

Time in cognitive development

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The topic of this chapter is the development of temporal understanding, and in particular the question as to when children can be said to be able to grasp temporal concepts such as ‘before’ and ‘after’. One specific idea we wish to look at is that the development of temporal understanding, and the emergence of a grasp of temporal concepts, is closely linked to developments in children’s understanding of causal relationships. There are, of course, substantive theories dealing with the general question of what concepts are, or what it is to possess a concept (see, e.g., Peacocke 1992, Fodor 1998). However, a detailed discussion of these issues is beyond the scope of this paper. Instead, we will start with a fairly rough, intuitive understanding of the explanatory project at hand that locates it somewhere in between two other projects familiar from the philosophical literature on time.

One such project is exemplified by attempts to provide what is typically referred to as a causal theory of time. As usually understood, a causal theory of time has it that there is a sense in which temporal notions can be defined in terms of causal notions. Key to causal theories of time such as Reichenbach’s (1956, 1957) is the thought that we can give an account of what makes one event a cause and another its effect, rather than vice versa, without using temporal notions. This, in turn, then allows us explain, e.g., what it is for one event to happen before, rather than after, another by reference to the relation in which a cause stands to its effect.

Even though causal theories of time are often characterized as claiming that temporal concepts can be analysed in terms of causal ones, they are not intended to provide a descriptive psychological account of the origins of temporal concepts.¹ Indeed, it has been argued that, if they were to be read as attempting the latter, causal theories of time would clearly be false.

Mackie takes this view for reasons he describes as follows:

Our concept of time is based on a pretty simple, immediate, experience of one event's following straight after another... Our experience of earlier and later, on which our concept of time direction is based, itself remains primitive, even if it has some unknown causal source. (Mackie 1977, quoted in Sklar 1995: 218; see also Sklar 1981)

Mackie's words here point to a second type of philosophical project – that of giving an account of the phenomenology of experiences involving, e.g., movement and change. Part of his claim seems to be that there are direct experiences of events unfolding in time that a subject can have without any grasp of the particular types of causal facts at issue in causal theories of time. This is perhaps difficult to deny. However, Mackie also seems to think that our possession of temporal concepts can somehow be straightforwardly explained by appealing to such experiences, which is much less obvious (see also Hoerl 1998).

In what follows, we will describe a number of ways in which young children can be sensitive to, learn about, or keep track of the temporal order of events in a sequence that, arguably, can be explained without invoking a grasp, on the part of the child, of temporal concepts such as 'before' and 'after'. In each case, we will argue that the sensitivity to temporal relations shown by the children is tied very closely to their directly experiencing events in sequence, and that it is the sequence in which events are experienced, rather than any ability to

¹ For a similar distinction between normative and descriptive approaches, in the case of causal concepts, see Woodward 2007.

reason about sequences, which might actually explain children's competence in the early stages of development. Now, put very schematically, at least some of these temporal abilities either do already involve "experiences of earlier and later", to use Mackie's words, or they do not (where one stands on this issue will typically depend on whether one adopts a form of non-conceptualism or a form of conceptualism about temporal experience). If they do, then arguably there is more involved in the possession of temporal concepts than can be explained by a mere appeal to such experiences. If they do not, then it appears that we might need to explain children's ability to have experiences of earlier and later, at least in part, in terms of their grasp of temporal concepts, rather than vice versa (or the two explanatory tasks may actually be of a piece with one another).

Thus, it may be true that possession of temporal concepts does not require anything like a grasp of a causal theory of time, but neither, it seems, can we account for the acquisition of temporal concepts simply by gesturing at experiences of temporal relationships. From a developmental perspective, the crucial question we need to ask is: in what kinds of contexts do children first need to engage in reasoning about temporal relationships using concepts such as 'before' and 'after', rather than just relying on some more primitive sensitivity to temporal relations? This is the question we will focus on in this chapter.

The role of temporal priority in children's causal judgments

One of the most immediately obvious areas of research to turn to in considering whether young children can reason about before and after relationships is research that has been done on whether or not children's causal judgments respect the 'temporal priority principle', i.e. the principle that causes must precede their effects (e.g., Bullock, Gelman, & Baillargeon 1982, Kun

1978). When it comes to selecting one amongst several potential causes for an effect, do children restrict themselves to candidate causes that temporally precede the effect, or do they sometimes judge that an event that occurred after the effect was its cause? Bullock and Gelman's thorough study (1979; see Bullock et al. 1982), which we will discuss below, is often cited as providing definitive evidence that children as young as three do make use of a temporal priority principle in their causal judgements. Indeed, following their study, very little subsequent research was conducted on this issue, perhaps because many researchers believed that the issue had been empirically resolved. Yet, others have viewed this principle as one that is adopted relatively late in development (Piaget 1930, White 1988). For example, Shultz, Altmann and Asselin (1986) argued that while use of generative transmission rules is pervasive in 3-year-olds, such children do not reliably exploit temporal priority (but see also Shultz & Kestenbaum 1985). Other experimental studies that suggest that children's causal judgements do not always accord with the temporal priority principle include Shultz and Mendelson's (1975) study and that of Sophian and Huber (1984), which we will also discuss briefly below (see also Das Gupta & Bryant 1989).

