# **Mere Recurrence and Cumulative Culture at the Margins**

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**Abstract**

The consensus formulation of cumulative culture characterizes cumulative traditions as information transmitted by high-fidelity learning that generates incremental improvement over time. While this formulation is effective for studying paradigmatic cases (e.g. Holocene-era hominin toolkits), it is less so at capturing and explaining putative cases at the margins—for instance, some recurrent behaviors observed in social animal species. This paper argues against the consensus formulation in favor of a minimal one, which links cumulative culture to what we call ‘copying know-how’ and the transmission of trait form. As we argue, these elements are better able to characterize putative instance of marginal cumulative culture. Yet by rejecting incremental improvement, the minimal formulation raises a tricky empirical problem we call ‘mere recurrence’: distinguishing cumulative culture from other processes that sustain recurrent behavior. We highlight three broad types of processes that generate mere recurrence, distinguishing them from copying know-how. Finally, we put the assembled conceptual tools to use in a case study, distinguishing the accounts of cultural epidemiologists from those working on the zone of latent solutions—arguing against those that have tried to align the two.

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## **1 Introduction**

Narratives of hominin evolution revolve around the origin and exercise of capacities for cumulative cultural change. These capacities support the emergence, maintenance and change of cumulative cultural traditions: traits whose existence and form causally depend on the form of past trait tokenings. Cumulative cultural change in turn explains the technological and epistemological achievements of hominins and the processes involved are often taken to be distinctively hominin, distinguishing Upper Pleistocene hominins from earlier hominin species, australopithecines and most, if not all, non-human animals (Henrich [2016]; Tennie *et al.* [2017]; Sterelny [2021b]). These claims rest on an extensive body of theoretical models, comparative studies, and experimental trials that explore the evolution of cumulative culture capacities, the influence of these in hominin history, and how these facilitate dynamics of cultural change.[[1]](#footnote-1)

Much of this work focuses on paradigmatic instances of cumulative culture: traits with clear histories of accumulated modifications that have led to increases in complexity, adaptiveness, and efficacy (Buskell [2020]). Such traits include the complex clothing and toolkits of high-latitude hunter-gatherers (Boyd *et al.* [2013]). A useful signal of paradigmatic traits is that they are too complex for any one person to reinvent during their lifetime. Complementing this work on paradigmatic traits is research targeting the origin of capacities for cumulative culture. This research focuses on cases at the margins: traits that lack some or even all features seen in paradigmatic cases. These are recurrent traits that have accumulated modifications at some point in their history, but modifications which may not have necessarily brought about improvements in complexity, adaptiveness, or efficacy. Such cases of marginal cumulative culture are observed in the prehistorical traces of early hominin life, and perhaps, in a number of non-human animal species (hereafter; ‘animals’). While identifying marginal cumulative culture is a non-trivial task, it is crucial to understanding the conditions under which capacities for cumulative culture can evolve and the circumstances that might lead to hominin-like capabilities. It does so by helping researchers to understand the mechanisms and conditions involved in cumulative culture, to chart the distribution of those mechanisms across the animal kingdom, and to link this information into a narrative of cognitive evolution and cultural change.

This paper provides conceptual tools for identifying cases of marginal cumulative culture. We do so by arguing against the consensus formulation of cumulative culture at work in the literature in favour of a minimal one. As we show, the consensus formulation relies on abstract characterizations and a lumping of concepts—and these can obscure distinctions needed for describing and evaluating putative cases of marginal cumulative culture.

The plan for the paper is as follows. In the next section, we discuss the consensus formulation of cumulative culture and sketch our minimal alternative. This sets up our analysis of the consensus formulation: how it unhelpfully lumps together concepts of ‘copying’, ‘fidelity’, and ‘imitation’, and builds in an unnecessary commitment to incremental improvement. Accepting our minimal formulation, however, introduces a problem we call mere recurrence. We discuss three families of explanations that generate mere recurrence (innate responses, limited repertoire exploration, and recognition and retrieval) and distinguish these from cumulative culture. We then show how our conceptual tools can illuminate nearby positions in the literature: here, distinguishing the arguments and concerns of cultural epidemiologists (hereafter ‘CE’; Sperber [1996]) from those researching the ‘zone of latent solutions’ (hereafter ‘ZLS’; Tennie *et al.* [2009]).

Before these analyses, it is worth noting that this paper engages in terminological stipulation. We defend a deflationary definition of ‘copying’: copying is learning the form of traits. This we understand as learning that involves a causal dependency relationship between the organized, constituent elements of observed traits (trait form) and what is subsequently acquired by learners.[[2]](#footnote-2) Learning involves ‘copying’ when intervening on the form of observed traits would lead to changes in what learners ultimately acquire.[[3]](#footnote-3) Fine-grained interventions changing trait form (the moves of a dance, say) will lead to fine-grained differences in traits acquired by copiers, but not in those using some other mechanism (stimulus enhancement, say).

Copying trait form means learning how to produce constitutive elements, and/or how they are related (for instance, sequentially or hierarchically) so as to generate the overall trait. Our use of ‘copying’ can thus be taken as shorthand for ‘copying know-how’ or ‘form copying’, and we use these last two expressions interchangeably.[[4]](#footnote-4) This use of ‘copying’ is deflationary insofar as it aligns with folk usage, and does not identify ‘copying’ with a specific mechanism. As we demonstrate in more detail below, this language helps to distinguish learning that can support cumulative traditions of know-how from that which cannot.

## **2 Two Formulations of Cumulative Culture**

The cognitive capacities underpinning cumulative culture are taken to function like a ratchet: since these capacities prevent ‘slipping back’ to earlier or less sophisticated forms. Moreover, these capacities are taken to be general, applicable across various task domains. Characterizing culture merely as ‘information’—absent further details about how it is instantiated—further supports claims that such capacities are generally applicable. Lastly, when cumulative cultural capacities work alongside means for identifying favoured trait variants, then ‘ratcheted’ learning can support the incremental improvement in traits over time. Putting these elements together yields what we call the consensus formulation of cumulative culture:[[5]](#footnote-5)

**Traits as Information**: culture can be adequately operationalized as information carried by a variety of material vehicles (for instance; utterances, artefacts, behaviour);

**High-fidelity learning**: learning supports the faithful reproduction of information, and;

**Incremental Improvement**: cultural traits increasingly improve (for example, in adaptiveness, complexity) over their history.

The consensus formulation thus contains an abstract operationalization of culture (traits as information), an abstract characterization of the individual-level cognitive capacities necessary for cumulative cultural change (high-fidelity learning), and a generic description of how traits tend to develop and change over time. Mesoudi and Thornton ([2018]) refer to the elements of this formulation as ‘core criteria’, noting that paradigmatic cumulative culture can be further characterized by ‘extended criteria’, like cultural recombination and exaptation. Such ‘extended criteria’ are useful to further describe the histories of cultural traits. In particular, to explain how complex, causally opaque, yet adaptive behaviours (for instance, the specialized toolkits of hunter-gatherers, agricultural technology and practices, and medical knowledge and food-taboos) could emerge from the unmysterious operation of causal mechanisms. The general point is that the history of paradigmatic cumulative cultural traits can be explained in terms of the learning, maintenance, and incremental improvement of traits over time.

At the margins, however, the consensus formulation breaks down. For these are situations where it is difficult to discern the learning processes involved and whether incremental improvement has taken place. Are the grub foraging tools of New Caledonian crows, cut from pandan leaves, cumulative culture? What about the lithic technologies of the Oldowan? The nut-cracking, hand-clasping, or ant-dipping techniques of apes? These are situations where the abstract operationalizations of the consensus formulation may obscure important distinctions and phenomena. Yet these are precisely the situations one needs to investigate to understand the conditions and timings for the origin of cumulative cultural capacities, and their distribution in the animal kingdom. This points toward a need for more sensitive concepts and tools.

