



The Psychology of Time Perception

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palgrave
macmillan

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ISBN 978-1-137-40882-2 ISBN 978-1-137-40883-9 (eBook)
DOI 10.1057/978-1-137-40883-9

Library of Congress Control Number: 2016938827

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Preface

The composer Gustav Mahler is supposed to have said “A symphony must be like the world. It must contain everything.” While this might be true of a Mahlerian symphony, it certainly is not true of this book on time perception. The volume you are reading does not contain everything that is known about time perception, or even everything that you might want to know. Its content is intended to provide the reader with an overview of some of the main trends in fairly recent work on the psychology of time, carried out over the last 30 or 40 years, although some historical issues are also discussed, as is a small amount of the philosophy of time. It is a personal selection of topics, albeit—I hope—a choice that is not too idiosyncratic. My aim is to provide the reader with an introduction to work in time perception which I believe to be interesting, important, and influential. An emphasis in the book, which reflects my own interests, is on ideas and theories underlying time perception research, rather than with just providing a summary of results, although a significant amount of experimental data is discussed, sometimes in considerable detail. The theories I mention have generally been simplified in the cause of exposition, and are all more complex than I am able to describe in this book, but the reader may consult the original articles cited in the text for details. I only hope the inventors of these theories agree that my discussion of their work has captured most of their essence, if not all the minutiae. Some topics that people might have wanted to read about, like

rhythmical timing or time in music, are not included, as they have tended to develop separately from what I consider to be mainstream time perception, which has been strongly focussed on the perception of duration, the judgement of how long things seem to last. I have also omitted any discussion of the cognitive neuroscience of time perception. Although this topic occupies the attention of many researchers at the time of writing, thus far their efforts have resulted in few firm conclusions that can be easily communicated. Indeed, none of the topics treated in the book would be significantly illuminated in any way by the neuroscience of timing in its present state, at least in my view. Finally, the reader is warned that my own contribution to the field has been exaggerated here, but if you are not interested in your own work, why should anyone else be? In any case, the considerable effort of writing this book, which among other things has brought home to me how little I know about the subject, has surely earned me this privilege.

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Acknowledgements

I am grateful to the American Psychological Association, Elsevier B.V., and Taylor & Francis for permission to reproduce many of the figures used in this book.

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1

Overview

As mentioned in the preface, the aim of this book is to provide the reader with an introduction to what I believe to be the most important areas of time perception over the last 30 or 40 years. It is focussed mainly on the psychology of timing in humans, although Chap. 9 discusses animal timing. Animal timing has been an important precursor of ideas in the contemporary study of time perception in humans, mostly through the development of *scalar expectancy theory* (SET), initially proposed to explain animal timing, but in some ways the dominant theory of human timing until recently, and perhaps still. In general, however, the study of animal learning and behaviour plays a much smaller role in psychology today than in the past, and so presenting a very extensive account of animal timing early in this book seemed inappropriate, and likely to discourage many readers. To address this, I have placed the topic of animal timing in Chap. 9, where readers will find some of the most intellectually fascinating ideas in the whole of the field of time perception. Chapter 2 discusses a little of the philosophy of time, and some of the history of time perception research leading to the development of internal clock theories of human timing, which have been so influential. Chapter 3 discusses SET, the principal internal clock-based account of human timing,

