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A PUZZLE CONCERNING TIME PERCEPTION

ABSTRACT. According to a plausible and influential account of perceptual knowledge, the truth-makers of beliefs that constitute perceptual knowledge must feature in the causal explanation of how we acquire those beliefs. However, this account runs into difficulties when it tries to accommodate time perception—specifically perception of order and duration—since the features we are apparently tracking in such perception are (it is argued) not causal. The central aim of the paper is to solve this epistemological puzzle. Two strategies are examined. The first strategy locates the causal truth-makers within the psychological mechanism underlying time perception, thus treating facts about time order and duration as mind-dependent. This strategy, however, is problematic. The second strategy modifies the causal account of perceptual knowledge to include a non-causal component in the explanation of belief-acquisition, namely *chronometric explanation*. Applying this much more satisfactory approach to perceptual knowledge of time, we can preserve the mind-independence of order and duration, but not that of time's flow.

One might find it a difficult question, whether if there were no soul there would be time or not. For if it is impossible that there should be something to do the counting, it is also impossible that anything should be countable....

Aristotle, *Physics* IV.4

It is in my own mind, then, that I measure time. I must not allow my mind to insist that time is something objective.

Augustine, *Confessions*, XI.27

## 1 THE PUZZLE

I am looking at the clock on the mantelpiece, and note that both hands are pointing to twelve. Here, surely, is a straightforward case of veridical perception. There is the clock, and I am looking at it in near-ideal conditions. Without question, I see the clock, and the position of the hands, and I do so in an apparently unmediated way. Only, perhaps, when I entertain the thought that I might not be looking at a clock at all, but hallucinating, does this simple ‘direct realist’ view as to what I see when I look at something come into question. Assuming that I could not tell the difference between the case in which I genuinely see the clock and one in which I am hallucinating, we have to explain what the two cases have in common, and this is where the ‘indirect realist’ case exercises a grip on our thinking. In both cases, I see *something*, and that something must be the same in both cases (since they are qualitatively distinguishable), and since it cannot be the clock—this being entirely absent in one case—it must be something else, nearer to the mind, and this we may call a sense datum. Or so goes a familiar line of thought,<sup>1</sup> and it does not impress everyone. For many, the direct realist approach is still an option, since we do not have to concede (they say) that what the cases of veridical perception and hallucination have in common is sameness of experiential object.

But now the clock strikes noon, and I perceive a host of other items: not merely a series of sounds, but one chime as *following on* from another, the *interval* between chimes, and that interval as remaining *the same* in each pair of chimes. All these are instances of time perception, in that the content of the perceptions seems irreducibly

temporal. But perceiving time in this way, and perceiving the clock, seem very different kinds of experience. Even if we confine our attention just to veridical time perception, when our senses do not deceive us as to the order or duration of events, the direct realist approach seems much less tempting than in the case of ordinary perception of objects. In fact, it is not clear that direct realism about time perception is even an option. Why is this?

According to the title of a paper by the psychologist J.J. Gibson, 'Events are perceivable but time is not.'<sup>2</sup> Insofar as we think of time as something independent of the events within it, as an unseen, featureless medium, we could hardly fault this description. But whether or not time is independent of its contents, events themselves have temporal features: they occur in a certain order, and they last for a certain amount of time. And if we were completely insensitive to these features, then it would be a mystery how we come to be aware of motion, interpret Morse code, or appreciate music.

However, it is one thing to form beliefs about order and duration on the basis of our perceptions, and quite another actually to *perceive* order and duration. If the meaning of Gibson's dictum is that, although we may come to be aware of the temporal features of events, those features are never themselves the objects of our perceptual states, then a number of considerations tell in its favour.

First, there is no specific organ for the time sense. Whereas light is registered by the visual system, and sounds by the auditory system, there is no anatomically identifiable system for time awareness. It is true of course that perception of shape is cross-modal: we are aware of it in both vision and touch (and bats perceive it in terms of variation of high-frequency sounds), and yet there is no obvious objection to the direct realist perception of shape. But there is a relatively straightforward story to be told about the way in which the shape of, say an apple, can be an object of perception when the apple is (although the details of the story may be complicated): the shape of the apple modifies the distribution and properties of light rays reflected from its surface and which then hit the retina; it also modifies both the distribution of pressure exerted by the apple on our touch receptors, and the kinaesthetic input as we close our hands around it. With time, in contrast, it does not make sense to suppose that, when a given event such as the ringing of the telephone is perceived, the duration of that event, or its

occurring after some other event, somehow modifies the input, allowing us just to *hear* its duration and position vis-à-vis other events. We are only aware of how long an event lasted when it has receded into our phenomenal past—when, in other words, the event has ceased to be an object of perception.

Second, perception has temporal limits. What we perceive, we perceive as present, as happening *now*. But from this commonplace it seems to follow that a currently perceived event, or rather that bit of it that is being perceived, cannot be divided into *apparently* earlier or later parts. Of course, the item perceived will in fact have earlier and later parts, for only something that lasts for more than a certain duration will be perceived at all. But if something is perceived as present, then it cannot be perceived as having earlier and later parts. This lack of temporal discrimination for sufficiently short stimuli defines what is often called, in a phrase coined by E.R. Clay but made famous by William James, the ‘specious present’. The experienced present is ‘specious’ in that it is not the durationless boundary between past and future, but rather something that takes up time.<sup>3</sup> But if what is perceived is perceived as happening now, then there is no room for the perception of time order, for that would involve perception of things as non-simultaneous, whereas two events that are perceived as happening now are, necessarily, perceived as simultaneous. What of duration? A similar problem presents itself here. To perceive an event as lasting a certain period of time, we have to perceive it as having earlier and later parts. But of course, these parts cannot all be perceived as happening now, for then they would be perceived as simultaneous. So duration is not something that can be an object of perception.

Third, whereas it is possible to be aware just of the colour of an object—I can focus on its redness, say, to the exclusion of all else—it is not possible to be aware just of the relation of temporal subsequence when it obtains between two events. To see one event as following on from another, I have to be aware of the events themselves. The relation by itself cannot be an object of perception as colour by itself can. Similarly with duration: I cannot be aware just of the duration of an event. Somehow, the awareness of order and duration emerges from a perception of the events.

So, on the one hand, our perceptions inform us of the order and duration of events. Moreover, the process appears to be a non-inferential one: we can become aware of temporal features without having consciously to derive them from other information.

But, on the other hand, the usual models for ordinary perception, of shape and colour for example, are not applicable to time. In particular, order and duration are not objects of perceptual states. What then are the mechanisms underlying our perceptual awareness of time order and duration? This is the psychological problem of time perception. Here is one psychologist's perspective on the problem:

There is no process in the external world which directly gives rise to time experience, nor is there anything immediately discernible outside ourselves which can apprehend any special 'time stimuli'. It is therefore not too surprising that psychological research on time as a dimension of consciousness has been so diverse, so incoherent, and so easily forgotten. (Ornstein (1972), p. 96.)<sup>4</sup>

Of course, a psychological problem requires a psychological answer, not a philosophical one. But there is a philosophical dimension to the issue, one concerning the epistemological status of our perceptual awareness of the temporal features of the environment. If we can take it as a datum that we can form, on the basis of our perceptions (by some mechanism yet to be determined), beliefs concerning both time order and duration, we can also take it as a datum that these beliefs are at least capable of being, and generally are, a form of perceptual knowledge—although of course we often make mistakes. Now, according to an influential and plausible theory of perceptual knowledge, the truth-makers of those beliefs should occur in the causal history behind our acquisition of them.<sup>5</sup> But one moral of the disanalogies we were drawing attention to above between ordinary perception and time perception is that *time order and duration are not features of events that cause our perceptual states*. And if they are not the causes of our perceptual states, then it is hard to see how they could be the causes of beliefs that arise from those perceptual states. This suggestion, that order and duration do not play a causal role, will be confirmed when we come to look at models of time perception. It is a problem, then, to explain, compatibly with the causal theory of perceptual knowledge, how time perception can lead to knowledge of the temporal features of the environment. This is the *epistemological puzzle* of time perception. Solving this puzzle is the aim of this paper.