Our aim is to develop generalisable concepts; show their usefulness; and point out the painstaking empirical work needed to distinguish cumulative culture from other kinds of behavioural recurrence. These concepts and distinctions are defended in more detail below as we argue for a minimal formulation of cumulative culture.[[6]](#footnote-6) This formulation modifies the characterization of what is learned and how it is learned, and contains just two criteria:

**Trait Form:** traits should be operationalized in terms of their constituent elements (for example, steps in a behavioural sequence) and organized relationships to one another (for instance, hierarchical, sequential), and;[[7]](#footnote-7)

**Copying Know-How:** agents acquire trait form—in whole or in part—through social learning that is causally dependent on the observed trait form.[[8]](#footnote-8)

As we argue below, this minimal formulation is better suited for evaluating putative cases of marginal cumulative culture.

## **3 Copying, Imitation, and High-Fidelity**

Many in the cultural evolutionary and comparative cognition literatures might be puzzled at our proposed re-formulation. After all, isn’t high-fidelity transmission just the same as copying? We think not and argue that it is a mistake to conflate the two. Explaining why we think this requires looking at the history of term ‘high-fidelity transmission’. Doing so provides an entry into the broader analyses of the consensus formulation.

The frequent identification of ‘high-fidelity transmission’ and ‘copying’ can be traced back to work in both primatology and formal modelling. Formative work on the cognitive capacities underlying cumulative culture by Tomasello ([1999]; Tennie *et al.* [2009]) seemed to identify high-fidelity copying (Tomasello’s ‘imitation’) as being central to the ratchet effect. Complementing this research were early cultural evolutionary models (Cavalli-Sforza and Feldman [1981]; Boyd and Richerson [1985]), where learning was represented as a failure-prone process of transmission from one individual to another. Often operationalized as the result of a single encounter (single-instance), successful learning was the acquisition of an identical trait (lossless duplication). Though this formalization of learning was at best a sketch—it stuck. It stuck mostly because it sufficed to explore the cultural evolutionary patterns that emerged when traits were faithfully passed on, rather than the specific processes involved in creating and maintaining those patterns.

Bolted on to this abstract characterization of how learning took place was a similarly abstract characterization of what was transmitted. Culture was defined simply as ‘information’—'information’ that could have been acquired by other means, say, trial and error learning (Boyd and Richerson [1985]; Henrich [2004]). This definition made few descriptive claims or prescriptive demands on what could count as ‘information’ (Lewens [2015]). This meant that while ‘information’ was a flexible platform for thinking and modelling, it did not discriminate between different learning mechanisms or between different kinds of information that might be learned.[[9]](#footnote-9)

We think the consensus formulation captures a set of prevalent assumptions in the cumulative culture literature. This is so even as the literature has continued to develop new models and explore the link between learning and cumulative culture. Consider Henrich’s ([2004]; Henrich and Boyd [2002]) models of skill-based learning that include explicit considerations of the way that complex traits can introduce noise or error in learning. What these models show is that noise or error at the individual-level can be compensated for by population­­-­level structures (notably, effective population size). Thus, a population can support high-complexity traits, even if individual-level learners are not always perfect. Yet individual-level learning is still assumed to be high-fidelity—just high-fidelity learning subject to sources of error (Henrich [2004], p. 201).

To be clear, our focus is on the individual-level cognitive capacities that support cumulative culture. And even if models and experiments have challenged and complexified our understanding of such capacities, the consensus formulation remains central to presentations of cumulative culture by proponents and opponents alike.[[10]](#footnote-10) This is a picture where ‘copying’, ‘high-fidelity’, and ‘imitation’ simply means lossless duplication: the acquisition of an identical trait (perhaps in a single-instance of learning). This duplication may be subject to sources of error—but duplication remains the assumed baseline.

While we think this picture of cumulative culture underwrites fruitful empirical models, we think the assumptions of lossless duplication, single-instance learning, traits as information, and incremental improvement can—and often does—obscure important features of how and what is learned. These arguments support our minimal formulation of cumulative culture, and our redefinition of ‘copying’ as ‘copying know-how’. In the next four subsections we discuss these assumptions in more detail.

### **3.1 Lossless Duplication and Single-Instance Learning**

As we’ve said above, the characterization of ‘high-fidelity transmission’ used in many cultural evolutionary models is an abstraction, one that renders tractable explorations of populational information dynamics. Over time, however, this assumption has sometimes become less an abstraction than an assumption about how learning actually works. Researchers began to identify ‘high-fidelity transmission’ with the processes that supported cumulative cultural traits.

This was most conspicuous in the work of memeticists (Dawkins [1976]; Blackmore [1999]) who relied upon strong analogies between biological and cultural evolution. In particular, these researchers linked processes of learning and genetic replication: just as DNA was copied faithfully via the mechanisms of cellular reproduction, so too were ‘memes’ copied faithfully by replicative social learning mechanisms. This thinking could also be found in the now-dominant dual-inheritance paradigm. Henrich and Gil-White’s ([2001]) ‘info-copying’ is a notable example. In both cases, learning was characterized as being akin to a camera or photocopier: a mechanism that replicates the available information in a flash. Or, in other words, learning was lossless duplication.

This is a particularly strong reading of ‘high-fidelity transmission’. And while it did not and does not characterize all work on cumulative culture, the reading is prevalent and widespread. Importantly, this strong reading is also the one targeted by critics of dual-inheritance theory. Pointing to transmission-chain experiments, these critics argued that high-fidelity transmission is not a good characterization of human learning (Sperber [2000]; Scott-Phillips [2017]). Looking at these critiques, and the experimental paradigm they employ, is useful for showing why lossless duplication and single-instance learning are problematic assumptions for accounts of cumulative culture.

In typical transmission-chain experiments, a cohort of participants is put in sequential order. A ‘seed’ stimulus is given to the first participant, who after viewing it for a short period of time, is asked to replicate it. This ‘replication’ is then used as the input for the next participant(s), who repeats the procedure. These experiments have tended to show that learners readily transform the stimulus they are learning; for example, by incorporating greater hierarchical organization (Mesoudi and Whiten [2004]), dropping extraneous facts (Eriksson and Coultas [2014]), and compressing details (Tamariz and Kirby [2014]). Critics leverage such results to argue that learning is likely to be transformative across a range of circumstances, and moreover, that this means it isn’t duplicative—except, perhaps, in rare circumstances (Sperber [2000]. See also: Wasielewski [2014]; Reindl *et al.* [2017]).

But these experiments do not show that humans lack mechanisms of high propensity fidelity. What these experiments do is manipulate the learning environment to decrease the episodic fidelity of learning—the similarity between traits in any particular learning episode—in order to amplify transformational biases (Charbonneau [2019]). It is worth highlighting two of these manipulations here before turning to consider issues around fidelity in the next sub-section.

First, and importantly, the stimuli used in transmission-chain experiments are typically presented only once and for short periods of time (from seconds to minutes). Agents are then asked to reproduce that stimulus as closely as possible. This is unlike most learning situations. Especially in humans, but also in animals, learning is a temporally extended affair, often with multiple occasions for experimentation, failure, and reflection in environments rich with material and social information (Morin [2016]; Sterelny [2021b]).

Second, transmission-chain experiments often use arbitrary, nonsensical, or loosely structured stimuli, presented with little context. Again, this is unlike much human learning, which is often supported by rich and contextually-appropriate background information (Tomasello [2014]). Where this is lacking, learning is often supported by models that actively emphasize or exaggerate salient details, or by enriched environments that provide targets or models and tasks for novice learners (Flynn *et al.* [2013]). All of these features can act in harmony, facilitating the reliable and robust acquisition of very similar trait tokens.

