrison 1990), political ideologies (Rappaport 1990), and other sorts of representations.

For the purposes of my discussion, we might brand all of these approaches 'sociological'. In so far as they offer 'explanations' for the prevalence of particular kinds of representations (locally or globally), they do so with reference to other representations (dubbed economic, political, religious, or whatever). Very few anthropologists have attempted to account for the recursive, contagious quality of particular representations in terms of species-specific properties of the mind or brain. Sperber's approach is very unusual in this respect. Sperber, and a few others (see, for instance, Hirschfeld & Gelman 1994), have been arguing that there are specific mechanisms in our neural hardwiring that make us more likely to reproduce certain types of representations than others. According to this view, culture is constrained not only by its systematizing logics and politico-economic dynamics, but by the 'micro-mechanisms of cognition' (Sperber 1985: 78) through which all representations are processed and reproduced.

Consider, for example, studies of the religious phenomena known as 'cargo cults'. The incidence and spread of these cults in the late nineteenth and twentieth centuries seemed to lend itself to an epidemiological interpretation. Many Western observers described these cults as if they were viruses, reaching epidemic proportions in some areas and becoming endemic in others (for instance, compare Williams [1928: 14-23] and Sperber [1985: 74]). Most attempts to explain the spread and recurrence of cargo cults have been sociological in character. Typically, these cults have been seen as a reaction to colonial domination and exploitation, as an attempt to unify indigenous peoples in the pursuit of revolutionary goals. Even intellectualist and psychologistic interpretations have focused primarily on the formal relations between indigenous and colonial cultural 'systems'. If, however, one were to ask why concepts of ancestors and other spirits were so widespread in the first place, scholars such as Sperber and Boyer would argue that sociological theories could never provide a comprehensive answer. At least part of the reason, they would argue, is that all humans are susceptible to concepts of this kind because of genetically specified mechanisms in the brain.

According to Sperber (1985: 77), cultural transmission is a process in which mental and public representations are being constantly converted into each other. For example, A produces a public representation (such as a sentence or a gesture), which is perceived by B who then forms a mental representation of it. B later externalizes his mental representation so as to produce a public representation very much like A's. This is perceived by C, who in turn reproduces the process, and so on. People only externalize (and thus 'transmit') representations that are memorable (or 'relevant' – see Sperber 1994: 50). But part of what makes a representation 'transmittable' is not simply an outcome of the sociocultural system in which it occurs; to some extent it is an outcome (so the argument goes) of certain genetically determined cognitive devices. For example, Boyer (1994) suggests that humans automatically develop certain expectations about solid objects (that they should move in continuous paths, not pass through each other, fall when released in mid-air, and so on); concepts of ancestors, of the sort prevalent in many cargo cults, arise from the violation of these hardwired expectations, and for this reason 'stick' in the memory and tend to be widely transmitted.

Having established the principle that certain representations which violate our intuitive expectations have a 'contagious' quality, it becomes possible to form lists of these sorts of representations. Boyer has specialized in the listing of concepts of extra-natural agency which violate our expectations in myriad specifiable ways (see, for instance, 1992; 1994). Sperber has also produced lists of these sorts of concepts (1985: 84-5). But, in addition, Sperber provides *ad hoc* lists of representations which are 'contagious' because they *fit with* (rather than violate) our hardwired expectations of the world. Information that can be 'slotted' into taxonomies, and simple narrative structures (for instance, fairy tales), are favourite examples (1985: 81-2; 1994: 48). But an even more obvious illustration, following the spirit of a Chomskyan project, would be syntactical representations, assimilable to hardwired language-processing devices. By the same token, Sperber provides numerous examples of representations that are intrinsically hard to remember, such as twenty-digit numbers (1985: 80), an account of the day's events on the stock exchange (1985: 78) and solutions to crossword puzzles (1985: 85).

Sperber's theory of the epidemiology of representations is premissed on a vision of the mind-as-computer,[1] in which neural hardwiring is linked to the concept of 'modularity'. Sperber defines a 'module' as 'a genetically specified computational device in the mind/brain . . . that works pretty much on its own inputs pertaining to some specific domain and provided by other parts of the nervous system' (1994: 40).[2] Cognitive science has proposed a limited variety of modules, providing the basic hardware for learning. This genetically transmitted hardware is activated through the assimilation of socially transmitted software: the rules, values, norms, classifications and other representations of a given culture. In general, this approach allows that the content and organization of our mental software can be quite effectively explained by means of social/cultural theory. But, according to Sperber, at least a few aspects of its content and organization are specified by modular hardwiring, and therefore require a cognitive explanation.

I now present a detailed critique of Sperber's approach to the 'transmittability' of representations. This is followed by a description of some recent research in neurology and artificial intelligence which suggests a rather different approach. I then explore the possibility of an integrated, cross-disciplinary theory of cultural transmission based on a synthesis of recent theories in anthropology, psychology and neuroscience.

Rethinking relevance

Sperber's original 'law' of the epidemiology of representations (1985: 86) stated that only easily remembered representations become part of culture. More recently he has expressed it as the rule that only *relevant* representations become part of culture (Sperber 1994: 50). Nevertheless, there are compelling reasons to doubt that the memorability of representations could ever be an outcome of invariable, genetically specified features of cognition.

One of Sperber's examples of a hard-to-remember representation was a twenty-digit number. Certainly, I would be unlikely to remember a twenty-digit number if it was gabbled at me on a single occasion. But if I can remember the telephone numbers of three friends in London, it follows that I can remember more than twenty digits without difficulty. The reality, of course, is that we can all recall a great many strings of numbers which, if placed end to end, would amount to hundreds of digits. Although we often adopt mnemonic devices to remember unfamiliar digital strings, the act of dialling a telephone number many times is sufficient to enable us to recall it without having intended to learn it. One of the longest strings of arbitrary digits which most of us have to learn is the alphabet. But even pre-school children seem to have no difficulty recalling the twenty-six digit sequence, simply as a result of frequent exposure to it.

