The Proper Treatment of Events

Michiel van Lambalgen
and
Fritz Hamm
The Proper Treatment of Events
Explorations in Semantics

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   Michiel van Lambalgen and Fritz Hamm
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Michiel van Lambalgen
and
Fritz Hamm
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This book studies the semantics of tense and aspect from the vantage point of cognitive science. We start from the hypothesis that one may learn something about the coding of temporal notions in natural language by looking at the way human beings construct time. This formulation may surprise some readers: surely we perceive rather than construct time? In the first part of the book, ‘Time, events, and cognition,’ it is argued that, on the contrary, time is a construction, and that it is far from obvious why humans should experience time at all. The provisional answer to the latter query is that the experience of time is intimately related to the need for planning. This suggests that the linguistic encoding of temporal notions is best explained in terms of planning and its next of kin, causality.

Part II, ‘The formal apparatus,’ introduces a fully computational theory of planning, a version of the so-called event calculus as used in AI, reformulated in constraint logic programming. The formalism introduced here is somewhat more technical than is customary in semantics books. The formal setup we have chosen reflects our belief that semantics, in order to be cognitively relevant, should start from a computational notion of meaning. Using the traditional terminology of sense and denotation, our point of view can be described succinctly thus: ‘the sense of a linguistic expression is the algorithm which allows one to compute the denotation of that expression.’ An added bonus of such a computational approach is that the step from theory to implementation need not be very large. This part requires a rudimentary acquaintance with logic programming, but the necessary background is provided in the Appendix. Exercises are provided which help the reader to master the material. In Part III, ‘A marriage made in heaven – linguistics and robotics,’ we apply the formalism of Part II to a variety of data. For instance, in a chapter devoted to French past tenses, the peculiar interaction between sentence order and verb tense which yields event order is studied in great detail, as an example of the computational power of the theory. This chapter has a pedagogical purpose as well, since the required derivations in logic programming are exhibited in full. The other chapters, for instance those on grammatical aspect and on coercion, require the same computational machinery, although fewer details are given; but in the exercises which follow the chapters, the reader is invited to construct the derivations herself.
Some indications on how to use this book. It is not necessary to read the book from cover to cover. If the reader is not overly interested in the cognitive background provided in Part I, she needs to read only Chapter 3, with perhaps the occasional glance back to the earlier chapters. Readers not interested in earlier formal approaches to events may skip Chapter 2 except for Section 1. In Part II, Chapter 6 can (and perhaps should) be skipped at first reading, in the sense that the chapters on tense and aspect in Part III can by and large be understood on the basis of Chapters 4 and 5 only. Chapter 12 on nominalization, however, requires Chapter 6 essentially. Throughout the book, paragraphs between ‘**’ indicate elucidations of a technical nature. These can be skipped without loss, and the same holds for most endnotes. There is a website accompanying the book (see http://staff.science.uva.nl/~michiell), which contains proofs not provided in the text, suggestions for additional reading, slides for instructors, and, more likely than not, errata.

It is a pleasure to record our intellectual debts here. Keith Stenning introduced us to cognitive science, and made us see how our thinking on time and tense tied in with current debates on memory architecture. Mark Steedman read the entire manuscript and provided valuable and encouraging feedback. Darrin Hindsill gave us expert advice on historical linguistics and he and Orrin Percus came to our aid when we had questions about present usage of English. Fabrice Nauze co-authored Chapter 9 on French past tenses. Katja Jasinskaja and Peter Kühnlein at Bielefeld carefully read part of the manuscript and suggested many corrections. Kai-Uwe Kühnberger and Graham Katz taught a class at Osnabrück based on our previous work, which again led to many suggestions for improvement. Uwe Mönnich contributed excellent advice on most topics discussed in this book. Many thanks to all of them.

Régine Pernoud wrote in her Héloïse et Abélard: ‘Men know little about love, but logicians least of all.’ Quite so. We dedicate this book to our children: Stijn, Jacob, and Max.