Making things a little more explicit, the puzzle arises from the following conjunction of plausible and defensible propositions:

*The causal truth-maker principle:* Perceptual beliefs that qualify for the title 'knowledge' are caused by their truth-makers.

*The acausality of order and duration:* The objective order and duration of events are not the causes of our perceptual beliefs concerning order and duration.

Together, these two appear to imply that, even if there is such a thing as time perception, it cannot count as knowledge, since the truth makers of our beliefs in these cases play no role in the causal history of those beliefs. (To derive this result formally, we have of course to add what may seem the rather obvious proposition that actual order and duration, or facts concerning them, are the truth-makers of perceptual beliefs about order and duration.)

Plausible though they may be, something needs to be said in defence of the two propositions, especially in view of their implication. First, the causal theory of perceptual knowledge, of which the causal truth-maker principle is a component, may be vulnerable on other grounds. Second, the acausality of order and duration may seem too strong a lesson to draw from the disanalogies between time perception and perception of shape or colour. The next section, then, is concerned with a defence of the component propositions of the puzzle. The section following introduces two plausible models of time perception. My concern is less to establish their correctness as to show how, if correct, they confirm the acausality principle. We then turn, in §4, to an Augustinian resolution of the puzzle, one that treats time, or at least certain aspects of it, as mind-dependent. This resolution turns out to be problematic, and in §5, I shall argue for a rather different approach. The moral of the story is twofold: first, that we need to modify the causal theory of knowledge if it is to apply quite generally to perceptual belief; second, that a proper understanding of the way in which our perceptual beliefs concerning temporal properties are both explained and made true may teach us some important truths about the nature of time.

### 2.1 *The causal truth-maker principle*

The causal truth-maker principle (hereafter CTMP) is appealing, first because perception is evidently a causal process, and second because it successfully discriminates in very simple terms, and in a wide range of cases, true beliefs that constitute knowledge from those that do not. For example, I see someone I take to be Julian, riding a trishaw down the street. I form the belief that Julian is riding a trishaw, and I happen to be right about that: Julian is indeed riding a trishaw at the very moment I form my belief, but the person I saw was his brother, Ivan. Here, the truth-maker was not among the causes of my belief, which therefore fails to count as genuine knowledge. And so we can go on multiplying the examples. However, there are some trickier cases where knowledge, or the lack of it, is not so easily captured. They fall into two groups: those that call into doubt the *sufficiency* of the causal link with truth-makers to confer the status of knowledge on a belief, and those that call into doubt its *necessity*. Strictly, only the latter directly threaten the CTMP. However, the CTMP gains some of its plausibility by being part of a wider causal theory of knowledge. If that theory is vulnerable to objections, the CTMP loses some of that plausibility, even if the objections do not strictly conflict with its truth. It is not my intention in this paper to defend a fully worked-out causal theory of knowledge, but I need to show the possibility of expanding the CTMP so as to provide a plausible theory of perceptual knowledge.

Here, then, are the kinds of case that cause difficulties for the causal theory:

(a) Against the sufficiency of the causal link with truth-makers

(i) *Unreliable causes*. I am looking at a series of photographic slides that are being projected onto a screen. Unknown to me, some of the slides have been placed in the projector the wrong way around, so the screen image in these cases is left-right inverted relative to the original subject. I am currently looking a slide of, say, a street, and so



form beliefs concerning the relative positions of the buildings, etc. Since this slide has not been inverted, my beliefs are true, and they are caused (ultimately) by their truth-makers, but they do not count as knowledge.

(ii) *The presence of relevant perceptual equivalents.* I am looking at a scene through a window. Unknown to me, the scene has been reflected by a series of mirrors, in such a way, however, that the apparent spatial relations between me and the various objects in the scene exactly matches their actual spatial relations. Again, although the truth-makers and the causes of my beliefs coincide, those beliefs do not count as knowledge.<sup>6</sup>

(iii) *Deviant causal chains.* I believe that there is a dagger in front of me on the basis of a visual experience that is caused by a state of affairs precisely matching my belief, but via a 'deviant' causal chain. E.g. my experience is caused directly by stimulation of my brain by electrical impulses delivered by a machine operated by a scientist whose intention it is artificially to replicate experiences the kind of which I would be having were I actually perceiving the dagger that is in fact in front of me.<sup>7</sup> I believe, but do not *know*, that there is a dagger in front of me.

(b) Against the necessity of the causal link with truth-makers

(iv) *Beliefs with conventional conceptual content.* I see a tree, and, having some arborial expertise, form the (correct) belief that it is an Ilex oak. I can be said, in fact, to *know* that this is an Ilex oak. The truth-maker of the belief has to do with a conventional system of classification, however, whereas the causes of the belief are simply to do with the intrinsic properties of the tree.

(iv) *Demonstrative thoughts.* I think, looking at the girl who has just walked into the café, 'That's Monica'. Since the person I am looking at *is* Monica, the truth-maker of my belief is that Monica = Monica. But this fact is a necessary one, and so cannot be the cause of my belief. (On the grounds that causal relations entail counterfactual relations, and counterfactual relations can only obtain between contingently existing facts.) My belief can nevertheless be classed as genuine knowledge.

The first case can be dealt with by appeals to reliability. The process by which I form beliefs—looking at slides that may or may not be inverted—is simply not a reliable one.

The example shows that whereas there are many cases where reliability can be cashed out simply in terms of a causal link with the truth-maker, there are others where this is not enough. Reference must be made to the tendency of the belief-generating process to produce true beliefs, or (to put it another way) to the high probability that the process will generate beliefs *via* their truth-makers. A similar proposal recommends itself in the second case. Actually, it is not clear that the mere presence of the mirrors (and my ignorance of them) undermines the epistemic status of the belief. Only perhaps if the mirrors were regularly moved around in such a way that it is just a matter of luck whether what is presented corresponds to the scene or not would we want to deny that I *know*, on the basis of my perceptions, where things are. But then the second case is just a variant of the first.

The third case does introduce a new element, that of the deviant causal chain, which plagues causal theories of perception, memory and action. In the case described, the deviancy of the chain undermines the experience's claim to be a genuine perception of the dagger. But is this a problem of knowledge? It may be possible to gain knowledge of the dagger by means of a visual or apparently visual experience, even if one cannot be said to be *perceiving* the dagger. And perhaps the criterion we use in deciding whether we have knowledge in this case will depend on the reliability of the process by which we come to have the belief, so that, once again, the case can be assimilated to the first. However, this may not go quite far enough. The fact remains that I mistake the immediate cause of my experience. I am not, as it turns out, really seeing the dagger. So how can I know that there is a dagger in front of me? But, if this is so, then it suggests that reliability is not enough. The causal chain leading to a belief may be both reliable (in that the belief thus caused has a high probability of being true) and yet deviant. So what distinguishes the deviant case from the non-deviant case in such a way that explains how non-deviant chains can lead to genuine knowledge? One proposal is to introduce the notion of *higher-order* reliability. A process may be reliable, as in the case of the honest scientist stimulating my brain, and yet not itself have been generated by a reliable process. In the case of ordinary perception, it is not only reliable, it also exhibits higher-order reliability: our perceptual systems have evolved through a process of natural selection which itself makes it highly likely that perceptual systems will be reliable. Deviant cases, arguably, do not exhibit this higher-

order reliability. The possibility remains, perhaps, of a causal chain whose deviant nature prevents the result from being classified as a genuine perception, even though the process leading to the apparently perceptual belief exhibits higher-order reliability. In this case, I would be tempted to say, we have knowledge but not perception. Deviancy *per se* need not be a threat to knowledge, as it is to perception, memory and intentional action.

Now let us turn to the alleged counterexamples to the necessity of a causal link between truth-maker and belief. Consider the Ilex oak. Is this really a problem? *All* perceptual beliefs, let us concede, will have some conceptual content (assuming that they have a propositional structure; it may be that there are some perceptions lacking that structure that do not possess conceptual content, but that is not the issue here since we are concerned only with perceptual *beliefs*). Those concepts will have their origins beyond the experience they help to structure. Does that matter? Given the admittedly conventional system of classification, all that is needed for my belief that this is an Ilex oak to be true are the intrinsic properties of the tree. And given that I possess the relevant concepts, and am suitably oriented vis-à-vis the tree, those same intrinsic properties will be sufficient to cause that belief.