We agree with critics that human learning is rarely akin to context-free, lossless duplication. Yet we also urge further reflection and attention to ethnography and experiments with greater ecological validity. When one does so, one finds that learning can and does lead to the recurrence of similar traits, when supported. This may involve lowered opportunity costs, multiple episodes of learning, several demonstrators, explicit teaching, scaffolds, enriched environments, or even previous bits of know-how. Learning isn’t ‘high-fidelity’ if that means ‘lossless duplication’, but it might be ‘high-fidelity’ if one takes the long view. Over multiple learning episodes, extended periods of time, and in supportive learning environments, similar traits can be reliably learned and transmitted.

### **3.2 Fidelity and Information**

As the above discussion has already introduced, the term ‘fidelity’ supports several readings (Charbonneau [2019]). Often, these claims are made about specific mechanisms. Imitation, for instance, is thought to be ‘high-fidelity’, while mechanisms like stimulus enhancement, ‘low-fidelity’. These plausibly differ in what Charbonneau calls propensity fidelity: the differential capacity for mechanisms to produce similar trait tokens over time. In other instances, what is at stake is the similarity between two trait tokens after an instance of learning. This is episodic fidelity. A mechanism may have high propensity fidelity, even if it supports learning with low episodic fidelity in any particular instance.[[11]](#footnote-11)

In early presentations imitation was often introduced as the mechanism underwriting cumulative culture (Tomasello [1999]). These early presentations were what we would now call a mechanism sketch: an abstract and incomplete description of a token mechanism that requires further empirical description (Machamer *et al.* [2000]). What causes problems is when the paradigmatic outcome of cumulative cultural evolution—recurrent trait form, linked through social learning—is read into the process itself. That is, because cumulative culture involves the faithful and reliable recurrence of trait form, such faithful, reliable recurrence must be the function of the learning mechanisms that support it.

This is a tendentious assumption. Even if it were found that only humans have capacities for imitation, and only humans have cumulative culture, it is wrong to assume that imitation is necessary for any particular instance of cumulative culture.[[12]](#footnote-12)

The move to identify ‘imitation’ with ‘high-fidelity’, and both with ‘cumulative culture’, goes too far too quickly. These moves generate a contrast between ‘high’ and ‘low’ fidelity mechanisms that collapses at least two important differences. The first is the difference between better and worse copying (in our technical sense of copying). The second is a difference between the type of knowledge at stake in any learning situation—whether one is learning the know-how to produce a trait, or auxiliary information about where to deploy a trait, or to what. Pointing out these differences shows why copying know-how is central to a revised understanding of cumulative culture, and why ‘information’ is sometimes too coarse a label for what is transmitted.

Consider the standard example of a ‘low’ fidelity mechanism: stimulus enhancement. This is social learning where agents acquire salient information about a feature or object in their surroundings. For instance, when animals crack and eat nuts, conspecifics can glean that ‘nut-objects’ are salient. Stimulus enhancement does not involve learning information about how to interact with the world, only about what is salient—stimulus enhancement thus transmits ‘know-what’ information, but not ‘know-how’ (Bandini *et al.* [2020]).

This is one important difference between kinds of learning situations: they can differ in the type of knowledge at stake. In addition to know-how (behavioural) and know-what (recognitive), there is know-where (locational), know-when (temporal), and know-that­ (classificatory) potentially supported by distinct types of learning mechanisms[[13]](#footnote-13). We think this points to a problem in the consensus formulation’s use of ‘information’. When researchers speak merely about the transmission of ‘information’, they abstract away distinguishing features of the content transmitted during learning (among many other features). Yet we take differences in the content transmitted—differences in the kinds of knowledge at stake—to be important, as they may feed into distinct kinds of mechanisms. Differentiating ‘information’ into distinct kinds of knowledge can help to remedy this situation.

With this in hand, we can return to the contrast between ‘high-’ and ‘low-fidelity’. Distinguishing different types of knowledge (how, what, where, that, etc.) is needed for an apples-to-apples comparison of the propensity fidelity of mechanisms.[[14]](#footnote-14) This allows us to state our interest in mechanisms that support the copying of know-how—for it is these mechanisms that support the cumulative cultural processes of form retention and modification over time. And while these mechanisms may support the learning of different types of knowledge, they need not (see Heyes [1994]; Hoppitt and Laland [2013]).[[15]](#footnote-15)

Even when focusing on copying know-how, however, issues of fidelity can be complicated. Propensity fidelity is a statistical notion, and this means that even mechanisms of high propensity fidelity might not generate similar trait tokens in any given instance of learning. Furthermore, such mechanisms may be extraordinarily sensitive to specific learning environments. Several authors have argued, for instance, that the human reliance on epistemically enriched environments, background information, and overt teaching often leads to overestimating the propensity fidelity of human copying capacities in cumulative culture (Avital and Jablonka [2000], Sterelny [2012]).

### **3.3 Incremental Improvement**

Perhaps the most contentious aspect of our minimal formulation is the rejection of incremental improvement as a necessary feature of cumulative culture.

This is in part a battle of intuitions. Some maintain that incremental improvement is essential to cumulative culture. Indeed, Mesoudi and Thornton ([2018]) include it as a ‘core element’. For those like Mesoudi and Thornton, what explains human success is the ability to produce ever more adaptive and (perhaps) complex pieces of kit. The sophisticated and well-adapted tools, shelters, and clothing of hunter-gatherers in high latitudes being excellent examples.[[16]](#footnote-16)

Yet we think this erroneously builds into the cumulative culture concept a feature seen only in paradigmatic (human) cases and has the consequence of ruling out many cases one should want to treat as cumulative. So, for example, it seems reasonable to treat pottery decoration as a target for cumulative cultural evolution. As pottery decorations are transmitted, they can accumulate changes—retaining variation in ornamentation over time. Yet such changes need not involve concomitant increases in fitness, complexity, or other notions of improvement.[[17]](#footnote-17) The point generalizes. Incremental improvement should not be taken as a necessary element of cumulative culture, because the modification and retention of changes to cultural traditions need not be improvements.

Modelling work suggests that cumulative culture—just like biological evolution—can involve the retention of adaptively neutral or maladaptive elements (Boyd and Richerson [1985]). These outcomes can be arrived at through directional change or the random exploration of trait spaces (Bentley *et al.* [2004]). Defining cumulative culture so that it rules out these possibilities seems ill-advised. Modifications need not be improvements—they just need to be retained.

This is one reason why our minimal account is preferable. In our formulation, cumulative culture simply involves the recurrence of similar forms causally produced by copying know-how. A single instance of copying —with any measurable fidelity—will count as cumulative culture. This formulation thus allows for cumulative cultural traditions that include maladaptive, neutral, or adaptive modifications.

### **3.4 Summary**

Let us bring the reflections of this section together.