One of Sperber's favourite examples of an easy-to-remember representation is the story of 'Little Red Riding Hood'. But, in fact, narratives in this genre can be extremely difficult to recall. For example, I recently asked several of my colleagues if they could recall a well-known Indian tale about three blind men who feel an elephant's leg, tail, ear and body respectively and conclude it is like a log, a rope, a fan and something without beginning or end. All I could remember was that it was about three blind men who tried to identify an object as an elephant by touching it. One colleague was certain that he had heard the tale but could not elaborate on any of the details I gave him. Another thought the story was about a donkey rather than an elephant (linking it with the parlour game, 'Pin the Tail on the Donkey'). Yet another had the blind men feeling the elephant's tusks, feet, and so on, rather than the anatomical parts actually featuring in the story. It is unlikely that these were all accurate renderings of versions of the tale which my colleagues had actually heard or read. My first informant expressed a sensation of having forgotten salient details. The second was aware of conflating different scripts. The third admitted that he was making creative inferences about the narrative from his general knowledge of an elephant's anatomy. In short, these sorts of stories can be much harder to remember than a twenty-digit number.

I am not, of course, trying to turn Sperber's argument on its head by suggesting that twenty-digit numbers are 'easy to remember' and that folk tales are 'hard to remember'. Most people (especially those with young children) can recall a repertoire of folk tales very accurately, even reproducing large sections of their narratives word-for-word. Others have difficulty remembering a simple string of four numbers (as I recently discovered to my cost at a cashpoint machine in Oxford). My point is that there is no such thing as a 'hard-to-remember' representation or an 'easy-to-remember' representation. Something is only easy or hard to remember under specific conditions.

Sperber could counter this argument by pointing to the statistical incidence of different types of representations in a variety of cultures. Myths and other formal narratives are clearly much more widespread in tribal societies than representations of twenty-digit numbers. Indeed, there is a certain tautology here in that the principal evidence that particular representations are an outcome of mental hardwiring is that they are widespread (see, for instance, Sperber 1994: 41). Nevertheless, it is by no means clear that all societies go in for story-telling (Pool 1984: 231-2), as one should suppose if we were hardwired to produce and reproduce elements of narrative genres. But there is a more persuasive point to make, which is logically rather than empirically motivated.

If the sorts of representations that we are hardwired to remember are only memorable under most conditions, but not all, then the conditions of transmission must be a causal factor in the memorability of *all representations* (a point with which Sperber would, of course, agree). Thus, if a particular representation is widespread then it must be undergoing transmission under a set of conditions which is typically present. The concept of hardwiring only comes into being through the 'bracketing out' of this typical set of conditions, and the pretence that it is irrelevant. Ingold makes a similar point in his critique of the genotype/phenotype distinction in conventional evolutionary biology (1994: 3, his emphasis):

> If the DNA of the genome were really a carrier of information, as the theory requires, then it must be possible to 'read off' the elements of the genotype . . . from the corresponding DNA segments ('genes'), *regardless of local conditions of development*. Yet in reality, there is no 'reading' of the DNA that is not itself part of the process of development; indeed it is only within the context of such a process that one can ever say what a particular gene is 'for' . . . The genotype, as a context-independent specification of form, thus exists only in the mind of the biologist.

A second commonsense objection to Sperber's line of argument is that it invokes radically different types of theories to explain intuitively similar things. We know, for example, that religious representations are extremely widespread, and that one recurrent feature of religion is a set of concepts of extra-natural agency. But various types of ethical concepts are equally widespread. Sperber's approach would explain the relevance (the 'transmittability') of the former in terms of cognitive hardwiring, and leave it to others, such as social theorists, to explain the 'transmittability'/relevance of the latter. Both types of concepts are commonplace, and both come about through the development of neural activity in social contexts, so why propose that the widespread incidence of one, but not the other, is explained by genetically specified cognitive devices?

A third objection to Sperber's epidemiology model is its neglect of emotions. This neglect is quite intentional (see Sperber 1985: 74) but it is also undefended. It is probably best understood in terms of the entrenched division in Western culture (and therefore in Western psychology) between concepts and feelings, cognition and emotion. As Toren (1994) has shown in her discussion of Fijian child development, our dichotomous representations of intellect and affect are not necessarily found in other cultures. From the viewpoint of a theory of transmission, we need to ask what limitations are imposed by the Western psychological assumption that cognitive and affective processes can be analysed independently. One way of doing this is to consider Sperber's and Wilson's (1986) theory of the role of relevance in communication, partly inspired by inferential models and recent findings in pragmatics. This work is particularly germane here because Sperber maintains that the crucial determinant of transmittability in his epidemiology model is *relevance* (Sperber 1994: 50).

The essence of Sperber's and Wilson's theory was that each individual operates in a 'cognitive environment', which consists of all the possible assumptions he or she is capable of making in relation to externally generated stimuli and internally generated memories. Put crudely, communication consists of altering other people's cognitive environments, such that they are able to make relevant inferences about one's intentions in doing so.

As a simple illustration of this process, Sperber and Wilson (1986: 48-9) invited us to envisage Mary and Peter sitting on a bench in the park. Peter leans back, so as to reveal to Mary a sight which his body would otherwise have obscured:

> as a result of Peter's leaning back she can see, among other things, three people: an ice-cream vendor whom she had noticed before she sat down on the bench, an ordinary stroller whom she has never seen before, and her acquaintance William, who is coming towards them and is a dreadful bore. Many assumptions about each of these characters are more or less manifest to her. She may already have considered the implications of the presence of the ice-cream vendor when she first noticed him; if so, it would be a waste of processing resources to pay further attention to him now. The presence of the unknown stroller is new information to her, but little or nothing follows from it; so there again, what she can perceive and infer about him is not likely to be of much relevance to her. By contrast, from the fact that William is coming her way, she can draw many conclusions from which many more conclusions will follow. This, then, is the one truly relevant change in her cognitive environment.

