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Memes Revisited

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ABSTRACT

In this paper, I argue that the adaptive fit between human cultures and their environment is persuasive evidence that some form of evolutionary mechanism has been important in driving human cultural change. I distinguish three mechanisms of cultural evolution: niche construction leading to cultural group selection; the vertical flow of cultural information from parents to their children, and the replication and spread of memes. I further argue that both cultural group selection and the vertical flow of cultural information have been important. More conjecturally, I identify a potential role for meme-based cultural evolution in the explanation of the 'human revolution' of the last 100 000 or so years, and defuse an important objection to that explanation.

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1 Introduction

In a deservedly famous paper, Lewontin developed a general characterisation of evolutionary processes by identifying the characteristics of a Darwinian population. As he saw it, evolution would occur in any population—whatever its nature—characterised by variation, heritability and differential fitness (Lewontin [1970]). My approach is different. Instead of determining whether human cultures are Darwinian populations, I argue that they have features that can only have evolutionary explanations. Human cultures are often remarkably well adapted to their environment, and sometimes such a fit between a culture and its environment can be explained only by evolutionary mechanisms. Australian aborigines, for example, survived in profoundly inhospitable conditions, for Australia is not just dry; it is infertile as well. Despite the unfriendliness of their surrounds, the local peoples survived on

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the basis of their rich knowledge of their environment; a technology based on locally available materials (supplemented with some trade) and a flexible and appropriate social organisation (Mulvaney and Kamminga [1999]). This impressive fit between aboriginal technical, ecological and social organisation and their environment is prima facie support for a broadly evolutionary view of culture. For we can safely assume that these adaptive features of their social life were not consciously designed for Australian conditions by some local Plato. Rather, they were assembled piecemeal, just as the biological adaptations of eucalypts to the same environment were assembled piecemeal. It is this incremental construction of a fit between agents and their world that hints at the operation of a selective mechanism. We invoke natural selection to explain the appearance of intelligent design when there is no designer; where we need a 'hidden-hand' explanation of design. So there is no need to invoke selection to explain the fact that aboriginal Australians now hunt saltwater crocodiles from motorboats and with rifles, rather than from frail canoes with spears. Saltwater crocodiles are very dangerous, and no doubt selection would act powerfully in favour of the new hunting methods. But we do not need a selective explanation here. With hunting with a rifle, the designers are in full sight: they are individual agents responding adaptively and intelligently to their new opportunities. And they are designing their own lives, making optimising decisions on the basis of freely accessible and easily used information. No hidden-hand evolutionary mechanism is necessary to explain their actions. We need a different explanation of the adaptive cultural complexes that are the multi-generational work of many. No one individual consciously designed the woomera.

Let's suppose, then, that we need some version of an evolutionary model of cultural change. But which? In its most standard presentation, biological evolution is seen as the result of the interaction between organisms in a population that vary in some of their characteristics. Perhaps on a particular island, rats vary in size. If larger rats are likely to have larger pups, and if size confers an advantage, then the average rat in the population will get larger over time (Mayr [1991]). But it is fruitful to think of evolution as a contest between gene lineages rather than organisms. This 'gene's-eye' conception of evolution underscores the importance of high fidelity replication for the evolution of adaptation. More importantly still, it reminds us that the adaptive phenotypic effect of a gene—the environmental effect that makes it more likely to be copied—need not be an effect on the body of the organism in which it travels. Genes typically make it to the next generation by co-operatively constructing a well-adapted organism. But that is not always their route to the future. Some genes have their crucial effects beyond the body of their carrier: some parasite genes have their crucial effects on host, not parasite, bodies. And some genes (so-called outlaws) replicate at the expense of the fitness of their carrier (Dawkins [1982]).

The fruitfulness of the gene's-eye view of biological evolution raises a parallel question for theories of cultural evolution. One way of developing an evolutionary theory of culture is by developing a two-channel theory of human inheritance. Human children resemble their parents because they inherit both genes and culturally transmitted information from them, and there can be selection on the phenotypic differences that arise from either channel (Mameli [2004]). Australian aboriginals evolved adaptations to their local environment, because the first colonists varied in their responses to their new conditions. Some of those responses were more successful than others, and because those early Australians tended to transmit their specific responses to their children, the more successful responses became more frequent in the population as a whole. In doing so, they became available as a platform for further improvement. But just as it was fruitful to view biological evolution through the gene's eye, perhaps it is fruitful to view cultural evolution through the meme's eye. On this picture, human cultural activity is the phenotypic effect of meme lineages expanding through time, lineages variously in alliance with some and in competition with others. Adopting this memetic perspective might enable us to explain maladaptive as well as adaptive features of human culture. Why, for example, do many cultures devote huge fractions of their limited resources to placating the Gods, given that there are no Gods to placate? Perhaps, as Dawkins suggests, such cultural maladaptations are the result of cognitive-cultural pathogens, virulent memes (Dawkins [2003]).

One of the aims of this paper is to assess the scope and limits of this memetic version of the evolutionary approach to culture. There are persuasive evolutionary explanations of the persistence and differentiation of identifiable cultural groups, and of culturally mediated adaptive action. Cultural evolution, broadly understood, is an essential element in the explanation of human cognition. But there are non-memetic theories of cultural evolution, and one of my goals is to locate memetic theories of cultural evolution within theories of cultural evolution more generally (Henrich and Boyd [2002]; Gil-White [2005]; Henrich et al. [forthcoming]). In the next two Sections I will further motivate evolutionary models of cultural change. In Sections 4–6, I sketch out the space of evolutionary models of culture and identify the distinctive features of meme-based views of cultural evolution. That done, I will develop a proposal about the distinctive role of meme-based theory within that space of evolutionary models of culture.