Some of the existing theoretical debate in this area gives the impression that the issue at stake in the experiments is children's ability to reflect on the relationships between two orders: the temporal order and the causal order. In this section, though, we will argue that there is another way of interpreting the experimental results. In particular, we will argue that some of the results of studies on the use of temporal priority in causal selection can be understood in terms of the idea that, whilst young children are sensitive to temporal structure in making causal judgements, they may not initially have a reflective grasp of the relationship between causal and temporal order.

Experimental studies in this area typically involve children seeing an event A, then an effect E, and then a further event B, after which they are asked whether A or B caused E. Thus, in Bullock and Gelman's (1979) study children saw the experimenter drop first one ball (event A) down a chute, after which a Jack-in-the-box jumped up, and then another ball was dropped down a different chute (event B). They found that even 3-year-olds tended to judge that A was the causally efficacious event. In Sophian and Huber's (1984) study, by contrast, 3-year olds were not above chance, on certain trial types, at choosing amongst two candidate events the one that was temporally prior to the effect. In their study, the effect was a toy animal doing a trick, and events A and B were two different kinds of sounds (clicking vs. buzzing). Importantly, their study involved an initial training phase, in which the effect was shown to covary only with B, and not with A. It was when children were subsequently shown a sequence in which A occurred before the effect and B after it, that some of them were prepared to judge that B had caused the effect.

How should we interpret these apparently conflicting findings? Consider, first, Bullock and Gelman's (1979) experiment. In a scenario in which children see A, then E, and then B, there are two ways in which children may end up judging that A is the cause of E. The first is that they actually recall the order in which the three events occurred (AEB) and then base their judgments on their memory for the event sequence, bringing to bear a grasp of the general principle that causes must precede effects. We will label this the *reasoning about order* account. The second is that children make such a judgement without actually remembering or reflecting on the order in which the events have occurred. Rather, causal learning processes may usually operate according to a default along the lines of: "ignore any events that occur after the relevant effect". Thus, once E has occurred, children may simply stop encoding any further events as

causally relevant to E. We will call this the *encoding default* explanation of children's success in selecting a temporally prior event as the cause of an effect. Use of such a default is non-insightful, since it does not involve thinking about event order and considering its causal significance. Yet it would normally be sufficient for accurate judgements because, under most circumstances, learning order is identical to causal order. That is, the order in which children find out about events is normally the order in which the events themselves occur (see also Lagnado, Waldmann, Hagmayer, & Sloman 2007 for this point).

The important contrast between the two types of accounts we are outlining is that on the encoding default account, children's causal judgments in the early stages of development obey the temporal priority principle as a result of the way in which the temporal relationships between observed events themselves affect how they are processed and encoded, whereas the reasoning about order account assumes that the principle itself is embodied in children's reasoning. In fact, on the former type of account, children need not even be able to remember and report or comment on event order. On the encoding default account, the order in which the events occur does indeed determine how the events are represented (i.e., as causal or non-causal), but order information itself need not even be part of that representation.

Note, however, that even the encoding default account assumes that children's encoding processes go beyond, for example, what is often assumed by some standard theories of animal causal learning. This account assumes that children do more than simply, for example, encode associations between events or information about the co-occurrence of events. Rather, it assumes that there must be some selective encoding of events in terms of their causal relevance. Nevertheless, this temporally-sensitive selectivity need not involve an explicit grasp of *why* it is that only some events should be considered causally relevant. Indeed, when Bullock and Gelman

(1979) directly asked children why they had chosen A rather than B as the cause, the youngest children (3-year-olds) very rarely gave an explanation that mentioned the order in which events had occurred, even using fairly lenient criteria for categorizing their explanations as temporal. This suggests that although their judgments may have respected the principle of temporal priority, they appear not to have an explicit grasp of the grounds of their judgments. In contrast, the majority of the 5-year-olds referred to the order in which the events had occurred in explaining their decisions, which suggests that, by this stage in development, a reasoning about order account may provide a better description of the basis of children's causal judgements.

How do the two accounts we have outlined fare in light of the findings of Sophian and Huber's (1984) study? At least on the face of it, those findings seem difficult to explain on a reasoning about order account. Arguably, in adult common-sense causal reasoning, the idea that causes precede their effects has the status of an inviolable principle (although there is of course considerable debate in philosophy on what, if anything, rules out the possibility of backward causation). If young children's causal judgements were also governed by the grasp of such a principle, it would therefore be surprising to find that they sometimes seem to tolerate violations of it. And even if we thought that somehow children don't treat the principle as inviolable, there would still be a *prima facie* contradiction between the belief that, generally, causes precede their effects, and their contrary judgement in a particular situation. On the encoding default account, by contrast, we need not credit the child herself with a grasp of the temporal priority principle to explain why her causal judgements are typically in accord with it. Thus, if the child were to judge, in a particular situation, that an effect was caused by an event that in fact succeeded it, this judgement would not be in contradiction with any general principle that the child also endorses.

To show how such a judgement might arise, all we need to do is explain how there can be situations in which the normal encoding default is not operative.

Arguably, just such an explanation is available in the case of Sophian and Huber's (1984) study. Recall that this study included a training phase, in which event B covaried with the effect and event A failed to do so. After this training phase, Sophian and Huber then examined whether children would judge that event A was the cause if shown an event sequence in which B occurred after its typical effect but A occurred before it, and they found that 3-year-olds were not above chance at choosing A over B.

