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# Enquire within: cultural evolution and cognitive science

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Cultural evolution and cognitive science need each other. Cultural evolution needs cognitive science to find out whether the conditions necessary for Darwinian evolution are met in the cultural domain. Cognitive science needs cultural evolution to explain the origins of distinctively human cognitive processes. Focusing on the first question, I argue that cultural evolutionists can get empirical traction on *third-way cultural selection* by rooting the distinction between replication and reconstruction, two modes of cultural inheritance, in the distinction between System 1 and System 2 cognitive processes. This move suggests that cultural epidemiologists are right in thinking that replication has higher fidelity than reconstruction, and replication processes are not genetic adaptations for culture, but wrong to assume that replication is rare. If replication is not rare, an important requirement for third-way cultural selection, *one-shot fidelity*, is likely to be met. However, there are other requirements, overlooked by dual-inheritance theorists when they conflate strong (Darwinian) and weak (choice) senses of 'cultural selection', including *dumb choices* and *recurrent fidelity*. In a second excursion into cognitive science, I argue that these requirements can be met by *metacognitive social learning strategies*, and trace the origins of these distinctively human cognitive processes to cultural evolution. Like other forms of cultural learning, they are not cognitive instincts but cognitive gadgets.

This article is part of the theme issue 'Bridging cultural gaps: interdisciplinary studies in human cultural evolution'.

## 1. Introduction

Populational models—such as dual-inheritance theory and cultural epidemiology—put minds at the heart of cultural evolution. Purely historical approaches take whole cultures as their units of analysis and ask about the forces that move these massive, mind-free entities from one condition to the next. By contrast, populational or 'kinetic' models take cultural change to be change in the frequencies of types in a population as the aggregate consequence of innumerable episodes of social learning: of episodes in which one mind acquires information from one or more other minds.

Given this spotlight on the mental, it is surprising that cognitive science rarely makes an appearance at the lively interdisciplinary party of cultural evolutionary studies. The hosts—evolutionary biology, mathematics and anthropology—are often joined by archaeology, economics, ecology, environmental sciences and philosophy. Psychology is certainly not excluded, but the invitations (or perhaps the acceptances) are not uniformly distributed across the discipline. They reach areas—such as comparative, developmental and social psychology—that are rooted in our common sense or 'folk psychological' understanding of the mind: in the blend of wisdom and old wives' tales that explain behaviour with reference to the thoughts and feelings, beliefs and desires, of whole agents (e.g. [1]). But the invitations rarely get through to areas of psychology that are more fully integrated with cognitive science, for example, cognitive psychology, behavioural and cognitive neuroscience, experimental psychology and psychophysics.

The term 'cognitive science' has been used since the early 1970s to refer to research in psychology, computer science, linguistics, neuroscience and philosophy that likens the mind to a computer. It casts thinking as 'information processing' and seeks to explain behaviour at a 'sub-personal' level [2,3]. That is, in contrast with folk psychology, which takes mental states of the whole agent (e.g. beliefs and desires) to be the drivers of behaviour, cognitive science typically explains behaviour as due to the activities of parts of the mind and of the interactions between these parts. For example, 'Stephanie said "blue" when she saw BLUE written in red ink because two parts of her mind—one responsible for naming colours, and the other for reading words—competed for control of Stephanie's speech mechanisms, and the reading part won the contest.' The sub-personal explanations offered by cognitive science are not familiar or intuitive, but they burrow deeper into the mind than folk psychology, and many have survived rigorous experimental tests [4].

In this article, I suggest that cultural evolutionists and cognitive scientists should party together more often because we need each other. Cultural evolution needs cognitive science for many reasons (for example, to test hypotheses about conformist bias), but especially to get empirical traction on a fundamental question: Are the conditions necessary for Darwinian evolution met in the cultural domain? Cognitive science needs cultural evolution to address another fundamental question: What are the origins of distinctively human cognitive processes? My primary focus here will be on the first question, on what cognitive science can do for cultural evolution. After some reflection on the question itself—on the possibility of 'third-way cultural selection' (§2)—I turn to a distinction, between 'replication' and 'reconstruction', which has been used by cultural epidemiologists to argue, against dual-inheritance theorists, that cultural change is not a selection process. Although inspired by research in psychology, I argue that the replication/reconstruction distinction is being used in a way that prevents cognitive science from informing debate about third-way cultural selection (§3). Making a first excursion into cognitive science, I reconstruct the replication/reconstruction distinction to root it more firmly in research on the sub-personal processes involved in social learning. This exercise suggests that cultural epidemiologists are right in thinking that replication has higher fidelity than reconstruction, but wrong to assume that replication is rare (§4). If replication is not rare, an important requirement for cultural selection—'one-shot fidelity'—is likely to be met. However, there are two other requirements, often overlooked by dual-inheritance theorists, for 'dumb choices' and 'recurrent fidelity' (§5). A second excursion into cognitive science suggests that these requirements can be met by 'metacognitive social learning strategies' (§6). To conclude, I offer a glimpse of the reciprocal relationship—what cultural evolution can do for cognitive science—using the origins of metacognitive social learning strategies as an example (§7).