A striking thing about Sperber's and Wilson's discussion of the role of relevance in communication is the absence of any treatment of its affective dimensions. From Mary's viewpoint, it seems reasonable to suppose that the sight of William approaching seizes her attention because it evokes anxiety, or perhaps irritation. In fact, in terms of the actors' sense of what is relevant in this situation, it seems very contrived to distinguish the emotional response from the cognitive one. To put this another way, Peter's act of communication is premissed on his assumption that both he and Mary know William, but their knowledge of William is simultaneously affective as well as conceptual. In this particular case, Mary's and Peter's affective responses to William's appearance are negative. It would be easy to change the story so that both Mary and Peter are fond of William, or one likes him and the other does not. But these changes would radically alter the nature of the act of communication which Peter carried out by leaning back. For example, if Mary and Peter know that they both dislike William's company, then Peter's communicative act probably engenders illocutionary force (Bloch 1974): it amounts to a request for evasive action. If, on the other hand, both Mary and Peter are fond of William, the communicative act engenders propositional force (Bloch 1974): it is primarily intended to inform Mary of a rather gratifying development. If, however, Peter knows that Mary knows that he *dislikes* William, and Mary knows that Peter knows that she *likes* William, then Peter's communicative act becomes extremely ambiguous. The act could be a request for evasive action or a neutral observation for Mary's benefit. If Mary is charitably disposed towards Peter, she might attempt to resolve the ambiguity by asking him if he would prefer they made their excuses, or preempted his arrival by taking evasive action. Alternatively, Mary could choose to leave the ambiguity unresolved, and select her own course of action without further ado. What is clear, however, is that affective responses, and assumptions about other people's affective responses, are an integral part of communication, as described by relevance theory.

One might wish to object that emotion only enters into certain communicative acts. We are no doubt all familiar with situations in which communication is highly charged emotionally, and a common result of this is what we colloquially refer to as 'failed communication'. Not infrequently, cues intended to be relevant are overlooked by those engaged in an argument, and our behaviours (verbal or otherwise) may be deemed relevant in ways we had not intended. Our particular Western representations of this kind of experience suggest an internal battle between cognitive and emotional responses in which one type of response seeks to gain mastery over the other. Cognition is strongly associated with tropes of objectivity, regulation and repression, and emotion with tropes of subjectivity, anarchy and inundation (cf. Toren 1994).

If it were really the case that only some communicative processes are premissed on affective states, then it would follow that the relevance theory merely needs to be expanded rather than reconstituted. Unfortunately, it is not so simple.

Returning yet again to the park, it could not be the case that the vision of William approaching is relevant in cognitive but not emotional terms. It is possible that it inspires only mild emotion, but in order to be relevant, William's appearance must be evaluated either positively or negatively. If it inspires neutrality, then it will be no more relevant than the sight of the ice-cream vendor or the unknown stroller. If one unexpectedly see somebody one knows, one automatically experiences a sense of wanting or not wanting to communicate with him or her. As far as I am aware there are no societies in which people, when unexpectedly confronted with an acquaintance, do not experience an impulse towards either communication or avoidance. But if such a society existed, and it contained parks and benches, then Peter's leaning back would probably not be an act of communication. The impulse to interact or escape upon recognition of an individual is not a species-specific trait of human beings. But it would certainly be classified as an emotional response in humans. Moreover, something very much like this is presupposed by more complex forms of communication, including language – a point to which I return.

In the next section, I describe Edelman's theory of neuronal group selection,[3] and show how it obviates the main problems I have identified in relation to the notion of modular hardwiring. Edelman's theory does away with the distinction between 'innate' and 'acquired' mental processes; it presents the possibility of a unitary theory of the formation of *all types* of representations; it does this by situating the process in a social and historical context, thereby establishing a bridge connecting neurology, psychology and sociology; and it integrates cognitive and affective processes. This theory, it seems to me, is a better starting place for an epidemiology of representations.[4]

The theory of neuronal group selection

One of the most striking discoveries of the brain sciences is the diversity of potential patterns of neuron firings in the brain. Humans possess approximately a hundred billion nerve cells, and the number of potential firing patterns is greater than the number of particles in the known universe. According to Edelman, learning is a process of natural selection within a potential population of virtually infinite firing patterns. To express this in concrete terms, we might imagine random firing patterns in neural centres governing motor activity to produce random behaviour, such as that exhibited in foetal development. The modularity thesis presupposes that child development follows a genetically specified schedule, such that appropriate structures for patterned forms of behaviour, such as clutching, crawling, talking and so forth, are pre-programmed. Edelman's theory, however, suggests that the developmental sequence results from the reinforcement of certain firing patterns through experience, and the weakening or elimination of others. This is why the potential number of firing patterns has to be as great as it is: learning is a process of elimination, of selecting out unwanted firing patterns and continuously accumulating repertoires that have a selective advantage. According to this view, engagement with the environment is not a process of *instruction* (as in conventional computer-like processes) but of *natural selection*.

Edelman describes his theory as the 'theory of neuronal group selection' (TNGS). TNGS is founded on three basic tenets. The first is 'developmental selection' (1992: 83), producing the topobiological dimensions and divisions of the nervous system. Edelman shows that even the neuroanatomy of organisms is not genetically programmed. DNA strings set constraints on brain formation, from foetal development onwards, but the eventual topobiological distribution of nerves in a given brain is the unique outcome of competition, governed by the principle of natural selection. Thus, in genetically identical animals (including human monozygotic twins) neuroanatomical circuitry is never identical. Moreover, the 'wiring' of an organism is constantly changing. Edelman describes these ever-changing links between nerve cells as a 'primary repertoire', constituting (at a given point in time) the range of links between which synapses could, in principle, occur.

The second tenet is 'experimental selection' (1992: 83-4), resulting in actual, as opposed to potential, synaptic connexions. Edelman shows that particular connexions become established through regular biochemical reinforcement in conjunction with the organism's behaviour. The resulting set of functioning circuits, established through natural selection, is described as a 'secondary repertoire'.

The third tenet is 'reentrant mapping' (1992: 85), consisting of the interactive processes between firing patterns (or 'brain maps'). The firing patterns involved in perceptual processes involve many different parts of the brain. In order to produce the experience of 'seeing' something, maps relating to shape, focal hues, motion and so on are simultaneously activated in different sectors of the neural system, and these sectors must be interconnected and co-ordinated. This process of co-ordination (that is, reentrant mapping) is also established through natural selection. Recursive reentry across neural sectors is reinforced in the same way as experimental selection. All three processes are linked to motor behaviour (producing inputs to the system or 'sensory sampling') via a process of 'global mapping' (1992: 89).