2 Cultural groups

Human groups are divided into culturally differentiated populations. Differentiation in itself is not remarkable. Many species vary in their phenotype across their habitats. Humans do not just vary. They live, interact, and mostly breed in culturally defined groups. Human social groups vary one from another in ways not predicted by differences in their physical environment. There are profound cultural differences between the different arid land peoples. Cultural groups are identifiable at a time and over time: they tend to have common and distinctive patterns of action, resource use, technology, family pattern, belief (Pagel and Mace [2004]). Yet individuals within cultural groups vary considerably in their experience of their social world. That is especially so if their social worlds are socially stratified and/or economically specialised. To the extent that individual behaviour reflects individual experience, and individual experiences vary, we would expect individual differences to accumulate and cultural identity to decay.

In view of the differentiating effects of individual experience, the persistence of identifiable cultural groups over time is persuasive evidence of a homogenising effect of a bounded flow of cultural information. That is especially true if the cultural practice has no obvious functional rationale: we probably do not have to invoke the bounded flow of information to explain why locals usually avoid falling over the neighbourhood cliffs. Agents' behavioural repertoires are determined not just by their varying individual experiences but by their common exposure to an information pool; to information from their peers and from the previous generation. This flow of information has conformist effects. Conformity can be generated through independent and co-existing mechanisms. One is a bias in the source of the information: if all members of a group take their lead from one or a few, for that reason alone their behavioural repertoires will become more alike. Copying the leader; copying the spectacularly successful; one-many intergenerational teaching traditions will all have conformist effects (Henrich and Boyd [2002]; Aunger [forthcoming]). Likewise any tendency to copy the majority view in your local community will stabilise homogeneity if it is ever achieved. Moreover, communities can have explicit norms of conformity: deviations from established patterns can be sanctioned (Henrich and Boyd [1998]; McElreath [2003]). But agents can have reason to adjust their own actions to conform to the majority practices without explicit sanctions. Conforming to others' expectations makes co-ordination with them easier, for your actions become more predictable to others. All cultures will have co-ordination problems akin to deciding which side of the road to drive: think, for example, of customs about when and where to meet after separating to forage. All agents have some interest in co-ordination (Shennan [2002]).

Moreover, these homogenising cultural processes will tend to damp down differences in individual experience. In a culture with strict conventions about dwelling design or family structure, all individuals will have similar experience of house design and family structure. If wives always leave the natal village to live with the husband's family, to that extent individual experiences will be homogenised. The differentiating effects of individual experience will be lessened.

The existence of bounded and homogenising cultural flows has important consequences for theories of cultural evolution. The cultural flow itself ensures that the informational resources of generation N are transferred, perhaps with variations, to generation $N + 1$: cultural profiles are inherited across generations. The bounds on this flow generate differences between groups while tending to suppress differences within them. These two effects make selection on cultural groups possible. In the next Section I focus on the intergenerational construction of informational and technical resources.

3 The cultural invention of adaptive complexes

Humans often succeed in making good decisions in informationally challenging environments. Often this capacity is culturally mediated: adaptive action depends on a multi-generational accumulation of knowledge and skill. We make good decisions in challenging environments because of the accumulation of cognitive capital by the groups in which we live. It is this accumulation that allows agents to make good decisions in the face of high information loads (Boyd and Richerson [2000]). To see the effect, consider the problem of gathering resources in a forager's world. This problem is crucial to fitness, and its solution depends on highly contingent facts of the local ecology and economy. For example, when a forager encounters a potential prey animal he has to consider (a) the probability of catching the animal; (b) the costs, including both risks and forgone opportunities, of catching it; (c) the benefits of catching the animal. No doubt foragers typically satisfice rather than optimise, but even a rough and ready decision procedure will depend on a complex mix of natural history information, technical expertise and self-assessment. Forager societies had to, and did, accumulate a lot of cognitive capital (Sterelny [forthcoming a]).

We do not always respond optimally, or even satisfactorily, to the challenges to human life. Yet often we do well. As evolutionary psychologists have pointed out, our adaptive resilience in the face of an informationally complex and unfriendly world poses a problem. It is hard to see how a biologically possible, computationally feasible, general purpose learning machine could reliably drive adaptive actions in such circumstances. Their response is to invoke modularity. Human minds are ensembles of innately structured special purpose systems, and we respond adaptively despite the high information load on our decision making, first because we do not have to learn much of this information, and second, in crucial domains of human action, we have algorithms designed to process relevant information optimally. However, modularity is not a general solution to the challenge posed by high information loads. For the informational demands on human action have often been unstable over evolutionarily significant time frames. The informational demands posed by ecological, economic, technical, social and reproductive decision making have varied extensively. Human environments have been too varied for Baldwin-style processes to wire into our heads most of the information we need (Sterelny [2003]; [forthcoming a]).

In my view, then, the explanation of our capacities for adaptive action depends on three processes of cultural construction. First, data-bases that support adaptive action have been assembled and improved generation by generation. Cultures accumulate cognitive capital. This is most obvious in the very extensive information foraging groups develop about their local natural history and geography, and the resources that geography offers. Second, the cross-generational construction of developmental scaffolding enables members of a culture to acquire cognitively difficult capacities with increasing speed and reliability. Generation N optimises the learning environment of $N + 1$. In *Thought in a Hostile World*, I argue that it is likely that the skills of folk interpretation are acquired rapidly and uniformly through scaffolding children's developmental environments. Third, our adaptive decision making depends on the construction of epistemic tools which prosthetically enhance the cognitive capacities of individual agents. These tools themselves are often the result of many generations of trial, transmission and improvement. For example, information about local geography in arid Australia is often encoded in easily-recalled narratives. To shift to a more technological example, ocean navigation was much enhanced by the invention of the compass, which, as Boyd and Richerson [2000] note, is a device built by seven or eight separate cycles of spread and improvement (Sterelny [2004], [forthcoming a]).