## 2. Third-way cultural selection

The most fully developed populational account of cultural evolution is known as dual-inheritance theory [5–8], or the 'California school' [9,10]. This impressive body of work is 'evolutionary' in at least three respects. First, it assumes that social learning—or, at least, the kinds of social learning that drive large-scale changes in human populations—is built on a set of genetic adaptations; natural selection acting on genetic variants has given humans psychological mechanisms—called 'learning biases' or 'decision rules'—that are specialized for learning from others. Second, dual-inheritance theory is very much concerned with how genetic evolution interacts with cultural change, with 'gene–culture coevolution'. This kind of coevolution occurs when a change in the socially learned characteristics of a population provokes a change in genetically inherited characteristics, or vice versa. The classic example of gene–culture coevolution is lactose tolerance [11]. Third, dual-inheritance theory is evolutionary at a methodological level: it borrows techniques from the study of genetic evolution, applying to socially learned characteristics mathematical models that were initially developed in population genetics. Thus, on the dual-inheritance view, cultural change is evolutionary at least by virtue of its relationships of interdependence with genetic evolution: because it is made possible by genetically inherited psychological mechanisms; in continuous interaction with genetic evolution and subject to analysis using mathematical tools developed by geneticists.

But is dual-inheritance theory 'evolutionary' in a stronger sense? Does it claim not only that cultural change is closely related to genetic evolution, but that the conditions required for the occurrence of Darwinian selection—variation, heritability and differential fitness—are present in the cultural domain [12]? Elucidating this distinction, and building on Godfrey-Smith's [13] analysis of 'Darwinian populations', Sterelny [9] points out that 'selective' explanations of cultural change are a subset of populational explanations. All populational explanations suggest that the frequency of types in a population at time $T + N$ is largely determined by their frequency at time $T$. However, selective explanations further suggest that 'the frequency of types at $T + N$ is importantly determined by selection on those types at previous time steps, with selectively favoured types at one step increasing in frequency at the next in virtue of that success, together with some mechanism (replication or otherwise) supporting resemblance between parent and offspring' ([9, p 43]). In common with Lewens [12], Sterelny doubts that dual-inheritance theory is designed to offer selective explanations because, in his view, the members of the California school 'do not seem to think of selection and fitness in causally robust ways' ([9, p 43]). For example, they rarely address *cui bono* questions [14]: when dual-inheritance theorists suggest that one cultural trait is fitter than another, they rarely specify who or what benefits from this fitness, or what is the nature of the benefit.

Sterelny and Lewens, philosophers of biology with a deep understanding of evolutionary theory and the contemporary literature on cultural evolution, may well be right about this, but my hunch is different. I think dual-inheritance theory *is* intended to provide selective explanations, and *is* committed to the idea that cultural change can be Darwinian in its own right, but the California school has not got round to addressing the questions that would make this hypothesis 'causally robust'. This hunch is based, in part, on the fact that the early development of dual-inheritance theory was much influenced by Donald T. Campbell, and his view of cultural evolution was unambiguously, and indeed evangelically, selectionist [15,16]. Also, to this day, when commenting on their project as a whole, and glossing the results of particularly models, the members of the California school write as if they are aiming for selective explanations. They emphasize the 'Darwinian' character of cultural evolution, refer to 'cultural adaptations', use the term 'selection' repeatedly and make explicit statements such as 'The logic of natural selection applies to culturally transmitted variation every bit as much as it applies to genetic variation' ([7, p 76]).

Only if the dual-inheritance project offers selective explanation does it have the potential to show that there is 'third way' in which human thought and behaviour can become adapted, can achieve a better fit with their environments. We know from sociobiology, evolutionary psychology and human behavioural ecology that human thought and behaviour can become adapted to their environments via natural selection operating on genetic variants (the first way; [17]). In humans, as in other animals, genetic evolution has produced behavioural propensities and cognitive processes that enhance survival and reproduction. We know from Enlightenment philosophy, experimental psychology and everyday experience that human thought and behaviour can come to fit their environments through the operation of cognitive processes lodged in individual heads (the second way). Some of these processes—known collectively as 'learning', 'intelligence', 'insight' or 'foresight'—make individuals, or, as in science, groups of humans working together, smart enough to come up with new solutions to old problems, to distinguish better from worse solutions and selectively to adopt the good ones. The crucial question is whether there is *another* way, a third way, in which human thought and behaviour can become adapted: a process that selects among cultural rather than genetic variants, and in which the adaptiveness of the selection does not depend on individuals or groups being smart enough to design novel solutions or to recognize what works and what does not [10,18,19]. Thus, the 'third-way' question is: Are human thought and behaviour made adaptive—made to fit their environments—not only by genetic selection and intelligence but, at least sometimes, by cultural selection?