In the case of the demonstrative thought, the obvious reply here is to deny that the truth-maker in question is *Monica = Monica*. There are, in any case, other grounds to question that *Monica = Monica* is the truth-maker, for the necessity of the truth-maker would appear to confer necessity onto the belief it makes true, yet ‘That’s *Monica*’, being clearly empirical, does not look like a necessary truth. There are a number of candidates for the role of truth-maker for demonstrative thought, but one that would satisfy the contingency constraint relates perceiver and object: my thought is true because the person who stands in the appropriate perceptual relation to me is *Monica*.

The causal theory of perceptual knowledge, it seems, is robust enough to deal with a number of apparent counterexamples. So the first proposition of our problematic pair will be hard to abandon. Let us now look at the second proposition.

## 2.2 The acausality of order and duration

It was suggested in §1 that, since order and duration are not the objects of perceptual states, they are not the causes of those states. This is not, in general, a safe inference. There are any number of hidden causes of our perceptual states, to do for example with the underlying psychological or physiological mechanisms of perception, which are never the objects of those states. But we are concerned with external features of the world, and it is hard to see how they can causally impinge on us if we never perceive them. But, in any case, there are other reasons for thinking that order and duration may not be the sort of features that are capable of entering into causal relations.<sup>8</sup> I offer here, not a knock-down argument to the effect that they cannot possibly causally affect things, but rather some awkward questions for anyone who thinks that they do.

What, first, is a cause? Or rather, what kinds of things are causal relata? Here is Davidson on the question:

Much of what philosophers have said of causes and causal relations is intelligible only on the assumption (often enough explicit) that causes are individual events, and causal relations hold between events. (Davidson (1967), 161.)

But if only events are causes, then order and duration cannot be causes, since order and duration are features of events, not themselves events. There is no *event* of the Great Plague's standing in the 'earlier than' relation to the Great Fire of London.

What then if we allow properties as causes? This seems plausible enough: the weight of the flour causes the needle of the scales to point to 4 oz. Order, however, is a relational property, as is duration (an event lasts five minutes if its final boundary is five minutes later than its initial boundary). Can relations be causes? In a well-known discussion of the existence of universals in *The Problems of Philosophy*, Russell makes the following observation:

Consider such a proposition as 'Edinburgh is north of London'. Here we have a relation between two places, and it seems plain that the relation subsists independently of our knowledge of it.....

...however...the relation 'north of' does not seem to exist in the same sense in which

Edinburgh and London exist. If we ask ‘Where and when does this relation exist?’ the answer must be ‘Nowhere and nowhen’. There is no place or time where we can find the relation ‘north of’. . . . Now everything that can be apprehended by the senses or by introspection exists at some particular time. Hence the relation ‘north of’ is radically different from such things. (Russell (1912), 56.)

If this correctly characterises ‘north of’, it also characterises ‘later than’. And, since duration is also a relational property, Russell’s observation would apply to that too. But now *causes* are items that have locations, both in space and time. Their having those locations is what helps to explain why they have their effects at the times and in the places they do. But if order and duration relations do not have locations, they are acausal.

However, as he makes clear, Russell takes the ‘north of’ relation to be a universal, and therefore something that other places can stand in to each other. What if instead we concern ourselves with the *trope*, the token of the type, *this very instance* of ‘north of’, relating Edinburgh and London? What is its location? We still face difficulties in arriving at anything other than an ad hoc answer to the question. There seems no good reason to locate the relation just in Edinburgh, or just in London. Perhaps, then, it is located in the region between Edinburgh and London. But how do we define this region? Is it just the straight line connecting the two? Is it the whole of United Kingdom? Should it not include the North Pole? Is it the surface of the Earth? Even if we are dealing with the trope rather than the universal, perhaps the best thing to say is that the relation is *nowhere*: it does not have a spatial location at all. The same worries arise for order and duration. There is a clap of thunder at 4 o’clock, and the rain starts pouring down at one minute past 4. These events are readily locatable. But what of the temporal relation between them? That relation, even if we treat it as a trope, is not readily locatable at 4, nor one minute past, nor any time in between. And what of the rainstorm’s property of lasting 20 minutes? Where is that in time? Again, we may be tempted to say that these properties have no temporal location: they exist timelessly. But if they are timeless, they cannot be causes. If we insist that these relational properties do have a location, only that are somehow spread out in a spatio-temporal region that includes the relata, and that is how those properties can be causes, we are still faced with the question: why, if they are spread out in space and time, are they not

capable of having effects in all parts of that region? Whether or not some ‘earlier than’ trope is the cause of my belief that the thunderclap preceded the rain, it cannot possibly cause my belief *before* I experience the rain. But then why not, if it exists before the rain does?

We might instead take causal relata to be *facts*, of which events and their properties are constituents. Indeed, given the argument that the truth-making role cannot be occupied by objects, events or properties, but only by structured combinations of them, namely facts,<sup>9</sup> it would seem that the CTMP may be committed to facts as causes. But this does nothing to relieve the worries expressed above concerning the location of tropes, since they also arise for facts about order and duration.

Some further worries, not to do with location: are there in fact any cases where we cannot explain away the apparent causal efficacy of temporal properties? Take the case of the egg’s being cooked because it has been boiled for 5 minutes. What is doing the causing here? The mere passage of time? No: the egg is cooked because of the individual events that took place during those five minutes. Or take a machine that produces one output, C, if the two kinds of input, A and B, occur in the order AB, and another output, D, if they occur in the order BA. Is the mere order of the inputs *itself* a cause? Or is the correct story rather something like the following: given an initial state of the machine, S1, the effect of input A is to change the machine’s state to S2. And when the machine is in S2, the effect of input B is the production of output C. But when the machine is in S1, the effect of input B is to change the machine’s state to S3, and the effect then of input A is not to change the machine state to S2, but rather the production of output D. On this account, it is not the mere order of inputs that determines the output, but what state the machine is in when it receives a given input. Now, if we are to take seriously the suggestion that order and duration *per se* can be causes, then there have to be cases where the natural form of explanation that applies in these cases of the egg and the machine is just not available. And this, intuitively, seems odd.

These are just expressions of puzzlement of course. But given that treating order and duration as causal is problematic in one way or another, it would be best not to give those properties a causal role in our account of how we acquire order and duration beliefs. And so we come back to the epistemological puzzle. In trying to solve it, it would help if we had some insight into the psychological mechanisms of time

perception. It should not be necessary to have at our disposal a detailed description of this undoubtedly complex process. Since the puzzle we face is one that is raised at a high level of abstraction, it should be enough to show that some plausible abstract description of how we acquire beliefs concerning order and duration through perception of events can be reconciled with epistemological requirements.

### 3 THE PSYCHOLOGICAL BASIS OF TIME PERCEPTION

It was argued in §1 that perception of precedence and duration cannot be confined to the ‘specious present’, as such perception would require discrimination between earlier and later events, or earlier and later parts of the same event. In explaining how our perceptions can give rise to an impression of temporal properties we have to appeal, therefore, to the operation of short-term memory. In the case of simple precedence, the mechanism might well be something like this: stimulus *a* is perceived, and its occurrence registered in the short-term memory. Stimulus *b* is subsequently perceived, and the representation of *a* in the short-term memory causes *b* to be represented as occurring after *a*. Perception of precedence therefore is not simply a matter of one perception preceding another, but that earlier perception causally affecting the later one (Mellor (1995), (1998)).

If we can allow simple introspection here as judge, this account seems very plausible. Perceptions do seem to be coloured by immediately preceding ones. However, there are two problems for this as a general account of the awareness of precedence. The first is that there are cases we can be aware that two perceived events are not simultaneous without being able to say which one came first (Hirsh and Sherrick (1961)). If there is any causal connection between perceptions in this case, it is evidently not sufficient to determine perceived order. The second is raised by instances of ‘backwards time referral’, where the perceived order of two stimuli, as reported by the subject, is the reverse of the order of the perceptions. These, and related cases, seem to require a rather different mechanism underlying order perception. The causal model above makes order perception sensitive to the time order of perceptions, but insensitive to its content. One might, however, consider an alternative model: order perception is

content-sensitive, but time-insensitive. That is, the perceived order may depend on the brain's decision as to what ordering best 'makes sense', given what the perceptions are of.<sup>10</sup>

However, these may not be serious objections to the causal model. In both non-simultaneity-without-order perception and backwards time referral, the events occur very close to each other in time, and different mechanisms may then come into play. Where there is a significant gap between perceptions, the suggestion that order perception could be time-insensitive becomes less plausible. The causal model might still be appropriate for standard cases. As far as the first kind of case is concerned, even if the mechanism for non-simultaneity perception is also a component of the more complex mechanism underlying awareness of time order, it may still be the causal order of perceptions that accounts for the perceived asymmetry. In the case of backwards time referral, it is a contentious matter when precisely a perception occurred vis-à-vis another.