At least one way of explaining this result is that Sophian and Huber's (1984) training phase, which is likely to have led children to judge that only B had the causal powers to make the effect occur and that A was causally inefficacious, ensured that the normal encoding default was not operative during the test phase. In other words, at test, A had already been encoded as causally inefficacious, so that when A occurred, followed by the effect, children were still looking for a cause. Under these circumstances, it is perhaps not surprising that, in at least some cases, their prior knowledge that B can bring about the effect won out. Thus, what we have called an encoding default account seems able to resolve the apparent conflict between Bullock and Gelman's (1979) results and those of Sophian and Huber (1984). A reasoning about order account, on the other hand, would have to provide some explanation as to why, if children grasp the general principle that causes precede their effects, they do not seem to apply such a principle consistently.

Further empirical work is needed to establish whether the encoding default account does indeed give the best description of young children's initial sensitivity to temporal order in causal selection. Our main aim in this section was to outline just how children's sensitivity to temporal

order, in the context of selecting between a number of potential causes for an effect, might be explained without invoking an ability, on the part of the child, to grasp temporal concepts. We have also pointed out that, on the encoding default account we have sketched, such judgements may not even require memory for the order in which events happened. This is not to say, though, that such memory would necessarily involve a grasp of temporal concepts. In the next section, we will suggest that there might also be a basic form of memory for sequences that does not require an ability to reason about temporal relationships. Again, our suggestion will be that what makes this basic form of memory possible is the fact that children directly experience events in the order in which they happen.

Two Accounts of Script Knowledge

In *The Principles of Psychology* Williams James writes: “A succession of feelings, in and of itself, is not a feeling of succession.” (1890: 629). Almost identical words can be found in Edmund Husserl’s *On the Phenomenology of Consciousness of Internal Time*. As Husserl puts it, “The succession of sensations and the sensation of succession are not the same.” (Husserl 1991: 12). James and Husserl are here concerned primarily with the question as to how time figures in perceptual experience, whereas our focus in this section will be on a particular kind of memory for familiar sequences found in young children, which is sometimes characterized by saying that they have acquired a script for the relevant sequence. However, the upshot of our discussion might also be put in terms of a variation on James’ slogan, viz. that a succession of representations, in and of itself, does not amount to a representation of succession (at least if the latter is supposed to involve a grasp of concepts such as ‘before’ and ‘after’). As we will argue, a

central question raised by research on children's acquisition of scripts is whether it can show that children possess the latter, rather than merely being able to entertain the former.

In the mid-1970s, Katherine Nelson and her colleagues began a groundbreaking program of research demonstrating that 3- to 4-year-olds seem to possess surprisingly robust and detailed knowledge about routine event sequences, such as what happens when you go to a fast food restaurant, or at a visit to the doctor's. As Nelson explains, at the time, "the term *event* was not widely used in psychology, and when it was it was usually interpreted as a conditioned response to a stimulus. Objects, object concepts, object perception and object categories were the focus of mainstream psychology, as well as developmental psychology, as had always been the case" (Nelson 1997: 1). Developmentalists usually attributed only "limited and fragmented action-object connections" (ibid.: 2) to children. By contrast, the children in Nelson's studies seemed to show relative complex knowledge about whole sequences of events and their temporal structure (see esp. Nelson & Gruendel 1981, 1986).

Nelson and her colleagues adopted the term 'script', originally introduced by Schank & Abelson (1977) as a theoretical construct in cognitive psychology, to describe both children's verbal reports of such event sequences and the representations underlying them. Their suggestion was that scripts in fact constitute a developmentally basic form of representation, geared specifically to the acquisition and retention of knowledge of recurring event sequences.

The following snippet from a conversation might perhaps provide a flavour of the basic idea behind the notion of a script. In it, an adult experimenter (E) wants to find out what a child (C) did during a recent camping holiday.

E: You slept outside in a tent? Wow that sounds like a lot of fun.

C: And then we waked up and had dinner. First we eat dinner, then go to bed, and then wake up and eat breakfast. (Fivush and Hamond 1990: 231)

If an adult was asked about a recent camping holiday, we would normally expect the answers to concentrate on events specific to that holiday. In retrieving memories of such specific events, though, she might be helped by general knowledge of the sequence of events that happens during a normal day. For instance, her attempts to recall might be guided by questions such as what she had for dinner and where she slept during that holiday. This is one way in which the notion of a script, and the role scripts have in memory, is sometimes understood in the adult literature. Now, it is of course possible to interpret the responses of the child in the above example along similar lines, i.e., in terms of the idea that the child is using his knowledge of the sequence of events that happen during a normal day to think back to events during the camping holiday, but failing to remember anything distinctive about those events. Yet, in so far as the child does indeed fail to remember anything distinctive about those events, an alternative interpretation is that he does not actually manage to think back to those events at all, but falls back on a memory capacity of a quite different, more primitive type that involves only the ability to rehearse the order in which a sequence of familiar events usually happens. Understood along these lines, scripts constitute a distinctive form of memory for sequences in their own right, a form of memory which encodes the order in which a certain type of event sequence typically unfolds, but without locating occurrences of that sequence at a specific location in time (see also Hoerl 2007).