I believe that dual-inheritance theory offers an affirmative answer to this question, whereas Lewens and Sterelny are not so sure. Only time (and members of the California school) can tell us who is right, but in the meantime it is clear that the third-way question is of fundamental importance. It is analogous to the challenge faced, and met, by Darwin. Darwin asked whether 'intelligent design' by God was the only way in which morphological characteristics could become adapted to their environments. The third-way cultural selection question asks whether natural selection operating on genetic variants and 'intelligent design' by human minds are the only ways in which behavioural characteristics can become adapted to their environments.

## 3. Replication and reconstruction

An alternative to dual-inheritance theory, 'cultural epidemiology' or the 'Paris school', has been gaining ground since the 1990s [20,21]. Like dual-inheritance theory, cultural epidemiology is a populational approach to cultural change. However, according to the Paris school, they disagree with their Californian cousins on the subject of selection. Paris argues that California is committed to third-way cultural selection—a positive answer to the third-way question—and that California makes cultural selection appear plausible by assuming, wrongly, that cultural inheritance typically involves 'replication'. By contrast, the Paris school denies there is a process of cultural selection producing improvement or adaptation of cultural traits—it offers a negative answer to the third-way question—on the grounds that, in fact, cultural inheritance typically involves 'reconstruction' rather than 'replication' [20–22].

What is the difference between replication and reconstruction, and why does it matter? The second of these questions has been given a much more satisfactory answer than the first. It is widely assumed—by dual-inheritance theorists, cultural epidemiologists and others—that the distinction matters because replicative processes have higher-fidelity products than reconstructive processes, and high-fidelity products, although not strictly necessary for selection [4,23,24], make selection more likely to happen, and a more powerful generator of adaptations when it occurs. In other words, and more slowly, it is assumed that replication and reconstruction are both psychological processes, or sets of psychological processes, in which cultural entities—ideas, behaviours and artefacts—play a causal role in the production of new, more-or-less similar entities. The products of these psychological processes are high-fidelity when the new entities closely resemble the old ones, for example, when the idea you form as a result of reading my words is very similar to the idea that inspired me to write them. High-fidelity inheritance enhances the probability and the power of third-way or 'cumulative' cultural selection—gradual improvement or adaptation of cultural variants over successive generations—because it preserves small improvements (the analogue of beneficial mutations), and thereby makes them available for further improvement in the future [25,26].

If this is correct, the distinction between replication and reconstruction matters a great deal—it is a key to answering the third-way question. To find out whether cultural selection is likely to occur, or under what conditions it is likely to occur, we just need to work out whether the social learning processes that mediate cultural inheritance are replicative or reconstructive, and that seems to be an eminently tractable empirical question. Indeed, there are already a number of laboratory experiments that appear to have made progress in answering the question (e.g. [22,27,28]). But there is a problem. Although many cultural evolutionists write confidently about replication and reconstruction, no one has characterized the difference between them such that replication and reconstruction could be distinguished empirically in psychological experiments *and* used as indicators of the fidelity of cultural inheritance in the real world.

The word 'replication' comes from the lexicon of molecular genetics, where it refers to a process of 'splitting and reassembly' of DNA, which occurs at cell division [29]. As far as I can tell, no one is claiming—or claiming that others are claiming—that cultural inheritance involves a precise analogue of this kind of splitting and reassembly. Rather, replication is almost invariably defined with reference to 'copying', but, as Godfrey-Smith [30] and Lewens [31] have noted, without an accompanying explanation of what is meant by 'copying' [21,32]. Consistent with everyday usage, and the way the term is used in research on social learning, 'copying' could be understood as any process in which entities play a causal role in the production of new, similar entities. However, this approach would bind the process of copying/replication too closely to its products [33]. In effect, it would define replication in terms of its relatively high-fidelity products and thereby squander the opportunity offered by the replication/reconstruction distinction: the opportunity to find out about the fidelity of cultural inheritance by examining the features of the psychological processes through which it occurs. Only if we know about the processes of cultural replication, can we work out the range of inputs over which there is a match between input and output sufficient to support cultural selection.

Thus, the distinction between replication and reconstruction has considerable promise when replication and reconstruction are viewed as two different types of psychological process, one of which, by hypothesis, yields higher-fidelity cultural inheritance than the other. In this case, the likely fidelity of cultural inheritance in a given domain across time could be assessed using data that are readily available: data from humans alive today which tell us about the psychological processes mediating social learning in various domains. I have argued that this promise is not being fulfilled because replication and reconstruction are being defined not as types of psychological process—in terms of the operations, or sequences of events, that each instantiates—but by the extent to which their products resemble their social inputs. This approach conflates processes with products (replication and reconstruction with high and low fidelity), makes the argument circular and prevents cognitive science from getting a handle on a fundamental question about cultural evolution: does it involve third-way cultural selection?

