



Cumulative culture and future thinking: Is mental time travel a prerequisite to cumulative cultural evolution?

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ARTICLE INFO

Available online 28 August 2012

Keywords:

Future thinking
Episodic foresight
Mental time travel
Cumulative culture
Social learning
Ratcheting

ABSTRACT

Cumulative culture denotes the, arguably, human capacity to build on the cultural behaviors of one's predecessors, allowing increases in cultural complexity to occur such that many of our cultural artifacts, products and technologies have progressed beyond what a single individual could invent alone. This process of cumulative cultural evolution underlies human cultural success and has enabled us to reach and inhabit some of the most inhospitable environments on this planet. Why humans, but not other animals, have exhibited a cultural explosion has caused much deliberation. The human propensity to imitate, teach, "mind-read" and cooperate have all featured prominently in accounts of the prerequisites for cumulative culture. However, this may not represent the complete picture. In this article we consider whether there exists a link between future thinking, specifically prospective mental time travel, and the observed distribution of cumulative culture.

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Re-experiencing events from one's past and imagining events in one's future is referred to as "mental time travel" (Suddendorf & Corballis, 1997; Tulving, 2002a) and is well documented in humans (*Homo sapiens*). Many of the decisions we make in our daily lives involve some form of prospective thinking – imagining future scenarios by recasting past experiences – which, in turn, enables us to anticipate our likely reactions to potential future events. This ability releases humans from living solely in the present (Suddendorf & Busby, 2005; Suddendorf & Corballis, 2007), allowing the human lineage to act now to secure or avoid probable futures. In this paper we examine the implications of this release from the present, afforded by mental time travel and future thinking. Specifically, we examine whether the extent of future thought present in humans and nonhuman animals (henceforth referred to as animals) has influenced their extent of cumulative culture, a proposition that has received little attention. Since research effort in both domains has predominantly centered upon corvids and great apes, we restrict our discussions to these species.

Mental Time Travel and Episodic Thought in Nonhuman Animals

Much of the evidence of early future thinking in humans has been heavily reliant on verbal tasks (Atance & Meltzoff, 2005; Busby & Suddendorf, 2005; Hudson, Shapiro, & Sosa, 1995), posing a considerable hurdle when searching for comparable modes of future thinking in animals. This is especially true for the study of episodic foresight and mental time travel since they include a phenomenological component whereby the content of projections incorporate an awareness of self in subjective time (Tulving, 2002b), rendering them particularly difficult to assess without the aid of introspection and language. Despite

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this, considerable progress has been made in identifying behavioral markers of future thinking that can be tested in non-verbal species (Suddendorf & Busby, 2005).

Many animal behaviors are orientated toward the future: for example, hibernation constitutes a fixed behavioral pattern that is orientated to future survival (Suddendorf & Corballis, 2007). While such behaviors are clearly adapted toward the future, fixed behavioral patterns do not necessitate future thought. In contrast, human modes of future thinking, present in young children (Busby & Suddendorf, 2005; Hayne, Gross, McNamee, Fitzgibbon, & Tustin, 2011), extend beyond fixed behavioral patterns to incorporate flexible forms of cognition that allow present behavior to be tailored toward possible future events. Thus, the question is posed: do all future orientated behaviors present in the animal kingdom represent relatively fixed evolved behavioral solutions, or can animals engage in mentally traveling backwards and forwards in subjective time? That is, as phrased by Roberts (2002, p. 473), “are animals stuck in time?”

