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What can What–When–Where (WWW) binding tasks tell us about young children's episodic foresight? Theory and two experiments☆

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ABSTRACT

We analyze theoretical differences between conceptualist and minimalist approaches to episodic processing in young children. The 'episodic-like' minimalism of Clayton and Dickinson (1998) is a species of the latter. We asked whether an 'episodic-like' task (structurally similar to ones used by Clayton and Dickinson) in which participants had to bind What (kind of object), to Where (location of object) to When (temporal duration from present) – WWW-binding – would produce the often-found developmental trajectory in episodic foresight performance of failure at 3 years, transitional performance at 4 and success at 5. Although failure at 3 years was reproduced, the performance of 4 and 5 year olds was likely affected by the executive challenge of inhibiting reference to the currently preferable item.

A survey of the recent theoretical positions on children's episodic cognition presents a rather complex picture. On the one hand, there is a division between conceptualist views of episodic abilities that equate episodic experience with 'mental time travel' (Suddendorf & Corballis, 1997; Tulving, 2005), meta-representation (Perner, 2001) and introspection (Perner, Kloo, & Gornik, 2007; Perner, Kloo, & Stöttinger, 2007) and, on the other hand, essentially 'minimalist' positions. There are two minimalist positions to be found. We call these '*episodic-like*' minimalism (Clayton & Dickinson, 1998), from comparative psychology, and '*Kantian*' minimalism (Russell, Alexis, & Clayton, 2010; Russell & Hanna, in press), from developmental psychology.

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This article has two goals: (a) to reflect on and defend these conceptual distinctions as being necessary for understanding varieties of episodic foresight in children, and (b) to ask whether a form of task inspired by Clayton and Dickinson's (1998) work can illuminate the early development of episodic foresight in children. In the latter case, this episodically minimalist procedure might unearth a more primitive form of ability.

We first describe the three theoretical positions, before explaining how the two kinds of minimalism can be applied to episodic foresight. We take the last term to equate to the 'episodic future thinking' of Atance and O'Neill (2001) and of Suddendorf and Corballis (2007) but use it in preference to that term in order to avoid the connotation of complex, step-by-step reasoning processes. We also outline work on episodic foresight inspired by Kantian minimalism (Russell et al., 2010). Finally, we report two studies that employ the episodic-like procedure – What–When–Where or WWW-binding – using a developmental approach.

1. Conceptualist theories of episodic thinking

Tulving (2005, p. 9) writes: "Episodic memory is a recently evolved late developing memory system. . .. [This] makes possible mental time travel through subjective time – past, present, future. This mental time travel allows one, as an "owner" of episodic memory ("self") through the medium of autonoetic [self knowing] awareness, to remember one's own previous "thought about" experiences, as well as to "think about" one's own possible future experiences. . .The essence of episodic memory lies in the conjunction of three concepts – self, autonoetic awareness, and subjective time. "Similarly, Suddendorf and Corballis (2007, p. 299) say: "The most flexible [form of memory] is episodic memory, which we suggest is part of a more general faculty of mental time travel that allows us not only to go back in time, but also to foresee, plan, and shape virtually any specific future event." These are clearly conceptualist views of episodic memory – as part of a cognitive system for moving subjectively through time, in both directions, armed with concepts of self and of temporal sequence.

In a similar vein, and within a developmental context, Perner (2001) proposes that there is something 'second order' about episodic cognition. It is not merely a re-experience of an episode (when of the past) but the re-representation ('meta-representation') of one's own experience conceptualised as such. According to Perner, the recollector does not merely represent an experienced encounter with the world but recollects the episode as personally experienced; to do this the recollector – or indeed future-oriented thinker – must be able to conceptualise the mental state she was in on that occasion, or will be in. This is why, Perner argues, episodic ability, such as that measured by free-recall versus cued-recall performance (Perner & Ruffman, 1995) and by direct-experience versus mediated-experience (Perner, Kloo, & Gornik, 2007; Perner, Kloo, & Stöttinger, 2007), correlates with performance on theory-of-mind tasks such as those tapping the appreciation that seeing leads to knowing and source-of-memory. A form of causal grasp is also implicated in the sense that the episodic recollector must appreciate that her present mental state was caused by the conceptualised past experience.

A third conceptualist view of episodic recall is proposed by Campbell (1994, 1997, 2002), in which the concept of temporal sequence is heavily implicated. On this view, the subject cannot have an episodic memory unless she has a conception of past time as objective and as consisting of subject-independent, particular, causally-connected event sequences. From considerations similar to these, Hoerl (2008, p. 458) suggests that "tensed thought requires a specific form of causal understanding, which animals and young children may not possess." If there is not such tensed thought, Campbell and Hoerl both imply, there can hardly be episodic past or future thinking.

2. Minimalist theories of episodic abilities

The two approaches to episodic abilities to be discussed here are minimalist in the sense that the fewest possible concepts are ascribed to the subject, leaving open the possibility that animals and children lacking adults' sophisticated conceptual apparatus might still exhibit some legitimate form of episodic memory and foresight. Of course, if some known action or object is being recalled – if, that is, there is a semantic element in the memory – this might suggest conceptual abilities; but this will not

necessarily be the case. As Kant remarked, "[H]e who sees his first tree does not know what he sees" (Kant, 1992). In other words, semantic content can be experienced without being conceptually grasped.

Episodic-like minimalism is essentially the theoretical position espoused by Tulving (1972) in his landmark chapter nearly 40 years ago that has come to serve as the framework for this position: "Episodic memory receives and stores information about temporally dated episodes or events, and temporal-spatial relations among these events" (p. 385). Clayton and Dickinson (1998) interpret this sentence to mean that so long as a creature can recall, on the basis of a single past experience, what happened where and when (WWW henceforth) it is utilizing episodic memory. In doing so they coin the term 'episodic-like memory' to make it clear that this is a definition based on behavioural evidence, stripped of any phenomenological characteristics, given the difficulty of assessing phenomenology in the absence of any agreed criteria in non-linguistic subjects.