With these general principles in mind, let us briefly consider one of a string of experiments in artificial intelligence, pioneered by a team of scientists in California and inspired by Edelman's theory.[5] The experiment involves a process of learning based on natural selection, as opposed to any form of modularity or instruction.

The experiment uses a motor-driven automaton with a primitive visual system linked up to a supercomputer. The automaton is equipped with a specific primary repertoire, equivalent to a very primitive neuroanatomy, in the circuitry of the supercomputer. This circuitry impels it to move around and take visual samples of its environment randomly. The automaton is also endowed with circuitry that reinforces specific perceptions, but not others. Separate circuits detecting stripy objects and bumpy objects are separately reinforced. Placed in an environment with a wide variety of objects, the automaton begins by sampling all objects randomly. Through experience, however, a 'secondary' repertoire of reentrantly connected circuits is established enabling the automaton to track only stripy or bumpy objects. The automaton shows that it is able to learn to distinguish stripy or bumpy objects from those that are neither, but also to distinguish those that are stripy *and* bumpy from those that have only stripes or only bumps. This is achieved through the selectional formation of global mappings. Although the automaton is a computer-based machine, it functions more like a brain than a computer: 'it categorizes only on the basis of experience, not on the basis of prior programming . . . [It] carries out categorization on value in a fashion that might be called embodied . . . Of course, the brain of a real animal has the capacity to assemble many more mappings of this kind' (Edelman 1992: 93, emphasis removed).

The automaton in this experiment is concerned with identifying two discrete variables and their simultaneous occurrence. But the automaton is not programmed to do this. It is an artificial animal capable of learning through a simulated process of neuronal group selection. The automaton does not have to know in advance that there exist objects which are stripy but not bumpy, bumpy but not stripy, stripy and bumpy, and neither stripy nor bumpy. But if it is 'rewarded' for finding stripy and bumpy objects, it can proceed to make all these distinctions through a process of natural selection. The dispensation of rewards in real brains is obviously a crucial mechanism for the theory of neuronal group selection.

Edelman argues that in *real* brains, synaptic connexions are strengthened by ascending diffuse emissions from the hedonic centres and limbic system. These neuroanatomical sectors are described as 'value systems', and they are linked to particular regulatory functions such as feeding, circulation, respiration, sexual arousal and so on. The biochemical emissions from the brain's value systems give rise to the experience of affective states (which of course affect regulatory functions as well as the nervous system itself). Edelman's argument is that certain configurations of firing patterns trigger emissions from the brain's value systems so as to reinforce the synaptic connexions entailed in those configurations. Thus, an emotionally stimulating configuration of firing patterns, for example, would stand a greater chance of being repeated than a 'neutral' configuration. In concrete terms, a baby may have the goal of transferring a hand-held object to her mouth; her cortex receives no pleasant impulses in response to random movements of the limbs, and so the random firing patterns in sensorimotor sectors are not reinforced. But when a particular random movement of the hand results in the object touching her lips, the synaptic connexions involved in this behaviour are strengthened. A particular configuration of firing patterns is thus cumulatively selected through experience. Note that the baby is in no sense 'programmed' to put things in her mouth. She has merely stumbled upon one of a range of potential behaviours that are satisfying. According to this theory, we are programmed for nothing, save to explore the potentialities of our bodies and environments via a process of learning by neuronal group selection.

The TNGS is clearly consistent with the plasticity of human thought processes. But in arguing against the concept of modular hardwiring, Edelman does not have to overlook or deny recurrent, species-specific cognitive patterns. Thought processes are constrained but in no sense 'programmed' by DNA segments. To be sure, the range and nature of human mental life are substantially different from those of a chimpanzee, and massively different from those of a frog; moreover, all humans probably think much more like other humans than like any non-human species. But these outcomes of neural development in each individual are not genetically specified; they are the outcomes of processes of natural selection through embodied experience of the world (as well, of course, as being a result of our species' evolution). Edelman (necessarily) argues that these selective systems are interconnected. Neuronal group selection in the brain occurs on a time-scale of minutes and hours, whereas in generations of organisms natural selection occurs over millions of years. But the principles are the same and each process gives shape to the other: 'a small loop consisting of the events in neuronal group selection leads to diverse phenotypic behaviours in different individuals of a species. These diverse behaviours provide the basis for ongoing natural selection in the grand loop of evolution. The two selectional systems, somatic and evolutionary, interact' (Edelman 1992: 97).

Thus, according to Edelman, human brains do not come pre-equipped with modules for classifying the world, for acquiring grammars, or for any other mental function. Rather, they are equipped with a mass of ever-changing circuitry capable of endlessly creating new maps, and new configurations of maps, through neuronal group selection. Thus, for example, no aspects of neural activity appropriate to the construction of a sentence are specified in advance; they come about by a process of gradual reinforcement through experience. In this respect, neural activity is rather like the massive hive of activity in a jungle (Edelman 1992: 69). There is no design or programme that directs the evolution of plants or animals. Adaptations to the ever-changing environment are not planned in advance, but they occur through the random discovery of fortuitous matches. Edelman describes the study of this selective process as 'the science of recognition', and this is the science which he considers proper to the analysis of brain functions: 'In considering brain science as a science of recognition I am implying that recognition is not an instructive process. No direct information transfer occurs . . . Instead, recognition is selective' (1992: 81).

Neuronal group selection and memory

For Edelman, the creation of memories is a gradual process in which particular configurations of firing patterns are strengthened through partial (but significant) duplication. As he puts it (1992: 102):

> The TNGS proposes . . . that memory is the specific enhancement of a previously established ability to categorize . . . This kind of memory emerges as a population property from continual dynamic changes in the synaptic populations within global mappings . . . In such a system, recall is not stereotypic. Under the influence of continually changing contexts, it changes, as the structure and dynamics of the neural populations involved in the original characterization also change . . . Memory, in this view, results from a process of continual recategorization. By its nature, memory is procedural and involves continual motor activity and repeated rehearsal in different contexts . . . Unlike computer-based memory, brain-based memory is inexact, but it is also capable of great degrees of generalization.