## 4. A reconstruction of replication and reconstruction

I think the potential value of the replication/reconstruction distinction can be recovered by using dual-system theory to develop Sperber's [20,33] suggestion that replication is 'stimulus-driven', whereas reconstruction is inferential. Dual-system models (not to be confused with dual-inheritance theory) have provided a framework for research on cognition ever since psychology became an empirical science [34], and they continue to inspire some of the most rigorous, cumulative work in the field [35,36]. These models vary in detail, but they are united in suggesting that thought, and especially human thought, is controlled by two systems, or types of process, that interact with one another. The operation of System 1 is typically characterized as bottom-up (or stimulus-driven), fast, involuntary, parallel, unavailable to conscious awareness, and based on information derived from genetic inheritance and associative learning. The operation of System 2 is top-down, slow, effortful, serial, available to conscious awareness, and based on information both from System 1, and generated by its own activity. System 2 acts as a more-or-less successful 'supervisor' or 'executive' with respect to System 1 [37]; it schedules, harnesses and augments the activities of System 1. The activities of System 1 lend themselves to characterization at the sub-personal level, whereas the activities of System 2 are more naturally characterized at the personal level, as things that are done by the whole agent.

Viewed from the perspective of dual-systems theory, social learning is replicative to the extent that information from another agent is picked up or encoded by System 1—in a fast, involuntary and possibly unconscious way—and reconstructive to the extent that encoding of information from another agent is done or supervised by System 2—in a slow, deliberate, conscious way. This is a reconstructed version of the replication/reconstruction—it is not the same as Sperber's replication/reconstruction distinction—but it is consistent with his suggestion that replication is stimulus-driven, and with the connotations of 'replication' that waft over from genetics. It makes cultural replication into a process that occurs 'all by itself'. Like genetic replication, it is not 'done by' the recipient of the ideas/alleles; it just happens. To make clear when I am using the dual-systems, reconstructed version of the replication/reconstruction distinction, I will refer to 'replication$^1$' and 'reconstruction$^2$'.

There is plenty of evidence of replication$^1$ in the cognitive science literature on social learning in humans and other animals. For example, there are many demonstrations that, in controlled laboratory conditions and when talking casually to others, humans engage in 'automatic imitation' or 'mimicry'. We copy the gestures of others—the way in which parts of the body move relative to one another—when we do not intend to copy: when copying interferes with us discharging our intentions and when we are apparently unaware of the other person's gestures or our own imitation of them [38,39]. Similarly, there is compelling evidence that, like other animals, humans readily acquire preferences and aversions through 'observational conditioning'—a form of unsupervised associative learning, and therefore solidly part of System 1. After seeing another person's face spontaneously wincing in the presence of an object, or showing disgust in reaction to a smell, the observer becomes fearful of the object, or apt to avoid eating anything with that, now nasty, smell [40,41]. Another kind of replication$^1$, rote learning, is evident in everyday life. Living as I do in the unusual world of an Oxford college, I have heard a particular prayer, a Latin grace, said many times by others. I do not understand Latin, and I never intended to learn the sequence of sounds, but when the time came for me to say grace, I could utter the words 'parrot-fashion'.

The same kinds of content—sequences of body movements, aversions and sequences of sounds—can also be socially learned by reconstruction$^2$. As a lousy tennis player, with a very limited repertoire of skilled tennis moves, I might try to copy the pro's serve by laboriously describing it to myself while watching—trying to capture in words the topography and timing of the action components—and then rehearsing this description in my mind as I grasp the racket and try to repeat the pro's performance. This would be an intentional, reconstructive$^2$ (and probably doomed) form of body movement imitation. Similarly, in episodes of what cultural epidemiologists call 'ostensive communication', I could acquire an aversion by hearing you say 'touching a hot iron is painful' or 'spinach is disgusting'. And, given the right education, people can certainly learn to say a Latin grace in the time-honoured, reconstructive$^2$ way: with the firm intention to learn and full command of the tongue of Ancient Rome.

The foregoing examples support two things that cultural epidemiologists have claimed about replication and reconstruction, but run counter to a third. They are broadly consistent with the idea that replication$^1$ is typically of higher fidelity than reconstruction$^2$; on average, System 1 social learning processes yield products that more closely resemble their inputs than System 2 social learning processes. Replicative copying of novel sequences of body movements can be very precise [42], but our action vocabularies are so limited that imitation-by-verbal-description is likely to be grossly inaccurate for all but the most topographically simple actions. Likewise, observational conditioning may be more likely than verbal instruction to result in the receiver developing an aversion to the same category of objects as the transmitter. An observationally conditioned aversion generalizes only to physically similar objects—for example, from a flat iron to a steam iron—but an instruction such as 'touching an iron is painful' could be taken to mean it is risky to contact any tool made of iron. And if a receiver understands the language in which a formula is expressed, they are more likely to 'correct' a component they regard as wrong, or to produce an utterance that means the same but sounds different, than if they learn by rote a sequence of phonemes that is, for them, meaningless. Thus, while it may be possible to make the fidelity of reconstruction$^2$ comparable with that of replication$^1$—for example, through extended periods of teaching, such as those involved in science education—it is likely that, on average, replication$^1$ is of higher fidelity than reconstruction$^2$.