Research on cumulative culture tends to focus on human capacities and the artefacts they produce. Looking at the exercise of these capacities, however, shows them to be underwritten by multiple and distributed structures and processes. These include engineered environments, simplified and exaggerated tasks, structured learning regimes, explicit standards of proficiency, and suites of social learning mechanisms. Humans are often able to observe multiple models, to experiment with behaviours and artefacts, and benefit from direct teaching (including teaching of know-how). Moreover, humans often have multiple trials and opportunities to bring their behaviour into line with standard or correct performances (Sterelny [2012]). Over time, cultural evolution itself may produce new and improved mechanisms and structures for learning (Heyes [2018]). So if there is a ‘ratchet’ at work in cumulative culture, it cannot be identified with a particular process, but rather a diverse and interacting assemblage of structures and processes.[[18]](#footnote-18)

These reflections point to some problems involved in assuming high-fidelity learning as part of the formulation of cumulative culture. Recognizing these problems suggests one should adopt a more minimal characterization of the learning involved. Cumulative culture involves the learning and retention of how to produce a trait: the organized elements and element relationships involved in generating the overall behaviour or artefact. Copying, in our technical sense, means the acquisition of trait elements and/or interrelationships in way that is causally dependent on the form of past trait tokens. But copying need not be lossless duplication. It can be minimal: the mere retention of elements and/or element relationships of previous trait tokens. Even when both episodic and propensity fidelity are low, what is learned can still be an instance of cumulative culture, so long as know-how is copied.

This might seem surprising. After all, a central contention of work in cumulative culture is that it is sustained by high-fidelity learning processes that ensure high episodic fidelity. But consider the transmission of skill, especially in translucent problem domains—tracking, say—where the causal structure is at best only partially accessible to learners. In such circumstances, any particular instance of learning is likely to be of low episodic fidelity. Learners will not be able to pick up on the subtle causal distinctions made by more proficient models. The rough classification of prints and scat might be readily learned, but how fresh are they? Where do they point? Determining the recency of spoors, what they say about the animal, and how to combine these clues with information on environmental disturbances to determine where to look and how to hunt are hard-won capacities. From what we know of contemporary forager populations, adolescents typically take years before they master such skills and contribute more calories to the group than they consume (Kelly [2013]). This is suggestive of a process of both low episodic and propensity fidelity.

But skills like tracking and hunting are also directly related to subsistence and fitness, and thus there is a strong incentive to learn from and ideally improve on skills. But not all traditions are so constrained by subsistence considerations—leaving some cultural traditions to more freely explore cultural trait spaces. Such explorations can be directional or stochastic; generating traits that are adaptive, maladaptive or neutral. And yes, in some instances, these explorations may be subject to learning biases and selection regimes that generate adaptive fit and complexification—but this is not a necessary feature of cumulative cultural change.

### **4 The Problem of Mere Recurrence**

Rejecting incremental improvement, however, raises a new empirical issue—perhaps the key issue in identifying cases of marginal cumulative culture. Rejecting incremental improvement means that traits might count as cumulative even when displaying no change over time. This can happen in multiple situations, mostly plausibly when know-how is copied but is also strongly constrained (for instance, by selection regimes). Such stasis is surprising, since the literature has generally assumed that cumulative cultural traits not only change over time, but in particular, change directionally towards greater adaptiveness or complexity.

Of course, in many cases this stasis will be merely temporary or apparent: change and accumulation will be part of the history of a trait, even if it does not change over some arbitrary span of time.[[19]](#footnote-19) The histories of conventions, rituals, and artefacts can often display such stasis when strategies settle into a stable equilibrium and alternates accrue prohibitive costs. Looking back in time will reveal how such traditions arose, and perhaps help explain, the systemic features that account for such stasis. And though static conventions, rituals, and artefacts are not marginal instances of cumulative culture, they are far from the paradigmatic instances at the core of the consensus formulation.

It is when one turns to consider marginal instances of cumulative culture, however, where the problem becomes pressing. For there may be traits, maintained by copying (in our technical sense of the term), that have not yet acquired modifications. Again, such traits will count as cumulative on our minimal formulation. Perhaps some instances of ape culture are cumulative cultural traditions in this sense. Several such traditions have been characterized as know-how perpetuated by social learning (Whiten *et al.* [1999]; McGrew [2009]). These look like cumulative culture, but are they?

The worry is that there are non-copying processes that might generate the same outcome. This is a problem of equifinality: there are other processes that can both generate and maintain similar trait tokens over time. Nonetheless, the persistent production of similar traits might seem to be a cumulative tradition. Copying know-how might be responsible—but may not. The problem is an empirical one of distinguishing cumulative culture from mere recurrence—where the causal links between trait tokens do not run through copying, but some other set of mechanisms.

Importantly, mechanisms of mere recurrence are insufficient for underwriting cumulative culture on either the consensus or minimal formulation. Below, we will describe three types of processes that generate mere recurrence. Distinguishing these different kinds of processes from know-how copying helps to better articulate the extension of that term, and to show some of the unexpected problems that arise at the margins of cumulative cultural evolution. We deploy these analytical resources at the end of this section when we examine two theories (the ZLS and CE) which both argued (in different ways) that putative cases of cumulative culture can be merely recurrent. Though some have recently argued that these two accounts appeal to the same underlying explanatory mechanisms (Scott-Phillips [2017]), we argue instead the two appeal to different types of processes.

### **4.1 Innate Responses**

A familiar family of causal explanation involves innate responses.[[20]](#footnote-20) These posit an evolved mechanism that, when triggered, reliably generates behaviour in the here-and-now, or sets in motion a developmental process that in turn reliably generates downstream behaviour. To use two well-worn examples: small, dark, moving stimuli reliably evoke prey-catching behaviour in frogs (an innate behavioural response) and the first experience of movement by ducklings reliably triggers maternal imprinting (an innate developmental process).

The stimuli evoking these innate responses may appear arbitrary. This should be read as historical arbitrariness linking the triggering stimulus and the outcome behaviour. As Fiona Cowie ([1999]) notes, there are many potential solutions to evolutionary problems, and multiple kinds of stimuli might plausibly have sufficed for purposes of natural selection. Maternal imprinting in ducks, for instance, is plausibly triggered by movement, since in the evolutionary past, it was a reasonable bet that ducklings’ first experience of movement would be from their mother. But other kinds of reliable stimuli might have served equally well. The first occasion of a certain colour might do the trick, on the assumption that the first such coloured stimulus ducklings would have encountered would be the bill of their mother.

But stimuli need not be arbitrary. Yawns can solicit yawns (‘motor contagion’) and emotions can solicit similar emotions (‘emotional contagion’). Here, stimuli ‘release’ matching behavioural expressions.[[21]](#footnote-21) The key point is this: whether it is a behavioural or developmental process that is evoked—and whether the evoking stimuli is arbitrary or not—innate responses can generate recurrent behaviour over time, without any copying (Tooby and Cosmides [1992])[[22]](#footnote-22).

### **4.2 Limited Repertoire Exploration**

The next family of explanations posits not innate mechanisms but (often innate) limitations and/or biases on the repertoire of behavioural elements that an organism can produce, and thus a limit on the range of expressible know-how. This repertoire may be composed of simple and non-combinable elements, or elements that can be chained together to produce complex behavioural sequences, or some combination of the two. Yet whatever composes this repertoire it is limited. Moving beyond the repertoire may either be impossible (there are hard constraints on what repertoire elements can develop), may be unachievable, or may be unsustainable without substantial external scaffolding.[[23]](#footnote-23)

Though limited, such repertoires can be powerful. We can see this by drawing on the notion of affordances from ecological psychology. Affordances are relata between behavioural repertoires and environmental features that can be exploited (Chemero [2009]). While repertoires can be constrained, the uses to which they are put need not be. We can see this by returning to an example made above. Stimulus learning can support the acquisition of new affordances through the transmission of know-where or know-what. Once attention is directed towards specific objects or locations, individual learning can be used to explore the situation and affordances available. But such enhancement-facilitated learning does not involve copying know-how.