The construction of natural history data bases, developmental environments, and cognitive technologies contrast decisively with the replacement of spears by rifles in hunting crocodiles. For they are multi-generational, population level processes. No single individual makes a natural history data base or invents an optimal developmental environment for the acquisition of some complex skill. These multi-generation constructions are adaptive but undesigned, and hence to explain them, some form of a hidden-hand mechanism is necessary. Some such mechanism is needed to explain the construction, spread, and social entrenchment of these props for adaptive action.

In my view, there have been at least two and possibly three hidden-hand mechanisms that have played a role in the cultural construction of these complexes. One is niche construction; another is dual inheritance. A third, and this is much more conjectural, is meme replication. I discuss them in turn.

4 Niche construction models

Organisms do not just respond to their selective environments; they change them. Organisms are active, partially constructing their own niches, and this is especially true of us. Moreover, we do not just change our own environment, we change that of the next generation, both physically and informationally (Laland et al. [2000]; Odling-Smee et al. [2003]). On a niche construction model, generation N collectively modifies the environment of generation $N + 1$ in ways which scaffold the development in the downstream generation of the skills and information of the upstream generation. Learning can be organised and supported in ways that make it more reliable. So consider, again, the skill and knowledge base of forager lifestyles. Suppose that knowledge base is acquired in the $N + 1$ generation through the collective modification of their developmental environment by generation N. That is, suppose:

(a) There is the public broadcast of crucial information. Local natural history might be taught through ceremonies, rituals, story-times, in which one or a few adults broadcast to audiences including the children of the group, or by encoding this information in art and decoration to which all are exposed.

(b) Children learn crucial technical vocabulary from the community as a whole. Likewise, they acquire linguistic cues of similarity and difference about their natural world diffusely, from their community as a whole.

(c) There is a division of informational labour. Salient individuals of generation N (elders, lore masters, respected hunters and craftsmen, shamans, etc) act as teachers, guides, or mentors to many children of generation $N + 1$.

(d) The technologies and techniques of many members of generation N are available as templates and props for the development of craft skills for most of generation $N + 1$.

(e) The children in the group move through the environment exploring it, not just with their parents but also with other adults or in larger groups.

To the extent that these conditions are satisfied, information flows diffusely and collectively from generation N to generation $N + 1$. To the extent that information does flow collectively, niche construction is our best model of the generation-by-generation accumulation of skill, technology and information. The ordinary resources of cognitive psychology and human behavioural ecology will suffice to explain the individual response of members of generation $N + 1$ to their environment. But that environment is in many ways the creation of the previous generation. The changing phenotypic trajectory of the population is explained by a systematically changing developmental environment. Suppose for example that an innovation occurs in N and spreads horizontally. The collective organisation of the learning environment of $N + 1$ then ensures that it is not lost with the death of the old generation.

Selection enters this picture not at the level of individuals within the group, but at the level of the group as a whole. For on this model there are no within-generation differences in culturally transmitted resources on which selection can act. At the limit of collective transfer, all of the $N + 1$ generation get the same informational resources from the previous generation. So to the extent that selection is acting, it is acting at the level of groups, not on individuals within groups. However, selection at the level of groups is likely to be powerful. For bounded cultural flow of the kind discussed in Section 2 sets up the conditions that make group selection strong. Group selection is powerful to the extent that (a) groups vary one from another in ways relevant to group–group competition; (b) they tend to generate new groups with their own characteristics; (c) they are internally homogenous, suppressing within-group differences. Bounded cultural flow increases the extent to which human populations satisfy these conditions. In particular, conformist mechanisms obviously promote homogenisation. To the extent that conformist traditions entrench arbitrary norms, they promote differentiation too, increasing the variation that feeds into cultural group selection. If bounded flow mediated by niche construction takes place in a set of adjacent and interacting cultures, cultural group selection will act on them.

5 Dual inheritance

We get a different picture to the extent that the flow of information from generation N to generation $N + 1$ is of high fidelity, reliable and vertical. If crucial life skills are mostly passed from parents to children, and if these skills are passed on reliably and with high fidelity, then human populations will have selectable differences that depend on mechanisms of cultural inheritance. Human phenotypes of generation $N + 1$ will vary systematically as a result of differences in parental information in generation N. Some of these phenotype differences will have fitness consequences. Moreover, there is the potential for cumulative evolutionary change, for under these circumstances parentally transmitted information satisfies Dawkins' replicator condition. If a variant form arises in the N to $N + 1$ transmission, that variant will be transmitted to the $N + 2$ generation. Differential individual success will lead to differential transmission of information. Packages of inherited developmental resources including culturally-transmitted information will change in frequency in the population and change over time due to differences in the biological fitness of individuals in the population. In their *Animal Traditions*, Avital and Jablonka [2000] argue this mechanism has been important to the evolution of both animal and human behaviour.

There are important differences between niche-construction and cultural-inheritance models of the accumulation of cognitive capital. One important difference is the kind of selective mechanisms responsible for the two processes. Individual selection will tend to favour vertical transfer, for it preserves individual advantages within the group. Thus we might expect shamans, lore masters, those with detailed knowledge of the natural history of animals being hunted, and those with complex technical skills to transmit their specialist knowledge selectively, to their sons and daughters (especially when the artefacts in question are difficult to reverse-engineer: it is hard to work out how to make a pot by examining the finished product). There is some evidence that ritual knowledge really is transmitted vertically in most cultures (Shennan [2002] pp. 223–4). Perhaps that is because ritual knowledge is not knowledge at all, and hence cannot be reverse-engineered. The information needed to make a pot, detoxify food, or make a canoe might be hard to rediscover, but it is not impossible.