When it comes to perception of duration, whether of a single stimulus or of the interval between stimuli, the mechanism must be more complex. The considerations of §2 lead us to suppose that duration is not the kind of thing that can impinge on us directly. So how do we become aware of it? The answer appears to be that we 'perceive' the duration of an event by *mimicing* it. There is now a considerable amount of evidence supporting the suggestion that organisms sensitive to time have internal time-keepers, or 'biological clocks'. Given the huge variety of time-sensitive behaviour in animals, including hibernation, circadian sleep cycles, and locomotive control, it seems likely that there is more than one biological clock governing behaviour. Concentrating on the kinds of case that require fine temporal discriminations, the basic mechanism proposed by *scalar timing theory* involves a neural *pacemaker*, emitting regular pulses, and an *accumulator*, which records the number of pulses emitted by the pacemaker for a given period. Perception of the duration of a given stimulus, according to this theory, involves the following mechanism. Onset of the stimulus causes a switch connecting the pacemaker and accumulator to close. The accumulator then records pulses until the cessation of the stimulus causes the switch to open, breaking the connection. The accumulator's record may then lead to a judgement of duration, or can be stored in the memory for comparison with other stimuli (Gibbon, Church and Meck,



1984.) In one variant of the model, the pacemaker produces pulses at intervals that are variable but whose average duration is nevertheless constant.

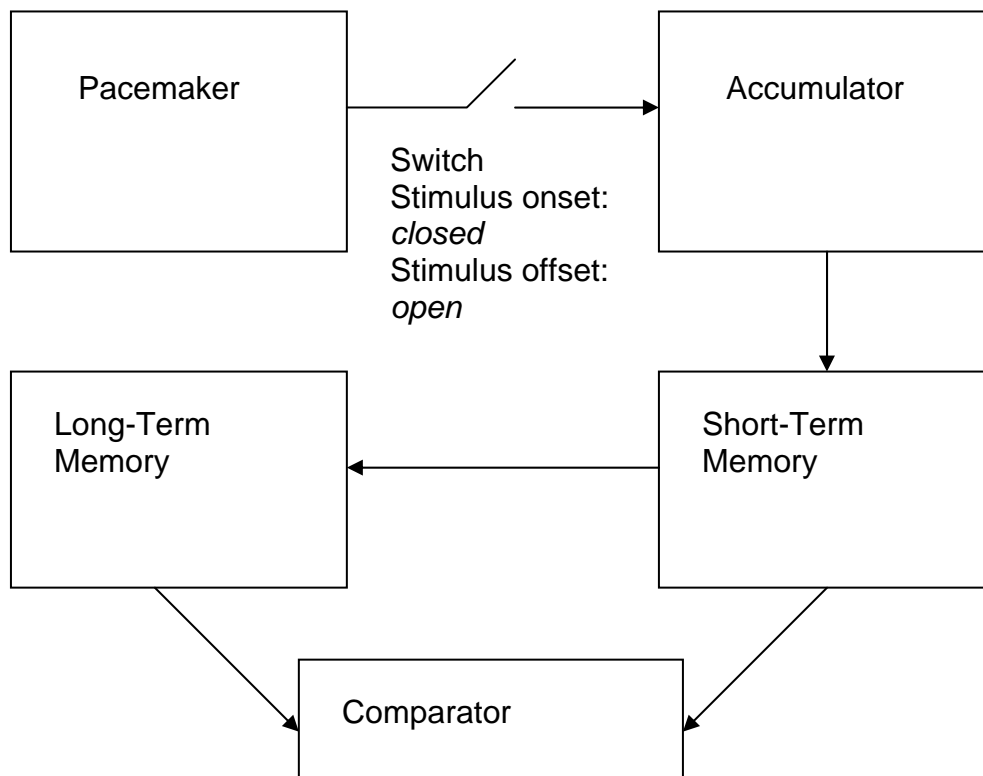


Fig 1: The scalar timing theory of duration perception

Appeal to the slowing down or speeding up of the rate at which the pacemaker emits pulses provides a simple explanation of the familiar fact that time seems to go faster in some contexts and more slowly in others. In some cases, the pacemaker appears to be very seriously altered, with potentially disastrous results. One of the most dramatic instances of this is the *Zeitrafferphänomen* or accelerated time phenomenon. In one case, a patient who had suffered damage to the left prefrontal cortex was driving his car when he suddenly found that objects outside appeared to be rushing towards him at an accelerated rate. Watching television was virtually impossible because events on the

screen were happening too fast to make sense of (Binkofski and Block, 1996). One explanation of his experiences is that the damage to the left hemisphere had caused the pacemaker to slow down its production of pulses. In non-pathological cases, the pacemaker pulse rate appears to be affected, or 'entrained', by external stimuli such as a series of high-frequency clicks (Treisman (1999)). It is a very plausible suggestion that the pacemaker may also be affected by drugs, since these produce marked distortions of time estimates (Friedman (1990)).

An alternative model for timing involves, not a single pacemaker, but a series of oscillators, whose cycles differ from each other but nevertheless have well-defined phases. Instead of an accumulator recording number of pulses is some mechanism that detects, at any one time, what phase each oscillator is in. Thus time from the onset of a stimulus may be represented qualitatively, rather than quantitatively, by the permutations of phases (Church and Broadbent, 1990).

The precise details of the mechanism do not matter in the context of addressing our epistemological puzzle. What does matter is the key idea underlying all these models, that of a regular (or averagely regular) neurophysiological process that is effectively a clock system. Thus the perception of time is not simply a passive reception of external stimuli, but an active structuring of stimuli based on an internal system of measurement:

The ear and eye respond to energies from the environment that impinge upon their receptive surfaces. The tongue and nose sample molecules. To orient us in space, the vestibular system depends on properties the body possesses as a physical object (its response to gravity and inertia). It would seem that the time sense relies on properties of the brain itself as a physical system, the propensity of neurons or neural networks to produce oscillations that can be used as timing devices. Thus one function of the brain may be to act as the sense organ for time. (Treisman, 1999, p. 244.)

Controversial though they may be, the models of time perception briefly presented in this section at least give us a starting point in our approach to the epistemological puzzle. What is interesting about these models is that they confirm our suspicion that order and duration do not play a causal role, for on neither model were these temporal properties appealed to as causes of our perceptual states. The challenge, then, is to show

how, if time perception is based on something like the mechanisms described by these models, it can lead to knowledge of the temporal properties of events. Since there is a tension between the CTMP and the acausality of order and duration, any resolution of it must pursue one of two strategies: revise our view of what makes perceptual beliefs about intervals true, or revise the causal account of perceptual knowledge. In the remainder of this paper, I shall look at both strategies.

#### 4 FIRST ATTEMPT TO DISSOLVE THE PUZZLE: ORDER AND DURATION AS MIND-DEPENDENT

##### 4.1 *An Augustinian inference*

The problem of accounting for time perception greatly exercised Augustine, and it led him ultimately to his extraordinary conclusion that time was all in the mind. Here was the initial difficulty:

But to what period do we relate time when we measure it as it is passing? To the future, from which it comes? No: because we cannot measure what does not exist. To the present, through which it is passing? No: because we cannot measure what has no duration. To the past, then, towards which it is going? No again: because we cannot measure what no longer exists. (Augustine (1961), p. 270.)