itself a variant of an earlier theory proposed by Treisman (1963). An appendix to that chapter presents an elementary account of some of the mathematics of internal clock theory. SET provides not only a general account of human performance on many timing tasks, but also specific theoretical models, notably the performance on tasks involving temporal generalization and bisection, which have been widely used, particularly the latter. Theoretical accounts of generalization and bisection, whether based directly on SET or otherwise, are discussed in Chap. 4. In that chapter, mathematical exposition is kept to a minimum, largely as a result of my own lack of competence. A reader wishing to understand some of the basic mechanics of SET-based models, which have been particularly important in areas such as the developmental psychology of time, will find here what I hope are simple accounts of their operation. Chapter 5 considers the role of cognitive processes such as attention and executive function in time perception, but also discusses fairly recent work on emotion and time perception. Chapter 6 examines retrospective timing, or “timing without a timer,” and passage of time judgements, including work from sociology and occupational psychology that is rarely mentioned in the mainstream time perception literature. In this chapter I also spend some time discussing the contents of Ornstein’s (1969) book, *On the Experience of Time*, which is frequently cited, probably little read, and these days rather difficult to obtain. Chapter 7 deals with timing in children. I begin with a discussion of Piagetian time psychology, with an account of some of the material in Piaget’s book *The Child’s Conception of Time*. This is another classic, and once again, I suspect, one that is little read, although the peculiarities and obscurity of the work give modern readers good excuses to avoid it. Later researchers in the Piagetian tradition, on the other hand, have developed Piaget’s ideas in a more digestible manner, and I discuss some of their work. The later part of this chapter discusses more recent research on timing in children, some of it inspired by SET. In Chap. 8 I review some of the work related to timing and ageing, including both laboratory studies and research on time experience in “real life,” with some discussion of the vexed question of whether time seems to “go faster” as people age. Chapter 9, mentioned earlier, introduces some of the main findings from, and theoretical models applied to, animal timing research. Readers jaded by the hegemony

of SET will find interesting competitors to it here. Chapter 10 is a kind of appendix, outlining some of the commonest methods used in time perception research. Readers unfamiliar with time perception studies will find outlines of some of the principal methods used here.

I should emphasize at the outset that this volume is not intended to be a “popular science” account of the psychology of time perception, but neither is it intended to be a highly technical work comprehensible only to specialists in the field. In this book, I have tried to introduce and explain the main trends in fairly recent time perception research in a way that should be accessible to anyone with a basic knowledge of psychology. I can only hope that I have succeeded with this aim, at least in part.

2

A Brief History of Time Perception

Philosophers and Time

The second part of Cardinal Newman's poem *The Dream of Gerontius*, set to music so vividly by Edward Elgar, describes the progress of the soul of Gerontius towards its judgement while beholding the sight of God. Newman tries to describe a situation without time, which the deceased Gerontius expresses like this:

*How still it is!
I hear no more the busy beat of time,
No, nor my fluttering breath, nor struggling pulse;
Nor does one moment differ from the next.*

Even with the augmentation of imagination that poetry sometimes elicits, this situation seems literally impossible for most people to conceive of (and for Newman as well: in the poem, events follow one another, occurring in a clear temporal sequence). The passage of time as a succession of events, or the feeling of passage of time during a persisting stimulus, seems such a necessary part of our everyday experience, that it is natural

to suggest it is in some way primordial and something that is essential for us to make sense of our impressions and the progress of our mental life.

Philosophers have long been fascinated by the nature of time and how we perceive it. Nichols (1891) provides a summary of many philosophical positions regarding time that were advanced through the late nineteenth century. One issue that divided philosophers and that has had practical consequences for the psychology of time is the question of whether the perception of time is innate or is based on some prior experience.

Kant, in his celebrated *Critique of Pure Reason* (1781/1900/2003), proposed that a sense of time existed a priori, along with the appreciation of space, as something innate and independent of experience. For example (p. 28)

Time is not an empirical conception. For neither co-existence nor succession would be perceived by us, if the representation of time did not exist a priori...Time is a necessary representation, lying at the foundation of all our intuitions. With regard to phenomena in general, we cannot...represent them to ourselves as out of and unconnected with time, but we can quite well represent to ourselves time devoid of phenomena.

In addition, he argues (p. 29) that

...the conception of motion...is possible only through and in the representation of time...

There is empirical research with children on the relations between time and change—and in particular, time and motion—and it is discussed in Chap. 7. As work reviewed there shows, it seems that judgements of time, or judgements of duration at least, are if anything *more* difficult to master than concepts like distance or size. Children also have considerable difficulty extracting the dimension of duration from other aspects of the situation presented to them. For example, if asked to judge which of two toy cars ran for the longer period of time, young children have difficulty dissociating the duration of the movement from the distance traversed. None of this suggests that time, at least in the form of conscious appreciation of duration, is an a priori phenomenon. However, as other research

shows, particularly that reviewed in Chaps. 7 and 9, very young children who have not learned to speak and non-human animals can be trained to adjust to the temporal requirements of experimental situations, suggesting that sensitivity to temporal regularities in the environment is not dependent on the possession of language that might provide the cognitive concepts of time familiar to adults.