The foregoing examples also support the cultural epidemiologists' denial that replication, when it occurs, depends on psychological mechanisms that are genetic adaptations for culture—that evolved genetically *for* high-fidelity cultural inheritance [21]. Imitation of body movement topography used to be thought to depend on such a genetic adaptation, or an 'innate module' [43]. However, the foundation of the innate module view was recently undermined by a large-scale study showing that human newborns do *not* imitate [44], and there is now a substantial body of evidence from adults, infants and nonhuman animals indicating that, rather than being genetically inherited, the imitation mechanism is constructed in the course of development through learning [45,46]. As for observational conditioning and verbal instruction, the former is a species of associative learning—a cognitive capacity that is far too ancient, in phylogenetic terms, to be an adaptation for culture—and even those who regard language as a human-specific genetic adaptation do not claim that it evolved specifically for high-fidelity cultural inheritance by verbal instruction.

However, the foregoing examples suggest that the Paris school is wrong in thinking that replication is rare. I suspect their preoccupation with cultural traits that are transmitted via language (e.g. religious beliefs, folk lore and fairy tales), combined with their rich Gricean view of how much System 2 inference is involved in linguistic communication, has led cultural epidemiologists to overlook a substantial body of research in cognitive science showing that sub-personal, System 1 processes can mediate the cultural inheritance of gestures, skills, preferences and, with the appropriate social support for rote learning, linguistic entities that are in an important sense meaningless for those who utter them [38–42].

In summary, reconstructing the distinction between replication and reconstruction so that it is more firmly rooted in cognitive science, and does not merely define replication as high-fidelity transmission, suggests that the Paris school is right on two counts and wrong on a third: replication$^1$ is more likely than reconstruction$^2$ to support high-fidelity inheritance—to result in the receiver receiving something similar to what the sender sent (deliberately or inadvertently)—and this is not because replication$^1$ mechanisms are genetic adaptations for cultural inheritance. However, there is no reason to think that replication$^1$ is rare. Indeed, the ease with which automatic imitation, observational conditioning and rote learning can be observed in the laboratory and in everyday life suggests that cultural replication$^1$ is a pervasive feature of human lives.

## 5. Cultural selection requires more than replication$^1$

Several commentators have recently argued that too much fuss is being made about the differences between dual-inheritance theory and cultural epidemiology, and that disagreements between the California and Paris schools are more apparent than real [24,27,47]. For example, surveying the results of transmission chain experiments, Acerbi & Mesoudi [27] conclude that there is enough evidence that cultural inheritance can be replicative (they use the term 'preservative'), for us to be confident that, at least in some domains and at certain levels of granularity, there is selection on cultural variants. This may well be true if one takes 'selection' to be no more than a synonym for 'choice'. In that case, to say that there has been 'selection on cultural variants', means only that the frequency of types in a population at $T + N$ has been influenced by learners' choices among variants to copy at previous time steps. However, if one is interested in the third-way question, cultural selection means more than this. In the third-way context, cultural selection occurs when (i) a change in the frequency of types in a population constitutes improvement or adaptation (i.e. the frequency of types that do a better job, with respect to human purposes, increases more than that of types that do the same job less well) and (ii) this improvement is *not* due solely to smart choices by agents; to learners choosing to copy the better variants because they, the learners, recognize the 'betterness' of the better variants. If the improvement is due to smart choices by learners—for example, if people use durable rather than disposable shopping bags because they understand the former to be better for the environment—thought and behaviour are becoming adapted in the second way, not the third way [13,18].

Third-way cultural selection requires a good deal more than replication, or even replication$^1$. As the previous paragraph indicates, one additional requirement is for 'dumb', blind or trusting choices by learners, which nonetheless make better variants more likely to be copied than inferior variants. These choices could be made with deliberation, and via sophisticated cognitive processes, but they must *not* depend on learners detecting, individually or collectively via foresight, the betterness of better variants [10]. Intelligence in the sense of insight into what will and will not 'work', whether uniform or highly variable within a population, is a threat to third-way cultural selection; it increases the chances that adaptation will occur in the second, rather than the third way.

A second additional requirement is for another kind of fidelity. Replication$^1$ delivers 'one-shot fidelity'; processes such as imitation, observational conditioning and rote learning make it likely that, in the course of a particular episode of social learning, the receiver will acquire an idea or behaviour similar to that of the model agent. But for improvements to accumulate—for cultural selection in the strong sense—'recurrent fidelity' is also needed; the idea or behaviour must remain similar to that of the model, in memory and over episodes of activation or use, until it is passed on to one or more other learners. A little more formally: 'one-shot fidelity' is the fidelity with which a trait, t, is initially learned from an expert, A, by a novice, B. A fair degree of fidelity at this initial stage is undoubtedly necessary for cultural selection, but it is radically insufficient. For improvements to accumulate, 'recurrent fidelity' is also needed: B must retain t—keep doing what A did, or keep believing what A believed—until C, a novice of the next cultural generation, acquires t from B. The t needs to be insulated from loss or modification between acquisition and re-transmission [48–50].