Thus individual selection will tend to promote differentiation within a culture. In contrast, niche construction processes will tend to make for more homogenous groups. To the extent that a co-operative milieu has been established and cultural group selection is strong, it will tend to favour shifts to collective transfer of information from N to $N + 1$. Collective transfer optimises individual learning: it gives the $N + 1$ generation a chance to learn from the most skilled and knowledgeable members of the N generation, and it gives each member of the $N + 1$ generation more experience. If pot-making is a public rather than a private process, even if pot-makers do not vary significantly in individual skill, children will see pots being made more often. They have more learning opportunities. As Boyd and Richerson point out, adding redundancy in the form of multiple sources of key information can be very important in preserving information, especially if particular episodes of transmission have a high failure rate (Richerson and Boyd [2005]). If transmission were strictly vertical, errors in transition might gradually degrade a skill.

Moreover, skills crucial to the group are less likely to be lost with collective transfer, though if the group is very small, the risk is still quite high. If pot-making or fire-starting is transmitted only in one or a few family lineages in the group, unlucky accidents can deprive the group as a whole of these skills.

The ethnographic record shows technological losses that may well be the result of such accidents. Islands in Oceania have lost canoe, pottery and bow and arrow technology (Mesoudi et al. [2004]). The Torres Islands lost their canoe-making capacities [Shennan [2002] pp. 55–56). If not very many people possess a skill, the chance of losing it is surprisingly high. Tasmanian aboriginal people had very depauperate technologies by the time of first European contact, and archaeological evidence shows that technologies were lost after these peoples became isolated. These losses were very extensive: all bone-based technology; all fishing technology; the capacity to ignite fire; cold weather clothes, and most stone technology. To fight and hunt, Tasmanians were reduced to one-piece spears, throwing clubs and rocks. Henrich's models of this process suggest that the key variable was a fall in the absolute number of individuals with the crucial skill (Henrich [2004]).

Intriguingly, though, evolvability—the potential for adaptive improvements in the group's stock of cognitive capital—is not maximised by collective, diffuse flow between the generations. Sperber and Atran have emphasised that we can have transfer without copying. They make their point in terms of ideas: my Little Red Riding Hood story is a construction from the many versions of this story I have heard. It is inferentially rebuilt from many experiences rather than copied from one. If, likewise, a child's potting technique is a blend—an average—of the different potting techniques she has been exposed to, then a new and improved variation in N will not make it to $N + 1$. If diffuse transfer makes a child's skills or knowledge base sensitive to all the exemplars he or she has been exposed to, then the conditions for the cumulative improvement of technique are undermined. If the inheritance of information is diffuse, many to many, then it will fail to meet Dawkins' replicator condition. This is a version of the famous blending problem pressed against Darwin by one of his nineteenth century critics. Diffuse transfer makes the flow of knowledge between the generations more reliable at the expensive of innovation potential (Sterelny [forthcoming c].

Perhaps, then, evolvability is maximised by predominantly vertical transfer, but with occasional oblique or horizontal shifts. If copy fidelity between the generation is high (for otherwise as Boyd and Richerson show, we need multiple sources to compensate for error), perhaps a learning rule of 'copy your parent, unless the neighbour's technique is obviously much more successful' might be best of all for the culture as a whole, though not for the innovator. Oblique transfer can enable an innovation to spread through a group more rapidly. An improved way of water-proofing canoes will spread from the innovator in N to all the members of $N + 1$. Such rapid spread will boost the efficiency of the group as a whole. Moreover, the new way of making canoes will be available to everyone in the group as a platform for further improvement[1].

It is very likely that niche construction and dual inheritance co-exist, and both play important roles in the cultural construction and stabilisation of human information gathering and information processing skills. I suspect, though, that there is some tendency for cultural inheritance to erode into niche construction. For it is often hard to maintain exclusive rights to information. Imagine trying to keep information about how to make a fish-trap to yourself in a small scale community.

6 Memes

In models of cultural inheritance, information transfer plays a crucial role in establishing selectable parent/offspring similarities. But the individual biological fitness of organisms determines the further spread of this information. As I see it, the crucial element of a meme-based theory is that the fitness of the memes themselves plays a crucial explanatory role. I think there is a genuinely memetic explanation of the accumulation of cognitive capital. But in developing this possibility, we have to abandon the idea that memes are ideas. Dan Sperber and Scot Atran have argued that the flow of cultural information cannot modelled as memetic replication. The genes in me are copies of specific genes in my parents, formed at a particular time and place from a specific template. The flow of ideas from parent to offspring is not a true copying process. A child's version of Little Red Riding Hood will typically be constructed from many sources and through many exposures. It is not a copy of a particular version (Sperber [1996]; Atran [2001]).

Moreover, while it is easy to identify the primary locus of competition between genes, the same is not true of memes. Genes compete with other alleles at the same locus on a chromosome. And they compete primarily by causing differences in the organism's phenotypes. So different haemoglobin alleles compete with one another by making different kinds of haemoglobin, and co-operate with all the other genes at other loci—with the lung-makers, the leg-makers, the eye-makers. What is the equivalent of all this for memes? If memes are ideas, with what are they in competition? If the idea of the

[1] However, there is a potential downside to oblique transfer. If the flow from N to $N+1$ is through copying from a few key individuals (the master craftsmen of N, or the prestige leaders of N) changes in their practice will have fast effects. There will be rapid spread from these key vectors to the group as a whole, thus creating the platform for further improvement. However, if this is the process of cultural transmission, unless an innovation occurs in the practice of these key vectors, or unless they are sensitive to innovations made by others in their generation, innovations in N will be lost in $N+1$. Key-teacher transmission by the N-generation to the $N+1$ generation eliminates the evolutionary significance of most variation in the practice of the N-generation.

skateboard flourishes and grows, lodging in mind after mind, which ideas are thereby displaced? Skateboards need not spread for the idea of a skateboard to spread. The Quidditch-idea has spread without quiddich actually being played. And while the sale of skateboards might reduce the sale of mountain-bikes, there is no reason to suppose that it reduces the spread of the mountain-bike idea. There is surely one in the minds of skateboard users.