Edelman's argument fits quite well with notions of *stereotypic scripts* for familiar situations (see Schank & Abelson 1977), such as going to the doctor or to a restaurant. We all know, for example, that restaurant scripts involve variations on a sequence (such as entering, being shown to a table, consulting a menu, ordering, eating, paying, tipping, departing). The scope for variation is quite limited (you cannot depart before you enter, or eat before you order, and so forth), but there are differences between most fast-food restaurants (for instance, you pay before eating) and more conventional establishments. Scripts for these kinds of events are usually formed gradually, through experience and observation. One feature of these general scripts is that they tend to take precedence over our memories of *actual* episodes. If I eat at a particular restaurant every week, for example, I may be able to remember some unique details of my last meal but as time passes the meals seem to 'fade' into each other. I could not tell you anything unique about my meal six months ago, even though I could infer many general details about that experience from a typical script. In Edelman's terms, the available script at a given point in time is presumably a configuration of firing patterns which have been cumulatively reinforced, these patterns encompassing the common denominators of repetitive experiences.

But there are other types of remembering which do not work like this. Some memories, in fact, seem to be created in an instant, rather than cumulatively over time. Everybody can remember unique episodes from his or her past, some of which may have a remarkable vividness. These sorts of memories are referred to by cognitive psychologists as 'autobiographical' or 'episodic' memories. Particularly vivid and detailed memories of one-off events can even have a canonical structure in which location, activity, source, affect and aftermath seem to be recalled quite predictably (see Winograd & Killinger 1983). In cognitive psychology, this phenomenon is sometimes referred to as 'flashbulb memory' and is classed as a special type of episodic memory. Kulik and Brown (1982) have argued that the formation of flashbulb memories involves the activation of a particular neural mechanism.

From Edelman's viewpoint, this presents a problem. Natural selection in the brain involves a diverse population of firing patterns, with numerous recurrences of 'advantageous' patterns eventually establishing scripts (that is, particular configurations of firing patterns). Flashbulb memory does not appear to fit with this model because it suggests that just one set of firing patterns can be enough to produce a script. Clearly, neither of the models is adequate for a general theory of memory. If every set of firing patterns had the character of flashbulb memory, we would remember every moment of our lives with absolute clarity. And if every set of firing patterns was integrated into a cumulative process of selection, we would have no autobiographical memories – only general scripts for repetitive events.

It therefore seems necessary to postulate two broad types of memory (see Tulving 1972). But how might these types of memory be integrated into a theory of the brain? It is possible that the answer lies partly in the diversity of affective states. There is a massive discrepancy between the mild irritation or anxiety occasioned by bumping into a boring acquaintance and the terror of being threatened by an armed killer. The former is likely to evoke standard scripts for evasion, whereas the latter is likely to establish a script of its own, never to be forgotten. One of the features most commonly associated with 'flashbulb memories' is intensity of emotion. Extreme sensations of fear, lust, anger, horror and so on seem to make the episodes in which they are evoked more memorable as one-off autobiographical events. Thus, the terrifying ordeal, the first kiss, the violent confrontation and the shocking violation of morality, all appear to 'engrave' themselves on our memories. It is as if these emotive types of events burn an indelible firing pattern into the brain. The ascending diffuse emissions of the brain's value systems seem to be more intense on these occasions than on others (this, at least, is what one might expect if these emissions are the biochemical correlates of emotional states).

Following an extensive review of the literature on emotion and memory, Christiansen (1992) concludes that there seems to be a positive correlation between the intensity of affective states and the vividness and longevity of episodic memories. Nevertheless, this could only be part of the story, if only because some affective memories decay faster than others.

In addition to strong emotional content, a classic feature of 'flashbulb memories' is that they are triggered by *surprising* events. A surprising event is one that does not conform to our normal expectations; in other words, it is an event which is incongruent with existing stereotypic scripts. There would be nothing memorable about the sight of a woman riding her bicycle up King's Parade in Cambridge. It would, however, be hard to forget the sight of her riding a bicycle up the aisle of King's College Chapel during Holy Communion.

Wright and Gaskell (1992) argue that the experience of 'flashbulb memory' can be explained in terms of a cognitive processing loop. They suggest that when an event is perceived, the cognitive apparatus searches for a relevant script; if none is found the search continues until at last a reasonably adequate approximation to the event is remembered. The new event can then be attached to an existing script. Abnormal events would go around the loop many times before a suitable script is located. Wright and Gaskell suggest that flashbulb memories result from the failure to locate an adequate script: the cognitive apparatus becomes exhausted and settles for the creation of an entirely new script, in which all kinds of indiscriminate details are encoded.

It would be possible to modify Edelman's theory of neuronal group selection to accommodate the flashbulb phenomenon. Let us suppose that ascending diffuse emissions from the brain stem reinforce select firing patterns in different degrees, depending on the 'strength' of these emissions (that is, 'strength of emotion'). We could envisage two main classes of neural response to any kind of affective stimulus.

Response A would involve the substantial reproduction of already established firing patterns (giving rise to stereotypic scripts). Because of the cumulative reinforcement of certain parts of these firing patterns in the past, these would remain the most reproducible parts of the new firing patterns. We might refer to these particularly reproducible parts as a 'primary firing pattern'. 'Secondary' aspects of the new firing pattern (that is, ones that have not been cumulatively reinforced in the past, or not to the same degree) would not be repeated, or would be repeated weakly or infrequently and eventually decay. These would be aspects of our experience which are either not remembered or soon forgotten.

Response 'B' would involve the establishment of radically new firing patterns, reinforced by strong emissions from the brain stem which fail to correspond to already established firing patterns. This would account for the particularly vivid and enduring character of certain episodic memories, especially the flashbulb phenomenon.