What, then, are we measuring? Augustine's answer is that it is mental item: 'It is in my own mind, then, that I measure time.' An answer, we might note, that has clear parallels with the sense datum theory of perception. What he infers from it, however, is quite surprising: that the *object* of my measurement is a mental item, and since time belongs only to such objects, time itself is purely mental.<sup>11</sup>

Now, we might query Augustine's apparent failure to distinguish the direct object of measurement (a mental item) from the indirect object (the external event). But our epistemological puzzle provides us with a motivation, not unrelated to Augustine's

concerns, for his conclusion that time is mind-dependent. We can, as it were, update Augustine's argument using the components of our puzzle. So far, we have argued that the putatively mind-independent facts concerning time order and duration are not the causes, direct or indirect, of our corresponding perceptual beliefs. But the CTMP requires that the truth-makers of those perceptual beliefs that constitute knowledge be part of the causal chain leading to those beliefs. Now, although the items whose temporal relations we seem to perceive may be external items (two chimes of the clock, a flash of lightning and clap of thunder, the beginning and end of a musical phrase), the causes that are responsible specifically for the perception of order and duration are within the mind. So, the neo-Augustinian argument goes, we should look for the truth-makers of the relevant beliefs amongst the *psychological* facts. This would imply, of course, that time order and duration are mind-dependent.

The models of time perception we looked at in the previous section pave the way to this approach. The scalar timing theory, for instance, suggests a representative theory of perception, where the immediate object of perception is some mental representation of an external state. The mind-dependence strategy simply disposes of the external state (the duration of the event), leaving us just with the representation.

Let us now look in more detail at what this strategy involves—and whether it works.

#### 4.2 *Prospects for a psychological analysis of time order*

Our judgements concerning the temporal order of events depend in part on our spatial relations to those events. On the castle battlements, a cannon is fired to mark the hour of noon. Simultaneously, half a mile away, the town church begins to strike. People walking around the castle walls will hear first the noonday gun, and then the church bell. Those about to enter the church will hear first the bell's initial strike, and then the gun's report. Judgements based solely on observation and in ignorance of one's location vis-à-vis the observed events are therefore prone to error. We can capture this in terms of what I shall call the *objectivity constraint*: judgements concerning time order are objectively true or false; they are not simply a matter of opinion, so disagreements

between observers are genuine. Any theory of time order must either conform to the objectivity constraint, or give us a compelling reason to abandon it. Can the suggestion that time order is mind-dependent be reconciled with the objectivity constraint?

At first sight, it might seem that objectivity automatically rules out mind-dependence, but this in general is not so. Consider the case of spatially indexical beliefs, such as ‘The centre of the magnetic field is *here*’. This can be given perfectly objective truth-conditions, as follows: any utterance or thought, *u*, of that type, is true iff and only if *u* is located at the centre of the magnetic field. Whether or not those truth-conditions obtain is not a matter of subjective opinion. However, the ‘hereness’ picked out by such a token is still mind-dependent, in that it is not an intrinsic property of the external space, but rather a relation between that space and a *representation* of it. There would be no sense to the suggestion that, even in the absence of minds, some place would still be uniquely and absolutely *here*. The truth-conditions for ‘here’-judgements can both be mind-dependent *and* reflect the perspectival nature of such judgements. Any application of the objectivity constraint, therefore, does not automatically and question-beggingly imply mind-independence. Objectivity and mind-dependence are both exhibited by perspectival judgements.

If we represent judgements of time order as similarly perspectival, then we effectively identify actual order with perceived order. To retain objectivity, we have to build in the actual spatial relations between observers and events. Thus, the castle visitors’ judgement that the gun went off before the church bell struck was objectively true given their location, and the church visitors’ judgement that the bell struck before the gun went off was objectively true given *their* location. Only someone equidistant from castle and church could correctly judge that the two events were simultaneous. A consequence, however, of this perspectival treatment of order is that, as it stands, it implies that there cannot be relations of precedence among unperceived events. If this seems too strong, then we could consider the following compromise: we should distinguish between the relation of precedence, on which the direction of time depends, and the relation of temporal *betweenness*, which by itself does not give time its direction. We can treat the former as mind-dependent without treating the latter similarly. So, if we assume that temporal betweenness is independent of psychological facts, all that is required to give direction to the whole time series is the relevant

psychological relation between some facts in the series. Take the following, as yet undirected, series of events, ordered by the relation of temporal betweenness:

$$e_1 - e_2 - e_3 - e_4 - e_5 - e_6 - e_7$$

Now suppose only  $e_4$  and  $e_6$  in this series are perceived, by some observer  $O$ , and  $e_6$  is perceived as occurring after  $e_4$ . Then, given that  $e_5$  is between  $e_4$  and  $e_6$ , and  $e_4$  is between  $e_3$  and  $e_5$ , it follows that, relative to  $O$ ,  $e_3$  is earlier than  $e_5$ , although neither is perceived. Since time order is supposed on this model to be perspectival, however, the possibility remains that  $e_6$  will be perceived by some other observer as preceding  $e_4$ , and this would mean that the entire series would have a different direction for this observer. We do not need to concern ourselves with this consequence, however, since we cannot make precedence perspectival without making betweenness similarly perspectival, so this compromise is not an option. We can imagine two observers so situated that for one of them three spatially separated events occur in the order  $ABC$ , while for the other they occur in the order  $BAC$ . Unless betweenness is perspectival, one of these observers is wrong, thus upsetting the perspectival account of precedence.

Whether or not such a perspectival account is viable, however, it does not help us solve the epistemological puzzle. For it locates the truth-makers of time order judgements, not wholly in the mind, but in the relations between external events and observers. And if we try to represent these relations, or facts concerning them, as the causes of our perceptual beliefs, then we face the problems raised in §2.2, and little would have been gained by pursuing the mind-dependence strategy. On the other hand, if we treat the truth-makers of order judgements as wholly internal to the mind, then we may have restored their causal status, but at the expense of giving up the objectivity constraint. Is there a compelling argument for doing this? Well, that it disposes of the epistemological puzzle is an argument, but its force depends on the CTMP having a stronger hold on us than the objectivity constraint, and on the absence of any other plausible solution to the puzzle.

### 4.3 *Conventionalism about metric*

Intuition may favour the objectivity constraint in the case of time order, but it is perhaps somewhat less strongly in favour of objectivity when it comes to duration. *Are there objective facts of the matter as to the metric of time? Consider, for example, two successive swings of a pendulum: did the second swing take exactly as long as the first? Objectivism about temporal metric says that there is a fact of the matter as to whether it did or did not, independently of any means we have of establishing the fact.*

*Conventionalism about metric denies this. The truth or falsity of what we might call judgements of isochrony (that two intervals are of the same duration) depends on which clock we adopt as our standard. As Reichenbach articulates it, ‘The equality of successive time intervals is not a matter of *knowledge* but a matter of *definition*.....All definitions are equally admissible’ (Reichenbach (1958), p. 116).*

Since the assumption that there are objective facts about metric is a central aspect of our puzzle, conventionalism appears to offer a way out of the difficulty. The human brain (indeed, in many cases, the animal brain) is, according to well-confirmed psychological models, a clock system, and so provides one possible definition of isochrony. If so, then the conventional, clock-relative truth-conditions of perceptual judgements of isochrony will obtain simply by virtue of the psychological processes leading to those judgements. Cause and truth-maker will coincide.

Or will they? Reichenbach says that *all* definitions of isochrony are equally admissible. This appears to follow from the conventionalist assertion that no system by which we measure intervals of time is objectively more accurate than any other, since accuracy is defined in terms of one’s choice of system. But Reichenbach’s position seems unduly liberal. William Newton-Smith suggests that, even for the conventionalist, some judgements about isochrony are not merely eccentric, but false. There are some constraints on selecting a standard: ‘if I adopt some deviant clock which gives the ice age, the time between my last two heartbeats and a performance of Wagner’s Ring the same duration, I am just wrong.’ (Newton-Smith (1980), p. 163.) Our standard should be what we could call a *reasonable clock system* (RCS), but how, without invoking objective metric, do we determine what counts as an RCS? One criterion of an RCS would be that it be reproducible, such that different instances of the

system tend to remain approximately congruent with each other, and occasional failures of congruence would be readily explicable by means of a simple theory, allowing one to correct errant instances. In addition, the clock system should be compatible with the construction of a coherent physical theory (e.g. of motion). So, having thus defined what it is to be an RCS, the conventionalist can say that judgements of isochrony are true relative to some RCS. The crucial question is then whether the human brain constitutes an RCS or not. If not, then conventionalism can only offer an escape route from our puzzle if we adopt Reichenbach's liberal approach. As a time-measurement system, our biological clock is notoriously variable, and affected by such things as temperature, excitement and boredom, and of course drugs. Nevertheless, it is a more satisfactory clock system than some systems we might choose as the standard: were it not so, we would be unable to co-ordinate bodily movements as well as we do, nor detect subtle variations in the motion of external objects, nor be able to appreciate and produce music. Let us not be too particular, then, and designate our biological clock an RCS.