We’ll discuss limited repertoire exploration in more detail below, when we compare the ZLS and CE. To foreshadow those analyses here, Tennie and colleagues argue that what appear to be instances of ape cumulative culture are, frequently, behaviour that can be individually expressed by apes in the absence of copying opportunities. For Tennie, any ape behaviour that re-appears in this way constitutes traditions of mere recurrence, underwritten by the continual reinvention of similar traits. Yet limited repertoire exploration is a more general type of explanation, accounting for the mere recurrence of behaviours by positing limitations on behaviour that can be spontaneously produced.

### **4.3 Recognition and Retrieval**

This third and last family of explanations involves recurrence in a highly structured scenario. In these circumstances, what occurs is not learning how to produce a particular behaviour, but only to recognize that observed behaviour corresponds to know-how in one’s own repertoire.

These recognition and retrieval explanations appeal to mechanisms for generalizing stimuli. Some of these mechanisms are phylogenetically widespread. The literature abounds with examples of food-aversion studies—often on rats—that readily generalize features associated with a bad meal. But there are mechanisms that are less widespread. Humans may use a wide range of structures and processes to identify something as part of a broader class including testimony, linguistic labelling, and theory of mind.

Yet recognition and retrieval explanations have an additional constraint. Agents must not only recognize the stimuli as being an instance of a broader class, they must also produce another instance of that class by matching and then retrieving know-how from their repertoire. These kinds of behaviour are often only found in highly structured scenarios, for instance, in transmission chain studies. Recall that in these studies, sequentially arranged cohorts of participants are given stimuli to reproduce, with the output of one participant being used as the input for the next participant in the chain. These studies can distinguish between performance characterized by transformation—when agents transform arbitrary or unstructured stimuli—from those characterized by recognition and retrieval. When fed familiar stimuli, for instance the string ‘ABC’ or a simple drawing of a star, agents reliably recognize the stimuli and can retrieve pre-existing know-how—plausibly acquired through past copying—to produce a similar token (Sperber [2000]; Scott-Phillips [2017]). But given that this know-how had been acquired prior to the test situation, such recognition and retrieval does not involve copying know-how—or at least it does not require such copying in the here and now.

It is useful to distinguish recognition and retrieval from a nearby explanation. In template copying, agents use an artefact as a template for making a new artefact. Sterelny’s ([2006]) example of such template copying is the reproduction of a spear using another as a model. Similarly, one might use the decoration of a previously made pot as a template for making the next one. But while template copying appears similar to recognition and retrieval, it is in fact still a species of copying: elements of the trait (here, artefacts) are used like a set of instructions or as a bit of external memory.[[24]](#footnote-24)

Discerning whether an agent is engaged in copying or in recognition and retrieval is a tricky empirical matter, since what is retrieved may be knowledge gained through prior instances of copying. But recognition and retrieval is a genuine phenomenon that can be invoked in controlled circumstances, and in such circumstances, generates mere recurrence.

## **4.4 Marginal Culture and Mere Recurrence in Contemporary Research: the ZLS and CE**

The problem of mere recurrence is to distinguish genuine cumulative cultural traditions—traits resulting from copying know-how—from those that result from other processes. Especially in social animals, this can be exceptionally demanding.

Consider birdsong. Research has shown that many oscine birds have a window of developmental time at which they are sensitive to imprinting the song of mature individuals. These ‘close-ended learners’ use the imprint as a template that they attempt to match with their own vocalizations. This process of individual learning may itself be influenced by biases. This may include biases to attend to certain stimuli (conspecific songs of mature individuals) and to produce certain song elements. Zebra finches, for instance, appear to be biased towards producing a limited repertoire of song elements, such that if reared without exposure to wild-type songs, will eventually ‘reinnovate’ such song forms after several generations (Fehér *et al.* [2009]). What this work demonstrates is that distinguishing the contribution of different learning mechanisms, biases, and constraints is empirically tractable, but demanding.[[25]](#footnote-25)

Nonetheless, we think distinguishing these different ways in which mere recurrence can be explained can be helpful for formulating hypotheses about putative instances of marginal cumulative culture, and for distinguishing nearby positions in the literature.

Consider as a case study, a recent argument by Scott-Phillips ([2017]) who argues that two different research programs—the Zone of Latent Solutions (‘ZLS’) and cultural epidemiology (‘CE’)—are aligned. Examining this proposed alignment is interesting, in part because both the ZLS and CE have argued that putative instances of cumulative culture can sometimes be instances of mere recurrence. According to Scott-Phillips, both the ZLS and CE appeal to mechanisms of inferential reconstruction to explain cultural transmission, and this framework suffices for identifying and explaining instances of mere recurrence. Inferential reconstruction is what CE researchers call a ‘cognitive factor of attraction’: a causal influence on cognitive processes that bias the content of what is learned (Sperber [1996]; Buskell [2017]). Inferential reconstruction is thus a kind of copying (in our technical sense), facilitating the acquisition of trait elements and relationships—even if inferential biases mean that the episodic fidelity of any instance of learning may be low.

As noted above, CE researchers identify biases on inferential reconstruction using transmission chain experiments. Such experiments also reveal instances where something akin to lossless duplication occurs. When presented with a familiar stimulus like a star, participants readily replicate it—when the stimulus is the string ‘ABC’, participants can replicate the string ‘ABC’ (Sperber [2000]; Scott-Phillips [2017]). How can this be explained? CE researchers suggest this is an instance of recognition and retrieval: when passed the string ‘ABC’ and told to replicate it, participants recognise the stimuli, and can reproduce it by retrieving know-how from their repertoire. Importantly, however, such recognition occurs on the basis of past copying: learning how to draw a star or write the string ‘ABC’ relies on the past acquisition of know-how.

Researchers working on the ZLS allow for copying—in humans—but claim that many non-human animals do not have such capacities. According to the ZLS, many putative instances of animal culture are recurrent traits that result from individuals deploying elements from baseline repertoires, what they call form reinnovation. So if Scott-Phillips is right, then ‘reinnovation’ is something similar to inferential reconstruction.

Yet there are good reasons to distinguish the two. Consider the most well-developed body of work by ZLS researchers on apes. Such work has shown that what best explains the deployment of know-how by apes is not the past exercise of copying, but instead socially facilitated limited repertoire exploration. A few lines of evidence support this general claim: (i) apes do not copy know-how outside their baseline repertoires (Tennie *et al.* [2012]; Clay and Tennie [2017]); (ii) apes can reinnovate ‘complete’ traits when given partial demonstrations of trait form (Tennie *et al.* [2010]); (iii) apes in the lab can also spontaneously reinnovate putative cultural traits even without partial demonstrations (Tennie *et al.* [2017]); and (iv) many abilities (like copying know-how) taught to captive apes require substantial training and are extinguished without continuing support (Tennie [2019]). This evidence suggests constraints on the learning and production of ape know-how.

Despite some superficial similarities between the CE and the ZLS, there are good reasons to distinguish the two. For one, they seem interested in different questions. CE researchers are interested in the causal influences on human learning and highlight how such sophisticated capacities can lead to situations that appear to be cumulative—in fact, appear to be lossless duplication—but are in fact instances of mere recurrence resulting from the recognition and retrieval of previously acquired know-how. ZLS researchers by contrast are interested in the learning capacities of animals, and in determining whether any instances of animal culture are the result of copying know-how. In particular, ZLS researchers argue that ape cultures are indeed instances of mere recurrence explained by limited, but socially mediated, repertoire exploration in the absence of copying.

## **5 Conclusion**

Our arguments have made progress on four goals.

First, we argued against the consensus formulation of cumulative culture, and for our minimal formulation. In particular, we have argued against incremental improvement as a necessary component of cumulative culture and for the idea that cumulative culture should accommodate all instances of modification and retention—whether these are adaptively neutral or maladaptive.