M. v. L. and F. H.
Amsterdam and Tübingen
Part I

Time, Events, and Cognition
Chapter 1

Time

There is some sense – easier to feel than to state – in which time is a superficial and unimportant characteristic of reality. Past and future must be acknowledged to be as real as the present, and a certain emancipation from the slavery of time is essential to philosophic thought.

Bertrand Russell, Our knowledge of the external world

The epigraph, with which we wholeheartedly agree, is more or less the last nod to philosophy in this book. The reality or unreality of time has of course engaged philosophers since the dawn of philosophy, and since the seventeenth century, physicists have joined in the discussion as well. Whitrow’s The natural philosophy of time [130] (see also [131]) is still one of the best introductions to this area. Analytic philosophers have been particularly active here, focusing on the question ‘what must the world be like in order for tensed talk to make sense?’ A good source for this circle of ideas is the collection Questions of time and tense, edited by Robin Le Poidevin [70]. On the face of it, that question is precisely what our book should be concerned with, since it involves the semantics of tense, and the adequacy of this semantics as a description of the real world. On closer inspection, however, the correspondence turns out to be less close, since the ‘tensed talk’ at issue is a rather abstract version of actual temporal discourse, with ‘past’ and ‘future’ defined in terms of a single relation ‘earlier than’ only. We will see abundant evidence that this picture of the tenses is far too simple. By contrast, the point of departure of this book could be encapsulated by the question: ‘what must our minds be like for tensed talk to make sense?’, where ‘tensed talk’ is now meant in its full linguistic complexity.

It is a truism that we express temporal relations in language because we are able to experience these relations. It is less clear why human beings, unlike other animals, consciously experience time at all. The purpose of this part is to show that answers to this question may actually have some relevance for the semantics of tense and aspect. That is, we claim that the particular way in which temporal relations are coded in language reflects the human cognitive representation of time; moreover, we also claim that the intricate patterns of the linguistic encoding of time can be fully understood only if the mental construction of time is taken into account.
In a nutshell, the proposal is this. It will be argued that there is an intimate connection between time and planning, in the sense that the mental integration of past, present, and future occurs through planning. If this is so, then the linguistic representation of past, present, and future may also involve planning. The second and third parts of the book are then devoted to showing that planning, suitably formalized, leads to a fully explicit computational theory integrating tense and aspect. In this first part, especially Chapter 2, the reader can moreover find a psychological and mathematical discussion of the crucial notion of ‘event.’ Verbs and verb phrases are traditionally said to denote events – but what kind of entities are these? Or, to reformulate the question more in agreement with our general approach: how are events mentally constructed? We discuss some psychological work which points to the role of goals and plans in the memory encoding of events, and which provides evidence for the hierarchical organization of events as coded in memory. This will turn out to be of some importance for our treatment of tense in Part III.

We then continue the discussion with an axiomatic treatment of events. This is for three reasons: the reader may be (half-)familiar with Kamp’s axiomatization of event–structure, which plays some role in Discourse Representation Theory; it provides some insight into the vexed relation between events and time as a one-dimensional continuum, and it also provides a precise way of pinpointing what is wrong with the traditional concept of ‘event.’

1 Psychology of Time

The reader may be under the impression that, while there are of course many deep questions surrounding the physical concept of time (mainly in relativistic situations), time as consciously experienced is a much more simple affair. After all, ‘time flows,’ and we only have to perceive this flow, that is, the moving ‘now.’ In reality, it is not at all like this. Our conscious notion of time is a construction, as much dependent on the operation of the memory systems as on perception. We will now set out to explain this, as a prelude to answering the main question: why do we experience time at all?

It is convenient to discuss the cognitive basis of time by distinguishing three aspects:

1. time as duration;
2. temporal perspective: past, present and future;
3. time as succession.

We will discuss these in turn (gratefully using material summarized in Block’s collection [8]), and we will highlight connections to our main theme.
1.1 Time as duration

The durative aspect of time is least important from the perspective of the grammaticalization of time, since duration (‘5 minutes,’ ‘two days’) is only lexicalized, not grammaticalized.\(^1\) It is nevertheless not entirely irrelevant to our concerns.