We should stress that we have quoted the example above only as a possible illustration, and our aim is not to try to argue for one kind of interpretation rather than another of this specific example. Moreover, we are not trying to argue that young children in general only ever produce such script-like responses to questions about past events: It is widely accepted that 2-to-3-year-

olds can verbally retrieve, as Cordón, Pipe, Sayfan, Melinder, & Goodman (2004: 108) put it, “bits and pieces” of specific past experiences, particularly when prompted to do so by adults (for discussion see, e.g., Fivush 1993; Fivush & Schwartzmueller 1998). Yet, it is unclear to what extent doing so involves having an idea of particular events as located in the past and organised along a linear time series (see McCormack & Hoerl 1999, 2008). By contrast, script knowledge clearly does seem to involve a capacity of some kind to encode temporal relationships. Thus, the issue for us is how we should characterize the temporal abilities of a child at a stage of development at which she may be adept at acquiring script knowledge, but perhaps still lack a number of other temporal abilities. We can contrast two approaches to this issue.

John Campbell has recently suggested that considerations about the semantics of tensed expression might help us understand the difference between script-based thought about events and what he calls ‘ordinary thinking about time’, i.e., the mature ability to locate particular events in a linear time-line. Following Reichenbach (1947), Campbell conceives of tensed expressions such as ‘now’ as being governed by token-reflexive rules – e.g., in the case of ‘now’, the rule that any token of ‘now’ refers to the time at which it was produced. However, as Campbell also claims, two terms can share the same token-reflexive rule, in this sense, and still differ in their semantics, because the underlying domain of times in each case is different. This, he believes, is how we should think of the difference between script-based thinking and ordinary, mature thinking about time. In the case of scripts,

[t]he domain of times over which [the token-reflexive] rule is defined will not, of course, be times drawn from our ordinary range of linearly organised times; they will themselves be times defined in terms of the temporal framework provided by the script. Within each

script times are temporally related; but we cannot express temporal relations between times identified in different scripts. (Campbell 2006: 6)

Another way of characterising Campbell's view is that, in ascribing to a child knowledge of, say, a fast-food restaurant script, we credit the child both with an overall representation of the order in which a sequence of events are arranged, and with the ability to orient herself within this order using tensed notions.² This might involve, for instance, the child's using her knowledge of the script to frame the thought that it is *now* time to tell the person behind the counter what she would like to order, and that the items she orders will be put on her tray *in a little while*. The critical sense in which, on Campbell's account, the child's cognitive abilities nevertheless fall short of those of mature thinkers is that her ability to give significance to these temporally token-reflexive terms is exhausted by her ability to orient herself within the relevant script.

Campbell's view may be contrasted with one that is perhaps hinted at in the following passage from Nelson:

The infant or young child does not consciously try to 'master' the script of a birthday party, for example (although the mother may have mastered it through deliberate planning), nor does the child try to remember how the bath sequence goes. Rather, through repeated occurrences, the pattern finds its place in the child's repertoire of event knowledge, a repertoire that provides the basis for action in repeated and in new events. (Nelson 1999: 242)

One way of understanding Nelson's words, here, is in terms of the idea that learning a script, at least at an early age, is not so much a matter of coming to think of a sequence of events *as* unfolding in a certain order, but rather a matter of coming to think of those events *in the right*

² For the notion of temporal orientation, see Friedman 1990, and Campbell 1994.

order (see also Hoerl 2008). On this view, there is no overall representation of the sequence in which the child then orientates herself with the help of token-reflexive notions. Rather, recounting a script, at least initially, actually involves representing those different events *in* sequence.

If this latter suggestion is along the right lines, it might also help shed some light on a controversy in developmental linguistics, where it has been claimed that, when children first come to use tense morphology, they don't actually use it to mark tense, but instead use it to mark aspectual distinctions. The specific empirical form this claim takes in what has become known as the 'aspect before tense' or 'aspect first' hypothesis is that children's use of the past tense is initially restricted to verbs describing events that result in a change of state or have a natural completion point (e.g. 'broke' or 'built'), whereas they use present tense or imperfective morphology with verbs that describe events that can go on for an indefinite amount of time (e.g., 'dancing'). Our intention here is not to assess whether or not the linguistic evidence supports this specific empirical prediction. Rather, we introduce the claim in order to point out that it can also be interpreted as a cognitive one about limitations in children's thought about events, according to which children initially think of events only in terms of aspectual notions such as 'ongoing' and 'completed', and perhaps also 'yet to start' (i.e., an aspectual notion focussing on inception rather than completion), before they are capable of employing tensed notions such as 'past', 'present' and 'future'.³

What exactly does the cognitive difference at issue here come to? One basic feature of tense, which is implicit in Campbell's approach as described above, is that tensed notions serve to locate an event within a wider domain of times by marking its relationship with the present

³ The notion of aspect of particular relevance here is that of grammatical aspect. See, e.g., Wagner 2001 for an overview of the existing debate in developmental linguistics and further discussion. See also McCormack & Hoerl 1999.

time. By contrast, if a young child is thinking of events only in terms of aspectual notions, there is a sense in which her focus is restricted entirely to the present itself. That is, she does not think of past and future events in their own right, as located at other points in time, but only about their current status as completed, ongoing, or yet-to-start. To transcend the perspective of the present, she would also have to be capable of thinking, say, of events she now thinks of as completed as having once been ongoing, or of events she thinks of as ongoing as completed in the future.