Neurology, psychology and social theory

At this point, it is possible to see the *potentiality* for a theory of transmission that integrates neurological, psychological and sociological perspectives. The *actual* integration of neurological and psychological theories is clearly a long way off. A comprehensive neurological account of 'simple' perceptual processes is not yet possible, let alone such an account of, say, a public oration. Nevertheless, if Edelman's line of thinking is broadly correct, a great deal of psychology starts from the wrong premisses – of which perhaps the most pervasive is the modularity thesis. The assumption of modularity does not necessarily affect the quality of the data collected in psychology and linguistics, but it may lead to invalid inferences from these data. Detailed examples are provided in Edelman's eloquent critique of Chomsky's notion of a 'language acquisition device' (1992: 241-52). Edelman argues that theories of 'cognitive semantics' (from Langacker 1987; Lakoff 1987; and others) are much more substantially consistent with neurological research than any notion of genetically specified mechanisms. Following Edelman's reasoning, 'hardwiring' is not a factor in the relevance/memorability of representations. All representations are created through integrated processes of engagement with the environment and, since the most stimulating aspects of the human environment are *social*, we are obliged to envisage all processes of transmission in terms that are simultaneously sociological, psychological and neurological. Let us consider an example of how we might proceed from here.

In a series of publications (Whitehouse 1992; 1994; 1995; in press), I have argued that divergent modes of ritual action engage different processes of memory. Highly routinized practices, such as liturgical rituals, are substantially encoded as stereotypic scripts. Each ritual performance conforms to a familiar, repetitive sequence. Participants could not possibly remember specific performances last year, or the year before that. They could only infer from their general, semantic knowledge that they probably performed a certain ritual at a certain time on a certain day.

By contrast, the infrequent and highly traumatic rituals found, for example, in systems of initiation and sporadic cult activity, engender primarily episodic memories. In many cases, these episodic memories are experienced as a direct violation of existing semantic knowledge. In a traumatic instant, one's everyday assumptions are challenged and overturned. These moments of intense religious revelation are recalled as unique, autobiographical events. These contrasting modes of ritual action involve very different assessments of relevance.

Consider, as an example of a routinized practice, formulaic responses in the Catholic Mass. The priest recites a set of familiar words or phrases, to which the congregation responds with fixed answers or repetitions. This, at least, is the general script. Although cognized as a repetitive, predictable sequence of behaviours, the reality is that no two performances could be identical. Nevertheless, subtle differences between performances are consistently bracketed out as irrelevant, so that the impression is of behavioural replication. Let us suppose, for example, that on one occasion the priest stutters over the penultimate 'amen'. Although members of the congregation would claim that they are repeating the priest's utterance, it would be unthinkable for any of them to repeat the stutter. The stutter is not part of the script and so it is disregarded as irrelevant. Few people (barring perhaps the mean-minded) would be able to recall the priest's slip of the tongue a few weeks later. We are dealing with a system of communication in which relevance is determined more or less exclusively in terms of general scripts.

As an example of the infrequent, traumatic mode of ritual action we might consider initiation rites in any number of Papua New Guinea societies. For example, among the Baktaman of inner New Guinea, first-degree novices are snatched from their parents' homes in the middle of the night and taken to a secluded place in the forest, where they are made to rub dew and pork fat on their bodies (Barth 1975: ch. 4). Among the Orokaiva of Northern Papua, novices are blindfolded with barkcloth hoods, mercilessly beaten by men disguised as spirits and corralled onto a ceremonial platform (Williams 1930; Schwimmer 1973; Iteanu 1990).

In the Baktaman case, novices have no prior knowledge of the initiation process. Their abduction in the middle of the night and the whole sequence of events which follows, fail to conform to any general scripts available to them. Not only are these experiences utterly mystifying and unfamiliar, they are profoundly frightening. In these circumstances, novices inevitably hunt in vain for recognizable forms of behaviour among their abductors. In neural terms, this presumably involves a massive reinforcement of novel firing patterns. I have elsewhere linked these sorts of episodes to the formation of flashbulb memories (see, for instance, Whitehouse 1995: 195, 206), as has Herdt in his discussion of Sambia religious experience (1989: 115).

In the course of the initiation process, it becomes clear to novices that their ritual experiences are pregnant with meaning. But, according to Barth (1975, 1987), this is not a process which draws on 'everyday' knowledge (that is, on semantic memory) but only on a secret corpus of knowledge engendered in the enduring episodic memories of initiation ritual. It is the nature of flashbulb memories that everything in the perceptible environment is encoded; nothing can be 'bracketed out' as irrelevant, for there is no script against which to determine 'relevance'. As novices advance through the grades of initiation, they begin to observe regularities between one set of episodic memories and the next, leading to the inferential construction of patterns and meanings.

In the case of Orokaiva novices, a certain amount of 'everyday' knowledge is probably brought to bear on the situation. Novices may associate the ceremonial platform, on which they are corralled, with the type of platform used for butchering pigs (Bloch 1992: 9). But being treated like pigs is hardly a familiar situation, and to get a sense of the emotive quality of this experience we could imagine how we might have felt as children, on being driven into a giant oven. So even when novices can make working assumptions about the relevance of particular ritual episodes, the process still involves a radically new configuration of scripts (that is, sets of firing patterns).

In my recent study of a religious movement in New Britain, Papua New Guinea (Whitehouse 1995), I argued that routinized and sporadic rituals, substantially encoded in semantic and episodic memory respectively, engendered very different political regimes. Routinized performances (such as liturgical rituals) tend to give rise to notions of anonymous communities, consistent with expansionary ideologies. Particular actors are not specified in general scripts for repetitive rituals. By contrast, more sporadic, traumatic rituals tend to evoke enduring memories of experiences shared by relatively small groups of people, promoting localized solidarity and cohesion. This is only the starting point of a much more intriguing and complex story, which leads to a recasting of dichotomous *sociological* theories of religion, from Weber, Gellner, Turner, Barth and others (Whitehouse 1995: ch. 8). The theory I have been developing on the basis of ethnographic research combines psychological and sociological arguments, but it is ultimately assimilable to the theory of brain functions outlined above. It approaches the topic of cultural transmission on the assumption that all neural/mental and social processes are mutually implicated.