Let us consider how we may estimate duration. It is useful to distinguish here between duration in passing or experienced duration, and duration in retrospect or remembered duration. The distinction makes sense of such cases as the following. A period of time filled with exciting events will seem short in passing, but long in retrospect. However, a period of time in which little new happens (e.g. a protracted period of illness, or waiting for connection to a helpdesk) will seem long in passing, but short in retrospect. This seems to show that attention is necessary to encode temporal information about duration: if attention is focussed on events rather than their duration, the latter type of information is not, or not correctly, encoded. Even when we do pay attention to the passage of time, our estimates may be fairly unreliable. There is no internal watch from which we can read off how much time has passed. It is not yet quite clear how we manage to give reliable estimates, in those cases where we do so. One possibility, of interest to us because it relates to our technical proposals in Part II, is that memory contains a number of scenarios with (realistic) default values of durations of activities. By ‘default value’ we mean the duration of an activity which proceeds normally, with a minimum number of interruptions. Experiences of time running slow or fast while performing an activity are then due to a comparison with the scenario for that activity. Jones and Boltz [56] demonstrated this by comparing judgments of durations of ‘natural’ melodies with those of malformed melodies. The latter lead subjects to wrong estimations (either too long or too short) about their durations. It will be seen below that scenarios such as envisaged in [56], containing temporal information about default values, play a very important role in our semantics for tense and aspect.

1.2 Temporal perspective

The various attitudes that people adopt in relation to past, present, and future are what characterize temporal perspective. It includes span of awareness of past, present, and future, as well as the relative weight given to these. This aspect of time is of course highly relevant to natural language. Temporal

\(^1\) One could argue, however, that it can become grammaticalized when combined with temporal perspective, for example in those languages which have separate past tenses for ‘less than one day ago,’ ‘one day ago,’ ‘a long time ago’ (for which see Comrie [18, pp. 83ff.]).
perspective is different from the apparently simpler notion of time as succession, because it introduces a vantage point, the deictic now, to which all events not co-temporaneous with ‘now’ are related as either ‘past’ or ‘future.’ Lest the reader think that it is somehow trivial to have a temporal perspective, we provide here an example of a dialog with a schizophrenic patient who apparently lacks the stable deictic ‘I–here–now’:

Interviewer: Are your uncles alive?
Patient: One died in France.
Interviewer: And which one are still alive?
Patient: After the father from the mother’s family, only Jasiek from France is still alive; he died already, he was killed in some kind of accident. [132, p. 32]

Although time as succession is conceptually simpler than its perspectival aspect, the ordering of events or instants is most likely computed from temporal perspective. William James pointed this out forcefully, in his classic discussion of the meaning of ‘now,’ or what he calls the ‘specious present’:

[T]he practically cognized present [i.e. the specious present] is no knife-edge, but a saddle-back, with a certain breadth of its own on which we sit perched, and from which we look in two directions of time. The unit of composition of our perception of time is a duration, with a bow and a stern, as it were – a rearward- and a forward-looking end. It is only as parts of this duration-block that the relation of succession of one end to the other is perceived. We do not first feel one end and then feel the other after it, and from the perception of the succession infer an interval of time between, but we seem to feel the interval of time as a whole, with its two ends embedded in it. The experience is from the outset a synthetic datum, not a simple one; and to sensible perception its elements are inseparable, although attention looking back may easily decompose the experience, and distinguish its beginning from its end. [54, pp. 574–575]

Before James, Saint Augustine had already pointed out, in Book XI of the Confessiones, that it is only possible to measure the duration of an event if in a sense its beginning and end are simultaneously present in awareness. Thus the present cannot be truly instantaneous. James bites the bullet, and posits that the present is in fact a bidirectional duration, one end looking toward the past, the other end looking toward the future. Memories of what is just past, and anticipation of what lies in the immediate future co-occur with current perceptions. Modern neuroscience has given some support to this picture [87]. There is evidence for the existence of a window of 3 seconds in which all incoming perceptions are bound together. After 3s, the brain asks ‘what’s new?’ and updates the complex of bound sensations with new impressions.