Consider, then, the perception of two successive stimuli by an observer who judges on the basis of their perception that the first stimulus was shorter in duration than the second. The truth of this judgement, according to the conventionalist, is relative to the choice of RCS. So which RCS is relevant here? The obvious answer is: the subject's own internal clock. This, as we saw above, guarantees the causal connection between belief and truth-maker. However, all judgements of relative duration will come out true on this answer, since it is trivial that the deliverances of any RCS are true relative to that same RCS. So we could no longer make the distinction we would want to make between those judgements that are accurate and those that are not. If, instead, we chose some other RCS as the standard, then we can distinguish between accurate and inaccurate judgements, since not all deliverances of the biological clock will coincide with those of the other RCS. The price of this manoeuvre, however, is that, except in cases of a special kinds, there is no causal connection between the judgement of relative duration and the RCS against which we are assessing the accuracy of the judgement. The exceptions here are provided by certain experimental conditions, such as the following intriguing case concerning instrumental conditioning in rats:



In the standard free-operant procedure, shocks are delivered, in the absence of responding, at fixed intervals...and each response postpones the next shock for a fixed period of time (the response-shock or R-S interval). There is thus considerable regularity to the distribution of shocks in time, and it is not surprising that this regularity should at least sometimes be reflected in the subject's behaviour. Although shock can be completely avoided by a rapid and sustained pattern of responding, a slower rate of responding may, if the timing is right, be equally effective. As training continues, some animals learn to avoid an ever-increasing proportion of shocks while emitting fewer and fewer responses, by timing the interval between successive responses to something shorter than the R-S interval.....

How is such behaviour to be explained? The obvious point to note is that the probability of responding over time maps the probability of shock. As exposure to the temporal regularities increases, so the subject comes to respond only at those times when the expected probability of shock is high. In the absence of any explicit stimuli, the passage of time since the last response can serve as a signal for the occurrence of the next shock, and also therefore as a signal that another response will cause the omission of this otherwise expected shock.

(Mackintosh, (1983), p. 169.)

Here an RCS is part of the experimental set-up, and is used to govern the time between certain stimuli. The RCS in question will then both cause, and define the accuracy of, the subjects' judgements. Thus truth-maker and cause will coincide. In other cases, the choice of RCS will be arbitrary. But is this a problem? After all, for the conventionalist, there is no objective fact of the matter as to whether  $s_1$  is shorter than  $s_2$  or not, so the subject is not tracking anything. A biological clock is simply a regulatory system, not a means of access to the objective properties of things.

However, if we ask for an explanation of our duration judgements, none is forthcoming on the conventionalist view of metric. Or rather what explanation there is, in terms of psychological mechanisms, seems incomplete. Putting this in the context of the scalar timing model, we might ask: given that we form a given belief on the relative duration of two stimuli on the basis of the numbers of pulses stored in the accumulator, what is it that explains the fact that just *this* number of pulses were collected by the accumulator? The conventionalist has no answer to give. We can push the demand for explanation further and ask why, if duration judgements are only trivially true or contentless, they are so useful. And even in the experimental case described above, where one might explain the rats' behaviour by saying that they are tracking the outputs

of some timing device, their success in doing so is mysterious unless one adds that the device in question marks out objectively isochronic intervals.

To sum up the discussion of this section, it initially appeared that that treating time order and duration as mind-dependent offered a way out of our puzzle. If we could locate the truth-makers of our beliefs in the psychological processes leading up to those beliefs, then cause and truth-maker would coincide. This strategy, if successful, would support Augustine's contention that the mystery of our ability to perceive time is best answered by taking time to be in the mind. However, this strategy appears to lead to an unacceptable subjectivism concerning our judgements—unacceptable not only because it is part of our intuitive conception of time that our judgements have objective truth-conditions (at least in the case of order), but also because the instrumental value of those judgements would be entirely mysterious.

So we must now ask whether we are *obliged* to take order and metric as mind-dependent in order to solve our puzzle. Is there still room for a view that takes these aspects as mind-*independent*?

## 5 SECOND ATTEMPT: ORDER AND METRIC AS MIND-INDEPENDENT

### 5.1 *Chronometric explanation*

In this section, we shall look at a second strategy for resolving the puzzle, one that involves modifying the CTMP. Instead of confining the explanatory relationship between perceptual beliefs and their truth-makers to one that is purely causal, we might expand it to include other, non-causal, components of explanation. The modified CTMP becomes:

*The Explanatory Truth-Maker Principle (ETMP):* Perceptual beliefs that qualify for the title of 'knowledge' have truth-makers that figure in a full explanation of the acquisition of those beliefs.

A full explanation of perceptual beliefs will of course include a causal component. But

what other kind of explanation might be relevant? In the case of perceptual beliefs about time order and duration, I propose that the relevant kind of explanation is one that is often assimilated to causal explanation, but should be distinguished from it, a kind I shall dub *chronometric* explanation. Chronometric explanation appeals to the temporal location and extent of things, or to the rate of change.<sup>12</sup> Often it will occur in the context of a causal explanation. Thus, a certain effect may be explained, not simply by the existence of an antecedent cause, but by the location of that cause in time, or by the interval between that cause and another item, or by the rate at which some antecedent change proceeded. Here are some examples of causal explanations that include chronometric explanations:

(a) *Why did the firework explode at t?*

Because it was lit five seconds before *t*.

(b) *Why did electricity flow around the system?*

Because the two buttons were pressed simultaneously, thus closing the circuit.

(c) *Why are the two traces on the Campbell-Stokes recorder the same length?*

Because the two intervals of sunshine that caused the traces were equal in duration.

Why should we need to distinguish between purely causal and chronometric explanation? Because, once again, of the difficulties raised in §2.2. The kinds of fact or property appealed to in chronometric explanation do not appear to be causal.

Appeals to the *rate* at which processes take place are also chronometric. This may seem rather surprising. It implies that we do not, strictly speaking, cause changes in the rate of processes, and also (since the effects of some things are also causes of others) that such changes in rate cannot themselves be the causes of things. We need to be careful how we articulate this point, however. The suggestion is not that changes in rate cannot feature in causal explanations, either as explanans or explanandum, but rather that such explanations must involve a non-causal element. Here are two problematic cases:

(d) *Why did the reaction speed up?*

Because a catalyst was added.

(e) *Why did the ball slow down?*

Because a force was exerted on it.

In both these cases, the explanandum involves facts about intervals. Yet the explanans appears to be purely causal, or at least it seems to involve an event or state that can be given a specific location. What I suggest is happening in these cases is this. It is a brute fact that a given process proceeds at a certain rate. Different processes may proceed at different rates. When some factor appears to be affecting the rate of a process, what it is in fact doing is determining which of a range of related processes is realised. A reaction in the presence of a catalyst is not the same reaction as one in the absence of a catalyst. (A catalyst is sometimes described informally as something which may affect the rate of a reaction without itself being directly involved, but theories of catalysis, whether chemical or physical, all ascribe a much more active role to the catalyst.) So what we have here is two factors: the purely causal fact that the catalyst causes a reaction of a certain type to take place, and the purely chronometric fact that that reaction takes place at a certain rate. Similar remarks apply to the case of motion.

So, having introduced the notion of chronometric explanation, we can now look at the role it plays in the explanation of how we acquire beliefs about order and duration.