We want to suggest that the idea that children first come to think of events in terms of aspectual notions, before becoming capable of genuinely employing tenses, actually fits in well with the type of alternative to Campbell's account of script knowledge that we have sketched above. According to that alternative, it is wrong to think of script knowledge in the very early years as involving one unified representation of a sequence of events and the temporal relationships in which they stand to each other, within which the child then orientates herself with the help of tensed notions. Instead, going through the script involves entertaining a sequence of different representations.⁴ Rather than encompassing the idea of different times across which the events making up the sequence are spread out, there is a sense in which each of these representations will simply be concerned with what is the case at the time it is entertained. Yet, that does not mean that such representations might not include aspectual notions marking the fact that, at that time, some events are ongoing, others completed, and others yet to come.

⁴ Interestingly, the dispute between tensed and tenseless theories in the metaphysics of time is also sometimes put in terms of the question as to whether there is a more global sense in which, even on a mature understanding of time, any representation of things in time is ultimately only a representation from one amongst a number of different perspectives, or whether a unified representation of time is possible (Dummett 1960, Fine 2005, Moore 2001).

A Kantian Interlude

If what we have said above is at least roughly along the right lines, there are potentially interesting parallels between developmental questions regarding children's script knowledge and some of the concerns that motivate Kant's Second Analogy of Experience in the *Critique of Pure Reason* (which is arguably a historical source for the claims made by James and Husserl that we quoted at the beginning of the preceding section).⁵

There is considerable debate as to what Kant's argument in the Second Analogy actually is, or indeed whether it is one or several arguments, and there is no scope here to engage with many of the exegetical and substantive questions that have been raised in this debate. Also, we need to stress that Kant's project is a specifically philosophical one, which is ultimately concerned with the very possibility of empirical thought and knowledge. There is no suggestion that it should have straightforward developmental implications. What might nevertheless make it fruitful to draw a comparison between at least one strand of thought in the Second Analogy and the kind of account we have given of young children's script knowledge is that both seem to deal with basic types of mental phenomena which themselves display an temporal order or organization that is determined by the order in which events or states of affairs are or were perceived.

Kant's main focus is on the *sequence of perceptions*, or perceptual experiences, that occurs when we observe a change in the states of an object, say a ship moving from one location on a river to another. He writes:

⁵ In what follows, quotations from the *Critique of Pure Reason* are taken from the Norman Kemp Smith translation (London: Macmillan and Co. Ltd., 1929). We have followed the usual convention of referring to the standard paginations of the first ('A') and second ('B') editions. Our account draws heavily on expositions of Kant's argument in the Second Analogy given in Bennett 1966; Guyer, 1987; and Strawson, 1966.

That something happens, i.e. that something, or some state which did not previously exist, comes to be, cannot be perceived unless it is preceded by an appearance which does not contain in itself this state. [...] Every apprehension of an event is therefore a perception that follows upon another perception. (A191/B236)

As he notes, however, we can have a succession of different perceptions also when there is no objective succession to be perceived. An example he uses is that of looking up and down the façade of a house. In Kant's words,

[t]he apprehension of the manifold of appearance is always successive. The representations of the parts follow upon one another. Whether they also follow one another in the object is a point which calls for further reflection. (A189/B234)

The issue, then, for Kant is what makes it possible for us to apply time-determinations such as 'before' and 'after' in empirical judgement. To do so, it seems, we need to have a sequence of different perceptions; yet, this alone is clearly not enough, since such a sequence can also occur when the perceived states of affairs in fact obtain concurrently. Put very crudely, Kant's solution is that we can distinguish the "subjective sequence of apprehension from the objective sequence of appearances" (A 193/B 238) only if we think of the latter as governed by causal laws, which, in turn, determine the order of the former in the case of the perception of changes. In other words, the possibility of using time determinations such as 'before' and 'after' turns on thinking, when there is a succession of two different perceptions, that the relation between the different states of affairs perceived is causally determined, such that one of those states must follow, rather than precede, the other.

Kant's starting point, as we have seen, is the idea that perceiving a sequence of events involves having a sequence of perceptions. Similarly, the account of young children's script

knowledge we have given above turns on the idea that a basic form of retaining knowledge of the order in which certain sequences of events happen simply consists in retaining an ability to entertain a sequence of representations. Kant also says that merely having a sequence of perceptions, by itself, cannot explain the ability to apply time-determinations in empirical judgement. On our account of script-knowledge, a similar point might be seen to apply, though in a slightly different guise, as the following might help to bring out.

Kant's point is sometimes put by saying that the possibility of time-determination, the ability to apply concepts such as 'before' and 'after' in empirical judgement, requires an implicit recognition that some of our perceptions are order-indifferent, but that there are also cases in which our perceptions necessarily happen in a certain order, because what is being perceived is an objective succession of events or states of affairs (Strawson 1966: 83). Kant's further claim, then, is that drawing this distinction requires a certain form of causal understanding. Now, on our account, script knowledge involves the ability to entertain a succession of representations, just as, according to Kant, the perception of succession involves a succession of perceptions. However, the issue of order-indifference vs. necessary order does not seem to arise in the same way in the case of scripts. Rather, the right thing to say seems to be that the child does implicitly recognize that the representations making up the script have to occur in a particular sequence, but that this recognition is a purely practical matter of knowing how to go on, for instance, when recounting or reenacting the script, rather than a matter of reflectively forming judgements involving time-determinations such as 'before' and 'after'.