Turning to the past, we find the obvious association of the past with memory. But what is colloquially known as ‘memory’ is actually an ensemble of several different systems. We may first distinguish between implicit and explicit
memory. The former is also known as procedural or skill memory: it is the repository of our ‘knowledge how,’ the various routines and skills. Explicit memory is usefully subdivided into long-term memory (comprising semantic memory and episodic memory), and short-term memory (itself comprising working memory and short-term storage facilities). Working memory is a computational arena of limited capacity, which is essentially involved in action selection. Like any computing engine, it needs some registers in which to hold transient information (analogous to RAM on a computer). Semantic memory contains conceptual and encyclopedic knowledge, that is, knowledge about word meanings and about regularities in the world. This knowledge is general in the sense that individual experience has been abstracted from. The true repository of individual experiences is episodic memory, which contains our ‘memories’ in the colloquial sense. Thus, in a sense, our past resides in episodic memory, but of course the retrieval mechanisms must function properly for us to be able to access the past. In fact, our temporal perspective (remembering the past, anticipating and planning the future) seems so natural that one may well wonder how it could be otherwise. Nevertheless, there exist clinical data which show that temporal perspective can be very different. Melges [76] discusses the case of patients with frontal lobe lesions; it is believed that such lesions may interfere with the action-selection capacity of working memory. Patients with frontal lobe lesions may become a slave to the demand characteristics of the present. Melges cites two examples: one patient who was shown a bed with the sheet turned down immediately undressed and got into bed; another patient who was shown a tongue depressor took it and proceeded to examine the doctor’s mouth. What is striking about these examples is that patients become dependent on the Gibsonian ‘affordances’ of their environment, which then act almost like stimulus–response bonds. Affordances (as defined by Gibson [42]) are the functional roles that objects may ‘wear on their sleeves’: in this sense a door ‘affords’ to go through it, and a bed with the sheet turned down ‘affords’ to go to sleep in it. But healthy humans use an affordance as a possibility only, to be used in the selection of actions toward a goal, and not as a necessity, i.e. as a condition–action rule.

This brings us to the cognitive representation of the future. The sense of the future seems to be bound up inextricably with the fact that humans are goal-oriented beings, as opposed to beings who are governed by large sets of condition–action rules. The realization of a goal is necessarily in the future, even though a representation of the desired state must be held in memory.

The connection between temporal perspective and being goal-oriented was investigated experimentally by Trabasso and Stein [120] in a paper whose title sums up the program: ‘Using goal-plan knowledge to merge the past with the present and the future in narrating events on line.’ The paper defends the thesis that ‘the plan unites the past (a desired state) with the present (an attempt) and the future (the attainment of that state)’ [120, p. 322] and ‘[c]ausality and planning provide the medium through which the past is glued to the present and future’ [120, p. 347]. Trabasso and Stein present the results of an experiment in which children and adults were asked to narrate a sequence of 24 scenes in
a picture storybook called *Frog, where are you?*, in which a boy attempts to find his pet frog which has escaped from its jar. The drawings depict various failed attempts, until the boy finds his frog by accident. The purpose of the experiment is to investigate what linguistic devices, in particular temporal expressions, children use to narrate the story, as a function of age. They provide some protocols which show a child of age 3 narrating the story in tenseless fashion, describing a sequence of objects and actions without relating them to other objects or actions; none of the encoded actions is relevant to the boy’s ultimate goal. Temporal sequencing comes at age 4, and now some of the encoded actions are relevant to the goal. Explicit awareness that a particular action is instrumental toward a goal shows up at age 5. At age 9, action–goal relationships are marked increasingly, and (normal) adults structure the narrative completely as a series of failed or successful attempts to reach the goal.