Many of the processes or 'decision rules' that dual-inheritance theory regards as integral to cultural evolution—such as 'direct bias', 'guided variation' and 'conformist bias'—are consistent with the idea that cultural change is a function of choice, but are threats to the possibility of third-way cultural selection. They militate in favour of selection in the weak sense—choice—and against selection in the strong sense. For example, direct bias is a threat to the requirement for dumb choices. In direct bias [5], later called 'content bias' [7], learners are supposed to survey all traits in the population, to evaluate their efficiency relative to other traits and, based on this evaluation, preferentially to copy the better traits. Although direct bias is clearly a selection mechanism in the weak sense—it relates to choices among cultural traits [27]—it involves (incredibly) smart choices by learners, and therefore any improvement or adaptation resulting from this bias would be due, not to third-way cultural selection, but to individual intelligence or insight. Similarly, guided variation, which occurs when cultural variants are modified by learning between acquisition and re-transmission [5], is a threat to recurrent fidelity; it reduces the chances that small improvements will be preserved as platforms for further improvement.

## 6. Metacognitive social learning strategies

Faced with the many requirements for third-way cultural selection, and threats against their fulfilment, cultural epidemiologists are sceptical about a third way, arguing that cultural change is rarely, if ever, a process of adaptation. By contrast, dual-inheritance theorists appear to remain optimistic about the possibility of cultural selection, but have not explained how the requirements could be met in spite of the threats [10,23]. This may have been part of what Sterelny ([9, p 43]) had in mind when he said that dual-inheritance theorists 'do not seem to think of selection and fitness in causally robust ways' (see §2 above). I share the optimism of the California school and believe that cognitive science can help us to think about cultural selection in more 'causally robust ways'; it can help us to explain how, against the odds, the requirements for third-way cultural selection could be met.

Let's take as an example the 'decision rules'—sometimes called 'social learning strategies'—that are, according to dual-inheritance theory, the basis on which learners choose which cultural variants to copy. These rules are a fundamental part of dual-inheritance theory, they explain directional change in the frequencies of variants in the population, but they have been consistently 'blackboxed' by the California school [51]. With some resolution, dual-inheritance theorists have refused to ask what social learning strategies are 'made of'—how they are implemented at the cognitive level. Opening the black box, and combing through research on social learning strategies in animals, children and adults, recently I found evidence that, from a cognitive science perspective, two kinds of rule guide choices about when, what and whom to copy [52]. The first, 'planetary' kind of decision rule is implemented by relatively simple, taxon- and domain-general psychological processes; mechanisms of attention and associative learning that are present in a broad range of species, come online early in development and process information from the social and inanimate worlds via the same computations. For example, agents who grab more attention because they are large, noisy or standing close to desirable objects are more likely to be copied than agents who grab less attention. Empirical regularities of this kind can be characterized by rules—such as *copy older individuals* (who tend to be larger), or *copy the successful* (who tend to be located near desirable objects)—but these rules, like the rules of planetary motion, are in the minds of researchers, not in the minds of the entities or agents the researchers are studying. The second, 'cook-like' kind of decision rule is implemented by complex 'metacognitive' processes: System 2 psychological processes that represent 'who knows'. More specifically, System 2 metacognitive processes represent the accuracy and reliability with which other cognitive processes, in the self and in others, represent the world [53]. The evidence suggests that these metacognitive social learning strategies are found only in humans, come online late in development and process social information in a domain-specific way. For example, they specify that, when building a boat, one should *copy the boat-builder with the largest fleet*, and when struggling with information technology, one should *copy digital natives*. Metacognitive social learning strategies are full-bloodied rules. They are consciously represented in the minds of choosing agents, guiding their behaviour in the way that a cook uses a recipe.

Unlike planetary rules, metacognitive social learning strategies have the potential to meet the requirements for cultural selection identified in the previous section—the need for dumb choices and recurrent fidelity.

(i) Dumb choices. Although mediated by sophisticated psychological processes, metacognitive social learning strategies are dumb in the sense that is important for third-way cultural selection: they bias an agent towards copying better variants without the agent being smart enough to know which variants are better and which are worse. They are alternatives to direct/content bias that leave room for cultural selection, rather than individual intelligence, to do the adaptive work. If I *copy the boat-builder with the biggest fleet*, there is a good chance I will copy a design that is especially successful. This is because fleets remain large when they are made up of boats that are unlikely to sink. But, crucially, I do not need to know this in order to make the right—the adaptive—choice of which boat design to copy. I do not need to be smart enough to know what makes a good boat good, or to have any theory about why the builder with the biggest fleet knows best. As long as I, along with other novices, slavishly follow the rule *copy the boat-builder with the biggest fleet*, adaptive innovations are likely to become more widespread and to form the basis for further improvements in boat design.