Setting this difference to one side, for the moment, it may be thought that something like Kant's appeal to causal understanding as a necessary ingredient in the possibility of time-determination might nevertheless be right, and might also explain what is involved in children

moving on from a mere capacity to acquire script-type knowledge to a grasp of temporal concepts such as ‘before’ and ‘after’. How exactly might a grasp of certain causal relations be involved in grasp of such concepts? If we take our inspiration from Kant, or at least from some of his commentators, we are likely to focus on two types of causal relationship.

Kant himself seems to have taken the conclusion of his argument to be that the possibility of time-determinations requires thinking of perceived events as falling under causal laws that determine the order in which those events happen. Such laws might determine a temporal order among events either by determining that a certain type of event necessarily follows, rather than precedes another, because the former is the cause, the latter the effect, or by determining that, given a certain initial condition, events necessarily follow one another in one temporal order rather than another (see Guyer 1987: 239f.).

According to one influential objection to Kant, however, his argument involves an illicit move from the idea of a necessary order of perceptions, in the case of an experience of an objective succession of events, to the idea that the objective succession of events is itself made necessary by a causal law. In Strawson’s words, Kant confuses “causal transactions or dependencies relating objects of subjective perception to one another ... with the causal dependencies of subjective perceptions themselves upon their objects” (Strawson 1966: 84). Thus, for Strawson, the focus of the argument should be on the role played in our grasp of temporal concepts by the idea that the order in which two events happen can have a causal impact on our psychology, by determining the order in which the two events are perceived.

For our purposes, we can set aside whether Strawson’s objection is to the point or misconstrues the Kantian project, as some have argued (see, e.g., Guyer 1987: 255ff.). For, both of the two lines of thought just sketched seem only to be of limited help from a developmental

perspective. Seen from such a perspective, a natural way of interpreting the first one is in terms of the idea that the emergence of a grasp of temporal concepts is connected to a type of causal understanding that involves a grasp of general scientific laws. And a natural way of interpreting the second one is in terms of the idea that a grasp of temporal concepts is connected to certain aspects of what is sometimes called a ‘theory of mind’ that have to do with the causal dependence of the temporal order of perceptions on the order of events perceived. In each case, the relevant type of causal understanding is invoked to explain a sense in which the subject can appreciate that there is a necessary order to (some of) her perceptions. As we have seen, though, script knowledge can involve an implicit recognition of a necessary order in a sequence of representations that does not seem to rest on any causal understanding. Thus, what both of the above suggestions must come down to, in effect, is that making judgements involving temporal concepts requires a more explicit way of making sense of the type of causal necessity in question, although they differ on how the latter should be conceived. Yet, an obvious question is how we can make more concrete what the relevant implicit/explicit distinction comes to, i.e., what can count as an explicit grasp in each case that can provide the required basis for the ability to apply temporal concepts. Even more importantly, though, we also have to ask what could count as a demonstration that children possess the relevant explicit grasp.

From a developmental point of view, a key question we need to ask is: what are circumstances that would provide clear evidence as to whether or not children have a form of understanding of sequences that cannot be explained by the possession of a script? And it is in this context that we should address the question as to how a grasp of causal relations might be involved in such understanding.

From this perspective, though, one particular set of causal connections seems absent from the discussion so far. The Kantian considerations mentioned above are concerned, either, with the idea that causal laws can determine the sequence in which two events happen, or the idea that the order in which two events happen, in turn, can make a difference to our psychology, in the form of determining a certain sequence of perceptions. Arguably, however, this leaves out a third idea, namely that the order in which two objective events happen can not just have psychological consequences, but can also itself have causal consequences in the mind-independent world.

In what follows, we suggest that one way in which children might manifest a sensitivity to temporal relationships that cannot be explained in terms of the capacities underlying, e.g., script learning is in contexts in which the order in which two events happen also has causal consequences outside the psychological realm and in which children can't rely on direct experiences of those events to work out those consequences.

Thinking outside the script: temporal-causal reasoning

The kind of account of early script knowledge that we have given above turns crucially on the idea that scripts are acquired through direct (and usually, though perhaps not necessarily, repeated) experience of the relevant sequence of events. In particular, the thought is that the sequence in which the child witnesses the events itself determines the sequence in which they will later be recalled, and this can explain a basic form of knowledge for sequences which does not require a reflective grasp of temporal relations between the events in those sequences. The idea that children's early script recall may not be underpinned by such a reflective grasp is not a new one: For example, Catellani (1991: 100) cautions that "the fact that young children's reports have an accurate temporal-causal sequence does not imply that they are able to use such

temporal-causal connections explicitly”. Researchers have tried to address this issue by examining, for example, how young children deal with misordered sequences or with requests to recall in backwards order (e.g., Catellani 1991; Hudson & Nelson 1983; Fivush & Mandler 1985). Typically, the findings suggest that there are notable developmental changes in performance on such tasks. The intuition behind such studies is broadly similar to the one being articulated here: that young children’s ability to recall sequentially, while impressive, is tied very closely to their having experienced events in a certain sequence and that they will have difficulty on tasks that require any sort of manipulation of the temporal relationships between events.