We can see from this that there is a connection between children’s developing sense of time, and their ability to structure the narrative as the execution of a plan toward the goal of finding the frog. The child of age 3 is glued to the present. The child of 4 includes causal relations between events, states of mind, and actions; these causal relations implicitly drive the narrative forward. The child of 5 can move from narrating a current action to mentioning a goal state to be attained in the future, and back again. The reason that there must be a gradual development of these capabilities is outlined in the following extract:

> Inferring goals and plans involves considerable social and personal knowledge and places heavy demands on a narrator’s working memory. The child who narrates events needs to attend to and maintain the current event in working memory; to activate and retrieve prior knowledge relevant to events, either in general or from earlier parts of the story, in order to interpret and explain the current event; and to integrate these interpretations into a context within a plan, all within the limitations of knowledge and working memory. In effect, over time the child is engaged in dynamic thinking, actively constructing and evaluating models and hypotheses about what is occurring. In so doing, the child creates a changing mental model that results in a long-term memory representation of what has occurred. [120, p. 327]

This extract again emphasizes the important role that construction plays in our sense of temporal perspective. If Trabasso and Stein are correct, the construction comes about because plans integrate past, present, and future. Working memory is essentially involved in this process of integration, and failures in its operation may show up in the resulting temporal perspective.

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2 This is a classic experimental paradigm for investigating the acquisition of temporal notions in children. See Berman and Slobin [7] for methods, results, and last but not least, the frog pictures themselves.

3 In fact, reading the protocol one gets the impression that the child’s conception of time is what William James called the ‘block universe’: ‘the world is like a filmstrip: the photographs are already there, and are merely being exhibited to us’ [130, p. 274]. One might object that this is precisely the experimental situation, but the important point is that older children are able to see the picture book as a flow.
1.3 Time as succession

The idea that time is simple finds its roots in the mistaken notion that we only have to attend to the succession of events in the outside world. As James [54, p. 591] clearly saw, this confuses a succession of judgments with a judgment of succession. As we have seen above, the latter type of judgment is only possible when the events are in a sense simultaneously present in awareness. But even this is clearly not yet sufficient. As might be expected, there are limits to the human ability to discriminate order. Here are a few more or less random examples to illustrate the point. If there are two visual stimuli with stimulus onset asynchrony (SOA) less than around 44 ms which are projected on the same retinal area, the stimuli are perceived as simultaneous. With slightly larger SOA’s, subjects experience flicker, i.e. they experience successiveness without necessarily being able to encode the order of the events. If in this case the stimuli are projected on different retinal areas, subjects experience apparent movement of the stimulus. Interestingly, temporal order judgments can be wide off the mark in such a case. The paradigm example is the case where the two asynchronous stimuli have different colors, say red and green: the subject then sees one moving stimulus which changes color from red to green in mid-trajectory! What is paradoxical about this phenomenon is that apparently the subject perceives the color green before the green stimulus has occurred. Only at larger SOAs, in the order of 100 ms, can successiveness proper be perceived, in the sense that the subject can make true judgments about the order of succession.4

Turning now to judgments of succession of events occurring over larger time spans, in all probability the encoding of succession of such events makes use of temporal perspective. Block [8, p. 6] puts this succinctly:

Perhaps in interaction with human cognitive processes, information relating to the ordering of events from earlier to later gives rise to the common idea that the progression of time may be represented as a line or an arrow. The continuously integrated functioning of perceiving, remembering and anticipating processes apparently produces a relatively automatic awareness of the successive ordering of events. This is a fundamental aspect of all temporal experiences beyond those that merely produce an experience of successiveness without the ability to discriminate temporal order. The primary psychological basis for the encoding of order relationships between events relates to the dynamic characteristics of information processing: in the process of encoding an event, a person remembers related events which preceded it, anticipates future events, or both.