According to Clayton and Dickinson, the food-recovery performances of the scrub jay (a food-caching bird) meets these requirements, with 'What' referring to the kind of food cached ('wax worms' – larvae – versus another less preferred food such as peanuts), 'Where' meaning the location of the cache in a sand-filled caching tray as defined by landmark cues, and When meaning how long ago the food type was cached. Note that tests were carried out in extinction, the food being removed from the caching trays by the experimenter prior to recovery, so that the birds had to rely on their memory of what they had cached where and when.

To consider 'When' in more detail, the birds refrained from re-visiting locations in which the preferred wax worms had been cached if the delay between caching and search was too long, because they had been trained to recognise that this food decayed to unpalatablility over such an interval. Instead, they visited the location in which a less preferred but long-lasting food (the peanuts) had been cached. After a shorter interval they returned to the wax worms.

Analogous abilities have been reported in the rat (Babb & Crystal, 2006) and in great apes (Martin-Ordas, Haun, Colmenares, & Call, 2010). There have been a number of subsequent studies demonstrating that scrub jay birds can keep track of foods that ripen rather than decay and that they can remember which particular perishable food decays when multiple foods are cached, each of which decays at a different rate. These experiments led Clayton and colleagues to argue that the jays encode this WWW memory in an integrated and flexible form (Clayton, Bussey, & Dickinson, 2003) – see Raby, Alexis, Dickinson, and Clayton (2007) and Correia, Dickinson, and Clayton (2007) for application of a similar experimental logic to planning-for-the-future tasks in jays. In interpreting this behaviour Clayton and Dickson call the jays' performance 'episodic-like' on the grounds that the animals cannot be interrogated about their experiences. They make no claim about the phenomenal content of the memories.

A number of commentators have resisted this kind of analysis, resulting in a vigorous debate – see Suddendorf and Busby (2003) and Suddendorf and Corballis (2008, 2010) for the sceptical case, and Clayton et al. (2008) and Cheke and Clayton (2010) for replies. For the present purposes, however, it is not necessary to address or resolve the debate about the jay data. Our concern is with the fundamental 'logic' of the WWW-binding approach and how it can be applied to young children.

In strong contrast, the second form of minimalism directly addresses the issue of the kind of phenomenal content episodic representation must have. The fundamental assumption is that if episodic memory is a form of re-experiencing, and if episodic foresight is a form or pre-experiencing, each of these must possess what is necessary for a mental representation to count as an experience at all. It is the phenomenal content of the representation that is of interest here and not the question of whether the subject can bind distance from present to kind of object and spatial location. Russell et al. (Clayton & Russell, 2009; Russell & Davies, in press; Russell et al., 2010; Russell & Hanna, in press) have argued, after Kant (1781/1998), that for something to count as an experience the possession of spatiotemporal content is necessary (the Kantian 'a priori' of space and time). The spatial element is egocentric, perspective-relative spatial content, and the temporal element is the simultaneity or succession of the elements *within* the episode. If this is correct, it follows that a necessary, but not sufficient, condition for children engaging in episodic foresight is that the mental representations involved should have egocentric spatial content.

Although the episodic-like and the Kantian views share minimalism, they are quite different. The division between them is not so great as between conceptualism and minimalism, but there certainly

is a significant divide (a) between a theory that places significant weight on 'how long ago' and a theory that ignores it completely, (b) between a theory in which 'where' is landmark-based and one in which 'where' is perspectival, and (c) between a position that eschews the phenomenal and one that embraces it.

3. Using minimalism to design new tests of children's episodic foresight

Kantian minimalism about episodic foresight entails that, insofar as the child envisages herself in some future situation, she will do so in terms of a particular *spatial* orientation. Russell et al. (2010) argued that one therefore should include an egocentric spatial element in developmental tests of episodic foresight. This point bears specifically on the use of a well-established technique (Mulcahy & Call, 2006; Osvath & Osvath, 2008; Suddendorf & Busby, 2005) for tapping episodic foresight in children and animals in which objects have to be set aside for future use. It is based on an original technique by Suddendorf (1994), later adopted by Tulving (2005), in which children are asked which objects they would like to save for a future occasion when they will be needed. For example, if there is a puzzle board in another room with no pieces of the puzzle present, and if children are told that they will be spending some time in that room, episodic foresight would be indicated by the children electing to take the puzzle pieces with them (Suddendorf & Busby, 2005). However, Russell et al. (2010) contend that as long as children are not required to envisage themselves acting in the future from a *particular position,* success on such tasks can be achieved in purely *functional* terms. That is, "their choices may be based on impersonal reasoning and functional knowledge. For example, the child's decision to take puzzle pieces with her into the room could have been based on no more than reasoning of the kind: 'Anybody left alone in that room will need puzzle pieces, so I'll pick some up'" (p. 57).

Russell et al. (2010) introduced a spatial-perspectival element into this kind of object-saving task in the following way. In their task, children played a game of blow football[1] on the first day and were asked which items they would keep behind to play the next day. Given that the ping-pong ball would be available, one such item would be the straw for blowing through, while some non-functional but semantically-associated items were not necessary (referee and team-supporter puppets, a team badge, and some football boots). The spatial element was introduced by constructing the table in such a way that it was impossible for a child to play from one of the sides because the platform was too low, making it necessary for a child to stand on a box to reach. They were told that they would play from the low-platform (unreachable) side the next day. They therefore had to save the box as well as the straw for future use. The assumption here was that at least some of the children would be encouraged to envisage themselves playing from the novel spatial perspective – one from which they had never played before.