I think Sperber and Atran are right: ideas are not copied. They are constructed via inference over many episodes and from numerically distinct sources[2]. In contrast to ideas, artefacts and skills are public and copied[3]. Stephen Mithen has rightly emphasised the importance of artefacts as exemplars, as templates. A fish-spear is both a tool and an informational resource; a specification of how to make a fish-spear (Mithen [2000]). A fish-spear, like a gene, can have specific descendants; spears that are its copies, made by aligning parts with the original, using the original to indicate bindings, weight, balance, perhaps decoration and other stylistic features. Likewise, a skill can be copied from a particular model; sometimes even from a particular demonstration. Moreover, artefact construction is resource-hungry, and different versions of the one kind of artefact do tend to displace one another. So we can make better sense of competition between artefact variants than between ideas.

In my view, a memetic theory is most plausibly seen as helping explain the 'human revolution'; that is, the hundred thousand years or so in which human technology diversified and differentiated, and in which the human resource envelope expanded. This is the period in which artefacts were most likely to be made by template copying: it is the period in which artefacts (and skills) were often inputs to template copying procedures and in which successful artefacts would be copied more often in virtue of that success. Meme fitness plays a crucial role in the explanation of take-off because characteristics of the artefacts and skills themselves are central to the explanation of take-off. Technological take-off depended on stumbling across technologies which were suitable for both replication and improvement.

This line of thought depends on identifying characteristics of technologies that make them readily and accurately copiable. Those are the features which make them fit qua memes, and hence they give us an account of meme fitness

[2] I am much less worried by Atran's claims that ideas are not typically transmitted with accuracy, for this objection is supported by a set of weak examples. Humans have an advanced set of practices for ensuring that ideas are transmitted with accuracy: catholic catechisms, school curricula and the like are all designed with this end.

[3] Robert Aunger argues against this. But his arguments depend on his choice of examples. His example of an artefact is a car produced on an assembly line, and such artefacts as these are indeed not memes because they are not input to template-copying. But that does not show that no artefact is a meme. Likewise, his example of a behaviour is a phrase ('$E = mc^2$'), not a skill (Aunger [2002], pp. 164–6, pp. 167–73).

that is independent of the actual replication rate of the meme. They anchor an explanatory notion of meme fitness: one that allows us to talk of the expected fitness of a meme. Fit memes are those with properties that make them apt inputs into template copying or imitation. In particular: (i) artefacts are more easily used for template copying if they are physically robust: for they will be stable and enduring. (ii) It helps if the physical materials from which they are made are readily available, and if the costs of making them are not too high. (iii) It is very important that the artefact be easy to reverse-engineer, that is, that the final form of the finished artefact does not conceal its history of production. Pots and compound bows are hard to reverse-engineer. It is hard to tell how a pot is made from examining the finished product. A fish-spear, on the other hand, can be readily reverse-engineered. (iv) Finally, artefacts are fitter if their design is error-tolerant: if crude, early versions of the technology give its users some reward.

On this view, it is no surprise that spear technology is an early technology. First, the simplest versions are useful: a strong sharpened stick offers both protection and offensive power. Second, spears are easily reverse-engineered: especially in their early versions, you can make a spear from a spear. Notice that this copying process need not be blind imitation: the template can be used as a reference point to guide the makers' trial-and-error learning[4]. Third, it is error-tolerant. You do not have to make a spear perfectly to get some benefit from it, and this reduces the cost of learning the technology: you do not have to throw away your first attempts. In this respect, spear technology probably contrasts with bow and arrow technology. A truly crude bow is pretty useless. Fourth, spear technology is relatively modular: it does not require an extensive technological base, nor rare or expensive materials. So it can be introduced independently of, and without disrupting, existing technical toolkits. Fifth, it is a technology that lends itself to stepwise improvement. This might proceed first by sharpening the stick, then hardening the point in fire. The next stage is likely to be mounting a stone tip, then sequential improvement of the blade; improving grip and balance; invention of a spear-thrower to improve range of thrown spears, and so forth. The spear is a fit meme, and we can establish its fitness independently of counting spear points in a prehistoric landfill.

Likewise some skills spread more easily by imitation than others. Skills are more easily imitated if they are easily segmented into subroutines that can be mastered or practised separately. It helps if the physical and informational

[4] The use of artefacts as reference points and guides in trial and error learning, or as a check on the accuracy of imitation learning shows that the distinction between 'copy the process' and 'copy the product' is often drawn too sharply. Many learning techniques are hybrids between product and process copying.

prerequisites for the skill are generally available. This will lower the cost of skill acquisition: again, in this respect, using a spear is more forgiving than using a bow. It helps that skills are not all-or-nothing, so that the skill can be gradually improved and so that there is some reward for crude or imperfect versions of the skill. Igniting a fire is an all-or-nothing action whereas maintaining a fire is not. As with technology, this helps in both initial discovery and in transmission, by reducing the cost of learning. If failures are dangerous (as in crocodile hunting), the cost of learning will be high, and such skills are less evolvable.