The Kantian concept that time is a “given” contrasts sharply with the position of Guyau (1890). Guyau’s *La genèse de l’idée de temps* not only explores the question of how time representations develop, but also speculates—often with arguments that appear strikingly modern—about many aspects of time perception that would later come to occupy the attention of experimental psychologists. Guyau was certain that notions of time could not exist a priori, and instead developed with experience from a number of sources. The quotes from Guyau that follow are in my own translation.

The genesis of the idea of time isempirical and derived. The idea of time, like that of space, is empirically the result of the adaptation of our activity and our desires... (p. 46).

The relation between the perception of time and space was also thought to be important, with concepts of time developing later than conceptions of space, according to Guyau, a position in accord with modern research, as mentioned above.

It is movement in space which creates time in human consciousness. Without movement there is no time (p. 47)

But time concepts were also believed to be derived from

...the notion of discrimination of differences, resemblances, number...and intensity (p. 22)

Guyau’s ideas have been particularly influential among French-speaking psychologists, who have made substantial contributions to the study of time perception in general and, more specifically, to the developmental

psychology of time, discussed in Chap. 7, where the issue of how temporal representations develop in young children has been of central importance. Guyau's ideas, however, also prefigure more recent discussions on the role of cognitive processes in time perception (Chap. 5), as well as ideas about "retrospective" time judgements (Chap. 6).

One question which has received particular attention from philosophers is what constitutes the *present moment*, or what James (1890) and others have called the *specious present*. In reading this text, one will likely have the impression of a sort of moving present. The line currently being read has some *present* quality, whereas earlier lines and paragraphs are located in the *past*, and there is something to come which is in the *future*. Two questions that have engaged both philosophers and psychologists concern the nature of this present experience and how long it actually lasts. Guyau regarded the present as a sort of small boundary between the past and future.

The true present should be an indivisible instant, a moment of transition between the past and the future, a moment which cannot but be conceived of as infinitely small, being born and dying at the same time. (p. 30)

However, subjectively, at least to this writer, the present seems to have some short but non-zero duration, a position held by most philosophers, although there is little consensus as to the actual duration of the specious present. In philosophical circles, a particularly influential treatment of the specious present, and time consciousness in general, is derived from Husserl (see Mensch, 2014, for a brief introduction to Husserl's ideas).

Husserl used the "saddle" metaphor introduced by James (1890): a person rides on the specious present like someone saddled on a horse. The "temporal" saddle is not the edge of some infinitely sharp knife (contrasting with Guyau's position); it has some extent, if only a short one. Husserl proposed that the moving present is actually composed of three parts. One is the present per se, the "primal impression," what we actually experience at the present moment. The second is the recent past, what Husserl calls *retention*. So far, most people would agree that this accords nicely with common sense. However, Husserl then adds what he calls *protention*: some aspect of the future which is included as part of the present moment.

Philosophers more recently have dealt with similar issues, albeit in a rather different way. One of their most important questions concerns the *phenomenal continuum*, how we experience the passage of time as it unfolds. Dainton (2014) provides a good introduction to the often thorny problems uncovered by philosophers when talking about “temporally extended” experiences. When we experience an event that has several parts—Dainton’s example is seeing and hearing a large rocket go off—there are visual and auditory aspects to the experience, plus a succession of events in time. Thus one question that arises is how “change and succession feature in our immediate experience” (Dainton, 2014, p. 101). Perhaps the most natural way of representing the event, and the one that Dainton himself advocates, is an “extensional” approach: the sights and sounds of the rocket are not momentary, but occur in a sort of temporal window, which is then replaced by another (perhaps partially overlapping) temporal window. However, another, perhaps less intuitively appealing approach, “the retentional model,” has also been advanced. Here, the whole event is perceived in a “momentary episode of experiencing,” which nevertheless may have multiple dimensions, giving it an extended subjective character, just as in some modern theories in physics, additional spatial dimensions are posited for elementary strings hypothesized to constitute the bases of matter. The full arguments are too complex for discussion here, but see Dainton (2014) for an introduction.