Half of the children in the study were asked to save the items that they themselves would need to play the next day (the first-person condition). The rest of the children were asked to say which items 'another little boy/girl' would need to play the next day (third-person condition). In the latter case, it was assumed, children would be more likely to reason in an a-personal, *functional* manner, not necessarily envisioning themselves acting from a particular position in space.

The 3-year-olds were unable to complete this task (although they could perform on a version in which they had to say what they needed 'right now' to play from the other side) and the 5-year-olds performed at an above-chance level. The 4-year-olds showed a distinctive, transitional pattern of performance, performing poorly on the first-person question but above chance on the third-person question about what another child would need. The authors argued that this was so because they were indeed reasoning functionally, not episodically, in the latter case. With regard to their performance on the first-person question, Russell et al. (2010) speculated that a form of growth-error was being committed, in which they used their newly-developed capacity for Level-2 perspective taking (Flavell, Everett, Croft, & Flavell, 1981) to envisage how things would look to themselves from the other side of the table. The essence of Level 2 perspective-taking ability lies in being able to represent not only what

[1] This is a table-soccer game in which two people complete, from different sides of a table, to blow a ping-pong ball into the opponent's goal with a drinking straw.

happens to be visible but how it looks or would look – the content of a perceptual field. However, in so doing they envisaged the non-functional as well as the functional items (as these would be elements within the novel visual field).

Can we conclude from these findings that assessing episodic foresight by requiring children to envisage from a spatial perspective will result in the kind of developmental trajectory found by Russell et al. (2010)? Is the inclusion of a spatial element necessary if one is to find this developmental trajectory? This seems not to be the case because episodic foresight tasks that have *no* explicit egocentric spatial content result in a similar trajectory (Atance & Meltzoff, 2005, 2006; Busby & Suddendorf, 2005; Lemon & Moore, 2007; Moore, Barresi, & Thompson, 1998; Suddendorf & Busby, 2005). A recent study by Suddendorf, Nielsen, and von Gehlen (2011) is something of an exception to this rule in that their 4-year-olds performed above-chance on a task in which children had to save a target tool. Taking all of these studies together, we might say that performance at age 4 on non-spatial tasks of episodic foresight is 'either transitional or adequate'.

Accordingly, if spatially-perspectival tasks and tasks that are not spatially-perspectival show roughly the same pattern of development. the argument for including a spatial-processing requirement in episodic foresight studies is weakened. Moreover, it is possible that a test of episodic foresight based on WWW-binding (from 'episodic-like' minimalism) rather than spatially-perspectival processing ('Kantian' minimalism) could produce a similar developmental pattern. If the same trajectory results as the one found by Russell et al. (2010), the need for inclusion of a spatial element is further weakened. Of course, children who succeed on episodic foresight tasks may in fact be engaging in spatially-perspectival thinking; but the only *explicitly* spatial element in the Clayton–Dickinson episodic-like procedures involves the locations of the food. (In our studies, as in the Clayton–Dickinson work, a preferred food would change its palatability over a long time interval but not over a short one, with each being in a different location.)

Quite apart from the relationship between performance on this task and the blow football task, it is of some significance to determine how children perform on tests of episodic foresight in which WWW-binding is required. At present, we do not know how application of a WWW-binding, jay-inspired methodology affects behaviour on episodic foresight tasks in children. If it were to turn out that performance shows the usual pattern of failure at age 3, transitional (or adequate) performance at age 4, and success at age 5, it would suggest that (a) the two kinds of minimalist approaches are tapping something similar, and (b) whatever that is it may itself underlie or equate to what other episodic foresight tasks are measuring. If however, performance turned out to be superior to the standard trajectory, it would suggest that the scrub-jay-inspired procedures are unearthing a more primitive means of planning for the future that is available to young children.

In our task, the preferred food is chocolate and the less preferred but acceptable food is biscuits. In one location (a hot box), but not in the other (a cold box), the preferred chocolate would melt after a long interval, while the biscuits would remain palatable in both. (Children were told that they were not allowed to eat melted chocolate because of the mess it would make.) This parallels the degradation of the wax worms in the Clayton and Dickinson study. In one condition (*Future-Self*) which paralleled the first-person condition in the blow-football task, the children saw the chocolate placed in the hot box and the biscuits in the cold box, after which they were asked to predict which box they would visit to get something to eat after either a long or a short interval of time had elapsed. In the other condition (*Self-Caching*) the children were presented with the hot box only and had to choose which food they would 'cache' in it, to be retrieved after either a long or a short interval. In the latter case the children were not being asked to imagine what they would do in the future, but only to reason about the future palatability of the food.

4. Experiment 1

4.1. Method

4.1.1. Participants

One hundred and fifty children were recruited of whom 29 were excluded due to food preference (preferring biscuits to chocolate), failure to attend both sessions, or experimental error. The final sample therefore consisted of 121 children (56 girls) between the ages of 36 and 72 months ($M = 53.43$).

All participants came from predominantly English-speaking families. Children were divided into three age groups: 3 years (M = 40 months, N = 41), 4 years (M = 51 months, N = 40) and 5 years (M = 67 months, N = 40).

4.1.2. Design

Participants were assigned to one of two conditions: the *Future-Self* condition (60 children), in which children were asked to envisage their own future action, and the *Self-Caching* (61 children) condition, which required children to act in the present to secure a future benefit. Participants were further subdivided by delay, with half the children in each condition told they were to experience a long delay and half a short delay. Thus, there were three between-subjects variables: condition (2), delay (2), and age (3), with at least 10 children per cell.

4.1.3. Testing environment

The testing environment was a laboratory playroom from which all toys had been removed. Two test boxes were placed approximately 18 in. apart on a table of approximately two-and-a-half feet in height. A video camera mounted on a side wall recorded all trials.