Thus there are technologies whose features make them especially 'fit' for propagation: they are easily copied. But they are not so easily discovered that they do not need to be copied. They lend themselves to cumulative improvement. They are not very expensive, for if they were, they would be affordable only in a context with very extensive specialisation, and hence could play no major role in explaining technological take-off. Their use does not depend on an extensive pre-existing technology. In that sense, they are relatively modular, for they can be added to an agent's repertoire without major other additions or deletions. On this picture, human technological takeoff would be a kind of human/meme coevolution.

7 Memes or minds?

I have distinguished dual inheritance models of cultural evolution from meme-based models by stipulating that in dual inheritance theories the fitness bearers are individual human agents, whereas in meme-based models the memes themselves are the fitness bearers. I further claimed that there is a plausible case to be made for the idea that meme replication plays an important role in the explanation of a crucial transition in human history: our establishment as a technology-soaked species. However, there is an important challenge to this meme-based explanation. No explanation that appeals to the fitness of these replicators is independent of human social and cognitive environments. For this reason, there seems to be an equivalent explanation of precisely the same patterns in early technology and its improvement that appeals to human psychology, human environments, and to networks of information flow. This alternative explanation appeals to what we find easy (or difficult) to learn; to what we need; and to what information others make available. On this picture, spear technology establishes, improves and spreads first, because spears help solve important human problems; second, because humans find it relatively easy to learn to make and use them, and third, because patterns of human interaction spread information about this technology. This explanation seems to zero in on the same facts as my memetic explanation. Yet in it memes disappear as evolving lineages. There is no appeal here to spear fitness, only to human fitness.

I have been discussing the social genesis of adaptive capacities. But a similar issue arises for the other string of the memetic bow: the appeal to memes in the explanation of maladaptive action. Richard Dawkins has strikingly and vividly suggested that religions of various kinds are cognitive viruses (Dawkins [2003]). For religions, and especially evangelical religions, spread horizontally rather than vertically. As a consequence of this transmission pattern, their replicative fate is not tied to the biological success of their hosts. If memes are ideas, they replicate only by inducing actions which advertise their presence and which tend to induce other agents to formulate their own version of that very idea. They spread horizontally by advertising their presence attractively, and there is no general reason to expect horizontal-spreaders to generate behaviour which maximises their hosts' fitness. For example, memes that spread horizontally are likely to seriously bias host behaviour towards ignoring future costs in favour of current rewards, by engaging in displays that are expensive but attractive. Zahavi has argued that humans, like other animals, are likely to have adaptive dispositions to engage in expensive displays, for the expense of the display guarantees the honesty of the signal it sends. Only the genuinely fit male can afford the risks of the duel, and hence his willingness to take that risk sends a signal of his genetic quality to appreciative female eyes (Zahavi and Zahavi [1997]). We can think of such memes as subverting such Zahavian mechanisms, inducing agents into expensive displays that they cannot afford. Memes that induce striking, or salient, or cool behaviour in their hosts will spread. They will do so even if those displays are so expensive to the host that they have seriously bad long-term consequences, just so long as they are attractive.

But as in the case of artefacts, there seems to be an alternative explanation that focuses on precisely the same phenomena, but one in which meme fitness plays no real role. Suppose we agree with Dawkins that religious ideas are both fundamentally irrational and costly to their hosts. Even so, the argument would go, we explain nothing by labelling religious ideas as cognoviruses or memes. To explain the prevalence of religion in human life we need to know why humans in so many cultures find religious ideas salient, credible, memorable. Religion would not be part of human social life if people found religious ideas absurd or unintelligible. The crucial problem is one of human psychology: explaining why we find occult-force explanations credible. Once we find out why humans find credible explanations of their environment in terms of occult forces, what else is there to explain? Likewise, once we find out why humans tend to have excessive discount rates, overvaluing current benefit at the expense of future cost, we will know why ideas can be both cool and destructive. We can explain the phenomenon—the spread of self-destructive patterns of thought and action—without appealing to the fitness of virus-like memes.

So there appear to be two explanatory perspectives on both technologies and cognoviruses. On the memetic perspective, it is the properties of the technologies or cognoviruses themselves which explain take-off. Of course, those properties are only salient in particular contexts. The spear-meme is fit only in certain human environments. On the alternative perspective, while some humans and human groups were fitter as a result of exploiting spear technology, their use of this technology is fully explained by human psychology and human environments. This is Sperber's line. Patterns in the diffusion of ideas are explained by our innate cognitive biases. These biases make some sets of ideas and technologies memorable, salient, easy to acquire and natural to teach. These are attractors. There is a vast ideational range created in human cultures, but only a small proportion of human representations become characteristic of any human culture, because they are sifted and sorted by our innate cognitive structures. It is these structures that are crucial to explaining the propagation of some ideas and the extinction of others (Sperber [1996]). We can replace an explanation that appeals to the properties of the technology by one that appeals to the psychology of the technology users.

There are two ways to resist this line of argument. One is to insist on the importance of causal interaction between technology and our cognitive biases. On Sperber's picture, these biases are causally prior to, and explain, the proliferation of some representations and the extinction of others. But it is not true that first there were these biases and then there came the diverse forms of human culture. The human mind and our cultural products have coevolved. In so far as our minds have fixed, innate biases these exist in part because of the technologies to which our lineage has been exposed and on which it depends. If Povinelli is right, we think about causal interactions in very unchimplike ways (Povinelli [2000]). If this is true, it is true because of the coevolution of our minds with the material products of our culture. Moreover, it is not at all clear that our cognitive biases are typically developmentally canalised. Our minds develop in a world of cognitive and physical technology, and it is arguable that these biases are developmental products of this environment (Dennett [2000]; Clark [2001], [2002]).