### *5.2 How time order can be explanatory*

Suppose you are waiting at the traffic lights, which are currently on red. You now see the amber light appear, followed shortly by the green light. Consider the causal account of your perceptual awareness of the order: you see the amber light, the content of which experience is then stored in the short-term memory, which then affects your perception of the green light. The causal order of our perceptions determines your belief concerning the time order of the events perceived. Within this psychological account are two explanations. One is purely causal: the amber light (*a*) causes your perception of it

( $P_a$ ); the green light ( $g$ ) causes your perception of it ( $P_g$ ), and that second perception is causally affected by  $P_a$ . These causal relations, however, are not enough by themselves to guarantee the truth of your belief that  $a$  precedes  $g$ . So, how does the truth-maker of your belief—that  $a$  is actually earlier than  $g$ —play any explanatory role in your acquisition of that belief?

First, we need to appeal to the following chronometric explanation: because of the high speed of light and the short distance between you and the events perceived,  $P_a$  and  $P_g$  are almost simultaneous with  $a$  and  $g$  respectively. In contrast,  $a$  and  $g$  are not even approximately simultaneous. These relations are set out in Fig. 2.

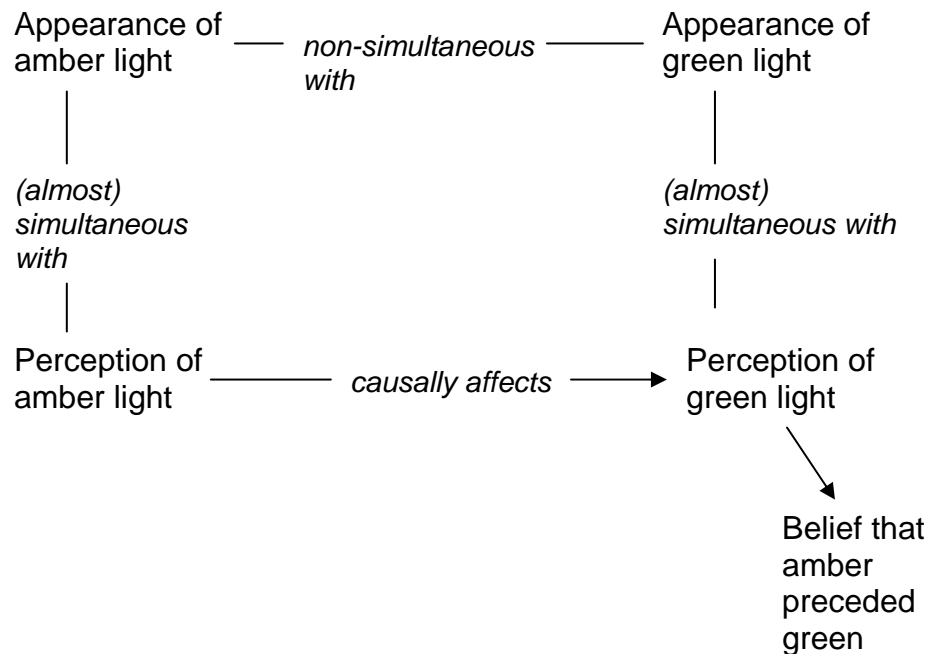


Fig. 2: Causal and chronometric elements in the acquisition of belief about time order

Now, there are two ways in which we might articulate the explanatory connection between truth-maker and belief.

The first way is this: the objective order of the external events,  $a$  and  $g$ , is what,

in part, explains how  $(P_a)$  can causally affect  $(P_g)$ . Because the perceptions are virtually simultaneous with the events of which they are the perceptions, the order of perceptions will mirror the order of events, which is what enables  $(P_a)$  causally to affect  $(P_g)$  rather than the other way around, which in turn explains why you perceive  $g$  as following  $a$ . Thus, the truth-maker enters, in a rather simple and obvious way, into the explanation of how you come to acquire your belief.

The second explanation is a little more interesting. Instead of explaining the causal order of your perceptions in terms of the time order of the external events, we could reverse the direction of causation. This involves an appeal to the causal theory of time order, of which the following is one of the simpler forms:

$x$  is earlier than  $y$  iff  $x$  is simultaneous with some fact that is a cause of some other fact that is simultaneous with  $y$ <sup>13</sup>

The non-simultaneity of  $a$  and  $g$  explains how there can be a causal connection between  $(P_a)$  and  $(P_g)$ , but does not determine its direction. It is the fact that  $(P_a)$  causally affects  $(P_g)$  and not vice versa that fixes the time order of  $(P_a)$  and  $(P_g)$ , and therefore,  $a$  and  $g$  themselves. For since  $a$  is (virtually)<sup>14</sup> simultaneous with a cause,  $(P_a)$ , of something,  $(P_g)$ , that is (virtually) simultaneous with  $g$ , it follows by the causal theory of time order that  $a$  is earlier than  $g$ . So this time the truth-maker falls out as a logical consequence of the explanation of the acquisition of your belief.

I favour the second of these explanations, because of its greater economy (the temporal relation is reduced to the causal relation) but, given the controversial nature of the causal theory of time order,<sup>15</sup> all I can do here is simply to display the two explanations as illustrations of how objective and mind-independent time order can be genuinely explanatory of the beliefs it makes true.

### *5.3 How duration can be explanatory*

Employing chronometric explanation (at least of the kind that involves reference to duration or rate, as opposed to just simultaneity) clearly implies a commitment to objectivism about metric. That is, chronometric explanation presupposes that there is a

fact of the matter as to whether, e.g., one interval is longer or shorter than, or equivalent to, some other interval, even in cases where one interval is not contained within the other. Assuming the legitimacy of this kind of (I submit, non-causal) explanation, we would expect it to be relevant in explaining our perceptual beliefs about metric.

So, let us say that I am presented with two successive auditory stimuli and asked to judge whether or not they were of equal duration. Suppose that I correctly judge that they are isochronous. According to the scalar timing theory, the onset of the first stimulus closes the switch between pacemaker and accumulator, which then encodes the number of pulses emitted by the pacemaker. Stimulus offset causes the switch to open. The encoded pulses now provide a measurement of the length of the first stimulus, which is stored in the short-term memory. The same process is activated by the second stimulus. The resulting two measurements are then compared, and a judgement of isochrony arrived at. Again, the purely causal facts are not sufficient for the truth of my belief. What more is needed is the chronometric explanation of why just these pulses were recorded by the accumulator. The chronometric explanation will appeal to the objective lengths of the intervals between stimulus onset and offset. These lengths then entail the truth about the isochrony of the stimuli. So, once again, the facts that provide a full explanation of how I come to acquire my belief that the two stimuli are isochronous include the truth-maker of that belief, and the Explanatory Truth-Maker Principle is satisfied.

#### *5.4 A compromise: A-series position as mind-dependent*

Objective, mind-independent facts about time order and metric can be genuinely explanatory of our perceptual beliefs. But not all aspects of time may have an explanatory role to play. So there may be room for compromise with the Augustinian position: perhaps some features of time are best understood as mind-dependent. Or so I shall argue in this section. The aspect I shall focus on is that of A-series position.

The term ‘A-series’ was first introduced by J.E. McTaggart, in his well-known distinction between two kinds of temporal ordering, which was the prelude to his notorious proof of the unreality of time ((1908), (1927)). The *A-series*, then, is the series

of positions in time which runs from the distant past, through the present, and to the distant future. The A-series position of an event is therefore its pastness, presentness or futurity. We might augment this and say that pastness and futurity is a matter of degree: something can be very recently past, or very distantly past, and so on. It is a characteristic of the A-series positions of events that they change, and this, which is nothing less than the passage of time itself, is an obvious and apparently entirely objective aspect of time, one that seems necessary for us to have any experience at all. McTaggart contrasted this with the *B-series*, which orders events according to the relations they stand in to other events—more specifically, according to their simultaneity or precedence relations. B-series positions do not change. If *a* is at any time earlier than *b*, it is so for all time. It is B-series relations and properties that we have been concerned with for most of this paper. However if, as we naturally assume, there is such a thing as A-series position, it is clearly logically connected to B-series position. If Sally’s birth is past, but Jilly’s birth is present, then, inexorably, Sally’s birth precedes Jilly’s. Given this logical connection, we need to decide which is the more fundamental: A-series position, or B-series position. Suppose that A-series facts are the more fundamental, and order facts supervene upon them. We might propose a reductive analysis along the following lines:

*a* is earlier than *b*  
iff:  
*a* is less future than *b*  
or  
*a* is present and *b* is future  
or  
*a* is past and *b* is present  
or  
*a* is more past than *b*

This is just one of a number of reductive analyses we could have proposed<sup>16</sup>, and one might regard some aspects of this particular one with suspicion: is the ‘less future than’ relation, for example, just a combination of two elements, namely the A-series ‘futurity’



position and the B-series 'earlier than' relation, and if so, does this not make the analysis circular? We do not need to engage with these and other worries concerning the precise terms of the analysis. The point to note is simply this: that *if* the B-series supervenes on the A-series, then *a*'s being earlier than *b* will supervene on *changing* properties, since change is the characteristic feature of A-series position. On the above analysis, for instance, the passage of time will run from the first disjunct on the list to the last.