We note also that psycholinguistic research that has examined children’s comprehension of the terms ‘before’ and ‘after’ has come to a similar conclusion. Although it is generally accepted that there are large developmental changes in the extent to which children spontaneously employ such terms (e.g., Orbach & Lamb 2007), studies examining children’s production of such terms in the context of script recall have found that even 3-year-olds will sometimes use them appropriately, and appear to interpret them accurately when used in connection with familiar event sequences (Carni & French 1984, French & Nelson 1985, see also Nelson 1996). Nevertheless, it is quite clear that the type of understanding thus manifested is highly limited. In particular, children of this age do not seem to reliably understand sentences in which the order in which events are mentioned does not correspond to the order of event occurrence (for discussion, see Harner 1982, Weist 1989, Winskel 2003). As with the work on children’s ability to manipulate sequences, this suggests that young children have difficulties thinking about the temporal relationships between events when the order in which they have to consider the events differs from their actual order.

We have recently carried out a series of studies in which passing the task at hand required children to reason about a series of events that they had not directly witnessed (McCormack & Hoerl 2005, 2007; see also McColgan & McCormack 2008, Povinelli et al. 1999). In particular, in each of these studies, what children had to realize was that a particular outcome was only possible if two events happened in a certain order rather than another. These studies yield further evidence in favour of the view that young children's sensitivity to the order in which events happen is tied closely to the child's having observed the relevant events in succession. However, they may also, in turn, be seen to give some indication as to the types of circumstances in which children might first start employing temporal concepts.

One of the studies (McCormack & Hoerl 2007) involved two doll characters, John and Peter, and a doll's house. The doll's house had a bathroom with a door that could be closed, so that children could not look inside, although the experimenter could still reach into the bathroom through the back of the doll's house. The children were told that the dolls' hair had got messy when they were playing outside, and that they were going to go into the bathroom to brush their hair. Three items in the bathroom were pointed out to the children: the hairbrush, which was sitting by the sink, and two differently coloured cupboards. The two dolls then went into the bathroom, and the door was closed behind them. After this, the experimenter said "You can't see John right now, but he goes first and gets the hairbrush and now he is brushing his hair. Now he puts the hairbrush in one of the cupboards. Peter goes last. You can't see him now, but he gets the hairbrush out and now he is brushing his hair. Now he puts the hairbrush into the other cupboard". Then bathroom door was opened, and each of the dolls could be seen standing beside one of the cupboards. It was explained to children that each doll was standing beside the cupboard that he had placed the hairbrush in, and they were asked two control questions to

confirm that they could recall the order in which the two dolls had brushed their hair. Finally, they were asked the test question “So, where do you think the brush is right now?” Five-year-olds could answer this question correctly, but 4-year-olds performed at chance.

Four-year-olds’ poor performance in this task contrasts sharply with the ease with which even 3-year-olds passed a modified version of the task. In this modified version, an identical procedure was used, except that the bathroom door was left open, so that children were actually able to see the relevant actions of the dolls.

What might explain the striking difference in children’s performance in these two tasks? Once again, it seems that the 3-year-olds’ ability to pass the modified version of the task turns crucially on the fact that they witnessed the relevant events in sequence. Success, in this case, can be explained in terms of what McCormack & Hoerl (2005) call temporal updating. In temporal updating, the child simply has a model of the world (e.g., of where certain objects are located) that changes as and when she receives information about changes in the world. In other words, there will be a sequence of changes to the child’s model over time as a result of the child receiving information about each event in turn, without the child herself having to reason about the order in which those events happened. Thus, in the modified version of the task, children could provide the right answer without having to consider the order in which the two dolls had acted. All they needed to do was retrieve a representation of the hairbrush’s location that had been appropriately updated in the course of the child’s observing it being moved first to one cupboard and then to the other.

By contrast, in the version of the task in which the bathroom door is closed, successful performance does seem to require reasoning about the order in which events have happened. In particular, children need to appreciate that the actions of the doll that went second undid the

consequences of the actions of the doll that went first in order to make use of the retrospectively provided information as to which doll had put the hairbrush into which cupboard.

This study (along with the others reported in McCormack & Hoerl 2005, McColgan & McCormack 2008, and Povinelli et al. 1999) thus serves to reinforce the idea, already discussed above in connection with the role of temporal priority in children's causal judgements and children's script-knowledge, that young children's sensitivity to temporal relations is tied to them finding out about events in the order in which they happen. Precisely because this type of sensitivity is not sufficient to pass the task, though, this study may also be seen to point to the type of context in which older children first start to reason about temporal relations using concepts such as 'before' and 'after'.