4.1.4. Materials

Two Pro-line Mini Coolers© of dimensions 30 cm × 20 cm × 20 cm acted as the "hot" and "cold" boxes. These have the capacity to warm or cool their contents. These boxes were of identical size and materials and of contrasting colours: red for 'hot' and white for 'cold'. The boxes were further differentiated by pictures on their fronts: a sun for 'hot' and a snowman for 'cold'. The food items used were a chocolate lollypop and a plain biscuit. To illustrate the effect of heat upon items liable to melt, four drawings were shown. Two of these depicted a snowman: one intact and one melted. The second pair of drawings depicted a chocolate bar: one intact, one melted.

4.1.5. Procedure

Each child was seen individually in the laboratory playroom. Parents were instructed not to assist their child either physically or verbally during the procedure, but were permitted to encourage him or her to perform the task.

The experiment took place during two sessions separated by a 24-h delay.

4.1.5.1. Familiarisation and training: Day 1. The first session served as a training session to familiarise children with the equipment employed in the task, as well as to make them aware of the consequences of leaving the food items in the two boxes over the two different delay periods. Session one began with the child entering the laboratory playroom and being shown the two boxes. The position of the boxes relative to each other was counterbalanced across participants. Each box was opened in turn, and the experimenter placed a hand inside and patted the interior. The child was asked to do the same and asked about the temperature. They were told, "Food keeps cool and fresh in the cold box." They were then asked, "What do you think would happen if you put a small snowman inside the hot box for a long time?" To illustrate this, a drawing was shown of a snowman. Most children typically gave the correct answer, but to make sure, a second drawing was then shown depicting a melted snowman, and they were told that he would melt. Children were then asked what would happen to a bar of chocolate left in the hot box for a long time and were again shown drawings to illustrate the point. Following this, children were shown two saucers, each containing a milk-chocolate teddy bear and a rich tea finger biscuit. They were asked what the bear was made of and informed that it was chocolate. The children were then instructed to open the boxes and place one saucer in each.

Children were then given experience of the effects of delay on the foods in the boxes. The order in which the two delays were experienced was counterbalanced, such that half the children experienced 'short' then 'long' and half the reverse. For the short delay, children were told, "Let's see what happens if we leave the things for a short time," before being escorted into the adjoining room for 3–5 min. On their return, children discovered that all items had remained intact. This was made explicit by asking the children about the state of the foods, and informing them that they could still eat them.

In particular, the child's attention was drawn to the fact the chocolate teddy in the hot box was still intact over the short delay.

For the long delay, the child was encouraged to "see what happens when we leave the things for a long time." Children then either accompanied their parent outside the building or played in another room in the building for 30–45 min. Over this delay period, the chocolate teddy bear in the hot box would melt completely, while the remaining three food items would remain intact. Upon returning, children were invited to inspect the contents of the two boxes, and in doing so it was stressed to them that items in the cold box had been kept fresh, the biscuit in the hot box had not melted and was still edible, but that "the chocolate teddy in the hot box has melted because we left it there for a long time." It was then pointed out that they could no longer eat the melted chocolate teddy because it had come off its stick and it would make a "terrible mess" if they attempted to do so.

Having experienced both delays, children were invited to select either an intact chocolate teddy or an intact biscuit to eat. Since preference for chocolate is necessary to the design of the study, children who chose the biscuit were not invited to return for the second (test) session, as noted earlier.

4.1.5.2. Test: Day 2. Upon arriving for the test phase of the experiment at the same time the next day, children were asked three pretest questions: 1. "What happens to chocolate in the hot box when you go next door for a short time?" 2. "What happens to chocolate in the hot box when you leave it for a long time?" 3."Are we allowed to eat melted chocolate?" After children's answers were recorded, they were presented two saucers, one containing an intact chocolate teddy, one containing an intact biscuit. The next stage differed according to condition.

For the *Future-Self* condition, children were asked to place the saucer with the chocolate teddy into the hot box and the saucer containing the biscuit into the cold box. They were then told that they would be going away for a long/short time and that when they returned, they would be able to have the food from *one* of the boxes. They were then asked the test question: "Which box do you think that you will open when you come back after a long/short time?"

For the *Self-Caching* condition, children were presented with only the hot box and told that the cold box "isn't working today." They were then informed that they were going to be going away for a long/short time and when they came back they would be able to have the food that was inside. They were then asked the test question: "Which food do you want to put in the hot box before we go away for a long/short time?"

The children's answers were recorded. They were taken with their parents to play for the appropriate amount of time. When they returned after the delay they were invited to open either box (Future-Self condition) or the hot box (Self-Caching condition) and inspect the contents. Regardless of their choice, they were then given the choice of an intact chocolate teddy and a biscuit. The latter choice served to establish the consistency of food preferences. No data were counted from children who opted for the biscuit.

4.1.6. Scoring

Children were recorded as performing correctly if they cached or predicted that they would choose the biscuit (if they experienced the short delay) or the cake (if they experienced the long delay).

4.1.7. Analysis

Analysis was predominantly binomial distribution tests and a Generalized Linear Model with a binomial scale response and a logit link function.[2]

4.2. Results and discussion

Inspection of Fig. 1 suggests that both delay and age affected performance. This was confirmed by the loglinear analysis: delay, $\chi^2(1) = 12.91$, $p = 0.001$; age: $\chi^2(1) = 6.02$, $p = 0.049$. There was no

[2] For pairwise comparisons, alpha values were adjusted proportional to the number of comparisons, using the formula $1 - (1 - 0.05)^{1/x}$.