(ii) Recurrent fidelity. Metacognitive social learning strategies can guide learners towards knowledgeable models with great precision, specifying the individual or type of person to copy in each of a range of task domains. As a result, they create conditions conducive to the development and evolution of processes that promote high-fidelity cultural inheritance. When there is a good chance that you are going to copy an adaptive variant, it is worthwhile investing time and energy in copying accurately and in detail. The processes that promote one-shot fidelity, replication[1] processes, include automatic imitation and rote learning (§4). The processes that promote recurrent fidelity are those that discourage guided variation, i.e. changing a cultural variant in the light of further experience between acquisition and re-transmission. As far as I am aware, no one has studied these processes from a cognitive science perspective. My guess is that they involve a variety of low-level processes (System 1) supervised by culturally inherited beliefs (System 2) about the importance of conserving cultural traits for group identity, or more specifically, about who is and who is not allowed to innovate in particular domains. As an example relating to group identity, I inherited from my mother the belief that Maids of Kent (women born to the east of the River Medway in the English county of Kent) decorate their apple pies with pastry in the shapes of oak, ash and elm leaves. In superstitious fear of being mistaken for a Kentish Maid (born to the west of the Medway), an identity with no practical consequences in my lifetime, this belief has prevented me from deviation. Every apple pie I have ever made has been decorated with an oak, an ash and an elm leaf. Consequently, there has been no opportunity for me to discover through reinforcement learning (also known as 'trial-and-error') that alternatives are quicker to assemble, more pleasing to the eye, or garner more compliments. And had I failed in childhood to suppress my System 1 inclination to innovate, no doubt my mother or grandmother would have restored recurrent fidelity by punishing my tinkering with a pained expression and a pastry knife.

Thus, thinking about social learning strategies from a cognitive science perspective reveals that there are two kinds of decision rules, and the metacognitive kind, found only in humans, has the potential to overcome many of the threats to third-way cultural selection identified by the California and Paris schools. Of course, this analysis begs the question of where metacognitive social learning strategies come from, and how they get to be so wise—questions I will take up in the latter part of the next section.

## 7. Cultural evolution of cognitive processes

So far, this article has considered only what cognitive science can do for cultural evolution. Now I want to consider, albeit briefly, the reciprocal relationship: what cultural evolution can do for cognitive science. This topic has been the focus of my work for the last few years [54]. I suggest that cognitive science needs cultural evolutionary theory to explain the origins and adaptiveness of distinctively human cognitive mechanisms—mechanisms such as causal understanding, imitation, language and mindreading (or 'theory of mind'), which are present in mature adult humans, but absent, or found only in nascent form, in other animals.

Evolutionary psychology—or, at least, the Santa Barbara school of evolutionary psychology [55]—suggests that genetic evolution is the architect of the human mind. According to this 'cognitive instinct' view, distinctively human ways of thinking are inborn. A human baby does not enter the world understanding causality, capable of imitating any action she sees, talking in complete sentences and understanding all about other minds, but she contains in her genes very specific programmes for the development of these capacities; programmes that are capable of building distinctively human, domain-specific cognitive mechanisms with minimal help from learning. The environment in which a child grows up is seen as merely 'triggering' or 'evoking' cognitive development.

The cognitive instinct view had some plausibility when it was introduced more than 20 years ago. For example, at that time there seemed to be compelling evidence that human newborns can imitate [56], Chomsky's 'universal grammar' account of language was still dominant among linguists [57], and it was widely accepted that autistic individuals have difficulty ascribing thoughts and feelings because they lack an innate module for theory of mind [58]. But, in the ensuing years, and partly through the emergence of social cognitive neuroscience—a potent blend of social psychology, cognitive psychology and brain imaging—the cognitive instinct hypothesis has become less and less plausible. We now know that human newborns do not imitate [44]; 'universal grammar' has been pared down to the point where Chomsky's claim is either untestable or indistinguishable from the alternative, pragmatic or constructivist, view of language [59,60]; and there is evidence that autistic individuals have many cognitive impairments, some of them, like 'weak central coherence' and problems with executive function, which are much more domain-general than theory of mind [61].

But if distinctively human cognitive mechanisms are not products of genetic evolution, where do they come from? No doubt 'learning', broadly construed, is a large part of the answer to this question, but it cannot possibly be the whole answer. People grow up in a broad range of environments. Therefore, if each developing human built his or her own specialized cognitive mechanisms through experience, it would be a staggering coincidence to find, as we do, that most people—at least, most people within any given culture—end up with the same set of mechanisms; for example, with mechanisms of causal understanding, language and theory of mind, each of which functions in much the same way as it does in other adults of the same social group. Furthermore, the 'learning' answer, by itself, does not explain why these shared cognitive mechanisms do their jobs reasonably well—why causal understanding gives us some insights into the workings of the inanimate world; language enables us to communicate fairly effectively and theory of mind allows us to predict what others are going to do. Learning alone cannot explain why, in this sense, distinctively human cognitive mechanisms are adaptive.