The general suggestion we want to make is that children first make proper use of concepts such as 'before' and 'after' in the context of reasoning about situations in which the order in which two or more events happen makes a difference to the overall outcome, i.e., situations that involve what we might call temporal-causal relationships. Such relationships might be seen to play a crucial role in children's grasp of temporal concepts because they allow children to give empirical significance to the idea that events happened in a certain order, in a way that goes beyond just thinking of them in that order. The task described above exemplifies one such temporal-causal relationship, because the actions of the doll that goes second undo the consequences of the actions of the doll that goes first. There are also other types of temporal-causal relationships, however. For instance, a certain outcome may depend on A happening before B, rather than B before A, with neither A nor B being able to produce that outcome on its own. Or B may produce a certain outcome either on its own or if followed by A, but not if preceded by A. Children's ability to reason about the whole range of such relationships has yet to

be explored systematically. If what we have argued is at least broadly along the right lines and a grasp of temporal concepts first emerges in such contexts, in which taking account of the order in which events happened is required to make causal judgements, further research empirical research on this issue seems merited.

The role of objects in a grasp of time as linear

In the preceding sections, we have argued that there is a range of basic ways in which young children can be sensitive to, learn about, or keep track of the order in which a sequence of events happens if they directly experience the events in that order. In each case, we have suggested that it is the sequence in which events are experienced, rather than an ability to reason about such sequences, that might actually explain children's competence in the early stages of development. Yet, we have pointed out that the order in which two events happen can also have causal consequences outside of experience, and we have suggested that situations in which this is the case play a crucial role in the emergence of a grasp of temporal concepts. That is to say, children first give significance to the thought of one event occurring before, rather than after another event in the context of situations in which the order in which two events happen might not just make a difference to the order in which they are experienced and perhaps later remembered, it also makes a difference to the state the world is left in.

In this final section, we want to discuss the relationship between the account we have offered and what might be seen as a rival account given by John Campbell.

Campbell's main focus is on autobiographical memory and on the question as to what it takes for a subject to give empirical significance to the linear structure of time in memory. Some theorists hold that there is a developmental dissociation between the ability to remember past

events and the ability to think of them as being arranged in a linear order, so that individual memories start of as unconnected “islands in time” (Friedman 2005: 151). Yet, even if we don’t take that view and instead think that the idea of events as arranged in a linear order is integral to autobiographical memory, we need to give some account of how we give substance to that idea. Crudely speaking, Campbell’s thought is that we give substance to the idea of remembered events as being arranged in a linear temporal order by thinking of those events as involving a common set of objects, and grasping the role objects play in transmitting causal influence across space and time. This is how Campbell summarizes this idea:

[T]he various narratives constituting the autobiographical memory of a single individual will be thought of as organised around a single linear time so long as there is some overlap in the persisting things which figure in the various narratives. These objects will ensure the temporal connectedness of all the times remembered by ensuring the potential causal connectedness of all the events remembered. (Campbell 1997: 116f.)

Straight off, though, it is at least not obvious that there couldn’t also be a way of picking up on the role that concrete objects have in transmitting causal influence over time that does not entail grasp of time as linear. Consider, for instance, the case of a child with a teddy that has been left bruised and battered by a variety of events, in the way teddies are prone to. Suppose we credit the child herself with some insight into how this has happened. For instance, the child might think of Teddy’s leg as having been chewed by the dog, the ear as having been torn on a fence, and the nose as having been squashed by sitting on it. At least on the face of it, there might be a way for the child to grasp all this without thereby being able to attach any significance, say, to the idea that the dog chewed the leg before, rather than after, the ear got torn. At the same time, though, we might nevertheless want to say that the child has some sort of grip on the fact that the

reason Teddy has all of those marks is that it's still the same Teddy that got into all of those scrapes. Certain kinds of planning abilities – e.g., putting Teddy in the suitcase before a holiday – might also show that the child has a grip on objects as being capable of transmitting causal influence over space and time.

To make good Campbell's claims about the role that thought about objects plays in grasp of time as linear, it seems the idea that objects transmit causal influence over time is perhaps not enough. Instead, we may have to look specifically at cases in which the fact that things happen to an object in a certain order rather than another make a difference to what the object ends up being like as a result. But this, of course, is just the idea that there can be temporal-causal relationships between different things that happen to the object, in the sense described in the previous section, and that it is the idea of such relationships that allows us to give substance to the idea of a linear order of past events. In other words, as we saw in the case of the Teddy, it seems we can make sense of a basic grasp of the idea of an object having been affected by certain events that doesn't entail grasp of the idea of those events having occurred in a particular order. By contrast, what does require the idea of a temporal order, in the case of the task described in McCormack and Hoerl (2007) is the thought of a particular kind of causal relationship between the two dolls' actions, in that each of them has the power to undo the effects of the other.

Where exactly does that leave Campbell's proposal? We can distinguish between a weaker and a stronger line one might take here. According to the weaker one, we need to draw some sort of distinction between a more implicit and a more explicit grasp of the causal role of objects. Campbell himself is possibly quite sympathetic to this kind of line (see, e.g., Campbell 1993: 92). The upshot of what we have been arguing would then be that part of what having a

more explicit grasp comes to, in this context, needs to be spelled out in terms of the idea that the subject can make sense of the idea that how an object is at one time depends not just on what has happened to it before, but also on the order in which things have happened to it. Once we take that line, however, it seems there's also a stronger one in the offing, because the real explanatory weight in accounting for a subject's grasp of the linear structure of time is carried by her understanding of such temporal-causal relationships. And this might make us wonder whether thought of the causal role of objects is indeed essential to a grasp of the linear structure of time, as Campbell claims. It seems that it can be so only if it is essential to a grasp of temporal-causal relationships.

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