Second, in arguing against the consensus formulation, we have shown that several key concepts—widespread in the cultural evolutionary literature—are lumped. Separating out processes from products, different types of knowledge transmission, and two distinct kinds of fidelity, we have argued that cumulative culture involves the social transmission of know-how in a way that causally depends on the form of past trait tokens. This we call ‘copying’ or ‘copying know-how’. This deflationary account of learning that supports cumulative culture is better able to identify putative instances of marginal cumulative culture.

Third, we’ve argued that by adopting our minimal formulation of cumulative culture—and in particular, by rejecting incremental improvement as necessary—we can formulate the key empirical problem facing putative instances of cumulative culture at the margins. The simple traits of social animals might be cumulative cultural traditions—but they might equally be an instance of mere recurrence. Equifinality means that recurrent behaviours may be the result of innate responses, limited repertoire exploration, or recognition and retrieval. Only recurrence that involves copying know-how are instances of cumulative culture but identifying when and where this occurs is a demanding empirical task.

Lastly, we’ve shown how our conceptual tools can distinguish between the commitments and accounts of positions that might appear to be overlapping in the literature. As we’ve shown, the CE and ZLS are committed to different explanations of mere recurrence, and indeed, appeal to very different kinds of cognitive mechanisms and explanatory targets in their accounts.

Because of the limitations on space, our discussion has left untouched a great deal of the empirical work on marginal cumulative culture. There are now substantial literatures on the putative cultural traditions of cetaceans, avians, canines, panins, and other organisms besides. It has also skirted past the similarly large literature looking at the evolution of capacities for learning, and narratives purporting to explain the super-charged cultural capacities of hominins. Given the focus of this essay—on developing conceptual tools—we hope these absences excusable. In future work, we hope to show how these tools can contribute to the stringent design and demanding analyses required in these literatures. Ultimately, we hope that this endeavour will help make sense of not only why hominins developed capacities that can generate paradigmatic cumulative culture, but when such a transition might have taken place.

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**References**

Acerbi, A. and Mesoudi, A. [2015]: ‘If We Are All Cultural Darwinians What's the Fuss About? Clarifying Recent Disagreements in the Field of Cultural Evolution’, *Biology & Philosophy* **30**, pp. 481–503.

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

Bandini E., Motes-Rodrigo, A. Steele, M., Rutz, C. and Tennie, C. [2020]: ‘Examining the Mechanisms Underlying the Acquisition of Animal Tool Behaviour’, *Biology Letters* **16**: 20200122.

Bentley, R. A., Hahn, M. W. and Shennan, S. J. [2004]: ‘Random Drift and Culture Change’ *Proceedings of the Royal Society B: Biological Sciences,* **271**, pp. 1443–50.

Blackmore, S. [1999]: *The Meme Machine*, Oxford: Oxford University Press.

Boyd, R. and Richerson, P. J. [1985]: *Culture and the Evolutionary Process*, Chicago: Chicago University Press.

Boyd, R. and Richerson, P.J. [2005]: *The Origin and Evolution of Cultures*. Oxford: Oxford University Press.

Boyd, R., Richerson, P. J. and Henrich J. [2013]: ‘The Cultural Evolution of Technology: Facts and theories’, in P. J. Richerson and M. H. Christiansen (*eds*.), *Cultural Evolution: Society, Language, and Religion*, Cambridge, MA: The MIT Press, pp. 119–42.

Bruno, J. H., Jarvis, E. D., Liberman, M. and Tchernichovski, O. [2021]: ‘Birdsong Learning and Culture: Analogies with Human Spoken Language’, *Annual Reviews of Linguistics*, **7**, pp. 449–72.

Buskell, A. [2017]: ‘What are Cultural Attractors?’ *Biology & Philosophy*, **32**, pp. 1–18.

Buskell, A. [2018]: ‘Causes of Cultural Disparity: Switches, Tuners, and the Cognitive Science of Religion’, *Philosophical Psychology*, **31**, pp. 1239–64.

Buskell A. [2020]: ‘Cumulative Culture and Complex Cultural Traditions’, *Mind & Language*, available at: <https://doi.org/10.1111/mila.12335>.

Caldwell, C. A. [2020]: ‘Using Experimental Research Designs to Explore the Scope of Cumulative Culture in Humans and Other Animals’, *Topics in Cognitive Science*, **12**, pp. 673–89.

Cavalli-Sforza, L. L. and Feldman, M. W. [1981]: *Cultural Transmission and Evolution: A Quantitative Approach*, Princeton: Princeton University Press.

Charbonneau, M. [2019]: ‘Understanding Cultural Fidelity.’ *The British Journal for the Philosophy of Science*, **71**, pp. 1209-33.

Chemero, A. [2009]. *Radical Embodied Cognitive Science*. Cambridge, MA: MIT Press.

Clay, Z. and Tennie, C. [2017]: ‘Is Overimitation a Uniquely Human Phenomenon? Insights From Human Children as Compared to Bonobos’, *Child Development,* **89**, pp. 1535–44.

Cowie, F. [1999]: *What's Within?* Oxford: Oxford University Press.

Dawkins, R. [1976]: *The Selfish Gene*, Oxford: Oxford University Press.

Dean, L. G., Vale, G. L., Laland, K. N., Flynn, E. and Kendal, R. L. [2014]: ‘Human Cumulative Culture: A Comparative Perspective’, *Biological Reviews* **89**, pp. 284–301.

Eriksson, K. and Coultas, J. C. [2014]: ‘Corpses, Maggots, Poodles and Rats: Emotional Selection Operating in Three Phases of Cultural Transmission of Urban Legends’, *Journal of Cognition and Culture* **14**, pp. 1–26.

Fehér, O., Wang, H., Saar, S., Mitra, P. P. and Tchernichovski, O. [2009]: ‘De Novo Establishment of Wild-type Song Culture in the Zebra Finch’, *Nature* **459**, pp. 564–69.

Floridi, L. [2015]: ‘Semantic Conceptions of Information’, in E. Zalta (*ed*.) *Stanford Encyclopedia of Philosophy*, available at: <<https://plato.stanford.edu/entries/information-semantic/>>.

Flynn E. G., Laland, K. N., Kendal R. L. and Kendal, J. R. [2013]: ‘Developmental Niche Construction’, *Developmental Science* **16**, pp. 296–313.

Fridland, E. and Moore, R. [2014]: ‘Imitation Reconsidered’, *Philosophical Psychology*, **28**, pp. 856–80.

Haidle, M. N. and Schlaudt O. [2020]: ‘Where Does Cumulative Culture Begin? A Plea for a Sociologically Informed Perspective.’ *Biological Theory*, **15**, pp. 161–74.

Haidle, M. N. and Schaludt, O. [2021]: ‘Not Necessarily Additive, Linear, or Beneficial’, *Current Anthropology,* **62**, pp. 224–25.

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. [2016]: *The Secret of our Success: How Culture is Driving Human Evolution, Domesticating our Species, and Making us Smarter,* Princeton: Princeton University Press.

Henrich, J. and Gil-White F. J. [2001]: ‘The Evolution of Prestige: Freely Conferred Deference as a Mechanism for Enhancing the Benefits of Cultural Transmission’, *Evolution and Human Behavior*, **22**, pp. 165–96.

Heyes, C. M. [1994]: ‘Social Learning in Animals: Categories and Mechanisms’, *Biological Reviews,* **69**, pp. 207–31.

Heyes, C. M. [2018]: *Cultural Gadgets: The Cultural Evolution of Thinking*, Cambridge, MA: Harvard University Press.

Hoppitt, W. and Laland, K. N. [2013]: *Social Learning: An Introduction to Mechanisms, Methods, and Models,* Princeton: Princeton University Press.