To explain why distinctively human cognitive mechanisms are both shared and adaptive, cognitive science needs cultural evolutionary theory. Until now, cultural evolutionary analysis has been applied only to 'grist'; it has been used to explain variation in, and the adaptiveness of, the products of thought—behaviour, skills and artefacts. I am proposing that it should also be applied to 'mills', to the mechanisms of thought—like causal understanding, language and mindreading—that control behaviour, mediate skills and, through those skills, produce artefacts. This kind of analysis, 'cultural evolutionary psychology', embraces the now plentiful evidence that the development of distinctively human cognitive mechanisms depends crucially, not merely on learning, but on social learning. Humans have a genetic starter kit consisting of enhanced social motivation, attentional biases (e.g. to faces and voices) and souped-up domain-general mechanisms of learning and memory. This starter kit allows complex, domain-specific 'modules' to be constructed in the course of development through social interaction. Distinctively human cognitive mechanisms are not merely learned, but culturally inherited, from members of the child's social group. They are shared within social groups because members 'catch' them from one another, and to the extent that they are adaptive—do their jobs well—it is because variant cognitive mechanisms have been winnowed by third-way cultural selection [54].

This kind of cultural evolutionary analysis can explain why, by hypothesis, there are metacognitive social learning strategies that promote third-way cultural selection of grist. The picture is of a population of social groups—groups of people defined, not by the genes they carry, but by geography and/or cultural characteristics such as language. The members of each social group subscribe to a common set of metacognitive social learning strategies. The decision rules are shared within groups because their inheritance is 'distributed', i.e. the rules are learned not only from biological parents (vertical transmission) and unrelated members of the parental generation (oblique transmission), but also from peers (horizontal transmission). Different social groups subscribe to different sets of metacognitive decision rules [62–65]. For example, group A's set of rules might differentiate more finely among task domains, or among potential models within each domain, than group B's set of rules. To the extent that the more precise rules really identify 'who knows'—the right people to copy in each domain—group A will be better able than group B to preserve adaptive innovations in the task domains for which they have more precise rules, and this will enable group A to develop, through third-way cultural selection, better boats, fish hooks or methods of baking bread. The resulting benefits to group A's living conditions make group A more likely than group B to persist, to expand through biological reproduction and immigration, and consequently to 'bud', producing offspring groups with similar metacognitive social learning strategies. Thus, group A is fitter than group B, where the fitness of a social group can be understood in relation to the number of descendant individuals (Type 1 fitness), or descendant groups (Type 2 fitness), that inherit the group's metacognitive social learning strategies [66].

Many metacognitive social learning strategies are sources of what dual-inheritance theorists call 'indirect bias' [5]. They instruct learners to decide what to copy, not by evaluation of the traits themselves (direct/content bias)—e.g. how swiftly a boat moves through the water—but on the basis of model characteristics—e.g. which potential model agent has the largest number of boats, cows or publications. Compared with direct/content bias and guided variation, indirect bias is certainly a friend of third-way cultural selection. It involves choices that are dumb in the relevant sense, and it does not militate against recurrent fidelity. However, indirect bias has been found, not only in humans, but in a broad range of other species for which there is no evidence of cumulative or adaptive cultural change. For example, vervet monkeys are more inclined to copy females, the philopatric sex, than males [67]. Therefore, by itself, the occurrence of indirect bias in human populations is not sufficient grounds for optimism about cultural selection. It is only when we focus on cognitive mechanisms—recognize that, in humans, indirect bias can be implemented by System 2, cook-like rules, as well as by System 1, planetary rules—that we begin to see how indirect bias can support cultural selection. Planetary social learning strategies can change as a function of the user's own, recent experience; for example, if a monkey finds that information from females has yielded higher payoffs recently, it will turn its attention from males to females. By contrast, because they can be expressed in language and thereby culturally inherited, metacognitive social learning strategies can distil the experience of many agents over an extended period of time. In other words, metacognitive social learning strategies tend to be 'wise' (see §6), to promote third-way cultural selection of behaviour, skills and artefacts, not merely because they implement indirect bias, but because they are themselves products of third-way cultural selection [51,52].

## 8. Conclusion

I have argued that conflict between populational models of cultural evolution—between dual-inheritance theory and cultural epidemiology—is important to the extent that it concerns the third-way question: Are human thought and behaviour made adaptive, not only by genetic selection and intelligence, but by cultural selection? Where this is the question at issue, easy attempts to reconcile California and Paris—by suggesting that California has quietly given up on third-way cultural selection, or by conflating weak and strong senses of 'selection'—are in danger of drawing attention away from a fundamental question about cultural change. I have also suggested that cognitive science, and especially the kind of psychology that concerns itself with sub-personal mechanisms, can help cultural evolutionary theory to address the third-way question (i) by refining the distinction between replication and reconstruction, so that it can be used more effectively to assess the one-shot fidelity of cultural inheritance, and (ii) by casting a spotlight on metacognitive social learning strategies. These decision rules, unlike their planetary counterparts, have the potential to meet the dumb choice and recurrent fidelity requirements for third-way cultural selection. In a coda (§7), I suggested that cognitive science needs cultural evolution at least as much as cultural evolution needs cognitive science: to explain the origins and adaptiveness of distinctively human cognitive processes. If that is correct, third-way cultural selection is much less likely to have been crowded out by natural selection on genetic variants, by the 'first way', than the Paris school assumes in its discussions of cultural attraction. But that is another story, to be told at another interdisciplinary party. Thanks for the invitation.

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