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The development of reasoning about the temporal and causal relations among past, present, and future events

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ABSTRACT

Children's capacity to reason about temporal and causal relations among past, present, and future events was investigated. In two studies, 4- and 6-year-olds ($N = 160$) received structurally analogous search and planning tasks that required retrospective or prospective temporal–causal reasoning, respectively. The search task was compared with a closely matched control task that did not require temporal–causal reasoning. Results revealed that (a) both age groups solved the control task, (b) 6-year-olds mastered both retrospective and prospective tasks, and (c) 4-year-olds showed limited competence in both retrospective and prospective tasks. The current study, thus, suggests that flexible temporal–causal reasoning develops in parallel for past- and future-directed reasoning, is qualitatively different from simpler forms of temporal cognition, and develops during the late preschool years.

Introduction

The ontogeny of temporal cognition has been the focus of much recent research in cognitive development. Most prominent, a growing body of work has focused on the capacity to mentally reexperience the past and to preexperience the future—often called "mental time travel" (MTT) (Atance, 2008;

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Suddendorf & Corballis, 1997, 2007). Theoretically, the basic idea behind research on mental time travel is that there is a unitary capacity to cognitively travel in time that underlies our thinking about both past and future events (Atance & O'Neill, 2001; Bischof-Köhler, 2000; Tulving, 1999, 2005). Empirically, MTT research suggests that the two capacities (to reason about the past and to reason about the future) emerge in synchrony and correlated fashion between 3 and 5 years of age (see Suddendorf & Redshaw, 2013, for a review). Joint emergence and systematic correlations between past and future cognition have been found, for example, in language understanding (yesterday/tomorrow) (Busby & Suddendorf, 2005; Harner, 1975) and tasks involving the concept of a past self (delayed self-recognition) and the concept of a future self (delay of gratification) (Lemmon & Moore, 2001). In addition, adult neuroscientific work suggests shared underlying neural substrates of episodic memory and episodic foresight (Addis, Wong, & Schacter, 2007; Klein, Loftus, & Kihlstrom, 2002). Converging evidence for fundamental cognitive changes at around 3 to 5 years of age comes from related lines of research on the development of temporal language (Friedman, 2004; Harner, 1980; Hudson, Shapiro, & Sosa, 1995), episodic memory (Gopnik & Graf, 1988; Nelson, 1993; Perner & Ruffman, 1995), and future planning (Atance & Jackson, 2009; Atance & O'Neill, 2005; Russell, Alexis, & Clayton, 2010; Thompson, Barresi, & Moore, 1997).

Less focus, however, has been put on the question of which *conceptual capacities* exactly underlie children's temporal cognition. Which aspects of time do children represent and in which ways? Our folk concept of time comprises a number of essential properties of temporal matters. At a minimum, time is conceived of as a sequence of events such that each event in time bears some temporal relations to the present (having happened *before* the past or going to happen *after* it). Relatedly, any two events in time stand in a definite temporal relation to each other and are linked by causal relations such that—asymmetrically—earlier events may causally have an impact on later events (but not vice versa) (Hoerl & McCormack, 2011; Kutach, 2011).

Mature thinking about time, thus, involves the appreciation of temporal–causal relations between events and the capacity to apply this explicit conceptual representation flexibly to past and future contexts. When we know that an effect, E, is usually brought about by a cause, C, and witness E taking place, we infer that C must have happened before. And when we plan for the future, we know that when we would like E to happen at a certain point in time, t_E, we would need to bring about C at some point in time before $t_{E.}$

This kind of explicit reasoning on the basis of temporal and causal information is sometimes called temporal–causal reasoning (TCR) (Hoerl & McCormack, 2011; McCormack & Hoerl, 2005). Crucially, this form of reasoning needs to be distinguished from simpler cognitive processes with which it might be confused such as merely understanding the temporal priority principle (causes precede effects) (e.g., Bullock & Gelman, 1979; Rankin & McCormack, 2013) or—most important—from processes that are sensitive to temporal–causal relations without explicitly representing them. One example of such simpler processes is children's capacity to keep track of the causal flow of events over time (without representing it explicitly) in varieties of invisible displacement object permanence tasks (Haake & Somerville, 1985; Piaget, 1954; Somerville & Capuani-Shumaker, 1984). In typical invisible displacement tasks, participants see an object, O, being occluded, say in the experimenter's fist, at time t_1. Then the fist moves into Box 1 at t_2, reappears at t_3, and moves into Box 2 at t_4 before the empty hand reappears from Box 2 at t_5. Crucially, at t_3 the experimenter opens his or her fist and—in different conditions—shows either that O is still there or that it is not there anymore before closing the fist again. The child's task is now to determine where O is. Arguably, this task can be solved in much simpler ways. Participants do not need to explicitly reason about temporal and causal relations. Rather, over time they can simply update their representation of the whereabouts of O based on the current perceptual information (in the one case, seeing directly that O got lost in Box 1 when the hand at t_3 is empty; in the other case, seeing the object at t_3 in the hand and then keeping track of the hand with the object and seeing directly at t_5 that the object got lost in Box 2 (see McColgan & McCormack, 2008).

In contrast to explicit temporal–causal reasoning, such updating is, however, limited in fundamental ways. Although TCR works flexibly into the past and future on the basis of information about the order of events and potential causal relations (in the past, present, or future), updating can be made use of only in the present in a given situation on the basis of perceptually available information.