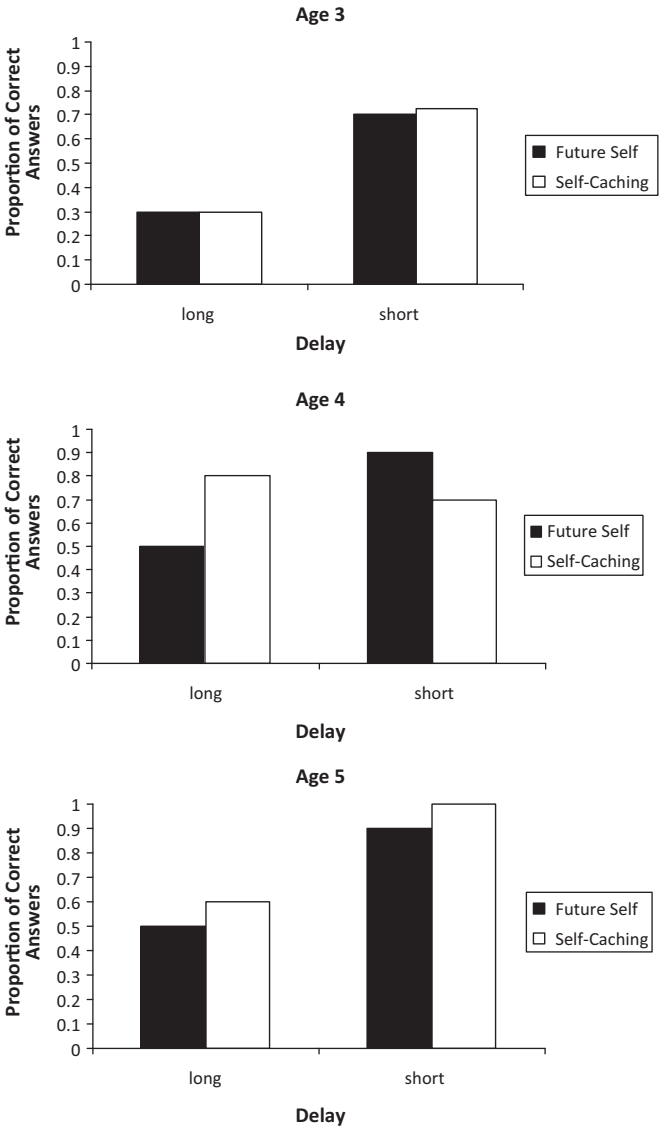

Fig. 1. Percentage of correct answers to test questions at three age levels under the Future Self and the Self-Caching conditions, and with two delay conditions, in Experiment 1 (10 children per cell and 11 at age 3 in Self-Caching short delay).

age × delay interaction, $\chi^2(1) = 2.38$, $p = 0.304$). Additionally, performance of the 3-year-olds did not differ significantly from chance, $\chi^2(1) = 0.02$, $p = 0.876$, while that of the 4- and 5-year-olds did, $\chi^2(1) = 8.10$, $p = 0.004$ and $\chi^2(1) = 10.00$, $p = 0.002$, respectively.

In the Self-Caching condition, 3-year-olds did not differ significantly from chance ($\chi^2(1) = 0.05$, $p = 0.83$) but 4- and 5-year-olds did, $\chi^2(1) = 5.00$, $p = 0.025$ and $\chi^2(1) = 7.20$, $p = 0.007$ respectively (see Fig. 2). In the Future-Self condition, no age group differed significantly from chance, 4- and 5-year-olds did show a trend toward better-than-chance performance: 3-year-olds, $\chi^2(1) = 0$, $p = 1.0$; 4-year-olds, $\chi^2(1) = 3.20$, $p = 0.074$; 5-year-olds, $\chi^2(1) = 3.20$, $p = 0.074$.

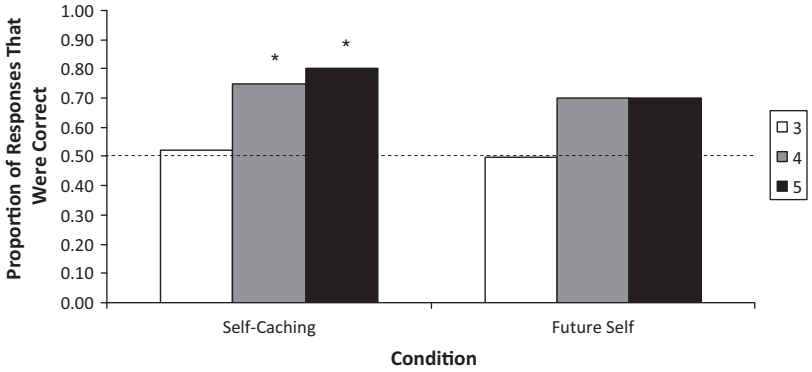

Fig. 2. Performance summed across delay at the three age levels and in the two conditions in Experiment 1. The asterisks indicate above-chance performance (see text for details).

The condition (Future-self versus Self-Caching) to which children were assigned did not have a significant effect on their success. The loglinear model produced no significant effect of condition on performance, $\chi^2(1) = 0.41$, $p = 0.521$. There was also no significant age × condition interaction ($\chi^2(5) = 0.21$, $p = 0.900$), no significant delay x condition interaction ($\chi^2(1) = 0.72$, $p = 0.396$), and no significant age × delay × condition interaction ($\chi^2(11) = 16.26$, $p = 0.132$).

The clearest outcome of this study concerns the poor performance of the 3-year-olds, which did not rise above chance level. Children older than 3 years performed adequately in the Self-Caching condition, but even the 5-year-olds performed at no better than a chance level in the Future-Self condition.

Consider how these data relate to those derived from the spatially-prospective blow-football experiment – and thus to the other (Kantian) form of minimalism described earlier. In the first place, poor performance of under-4s is repeated. However, in this study children did not find the putatively-functional (contrasted with the explicitly future-envisaging) condition much easier than the condition in which they were asked to imagine their future selves. Thus there is no parallel to the superiority of the third-person condition in older children, as in the blow-football task. Also, the oldest children's performance on the Future-Self condition was not impressive, with only half of the 5-year-olds answering correctly on the long-delay (the more challenging) condition of Future-Self. This outcome can be contrasted with the significantly better-than-chance performance evoked by the first-person question in the blow-football task at age 5.