That is, while encoding an event, one simultaneously recalls related preceding events, and anticipates related future events. The relation ‘e precedes now’ may

4 Data such as briefly described in this paragraph are obtained using extremely simple stimuli, such as tones of short duration and color flashes. In actual perception, where many stimuli jostle for attention, the processes leading up to a judgment of successiveness are more complicated, mainly because it then is no longer possible to treat the stimuli as point-like.
then be defined operationally as: ‘if I recall event \( e \), it must have taken place before now,’ and analogously for the relation ‘now precedes \( d \)’: if \( d \) is anticipated, it must lie in the future. The composition of these two relations then gives the relation ‘\( e \) precedes \( d \).’ The temporal ordering is thus overlayed with recollections and anticipations, and hence generally with contextual material. Interestingly, it thus seems that temporal perspective has cognitive primacy over temporal succession.\(^5\)

It also appears from the above quotation that the ‘precedes’ relation is not automatically encoded in memory, but requires conscious attention for explicit encoding, in the sense that one should remember related past events or anticipate future events, both of which are conscious activities. Without such attention, encoding apparently does not take place, just as we saw for the case of duration. Nevertheless, it also seems to be the case that ‘precedes’ has a privileged position among temporal relations in the sense that conscious attention to temporal structure focusses on succession, and not on other temporal predicates such as ‘begins before,’ ‘ends before’ or ‘overlap.’ We will discuss the logical relations between these temporal predicates below. It will turn out that, provided succession satisfies a few axioms including most importantly linearity, the other relations can be defined in terms of succession. Hence also in the logical sense succession is a fundamental relation.

## 2 Why Do We Have the Experience of Time at All?

Summarizing the preceding considerations, Michon’s attempt at a cognitive definition of time emphasizes its constructive nature:

Time is the conscious experiental product of the processes that allow the (human) organism to adaptively organize itself so that its behaviour remains tuned to the sequential (i.e. order) relations in its environment. [78, p. 40]

We do indeed have a conscious experience of time, and this is of course the sine qua non of grammatical representation. But one might ask why this is so: could we not have functioned equally well without conscious experience of time? It will be seen that we can learn something about the linguistic representation of time from a consideration of this question.

First a few explanatory remarks about the kind of answer to the ‘why?’ question that can be expected. There are two main types of answers here, functional and evolutionary. In a functional explanation, one looks at the function a particular capacity has in the whole of cognition. An evolutionary explanation tends to have a somewhat different focus: either the capacity is considered in

\(^5\) One is reminded here of the discussions surrounding McTaggart’s ‘A-series’ and ‘B-series,’ for which see, for example, Le Poidevin [70].
isolation, and explained as an adaptation to particular environmental pressures (e.g. the melanic moth on the blackened trees of Manchester), or it is considered as an exaptation, explaining the capacity as a fortuitous new use of a capacity evolved for other purposes (feathers evolved for temperature regulation, but were exapted for flight). We will discuss functional explanations first, and then move on to evolutionary considerations.

The above quotation from Michon rightly emphasizes that it is fundamental for an animal that its motor action must be ‘in tune,’ ‘in sync’ with the outside world. One might think that here awareness of time must play a role, thus providing a functional explanation for temporal experience, but that is not so. In principle there are two ways to achieve synchronization, with and without internal clock.

Assume for the moment that activity is governed by a motor-program, stored in procedural memory. This motor-program may be seen as an abstract plan that is implemented in ever greater detail as information seeps down the hierarchy. As an example, one may think of a motor-program for writing the letter ‘A.’ This case is of some interest, because it has been shown that whether a subject writes an ‘A’ with his (favoured) right hand, his left hand, or even his right and left foot, the ‘A’s produced share many structural similarities, thus leading to the hypothesis that the same abstract motor-program is in charge in all cases. For our purposes, the important point is whether time occurs as a control parameter in the motor-program, as an internal clock, to determine the relative timing of the actions to be performed. Sometimes such a parameter is indeed necessary, e.g. in bimanual coordination when tapping nonharmonically related rhythms. But sometimes the time parameter appears otiose, as in our handwriting example, where the motor-program apparently specifies only the general order of actions, not their time-course, which depends on interaction with the environment (e.g. type of pen, paper, clothing; constraints of musculature). This interaction is achieved not by synchronizing external and internal clocks, but by manipulating parameters (e.g. by simulation or learning) in which time occurs at most implicitly, such as force or momentum. Hence, time itself is not a control parameter in this case. For another example, take the case of a motor skill such as the catching of a ball by a goalkeeper. Here it appears to be unnecessary to compute the trajectory and the estimated time of arrival at the goal; if the ball is shot straight at the keeper, time-to-contact is inversely proportional to dilation of the ball’s image on the retina, and this information is directly available. In principle it is possible to act, i.e. catch the ball, on the basis of this information only, without any estimate of arrival time. It is of course also possible for the goalkeeper to be fooled by this mechanism, if a banana-shot comes his way.