A second response focuses on the dynamics of spear-making. Suppose it is true that the origin, spread, and improvement of spear technology is robust. Given that (a) spears can be reverse-engineered; (b) spears can be improved incrementally; (c) simple versions of spears are useful; (d) learning to make a spear can be partially successful, then this is a technology that will establish in many contexts and with many users. Indeed, it is surely likely that many simple technologies have had multiple origins, each in somewhat different circumstances. We can vary patterns of social contact amongst humans. We can vary the type and extent of teaching in a community, and the patterns of informational transfer. We can suppose human learning abilities are somewhat different. Even under these counterfactual suppositions, spears remain a learnable, useable and improvable technology. If spear technological take-off is robust in this sense, specific features of the human worlds of spear-making were not essential for its evolution. Within broad limits, the invariant features of the contexts in which spear technologies develop are features of the spears, not their human users. The essential features are those features of spears that make them apt for template copying and gradual improvement. Spear-technology would be robustly evolvable, and in explaining its evolution it would be right to appeal to properties of the spears themselves rather than their human users. Evolving spear technology is not sensitively dependent on a specific set of needs, social organisation, or learning biases. Haim Ofek has argued a similar case for fire. The existence of naturally occurring fires which can then be kept alive ensures that there are many opportunities to begin the process of domesticating fire. Moreover, both ignition technology and the use of fire are apt for stepwise improvement (Ofek [2001]). On these suppositions, fire technology is robustly evolvable.

Suppose all this is right. Then the technology involved in the human revolution does not depend on fine-grained details of human minds, social organisation, or networks of cross-generation information flow. It is the properties of the technology, not the properties of the people using it, that explain the role of spears, of fire, of traps and snares in early human technical take-off. Within broad limits, variations in human psychology and social organisation would not generate variations in the shape of early technology.

Of course, I do not know that early technical differentiation was robust in the ways I have suggested. But I do think the conjecture is plausible. It is less clear that a similar case can be developed for cognitive viruses. Some socially transmitted error is an inevitable cost of our being a species that relies heavily on social learning, and especially intergenerational social learning. Extensive information uptake by the ignorant from the apparently knowledgeable will have an error cost. The acquisition of fitness-reducing ideas from your neighbours is an inevitable error cost of extensive social learning. In taking others' advice about what to do and what to believe, we will have filters, evolved mechanisms of sales resistance, mechanisms to filter deleterious horizontal spreaders (Sperber [2001]; Sterelny [forthcoming b]). But unless agents are extremely reluctant to learn from others, such mechanisms cannot be perfect. Social learning is an ignorance curing mechanism. For that reason agents must often accept information that they are in no position to independently check. Filters are inevitably leaky, so some false beliefs are bound to spread by social learning.

Thus in any human-like social worlds characterised by extensive social learning, humans will download mistakes as well as insights from those around them. But the specific character of those mistakes may well be sensitive to fine-grained details of human psychology and human social worlds. It is quite likely that Sperber and other cognitive anthropologists are right to think that we find certain ideas memorable because of the ways our minds happen to be organised. From this perspective, Boyer's theory of religion is not a rival to meme-based theories because he thinks, with Sperber and Atran, that ideas are not strictly copied. It is a rival because he thinks that the transmission of religious ideas through human societies depends on rather idiosyncratic features of human minds (Boyer [1999], [2000], [2002]). Our cognitive set-up happens to make religious ideas both salient and memorable. Change our cognitive set-up, and those falsehoods would no longer spread socially, though doubtless others would. If this is right, in contrast to spears, the socially-mediated flow of false belief does not turn on the nature of the beliefs themselves but on the details of human psychology. Once we understand the psychology of religious belief, there is no phenomenon that a meme theory and only a meme theory can explain.

8 Conclusion

To briefly conclude, then, I have argued that human problem-solving capacities depend on the accumulation of cognitive capital. Individual intelligence is socially enhanced by multi-generational processes of cultural construction. That cultural construction takes two forms, and possibly a third. Downstream niche construction is important, as is cultural evolution. Memes and their evolution may also play a role, but only if the salient properties of the memes are robustly efficacious; only if their evolutionary upshot is insensitive to fine-scale variations in human psychology and human sociality[5].

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References

Atran, S. [2001]: 'The Trouble With Memes: Inference versus Imitation in Cultural Creation.' *Human Nature* **12**, pp. 351–81.

Aunger, R. [2002]: *The Electric Meme*. New York: Free Press.

Aunger, R. [forthcoming]: 'Three Roads to Cultural Recurrence', in D. Sperber (*ed.*), *The Epidemiology of Ideas*. New York: Open Court Publishing.

Avital, E. and Jablonka E. [2000]: *Animal Traditions: Behavioural Inheritance in Evolution*. Cambridge: Cambridge University Press.

Boyd, R. and Richerson P. [2000]: 'Memes: Universal Acid or a Better Mouse Trap?' in R. Augner (*ed.*), *Darwinizing Culture: The Status of Memetics as a Science*, Oxford: Oxford University Press pp. 143–62.

Boyer, P. [1999]: 'Cognitive Tracks of Cultural Inheritance: How Evolved Intuitive Ontology Governs Cultural Transmission', *American Anthropologist*, **100**, pp. 876–89.

Boyer, P. [2000]: 'Evolution of the Modern Mind and the Origins of Culture: Religious Concepts as the Limiting Case', in P. Carruthers and A. Chamberlain (*eds.*), *Evolution and the Human Mind: Modularity, Language and Meta-cognition*, Cambridge: Cambridge University Press, pp. 93–112.

Boyer, P. [2002]: *Religion Explained: The Human Instincts that Fashion Gods, Spirits and Ancestors*, New York: Vintage.