We now ask why the 4- and 5-year-olds' performance on the challenging long-delay condition of Future-Self was relatively poor. Only 10 of the 20 children at this age and in this condition said correctly that they would visit the box with the biscuit rather than the box containing the now-melted chocolate. There are two possible reasons for this poor performance. First, children may have found reference to their currently preferred food hard to inhibit (Atance & Meltzoff, 2006), so hard in fact that they do not attend to the fact that its state will be degraded. Alternatively, the children knew perfectly well that the chocolate would be melted, but they found the transformed condition one they wanted to investigate, and indeed they may have nurtured the hope that they would be allowed to try the chocolate soup after all.

Because the role of executive inhibition (Atance & Meltzoff, 2006; Carlson, Moses, & Hix, 1998; Russell, Mauthner, Sharpe, & Tidswell, 1991) in children's ability to act on behalf of their future self has, for good reasons, been much discussed (Lemon & Moore, 2007), we conducted a second study in order to decide between these possible accounts of the poor performance of the over-3s in the long-delay Future-Self condition – with 4-year-olds only and with a slightly larger cell-size. This was its rationale. In a task in which the preferred food becomes edible after a long delay period, but does not after a short period, the challenge to inhibit reference to the prepotent response will involve not choosing the currently edible but generally less-preferred choice. In this case the performance should be similar to that in the melting chocolate task. The chocolate choice was wrong in one case and now

the choice of the robust, less-preferred, but currently edible food will be wrong. If however – the other possibility – the children know perfectly well about the object's future state (edible), performance should be better: this knowledge will lead them to choose the generally preferred food that is not yet edible. Thus, in a second study, we gave children of 4 years a task with a similar structure to the melting chocolate task but in which cake mix turned into cake after a long interval. Here the less preferred but acceptable food was again a biscuit.

5. Experiment 2

5.1. Method

5.1.1. Participants

Sixty children aged between 47 and 62 months ($M = 54$ months) participated. Of these, 10 were eliminated for holding a preference for biscuits over cakes, leaving 50 children ($M = 54$ months), half girls. All came from predominantly English-speaking families.

5.1.2. Design

Participants were assigned to one of two conditions: the Future-Self condition ($n = 25$), in which they were required to predict their own future action, and the Self-Caching condition ($n = 25$) in which they were required to act in the present to secure a future benefit. They were further subdivided by delay, with half the children in each condition told they were to experience a long delay ($n = 26$), and half a short delay ($n = 25$). Thus there were two between-subjects variables: condition and delay. There were at least 12 participants per cell.

5.1.3. Materials

A Ready Steady Cook© children's oven and Pro-line Mini-Cooler© were used as the oven and the refrigerator. Dora the Explorer© cake mix and 'rich tea' finger biscuits made up the food choices. To illustrate the cake and the biscuit both in their edible form, two cards were shown, one with an iced cupcake, the other with a biscuit.

5.1.4. Testing environment

Participants were tested either in a laboratory playroom, as in Experiment 1, or in an empty classroom of a nursery school. The oven and refrigerator were placed approximately 45 cm apart on a low table. A video camera mounted on a side wall, or a camera placed on a nearby table in the classroom, recorded the trials.

5.1.5. Procedure

Parents were instructed not to assist their child either physically or verbally during the procedure but were permitted to encourage them to perform the task. Two sessions were separated by a 24-h delay.

5.1.5.1. Familiarisation and training: Day 1. The first session served as a training session to familiarise the children with the oven and refrigerator, as well as to make them aware of the implications of the two time delays on the state of the foods.

Day 1 began with children being shown the oven and the refrigerator. The positions of these were varied randomly. The children were then asked if they owned an oven and a fridge and to give an example of things you might put inside them and why. They were then told that "*food that isn't cooked goes into the oven and it makes it tasty*" and that "*food goes in the fridge to be kept nice and fresh.*" They were then shown the cards illustrating a cooked, iced cupcake and a rich tea finger biscuit and asked which they preferred. If the child indicated that they thought they were both tasty, it was stressed that only one could be chosen and the question was asked again. If they still could not show a preference no data were recorded. Children were then shown two paper cupcake holders filled with cake mix and two biscuits. They were asked if they had seen cake mix before and asked if they were allowed to eat it. They were then asked, "What would have to happen to the cake mix before you could eat it?"

All children answered with variants of "cook it" or "put it in the oven." Finally, they were asked if the biscuit was ready to eat.

Next, the children were told to place one cupcake container of cake mix and one biscuit in both the oven and the fridge, so that each contained one of each food type. Children were then told that they were going to go away for either a short or a long time (these conditions were counterbalanced such that half experienced the short then long delays and half the reverse) and "see what happens." In the short delay, children were taken into the adjoining room to look at some dinosaur stickers on the wall or play "Simon Says" for 3 min. They were then told, "We've been away for a short time now; let's go back and see what's happened." Children were told to open both the oven and the fridge and look inside. The experimenter then lifted out each of the cakes and showed that they were not cooked and so could not be eaten. The children were then shown that the biscuits had remained edible. In the long-delay condition, children were taken into another room in the building where they played with toys of their choice for 30 min. During this delay the cake inside the oven cooked completely. Upon returning, children were invited to inspect the contents of the fridge and the oven. They found that the cake in the oven had cooked but the cake in the fridge had not, while both biscuits were intact and edible. Children were then invited to eat the cake.

5.1.5.2. Test: Day 2. Upon arriving for the test phase of the experiment the next day, children were asked three sets of pretest questions: 1. "Did the cake cook in the oven when we went away for a short time? What was it like? Can we eat it when it's not cooked?" 2. "Did the cake cook in the oven when we went away for a long time? Could we eat it then? Was it tasty?" 3. "What was the biscuit like in the oven after a short time? What was it like after a long time?" Children's answers were recorded. The test phase then followed.