Most ethnographers can recall moments in the field when it dawned on them that certain of their behaviours in early interactions with locals would (in a native) have been deemed embarrassing, ridiculous, or downright offensive. Fortunately, our informants tend to extend to us the same tolerance normally reserved for very young children, and for this we tend to experience a disproportionate gratitude. But, in a very real sense, we do enter the field as children. Through the establishment of novel, affect-laden scripts, our insights and competences mature. Nevertheless, our susceptibilities to the representations of our hosts are not the outcome of a shared 'bridgehead' of genetically determined modules. What we have in common is a capacity for learning, against a rich and intricate background of prior learning. For the ethnographer, this background is usually systematically different from that of his or her 'informants'. In order to carry out successful ethnography, we have to start from the assumption that all the representations of an unfamiliar culture are equivalent to Sperber's twenty-digit numbers. None of them will (or should) come 'naturally'. We know how hard it can be to get to grips with complex genealogies or cosmologies, but if we think it is comparatively easy to grasp a given concept of extranatural agency, then perhaps we should think again. The flux of representations in a given community is only accessible through the labours of maturation, which is a gradual and cumulative process of learning by recognition, rather than a process of instruction. If Edelman is correct, and the brain is more like a jungle than a computer, then it is also a jungle within a jungle. The hive of activity in the brain is implicated in the hive of activity in society.

Following Edelman, 'susceptibility' to representations would be a function of the affective responses that strengthen configurations of firing patterns but also a function of prior synaptic changes in and between relevant sectors of the nervous system. These two variegated determinants of memory interact with each other through the socially situated development of the human organism. Thus, there are no susceptibilities that are genetic rather than social in origin. From this basic assumption springs the possibility of integrated neurological, psychological and sociological theories. I have given a brief example of how such theories might proceed. These are just the beginnings of an epidemiological model that is as relevant to anthropologists as it is to cognitive psychologists.

NOTES

This is a revised version of a paper prepared for the final meeting in a series of ESRC-funded seminars on 'Memory and Social Transmission', organized by Elizabeth Tonkin and me at the Queen's University of Belfast. I should like to thank those attending the meeting for their instructive criticisms. I am particularly indebted to Simon Harrison, Gerry Orchard, Laura Rival, Dan Sperber, Christina Toren, Dan Wright and the anonymous author of a report for the JRAI for reading and commenting at length on earlier drafts. I should also like to thank Tim Ingold and Christina Toren for allowing me to quote from their unpublished papers for our seminar series.

1 At issue in this article are the relative merits of competing visions of the mind-as-computer and the mind-as-jungle. It could be objected that modularity theory is no more computer-like than Edelman's theory (discussed below) and that both have been used in experiments in artificial (computer-based) intelligence. In addition to conventional digital computers (or 'Von Neumann machines'), there are modern analogue and neural network computers that process information in some respects without direct instruction or programming. Modularity implies extensive genetic instruction (neural hardwiring), whereas connexionist theories (see footnote 4) involve rather less programming. Nevertheless, as Edelman has repeatedly emphasized, his is the only available theory that envisages the brain as completely devoid of any processes of instruction, and thus totally unlike any kind of computer so far developed (see also Eysenck and Keane 1990: 507-9). The key to Edelman's approach lies in the role of emotion in mental life (or 'value systems' in neural activity). Edelman, as I explain, argues that the brain operates through a process of *selection on value*, obviating the need for computer-like instructions or programs and making the development of brain and mind much more like the process of natural selection in a jungle.

2 Thus, like Fodor (1983), Sperber envisages modules as innate ('genetically specified'). Many cognitivists would regard Fodor's insistence on the innateness of modules as an extreme position (see Eysenck & Keane 1990: 278). Sperber's view is even more extreme than Fodor's in so far as it entertains the prospect of extensive modularity in cognitive as well as perceptual systems – a view which Fodor himself would regard as 'modularity theory gone mad' (1983: 27; see also Sperber 1994: 39). A stimulus for the modularity thesis is the remarkable capacity of children to learn rapidly from what appears to be poor quality or incomplete information (see, for instance, Massey & Gelman 1988). Modularity provides one possible explanation for these data, but so too do certain connexionist theories, some of which are much more closely modelled on neural processes than any kind of modular theory (although see footnote 4). As will become clear in this article, my main objection to the modularity thesis is that it fails to tie in plausibly with neurological findings on the one hand and sociological theories on the other.

3 Edelman has described the theory of neuronal group selection in a series of quite technical volumes. My discussion here is based on one of his most recent books (1992) providing a particularly accessible overview of his work.

4 The theory of neuronal group selection is not the only alternative to the modularity thesis. Nevertheless, if we are looking for a theory that ties in substantially with neurological research, the main alternative to Edelman's approach would be some form of connexionism that envisages brain functions in terms of layered networks of units (rather than as unilinear circuits). Connexionist experiments in artificial intelligence have produced a certain degree of learning without instruction (see, for instance, Sejnowski & Rosenberg 1987). But connexionism suffers from some of the same drawbacks I have identified in relation to modularity theory. In particular, connexionism does not in any way integrate cognitive and affective processes. One consequence of this is that artificial intelligence experiments using neural network models cannot produce learning devices that are internally motivated. Edelman thus rejects connexionism as yet another theory of the mind-as-computer (1992: 226-27).

5 For a summary of publications on this topic, see Edelman 1992: 262.

REFERENCES

Barth, F. 1975. *Ritual and knowledge among the Baktaman of New Guinea*. New Haven: Yale Univ. Press.

——— 1987. *Cosmologies in the making: a generative approach to cultural variation in inner New Guinea*. Cambridge: Univ. Press.

Bloch, M. 1974. Symbols, song, dance, and features of articulation. *Eur. J. Sociol.* **15**, 55-81.

——— 1992. *Prey into hunter: the politics of religious experience*. Cambridge: Univ. Press.

Boyer, 1992. Explaining religious ideas: outline of a cognitive approach. *Numen* **39**, 27-57.