Clark, A. [2001]: 'Reasons, Robots and the Extended Mind,' *Mind and Language*, **16**, pp. 121–45.

Clark, A. [2002]: *Mindware: An Introduction to the Philosophy of Cognitive Science*, Oxford: Oxford University Press.

Dawkins, R. [1982]: *The Extended Phenotype*, Oxford: Oxford University Press.

Dawkins, R. [2003]: *A Devil's Chaplain: Reflections on Hope, Lies, Science, and Love*, Boston: Houghton Mifflin.

Dennett, D. C. [2000]: 'Making Tools for Thinking', in D. Sperber (*ed.*), *Metarepresentation: A Multidisciplinary Perspective*. Oxford: Oxford University Press, pp. 17–29.

Gil-White, F. [2005]: 'Common Misunderstandings of Memes (and Genes)', in S. Hurley and N. Chater (*eds.*), *Perspectives on Imitation*, Cambridge: MIT Press.

Henrich, J. [2004]: 'Demography and Cultural Evolution: How Adaptive Cultural Processes Can Produce Maladaptive Losses—The Tasmanian Case', *American Antiquity*, **69**, pp. 197–214.

Henrich, J. and Boyd, R. [1998]: 'The Evolution of Conformist Transmission and the Emergence of Between-Group Differences,' *Evolution and Human Behavior*, **19**, pp. 215–42.

Henrich, J. and Boyd, R. [2002]: 'On Modelling Cognition and Culture: Why Cultural Evolution Does Not Require Replication of Representations,' *Culture and Cognition*, **2**, pp. 87–112.

Henrich, J., Boyd, R. and Richerson, P. J. [forthcoming]: 'Five Misunderstandings about Cultural Evolution', in D. Sperber (*ed.*), *Epidemiology of Ideas*, New York: Open Court Publishing.

Laland, K. N., Odling-Smee, F. J. and Feldmann, M. W. [2000]: 'Niche Construction, Biological Evolution and Cultural Change,' *Behavioral and Brain Sciences*, **23**, pp. 131–75.

Lewontin, R. C. [1970]: 'The Units of Selection', *Annual Review of Ecology and Systematics*, **1**, pp. 1–14.

Mameli, M. [2004]: 'Nongenetic Selection and Nongenetic Inheritance', *British Journal for the Philosophy of Science*, **55**, pp. 35–71.

Mayr, E. [1991]: *One Long Argument: Charles Darwin and the Genesis of Modern Evolutionary Thought*, London: Penguin.

McElreath, R., Boyd, R. and Richerson, P. J. [2003]: 'Shared Norms Can Lead to the Evolution of Ethnic Markers', *Current Anthropology*, **44**, pp. 122–30.

Mesoudi, A., Whiten, A. and Laland, K. N. [2004]: 'Is Human Cultural Evolution Darwinian? Evidence Reviewed From The Perspective of *The Origin of Species*', *Evolution*, **58**, pp. 1–11.

Mithen, S. [2000]: 'Mind, Brain and Material Culture: An Archaeological Perspective', in P. Carruthers and A. Chamberlain (*eds.*), *Evolution and the Human Mind: Modularity, Language and Metacognition*, Cambridge: Cambridge University Press, pp. 207–17.

Mulvaney, J. and Kamminga, J. [1999]: *Prehistory of Australia*, Washington: Smithsonian.

Odling-Smee, F. J., Laland, K. N. and Feldman, M. W. [2003]: *Niche Construction: The Neglected Process in Evolution*, Princeton: Princeton University Press.

Ofek, H. [2001]: *Second Nature: Economic Origins of Human Evolution*, Cambridge: Cambridge University Press.

Pagel, M. and Mace, R. [2004]: 'The Cultural Wealth of Nations', *Nature*, **428**, pp. 275–8.

Povinelli, D., [2000]: *Folk Physics for Apes: The Chimpanzee's Theory of How The World Works*, Oxford: Oxford University Press.

Richerson, P. J. and Boyd, R. [2005]: *Not By Genes Alone: How Culture Transformed Human Evolution*, Chicago: University of Chicago Press.

Shennan, S. [2002]: *Genes, Memes and Human History: Darwinian Archaeology and Cultural Evolution*, London: Thames and Hudson.

Sperber, D. [1996]: *Explaining Culture: A Naturalistic Approach*, Oxford: Blackwell.

Sperber, D. [2001]: 'An Evolutionary Perspective on Testimony and Argumentation', *Philosophical Topics*, **29**, pp. 401–13.

Sterelny, K. [2003]: *Thought in a Hostile World*. New York: Blackwell.

Sterelny, K. [2004]: 'Externalism, Epistemic Artefacts and The Extended Mind', in R. Schantz (*ed.*), *The Externalist Challenge. New Studies on Cognition and Intentionality*. Berlin, New York: de Gruyter.

Sterelny, K. [forthcoming a]: 'Cognitive Load and Human Decision, or, Three Ways of Rolling the Rock Up Hill' in S. Stich, S. Laurence and P. Carruthers (*eds.*), *The Innate Mind: Culture and Cognition*, Cambridge: Cambridge University Press.

Sterelny, K. [forthcoming b]: 'Folk Logic and Animal Rationality', in S. Hurley and M. Nudds (*eds.*), *Rational Animals?*, Oxford: Oxford University Press.

Sterelny, K. [forthcoming c]: 'The Evolution and Evolvability of Culture', forthcoming in *Mind and Language*. in D. Walsh (*ed.*), *Twenty Five Years of Spandrels*, Oxford: Oxford University Press.

Zahavi, A. and Zahavi, A. [1997]: *The Handicap Principle: A Missing Piece of Darwin's Puzzle*. Oxford: Oxford University Press.