Kelly R. L. [2013]: *The Lifeways of Hunter-Gatherers: The Foraging Spectrum*, Cambridge: Cambridge University Press.

Lewens T. [2015]: *Cultural Evolution: Conceptual Challenges*, Oxford: Oxford University Press.

Lombard, M. [2016]: ‘Mountaineering or Ratcheting? Stone Age Hunting Weapons as Proxy for the Evolution of Human Technological, Behavioral and Cognitive Flexibility’, in M. N. Haidle, N. J. Conard and M. Bolus (*eds*.) *The Nature of Culture*. Dordrect: Springer, pp. 135-46.

Machamer P., Darden, L. and Craver, C. F. [2000]: ‘Thinking About Mechanisms’, *Philosophy of Science* **67**, 1—25.

Mesoudi, A. and Thornton, A. [2018]: ‘What is Cumulative Cultural Evolution?’ *Proceedings of the Royal Society B: Biological Sciences*, **285**: 20180712.

Mesoudi, A. and Whiten A. [2004]: ‘The Hierarchical Transformation of Event Knowledge in Human Cultural Transmission’, *Journal of Cognition and Culture* **4**, pp. 1–24.

McGrew, W. C. [2009]: ‘Ten Dispatches from the Chimpanzee Culture Wars, Plus Postscript (Revisiting the Battlefronts)’, in K. N. Laland and B. G. Galef (*eds*.) *The Question of Animal Culture*, Cambridge, MA: Harvard University Press, pp. 41–61.

Morin, O. [2016]: *How Traditions Live and Die*, Oxford: Oxford University Press.

Northcott, R. and Piccinini, G. [2018]: ‘Conceived This Way: Innateness Defended’, *Philosopher’s Imprint* **18**: 18.

Palagi, E., Celeghin, A., Tamietto, M., Winkielman, P. and Norscia, I. [2020]: ‘The Neuroethology of Spontaneous Mimicry and Emotional Contagion in Human and Non-human Animals’, *Neuroscience and Biobehavioral Reviews*, **111**, pp. 149–65.

Pradhan, G. R., Tennie, C. and van Schaik, C. P. [2012]: ‘Social Organization and the Evolution of Cumulative Technology in Apes and Hominins’, *Journal of Human Evolution*, **63**, pp. 180–90.

Reindl, E., Apperly, I. A., Beck, S. R. and Tennie, C. [2017]: ‘Young Children Copy Cumulative Technological Design in the Absence of Action Information’, *Scientific Reports* **7**: 1788.

Risjord, M. [2012]: ‘Models of Culture’, in H. Kincaid (*ed*.) *The Oxford Handbook of the Philosophy of Social Science*, Oxford: Oxford University Press, pp. 387–408.

Renner, E., Patterson, E. M. and Subiaul, F. [2020]: ‘Specialization in the Vicarious Learning of Novel Arbitrary Sequences in Humans but not Osrangutans’, *Philosophical Transactions of the Royal Society B,* **375**: 20190442.

Scott-Phillips, T. C. [2017]: ‘A (Simple) Experimental Demonstration that Cultural Evolution is not Replicative, but Reconstructive — and an Explanation of Why this Difference Matters’, *Journal of Cognition and Culture* **17**, 1—11.

Stanley, J. and Williamson, T. [2001]: ‘Knowing How’, *The Journal of Philosophy* **98**, 411–44.

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

Sperber, D. [2000]: ‘An Objection to the Memetic Approach to Culture’, in R. Aunger (*ed*.), *Darwinizing Culture: The Status of Memetics as a Sscience,* Oxford: Oxford University Press, pp. 163–73.

Sterelny, K. [2006]: ‘The Evolution and Evolvability of Culture’, *Mind & Language* **21**, 137–65.

Sterelny, K. [2012]: *The Evolved Apprentice: How Evolution Made Humans Unique*, Cambridge, MA: The MIT Press.

Sterelny, K. [2021a]: Foragers and Their Tools: Risk, Technology and Complexity. *Topics in Cognitive Science*, available at: <https://doi.org/10/1111/tops.12559>.

Sterelny, K. [2021b]: *The Pleistocene Social Contract*, Oxford: Oxford University Press.

Tamariz M. and Kirby, S. [2014]: ‘Culture: Copying, Compression, and Conventionality’, *Cognitive Science,* **39**, pp. 171–83.

Tennie, C. [2019]: ‘Could Nonhuman Great Apes Also Have Cultural Evolutionary Psychology?’ *Behavioral and Brain Sciences* **42**, pp. 37–9.

Tennie, C., Call, J. and Tomasello, M. [2009]: ‘Ratcheting up the Ratchet: On the Evolution of Cumulative Culture’, *Philosophical Transactions of the Royal Society B: Biological Sciences* **364**, pp. 2405–15.

Tennie, C., Call, J. and Tomasello, M. [2010]: ‘Evidence for Emulation in Chimpanzees in Social Settings Using the Floating Peanut Task’, PLoS One **5**: e10544.

Tennie, C., Call, J. and Tomasello, M. [2012]: ‘Untrained Chimpanzees (*Pan troglodytes schweinfurthii*) Fail to Imitate Novel Actions’, *PLoS One* **7**: e41548.

Tennie, C., Premo, L. S., Braun, D. R. and McPherron, S. P. [2017]: ‘Resetting the Null Hypothesis: Early Stone Tools and Cultural Transmission’, *Current Anthropology* **58**, pp. 652–72.

Tennie, C., Hopper, L. and van Schaik, C. P. [2020]: ‘On the Origin of Cumulative Culture: Consideration of the Role of Copying in Culture-dependent Traits and a Reappraisal of the Zone of Latent Solutions Hypothesis’, in S. Ross and L. Hopper (*eds*.) *Chimpanzees in Context: A Comparative Perspective on Chimpanzee Behavior, Cognition, Conservation, and Welfare*, Chicago: University of Chicago Press, pp. 428–53.

Tomasello, M. [1999]: *The Cultural Origins of Human Cognition*, Cambridge, MA: Harvard University Press.

Tomasello, M. [2014]: *A Natural History of Human Thinking,* Cambridge, MA: Harvard University Press.

Tooby, J. and Cosmides, L. [1992]: ‘The Psychological Foundations of Culture’, in J. H. Barkow, L. Cosmides and J. Tooby (*eds*.) *The Adapted Mind: Evolutionary Psychology and the Generation of Culture*, Oxford: Oxford University Press, pp. 19–136.

Wasielewski, H. [2014]: ‘Imitation is Necessary for Cumulative Cultural Evolution in an Unfamiliar, Opaque Task’, *Human Nature*, **25**, pp. 161–79.

Whiten, A., Goodall, J. McGrew, W. C., Nishida, T., Reynolds, V., Sugiyama, Y., Tutin, C. E. G., Wrangham, R. W., and Boesch, C. [1999]: ‘Cultures in Chimpanzees’, *Nature*, **399**, pp. 682–85.

Whiten, A. and Ham, R. [1992]: ‘On the Nature and Evolution of Imitation in the Animal Kingdom: Reappraisal of a Century of Research’, *Advances in the Study of Behavior* **21**, pp. 239–83

Woodward, J. [2003]: *Making Things Happen: A Theory of Causal Explanation*, Oxford: University Press.

Woodward, J. [2010]: ‘Causation in Biology: Stability, Specificity, and the Choice of Levels of Explanation’, *Biology & Philosophy*, **25**, pp. 287–318.