——— 1994. Cognitive constraints on cultural representations: natural ontologies and religious ideas. In *Mapping the mind: domain-specificity in cognition and culture* (eds) L. Hirschfeld & S. Gellman. Cambridge: Univ. Press.

Christiansen, S.A. 1992. Emotional stress and eyewitness memory: a critical review. *Psychol. Bull.* **112**, 284-309.

Edelman, G.F. 1992. *Bright air, brilliant fire: on the matter of the mind*. London: Penguin.

Eysenck, M.W. & M.T. Keane 1990. *Cognitive psychology*. Hillsdale: Lawrence Erlbaum.

Fodor, J. 1983. *The modularity of mind*. Cambridge MA: MIT Press.

Fortes, M. 1980. Anthropology and the psychological disciplines. In *Soviet and Western anthropology*. London: Duckworth.

Harrison, S. 1990. *Stealing people's names: history and politics in a Sepik River cosmology*. Cambridge: Univ. Press.

Herdt, G. 1989, Spirit familiars in the religious imagination of Sambia Shamans. In *The religious imagination in New Guinea*. (eds) G.H. Herdt & M. Stephen. New Brunswick: Rutgers Univ. Press.

Hirschfeld, L. & S. Gelman (eds) 1994. *Mapping the mind: domain-specificity in cognition and culture*. Cambridge: Univ. Press.

Ingold, T. 1994. The transmission of representations versus the education of attention. ESRC Seminar Series on Memory and Social Transmission, The Queen's University of Belfast.

Iteanu, A. 1990. The concept of the person and the ritual system: an Orokaiva view. *Man* (N.S.) **25**, 35-53.

Kulik, J. & R. Brown 1982. Flashbulb memory. In *Memory observed: remembering in natural contexts* (ed.) U. Neisser. San Francisco: W.H. Freeman.

Lakoff, G. 1987. Women, fire, and dangerous things: what categories reveal about the mind. Chicago: Univ. Press.

Langacker, R.W. 1987. *Foundations of cognitive grammar*. Stanford: Univ. Press.

Marx, K. 1954 (1894). *Capital: a critique of political economy*, vol. 3. Moscow: Progress Publishers.

Massey, C. & R. Gelman 1988. Preschoolers' ability to decide whether pictured unfamiliar objects can move themselves. *Dev. Psychol.* **24**, 307-17.

Pool, J. 1984 Object insaisissable ou anthropologie sans objet? *J. Soc. Océan.* **79**, 219-233.

Rappaport, J. 1990. *The politics of memory: native historical interpretation in the Colombian Andes*. Cambridge: Univ. Press.

Schank, R.C. & R.P. Abelson 1977. *Scripts, plans, goals, and understanding*. Hillsdale: Lawrence Erlbaum.

Schwimmer, E. 1973. *Exchange in the social structure of the Orokaiva: traditional and emergent ideologies in the Northern District of Papua*. London: C. Hurst.

Sejnowski, T.J. & C.R. Rosenberger 1987. Parallel networks that learn to pronounce English text. *Complex Syst.* **1**, 183-211.

Sperber, D. 1985. Anthropology and psychology: towards an epidemiology of representations. *Man* (N.S.) **20**, 73-89.

——— 1994. The modularity of thought and the epidemiology of representations. In *Mapping the mind: domain-specificity in cognition and culture* (eds) L. Hirschfeld & S. Gelman. Cambridge: Univ. Press.

Sperber, D. & D. Wilson 1986. *Relevance: communication and cognition*. Oxford: Blackwell.

Thomas, N. 1991. *Entangled objects: exchange, material culture, and colonialism in the Pacific*. Cambridge, MA: Harvard Univ. Press.

Toren, C. 1994. Shame: the affective dimension of Fijian children. ESRC Seminar Series on Memory and Social Transmission, The Queen's University of Belfast.

Tulving, E. 1972. Episodic and semantic memory. In *Organization of memory* (eds) E. Tulving & W. Donaldson. New York Academic Press.

Weber, M. 1930. *The Protestant ethic and the spirit of capitalism*. London: Allen & Unwin.

Whitehouse, H. 1992. Memorable religions: transmission, codification, and change in divergent Melanesian contexts. *Man* (N.S.) **27**, 777-97.

——— 1994. Strong words and forceful winds: religious experience and political process in Melanesia. *Oceania* **65**, 40-58.

——— 1995. *Inside the cult: religious innovation and transmission in Papua New Guinea*. Oxford: Univ. Press.

——— in press. Apparitions, orations, and rings: experience of spirits in Dadul. In *Spirits in culture and mind* (eds) J.M. Mageo & A. Howard. London: Routledge.

Williams, F.E. 1928. *Orokaiva magic*. London: Humphrey Milford.

——— 1930. *Orokaiva society*. London: Humphrey Milford.

Winograd E. & W.A. Killinger 1983. Relating age at encoding in early childhood to adult recall: development of flashbulb memories. *J. Exp. Psychol.* (General) **112**, 413-22.

Wright, D. & G.D. Gaskell. 1992. The construction and function of vivid memories. In *Theoretical perspectives on autobiographical memory* (eds) M.A. Conway *et al.* Netherlands-Kluwer Academic Publishers.

Jungles et ordinateurs : sélection des groupes neuronaux et épidémiologie des représentations

Résumé

Pour Sperber, le fait que les humains soient susceptibles à certaines représentations et non à d'autres peut s'expliquer par la présence de mécanismes mentaux d'origine génétique spécifique, qui à leur tour permettent de rendre compte de la récurrence universelle de certains concepts culturels. Il ajoute que d'autres représentations, pour lesquelles nous n'aurions aucune susceptibilité innée, se répandent pour des raisons sociologiques. S'opposant à la notion de programme génétique, l'auteur affirme que tous les processus mentaux sont construits socialement. S'appuyant sur une synthèse des dernières théories en matière de neurologie, intelligence artificielle, psychologie et anthropologie, il se prononce en faveur d'une théorie de la transmission culturelle qui serait transdisciplinaire et intégrée.

Department of Social Anthropology, The Queen's University of Belfast, Belfast BT7 1NN