Another contemporary philosopher, Ian Phillips, has dealt extensively with questions regarding the philosophy of time, some of which interlock with the psychology of time perception. One peculiarity of duration noted by many philosophers is that the “sensation” (or *quale*) of time itself has temporal aspects. No-one thinks that the sensation of green is green, or that the feeling of a 200-g weight itself weighs 200 g, but the “feeling” of, say, 2 s extends in time; indeed, it may actually last for 2 s. Therefore, the qualia of time are peculiar in that they seem identical to the thing felt, a unique property according to Phillips (2014). He accounts for this by taking what he calls the “naïve” view (the term is not pejorative here), which states (Phillips, 2014, p. 142) “that our experience inherits the temporal structure of the events which are its contents.” To return to our previous example, the quale of 2 s “inherits” the property of lasting for 2 s that the event observed possessed.

The naïve view is highly appealing to someone who knows nothing of the complexity of philosophical arguments, as it appears to avoid the seemingly counterintuitive problems that philosophers have invented about time, such as the “principle of simultaneous awareness,” which states that if one is aware of duration or succession, one is aware of it at one moment, thus raising the question of how extended temporal experience is possible (a position reminiscent of the “retentional” view mentioned above). The naïve view does encounter some difficulties, however, particularly those dealing with temporal “illusions,” where the physical duration of events, or even their order, can be misperceived. Phillips (2013, 2014) shows how many of them can be reconciled with the naïve view of time experience.

One of the most frequently cited—and to psychologists one of the strangest—philosophical positions regarding time is McTaggart’s (1908) argument that time does not exist, initially advanced in an article dramatically entitled “The Unreality of Time.” His reasoning, in simplified form, proceeds as follows. Time is about change, so any correct way of representing it must involve the possibility of change. McTaggart distinguishes two ways of describing events in time. One (called the “B-series”) uses relations such as “earlier” and “later,” as in “event X was earlier than event Y.” This B-series itself cannot represent change, as the temporal relation of X and Y is fixed, so something else is needed. McTaggart thus proposes an “A-series,” involving past, present, and future. Some event, therefore, passes from the future to the present, then to the past. This obviously represents change, so what then is the problem? The problem is that some event cannot simultaneously possess the properties of existing in the future, the present, and the past, so some way of distinguishing these possibilities needs to be developed. The way to do this is obvious if we have some concept of time: some event X is in the future at one time, the present at another time, and the past at yet another time. But the difficulty here is that we have assumed a concept of time to make the A-series non-contradictory (i.e. to avoid postulating, for example, that X is simultaneously in both the future and the past), yet the A-series is supposed to *provide* the very concept of time that is needed.

As McTaggart says, using the A-series

involves a vicious circle. For it assumes the existence of time in order to account for the way in which moments are past, present and future. Time then must be pre-supposed to account for the A-series.

McTaggart suggests that these problems imply that time does not exist. Perhaps a less dramatic conclusion would be to say that the ways in which we talk about time have unexpected hidden depths. McTaggart's article has been described as advancing "clearly one of the greatest of philosophical arguments" (Geach, 1979), although, perhaps unsurprisingly, many commentators have disagreed with his conclusion. One such objector is Corish (2005), who questions aspects of the logic in McTaggart's distinction between the A- and B-series, and argues that aspects of the A-series can be included in the B-series, so the two are complementary, and simply reflect different kinds of temporal relations, meaning that the existence of both does not give rise to paradoxes. To use his example, the death of Queen Anne was, and always will be, before the death of McTaggart himself, so the B-series relation of these two events is fixed. However, depending on the date on which a statement is made, these events can both be in the past, one in the present and the other in the future, one in the present and the other in the past, or both in the future, and so the "permanent" B-series relation does not preclude the changing, "impermanent" A-series-type temporal relations with respect to other events. Corish's (2005) article also provides references to the complex arguments surrounding McTaggart's assertion of time's unreality, and the interested reader is referred there as a starting point.

The Early Years of Time Perception Studies

Experimental psychology, as it developed in Germany in the second half of the nineteenth century, expended much effort on the study of sensation, using simple stimuli in psychophysical experiments relating objective stimulus measures, such as intensity, to the sensations they evoked. Fechner's famous *Elements of Psychophysics* (1860) was a landmark work of this type. Along with those involving vision, hearing, and touch, studies of duration judgements were common—in fact, relatively more