The upshot of these considerations is that many motor skills do not involve explicit time (e.g. in the form of a clock), which is there to become aware of. Hence, if our conscious experience of time has a function, it is most likely not that of facilitating synchronization. So why then do we need the experience of time?
Michon [78, p. 42] advances the hypothesis that an impasse in the process of action-tuning may lead us to explicitly lay out the order of actions to be performed, and their duration. This ties in with an intriguing hypothesis advanced by Suddendorf and Corballis [117], who claim that what they call ‘mental time travel,’ i.e. the possibility to revisit the past and to imagine the future, is really a corollary of the human ability to dissociate from the present, and in particular to imagine possible worlds and possible sequences of events. The argument leading up to this hypothesis is intricate, and, as is often the case in cognitive science (including this book), built upon a certain interpretation of the literature reviewed. Nevertheless, the synthesis presented by Suddendorf and Corballis is very suggestive.

They first contrast humans with the great apes and other animals, and note that whereas humans can travel backwards and forwards in time, and can sense their self in the not-now, other animals do not seem to have this capability. They propose what they call the ‘Bischof–Köhler hypothesis’ as a description of the difference:

> Animals other than humans cannot anticipate future needs or drive states and are therefore bound to a present that is defined by their current motivational state.

In other words, animals would not be able to entertain ‘conflicting’ states of mind such as ‘not hungry now,’ ‘will be hungry tomorrow.’ And, for that matter, neither can children age 3 or below. In one celebrated experiment from the family of ‘false belief tasks,’ the Smarties test, a child is shown a Smarties box, and asked what it expects its contents to be (for American readers: Smarties are M&Ms). The child happily answers ‘Smarties!’, but upon opening the box finds that it contains pencils instead. If one now asks the child somewhat later what it expected the content of the Smarties box to be, it answers ‘pencils.’ This is in line with the child’s answer to the question, what another person not present in the room will expect to find in the box; again the answer here is ‘pencils.’ The child thus appears to have no representation of its former self. In this sense also the child, unlike the adult, cannot experience its self in the not-now.

Suddendorf and Corballis then consider what cognitive systems subserve the apparently uniquely human capability to dissociate from the present. Implicit, or procedural, memory is not concerned with individual events, but with abstracting patterns from events, including their spatio-temporal characteristics, so implicit memory is no use in explaining time travel. Turning to declarative memory, we may note that semantic memory is able to represent singular facts, unlike procedural memory, but these have the character of learned not experienced facts. Therefore it must be episodic memory which holds the key to mental time travel. The originality of Suddendorf and Corballis [117] lies in the suggestion that episodic memory, seemingly concerned with the past, may actually be instrumental for our conception of the future. The first step in the argument is that episodic memory is not a static data structure, a repository of experienced facts. It rather involves a constructive activity, which draws upon other
cognitive abilities such as semantic memory. The second step is the observation that episodic memory actually offers a rather poor and unreliable representation of the past. This suggests that the primary function of episodic memory is therefore not veridical representation of the past, but rather a generalized capacity for imagining or constructing possible worlds, possible courses of action, of which the coding of autobiographical memories is only a corollary. If this is correct, our sense of time derives from being goal-oriented agents, as was indeed suggested by Michon [78, p. 42]. It is then but one step to hypothesize that the linguistic coding of time is also driven by the future-oriented nature of our cognitive make-up. The main purpose of this book is to work out this suggestion in full technical detail.