Innovative studies have investigated the extent to which animals anticipate future events (discussed in Roberts, 2012; see also Martin-Ordas, Atance, & Louw, 2012). Chimpanzees, bonobos and orangutans (*Pan troglodytes*, *P. paniscus*, and *Pongo pygmaeus*) have been found to select and retain functionally appropriate tools that enabled them to obtain future rewards, indicating future planning capabilities and perhaps even anticipation of future hunger (Mulcahy & Call, 2006; Osvath & Osvath, 2008). In corvids, scrub jays have been shown to preferentially cache food in a location they knew would be devoid of food in the forthcoming morning (*Aphelocoma californica*: Raby, Alexis, Dickinson, & Clayton, 2007) and alter their cache recovery and re-caching patterns dependent upon whether cache creation was observed by a conspecific, thus avoiding potential future cache pilfering (*A. coerulescens*: Emery & Clayton, 2001). Correia, Alexis, Dickinson, and Clayton (2007) found Western scrub jays (*A. californica*) moved beyond current motivational states, induced by food satiation, to preferentially cache food that was preferred at the time of cache recovery rather than at the time of caching (contrary to the predictions of the Bischof-Köhler hypothesis: Bischof-Köhler, 1985 and Bischof, 1978, cited in Suddendorf & Corballis, 1997). Finally, scrub jays (*A. coerulescens*) have been reported to possess “what”, “where” and “when” memories (WWW) or “episodic-like memory” (Clayton & Dickinson, 1998, 1999), which is of interest since the recall of events from the personal past has been closely linked to pre-experiencing events in the future (Addis, Wong, & Schacter, 2007; Schacter, Addis, & Buckner, 2008). Specifically, depending on the time lapse prior to cache recovery, scrub jays have been shown to recover a non-perishable food after a long delay and preferred, perishable larvae after a short delay (Clayton & Dickinson, 1998).

These examples of future thought in animals generated debate. Recent reviews by Suddendorf and colleagues raise concerns over whether such studies report genuine cases of future planning, future need anticipation and episodic thought (Suddendorf & Corballis, 2007, 2008, 2010; Suddendorf, Corballis, & Collier-Baker, 2009). The most prominent criticisms relate to the possibility of tasks being solved by associative learning rather than future need anticipation and planning (Suddendorf & Corballis, 2008, 2010), the frequent lack of control for current motivational states that could persist throughout investigations or be reinstated by cueing that negate explanations of motivation by future need (Osvath & Osvath, 2008; although see Correia et al., 2007) and the potential for behavior to be based upon semantic knowledge rather than episodic thought (the knowing versus remembering distinction; Roberts & Feeney, 2009; Suddendorf & Corballis, 2007; see Martin-Ordas et al., 2012). In line with this latter point, there is no evidence that “WWW” memories require projection of the self, a feature essential to episodic memory as described by Tulving (2001, 2005), nor the auto-noetic awareness that captures the conscious experience of recounted episodes and mental time travel. Thus, “WWW” learning may be “neither necessary nor sufficient” to surmise the presence of episodic memory or mental time travel (Zentall, 2006, p. 174).

Thus, while researchers have teased apart behavioral concomitants that may be representative of different forms of future thinking, much of the evidence in animals remains controversial. Although various animals appear capable of future cognition (see Roberts, 2012), there are at present little grounds to suppose that non-humans display mental time travel akin to humans, leading many to conclude that mental time travel, particularly into the future, is unique to our species (Atance & O’Neill, 2005; Suddendorf & Busby, 2005; Suddendorf & Corballis, 1997, 2007; Tulving, 2005). Hence we are left with the interesting question of what might be the consequence of living in the present or at least being confined to the immediate future, a question we now turn to by relating future thinking capacities to the, arguably, human capacity to ratchet up our cultural complexity.

Cumulative Culture in Humans and Animals

Culture, broadly defined, denotes group typical behavior that is transmitted via social learning (Laland & Hoppitt, 2003). Human cultures, including our technologies, artifacts and traits, have progressed over time, becoming more sophisticated, complex and efficient as generations pass. This cumulative process, often described as the “ratchet effect”, specifically encapsulates how high-fidelity social learning maintains our cultural accomplishments until such a time as new, beneficial modifications are invented, which in turn are propagated via high fidelity social learning (Tomasello, 1999). Thus, modifications accumulate across generations to gradually yield cultural products or traits that move beyond an individual’s innovation remittance (Tomasello, 1999; Tomasello, Kruger, & Ratner, 1993), or “zone of latent solutions” (Tennie, Call, & Tomasello, 2009). For example, when tracing academic achievement in various domains over the centuries, patterns of elevated knowledge discovery arise (Lehman, 1947) with contributions following a ubiquitous pattern of exponential growth (Enquist, Ghirlanda, Jarrik, & Wachtmeister, 2008). Similar cumulative processes are evident in human artifacts and artifact production; for example, Lower Paleolithic stone technology shows cumulative progression in its complexity and

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