In the Future-Self condition children were encouraged to put an uncooked cake into the oven and a biscuit into the fridge. Depending on delay type, they were then told that they were going to go away for either a long or a short time and told that when they returned they could open either the oven or the fridge (it was stressed that only one could be opened) and be allowed to eat what was inside. They were then asked the main test question: "When you come back, which will you open?" Children's answers were recorded and they were taken to play elsewhere for the specified delay.

In the Self-Caching condition, children were told that the fridge was broken and that only the oven could be used. They were then told that they were going to be allowed to put one food (cake mix or biscuit) into the oven before going away for either a long or short time and that they would be allowed to eat what was inside the oven when they returned. The children were then asked the test question: "Which one do you want to put in the oven?" The food the child put in the oven was recorded and the child was then taken to play elsewhere for the specified delay.

In both conditions children returned after the delay to recover the food. They were then offered a choice between a cooked cake and a biscuit to eat, to ensure that the preference stated on the first day had remained stable. If they did not choose the cake, no data were recorded.

5.1.6. Scoring and analysis

Children were recorded as performing correctly if they cached or predicted that they would choose the biscuit (if they experienced the short delay) or the cake (if they experienced the long delay). Analyses followed those employed in Experiment 1.

5.2. Results and discussion

Overall, children performed significantly above chance, $\chi^2(1) = 6.48$, $p = 0.011$. They also performed identically in the two conditions (Self-Caching and Future-Self); though within each of these they only showed a trend toward exceeding chance, $\chi^2(1) = 3.24$, $p = 0.072$ for both. When subdivided by condition and delay, only children in the Self-Caching condition who experienced the long delay performed significantly above chance, $\chi^2(1) = 9.31$, $p = 0.002$; however children in the Future-Self condition who experienced the short delay showed a trend toward better-than-chance performance, $\chi^2(1) = .3.00$, $p = 0.083$.

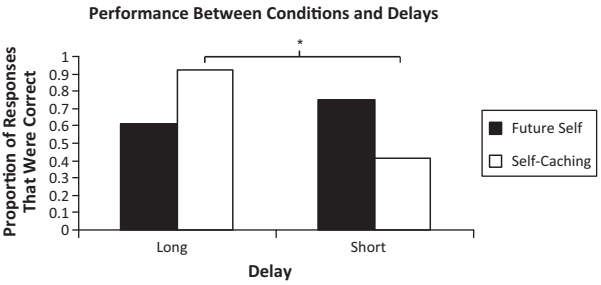

Fig. 3. The performance of 4-year-old children in Experiment 2, across two delays and two conditions. Thirteen children per cell in the long-delay condition and 12 children per cell in the short-delay condition. The asterisk indicates a significant difference.

Inspection of Fig. 3 confirms that performance in the Future-Self long delay condition differed little from that in Experiment 1: 61% (8/13) children were correct, compared to 50% in Experiment 1. This suggests that, in both tasks, the challenge was that of inhibiting reference to the currently preferable/edible food – chocolate in Experiment 1 and biscuit in Experiment 2. This can also explain the slightly better performance in the Future-Self short-delay condition – 75% (9/12) correct (which approached significance). It can also be noted from Fig. 3 that children in the Self-Caching condition paradoxically performed better under the long delay. Loglinear analysis indicated that there was no overall effect of condition, $\chi^2(1) = 0$, $p = 1.00$, or delay, $\chi^2(1) = 1.939$, $p = 0.164$, while there was an effect of delay on food-choice, $\chi^2(1) = 6.114$, $p = 0.013$. There was also a trend toward a delay × condition interaction, $\chi^2(1) = 6.441$, $p = 0.092$. Overall, there is a pattern of better performance in the long delay than the short delay condition in the Self-Caching condition, a pattern not seen in the Future-Self condition. When the data are stratified by condition, the Self-Caching condition showed an effect of delay, $\chi^2(1) = 5.581$, $p = 0.018$, but the Future-Self condition did not, $\chi^2(1) = 0.514$, $p = 0.474$. We can thus look at performance at each delay. Pairwise comparisons indicated that children in the Self-Caching condition who experienced the long delay performed significantly better than children in the same condition who experienced the short delay ($p = 0.002$), while no other pairwise comparison reached significance.

Why were children in the Self-Caching condition poor on the short-delay question and good at the long-delay question? To succeed on the latter and fail on the former they had to put cake mix in an oven. As this is the natural thing to do with cake mix, while being a highly unnatural thing to do with a biscuit, it is perhaps not surprising that the pattern of responses tended in this direction.

To summarise, we have found two areas in which children were challenged by this task. We argue that both of these challenges can be explained in terms of the pull of a 'prepotent response' (Carlson et al., 1998; Russell et al., 1991). In the first place, 49% of the children failed the Future-Self long-delay condition because they said that they would visit the location of the food that was currently edible (biscuit), with the prepotency here being about current preferability. In the second place, children gained a kind of illegitimate success on the long-delay condition of Self-Caching, while performing poorly on the short-delay condition, by virtue of the prepotent response of putting cake mix in an oven – basing their choice on semantic association rather than on the logic of the task.

6. General discussion

The findings from these studies suggest ways of thinking about whether, and if so how, one can assess something as complex as episodic foresight in terms of the essentially minimal process of WWW-binding. In general, the standard development trajectory was not replicated, but, as we shall see, there remains room for optimism about the empirical 'cash-value' of *both* kinds of minimalism.