1. In speaking of ‘culture’ and ‘cultural traits’ here, we have in mind the way these terms are operationalized and used in the evolutionary sciences, especially the literature in cultural evolution. This literature takes ‘culture’ to be information pools, and ‘cultural traits’ to be units of information or the expression of that information in behaviour. This use of the culture concept (and nearby ones, like ‘cultural trait’) contrasts with other uses familiar from the anthropological literature. For a survey of different models of culture, see: Risjord ([2012]). [↑](#footnote-ref-1)
2. This characterization develops Whiten and Ham’s ([1992], p. 247) definition of imitation as ‘B learns from A some part of the form of a behaviour’. The subsequent literature on imitation, however, has developed numerous and different definitions of imitation, many of which identify it with the activities of particular cognitive mechanisms (for instance; theory of mind, sensorimotor contingencies). One of our motivations for developing Whiten and Ham’s insight in terms of copying is to avoid committing the present analyses to such account of underlying mechanisms. For some reviews of the definitional issues around imitation, see: Heyes ([1994]); Hoppitt and Laland ([2013]); Fridland and Moore ([2014]). [↑](#footnote-ref-2)
3. We understand the ‘fine-grained’ nature of the dependency relationship as an expression of what Woodward ([2010]) would call ‘proportionality’: a standard for evaluating the accuracy and relevance of causal descriptions including all and only the information about the conditions under which relevant alternative effect-states will be realized (see also: Buskell [2018] for the application of such tools to culture). It should further be noted that though we use Woodward’s ([2003]) terminology, nothing substantive in this paper hangs on whether one adopts a manipulationist account of causation. [↑](#footnote-ref-3)
4. We use ‘know-how’ in an encompassing sense, picking out that knowledge involved in producing a particular trait (e.g. how to make a bow and arrow, how to dance the tango). We do not, however, take a stance on the philosophical literature that attempts to distinguish ‘know-how’ from ‘know-that’ or other ‘know-wh’s’ (Stanley and Williamson [2001]). [↑](#footnote-ref-4)
5. Recent reviews of the cumulative cultural literature can be found in Dean *et al.* ([2014]) and Mesoudi and Thornton ([2018]). Canonical characterizations of cumulative culture and the ‘ratchet effect’ can be found in Tomasello ([1999]); Boyd and Richerson ([2005]), and Tennie *et al.* ([2009]). [↑](#footnote-ref-5)
6. A nearby effort comes from Haidle and Schlaudt ([2020]), who argue for a radical reformulation of the cumulative culture concept around that of ‘habitus’ and Lombard’s ([2016]) ‘mountaineering’ metaphor of cumulative cultural change. While we agree that culture is a complex phenomenon, and just one of several inheritance systems (Avital and Jablonka [2000]), we would resist these authors eliminativist tendencies: we don’t want scientists ‘refraining from speaking of [cumulative cultural evolution]’. (Haidle and Schlaudt [2021], p. 225) [↑](#footnote-ref-6)
7. This leaves open how to concretely operationalize trait form. There are several plausible candidates in the literature (for a survey, see Buskell [2020]). One that seems useful for marginal cumulative culture is Pradhan *et al.*’s ([2012]) account of ‘technological levels’. [↑](#footnote-ref-7)
8. This characterizes a potentially expansive set of learning mechanisms. We leave this dependency claim at a general level anticipating that mechanisms in this set may display differential sensitivity to aspects of trait form. [↑](#footnote-ref-8)
9. Though we do not have the space to pursue the issue here, the use of ‘information’ in cultural evolution might benefit from greater attention to the philosophy of information, which has developed fine-grained tools for describing and analysing this polysemous term and its uses (Floridi [2015]). We thank an anonymous reviewer for pressing us on this point. [↑](#footnote-ref-9)
10. These have been helpfully gathered by Mesoudi and Thornton ([2018]). Critical reviews can be found in Sperber ([2000]) and Morin ([2016]). A helpful review of the experimental literature can be found in Caldwell ([2020]). [↑](#footnote-ref-10)
11. This is not to say that the determination of either propensity or episodic fidelity is easy. Trait forms are often complex, with elements and interrelationships at multiple levels of organization. This produces difficulties in determining the relevant level of grain for comparison (Acerbi and Mesoudi [2015]). [↑](#footnote-ref-11)
12. One might also worry that it is insufficient too, for instance, in situations where one lacks the relevant material or social resources to imitate. One might be able to imitate but have no one to copy—or one might lack the relevant materials to imitate the production of a particular artefact. [↑](#footnote-ref-12)
13. Note that negative or aversive information can also be transmitted, something one might call “know-how-not” or “know-what-not”. [↑](#footnote-ref-13)
14. It may also allow for fidelity comparisons of mechanisms that support learning of other knowledge types. Consider that honeybees have high-fidelity mechanisms for teaching, transmitting, and acquiring know-where information about both direction and distance to food sources. Yet these mechanisms do not support high-fidelity transmission in other knowledge categories. Waggle dances do not transmit know-how: each bee develops and uses the know-how to fly, land, and collect food on their own. [↑](#footnote-ref-14)
15. Even if the underlying mechanisms involved are overlapping, the nature of the task can lead to operational differences from case to case (Tennie *et al.* [2009]). Cross-species comparisons add further complications, as different species might be able to learn some types of knowledge socially, but not others. Data by Renner *et al.* ([2020]), for instance, shows that while orangutans lack spontaneous abilities for transmitting know-what, they have those for transmitting know-where. It is also plausible that mechanisms of learning may differ in their propensity fidelity at different points in development. [↑](#footnote-ref-15)
16. Though see Sterelny (2021a) for an analysis that questions the quick inference between complexity, adaptiveness, and the size of hunter-gatherer toolkits. [↑](#footnote-ref-16)
17. Though similar, the accumulation of adaptiveness, complexity, and efficiency are conceptually and empirical distinct (Buskell [2020]). [↑](#footnote-ref-17)
18. Lombard ([2016]) makes a similar point with the metaphor of ‘mountaineering’, suggesting that while cumulative culture is ‘anchored’ in past trait tokens, there are many flexible routes by which these traits can lead to further cumulative change. [↑](#footnote-ref-18)
19. For an example of this see bone tool ‘lissoirs’, which may remain static due to functionally optimality, see: Tennie *et al.* ([2020]). [↑](#footnote-ref-19)
20. We follow Northcott and Piccinini ([2018]) in treating ‘innateness’ as a contrastive causal claim sensitive to the explanatory concerns of the question at stake. [↑](#footnote-ref-20)
21. For an expansive review of the contagion literature, see: Palagi *et al.* ([2020]). [↑](#footnote-ref-21)
22. Note that the terminology of innateness went out of fashion in behavioural biology, due to the realisation that behaviour is in most cases flexibly developed. But our point holds true also for these accounts as long as the trait develops in similar form across individuals without the need to copy know-how. [↑](#footnote-ref-22)
23. As we will expand in more detail later, these claims about limitations are *ceteris paribus* claims. As explanations on ape language have shown, apes are able to add behavioural elements (signs, symbols) to their behavioural repertoire and reproduce them, but do so only after substantial learning trials in human-structured environments, and such behaviour is quickly extinguished without such support (Tennie [2019]). [↑](#footnote-ref-23)
24. Template copying itself is frequently used in ‘microsociety’ experiments, an experimental paradigm similar to transmission chains. In such experiments with children, copying templates can support learning of know-how that did not occur in baseline conditions (Reindl *et al.* [2017]). [↑](#footnote-ref-24)
25. It is important to note that zebra finches are not representative of all the oscines, and that there is cross-species variation not only in the timings of the various processes involved in song learning, but also in the mechanisms by which songs are learned and the learning strategies involved (Bruno *et al.* [2021]). This further points to the demanding empirical work needed to distinguish cumulative cultural traditions from those of mere recurrence. [↑](#footnote-ref-25)