The attempt in Experiment 1 to tap future episodic thinking in children by the use of a WWW-binding task, inspired by Clayton and Dickinson's (1998) work with jays, did not generally replicate the frequently found trajectory on episodic foresight tasks of failure at age 3, transitional or adequate performance at age 4, and success at age 5 (Atance & Meltzoff, 2005, 2006; Busby & Suddendorf, 2005;

Lemon & Moore, 2007; Moore et al., 1998; Russell et al., 2010; Suddendorf & Busby, 2005; Suddendorf et al., 2011). We did, however, reproduce failure at age 3 and a significant effect of age. The main respect in which our developmental trajectory differed from the one typically found was with regard to the degree to which the 4- and 5-year-olds struggled with the more demanding long-delay condition in which the palatability of the preferred food changed over time.

When the data from Experiments 1 and 2 are considered together, the reason for the older children's difficulty becomes clear: they were likely to have been experiencing difficulty with inhibition of the prepotent response of choosing the immediately-preferable object (Atance & Meltzoff, 2006; Carlson et al., 1998; Russell et al., 1991). Our first study demonstrated the influence of these executive challenges by requiring children, in the long-delay condition, to indicate the non-preferred food. Similar executive challenges were present in the second experiment in so far as reference had to be inhibited to the only food that was currently edible. Additionally, in the second study children were required to perform the unnatural procedure of putting a baked biscuit, but not raw cake mix, in an oven.

Returning to the comparison between the two minimalist approaches – the WWW-binding minimalism of Clayton and Dickinson (1998) and the Kantian minimalism of Russell et al. (Russell et al., 2010; Russell & Hanna, in press) – we see that, at least in comparison with the present studies, only the latter reproduced the standard developmental pattern of failure at 3 years, transitional or adequate performance at 4 years, and success at 5 years. In other words, the developmental pattern found here is different than the one found in the blow-football task. We now discuss the empirical prospects for each form of minimalism, as applied to episodic foresight.

With regard to the Kantian form of minimalism, which stresses the importance of the egocentrically spatial and temporal structure of the original experience, we presently only have data on the role of spatial-perspectival content from the blow-football study of Russell et al. (2010). Perhaps a different developmental trajectory would result were temporal information to be included along with the spatial information. Such a task may be more challenging or it may, by virtue of giving children more of the relevant kind of information, be easier. Recall that 'temporal' here does not mean time-from-the-present but means the temporal order or simultaneity of elements *within* the episode. How might this be tested? Children could be asked to envisage a future situation in which they decide to perform actions at certain locations in a certain order. If indeed this order is followed[3] when the time comes, and if we could be confident that children were not simply recalling what they had said earlier, one might credit them with the ability to bind the spatiotemporal elements of a future episode.

What are the prospects for unearthing a form of episodic foresight in young children using the WWW-binding procedure – Clayton and Dickinson's (1998) episodic-like minimalism? Is it inevitable that children will be challenged by such tasks, given that asking them to select the object that is currently less desirable will provoke an executive challenge?[4] It would not seem a logical necessity that participants be faced with the requirement to inhibit reference to a more desirable object. If children are presented with two neutral (or equally desirable or undesirable) objects one of which will become less or more desirable over a long, but not short, period when put in a certain place, but not when put in a different place, then the requirement to bind WWW remains. The child must reason in effect: "Will I seek out A or B, given that A is being placed at X where it will get better/worse after a long time?" In conducting such a study one must be on guard against illegitimate success based on semantic associations between places and valence, but this challenge seems surmountable.

On a more conceptual level, while success on an executively less challenging WWW-binding task of this kind would indicate a sophisticated level of reasoning about the future and what one will do in it, Hoerl's (2008) question can be raised in this context concerning whether success on such a task calls for 'tensed thought.' Here is not the place to debate this issue, but the fact that this proposed WWW-binding task does require reasoning about causal processes over time implies that the issue

[3] The authors are acutely aware that the study would have benefited from a systematic attempt to relate the children's predictions of where they would go for something to eat, in the Future Self condition, to facts about where they actually *did* go. Broadly speaking, in fact, the older children did fulfil their own predictions about their actions.

[4] These executive challenges did not exist for the jays in Clayton and Dickinson's episodic-memory work, because, being a memory task, the animals were never faced with a choice of acting on presently-available wax worms versus peanuts.

would clearly arise of whether one should credit children who can pass the task with a form of tensed thinking.

Finally, we return to the three-way theoretical division with which we began: conceptualist versus two kinds of minimalist views (episodic-like and Kantian). A critic of the conceptual framework proposed here could say that the reason we have found different developmental trajectories in studies inspired by the latter two positions is not because the children fell victim to executive challenges but because we have drawn the theoretical divisions wrongly, and that the main division should be between subjectivist/phenomenological views (conceptualist and Kantian) and the only view that explicitly eschews this level – the Clayton–Dickinson episodic-like view.

On this argument, one equates the emphasis on the subjective present in Tulving's recent writings (Tulving, 2005) and in the work of Suddendorf and colleagues, with the emphasis on egocentric, perspective-relative spatiotemporal processing found on the Kantian view. But the differences between the two views are fundamental, in our opinion. On the one hand is the Kantian claim that any experience, even the most primitive, will present objects in spatial positions and in temporal sequences relative to where the organism was located and to when the objects appeared to the subject. This seems entirely different from the heavily conceptual, heavily imaginative, subjectivity of the views of Tulving and Suddendorf. Indeed, in thinking about why 'egocentric' does not equal 'subjective,' consider Piaget's claim that younger infants code space 'egocentrically' (or are 'response learners;' Newcombe & Huttenlocher, 2000). On this view, they are not 'being subjective', but are *failing to draw* the subjective/objective distinction – one of the things that Kant's *Critique* is all about. Meanwhile, the subjectivity possessed by Tulving and Suddendorf's episodic thinkers is something dependent on their grasp of concepts. And so, in our view, the idea is eminently worth preserving that the fundamental distinction lies between conceptualist and non-conceptualist positions.

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