Let us suppose, then, that the B-series does supervene upon the A-series. Then the truth-makers of our beliefs about the order of two events (such as the appearance of the amber and green lights) will be the A-series positions, or facts about the A-series positions, of those events. The Explanatory Truth-Maker principle then requires that these truth-makers should also play an explanatory role in our acquisition of those beliefs (where the beliefs count as knowledge). But can A-series positions play such an explanatory role?

The problem here is that the supposed truth-makers of our order beliefs are constantly changing. At one time, our beliefs have one truth-maker (represented by one of the disjuncts in our truth-conditional schema above, or in some similar schema), at another, those same beliefs have a different truth-maker. What makes true your present belief that *a* preceded *g* is the *current* A-series positions of *a* and *g*. What made true that same belief a few seconds ago was their A-series positions *then*. But whatever it is that explains our belief-acquisition cannot be changing in this way. The explanation lies in whatever states of affairs obtained when I first acquired the beliefs, not what states of affairs obtain now, some time afterwards. If we describe the situation, as we did §5.2, in purely B-series terms, then the problem does not arise: explanation and truth-maker coincide.<sup>17</sup> It seems, then, that A-series positions are entirely *de trop* in explaining how we come to acquire beliefs about time order.

According to one theory of time, the *B-theory*, such positions are indeed *de trop*, and we can dispense with them entirely. A-series position, on this theory, is simply a feature of our representations of reality, not of reality itself. Statements attributing A-series position to events or states of affairs ('Matthew's birthday party is tomorrow') can be true, but only in virtue of non-tensed temporal relations between the statements themselves and the events of which they speak (e.g. Matthew's party being one day

after the day the statement is made). One could express this by saying that, for the B-theorist, A-series position is mind-dependent. If we can explain our acquisition of beliefs about order without recourse to the A-series, the ETMP gives us reason to suppose that order does not depend on A-series position at all. But since order *would* supervene on A-series position, *if* the A-series existed independently of any mind (for otherwise the logical connections between A-series and B-series position would be inexplicable), we have grounds here for supposing that A-series position is mind-dependent. Thus, we could agree with part of Augustine's conclusion: the A-series, at least, is in the mind.<sup>18</sup>

## 6 SUMMARY CONCLUSION

Psychologists have long recognized that time perception is not directly analogous to perception of objects and their properties, for the temporal features of events do not present themselves for inspection in the way that spatial properties do. Yet perception does inform of such things as the time order and duration of events: how? This psychological problem has a philosophical counterpart: if perceptual knowledge is definable in terms of perceptual beliefs whose truth-maker and cause coincide, how is it possible to have perceptual knowledge of time? For a number of considerations—the problematic nature of time perception, the difficulty of locating temporal properties in space and time, the fact that models of time perception do not include them as explanatory factors—point to the conclusion that time order and duration are *acausal* properties of events. This is the epistemological puzzle of time perception, and the central aim of this paper was to solve it.

That the causal theory of knowledge, *prima facie*, runs into difficulties in accounting for certain objects of knowledge is a familiar problem. The most-discussed examples are numbers, as the arithmetical Platonist conceives of them, and moral truths, as the realist conceives of them.<sup>19</sup> Problems arise in these cases because of the abstract status of such objects. It would, surely, be surprising if difficulties should also arise in a case of *perceptual* knowledge. But time seems to provide such a case.

One approach to the problem was to see it as arising from the assumption that

order and duration are mind-independent properties. If instead we look for the truth-makers of our perceptual beliefs about order and duration within the psychological mechanisms underlying our acquisition of those beliefs, that might restore their causal status. Such a strategy, if successful, would vindicate Augustine's view that, since it is within my mind that I measure time, time is mind-dependent. However, this leads to an implausible subjectivism concerning our beliefs, and no adequate means of explaining either their usefulness or how we acquired them at all.

A better approach is to modify the causal truth-maker principle. Instead of making causal relations between truth-maker and belief bear alone the burden of conferring the status of knowledge, we should require instead that the truth-makers play some form of explanatory role in the acquisition of perceptual knowledge. Explanation, even of a non-logical kind, is not invariably purely causal. And even in what might ordinarily be called causal explanation, there are non-causal components. Within such explanation, beside references to the causes themselves, there may also be reference to the properties and relations that structure those causes: their location in space and time, for example. It is a question worth pursuing whether a theory of knowledge based on this more inclusive conception of explanation could more easily accommodate knowledge of abstract objects. In the context of time perception, appeal to what I called *chronometric explanation* helps us solve the epistemological puzzle while retaining our belief in the mind-independence of order and duration.

Is there no comfort for Augustine, then? Well, maybe. One property, at least, is best treated as mind-dependent: A-series position. And given that Augustine habitually talks of time in terms of pastness, presentness and futurity, this is perhaps what he was saying all along.<sup>20</sup>

## NOTES

[1] See Ayer (1940) for a classic statement of the ‘argument from illusion’. For a more recent defence of the sense-datum theory, see Jackson (1977).

[2] This was an address given in 1973 to a meeting of the International Society for the Study of Time in Japan. The paper’s title is quoted by Pöppel (1978), who also quotes the following remark: ‘time is not a thing that, like an apple, may be perceived.’ The source for the remark is Woodrow (1951).

[3] In James’s words, ‘We are constantly aware of a certain duration—the specious present—varying from a few seconds to probably not more than a minute, and this duration (with its content perceived as having one part earlier and another part later) is the original intuition of time.’ (James (1890)) However, the extraordinary temporal range of James’s specious present, and its phenomenological divisibility into earlier and later parts, makes it a very different thing from what could be called the present of experience, namely what presents itself as happening *now*. This, much shorter, and phenomenologically indivisible, specious present, has a duration of something like a tenth of a second, although this varies from one sense modality to another, and perhaps from one time and subject to another. It is this second conception of the specious present, not James’s original conception, with which I am concerned.

[4] It is only fair to point out, in relation to the second part of this quotation, that Ornstein was writing over thirty years ago, since when there has been a considerable amount of research on time perception. And, even at the time, it might be considered a less than generous remark. See, e.g., Pöppel (1978) and Friedman (1990).

The second part of the first sentence in this quotation is rather puzzling. I am inclined to think that when Ornstein says ‘outside ourselves’ he means ‘*within* ourselves’, and that his point is that there is no obvious sense organ for time. The sentence, however, is not corrected in later editions.

[5] See Grice (1961) for a cautious defence of the causal theory of perception, and

Goldman (1967) for an early statement of the causal theory of knowledge. Goldman later abandoned the causal requirement (Goldman (1976)). Another version of the causal theory is presented and defended in Swain (1979).

‘Truth-maker’ is a philosophers’ term of art. It is intended to refer to whatever aspect of reality is responsible for the truth of an assertion, belief or proposition. I advance no views here about what kinds of entity—objects, events, properties, facts—are suited to play the role of truth-maker, since the argument does not require me to, although the issue is briefly touched upon in §2.

[6] This kind of problem is discussed in Goldman (1976), leading to a version of the reliabilist account of knowledge.

[7] See, e.g., Strawson (1974) and Peacocke (1979) for discussion of deviant causal chains.

[8] There is, in fact, something of a philosophical tradition that space and time are themselves acausal. For references and discussion, see Le Poidevin (1992).

[9] Here ‘fact’ is being used to mean a particular kind of constituent of the world, existing independently of language or thought, and not in the sense of true proposition. The argument for the truth-making role’s being occupied by facts, and not by particulars, properties or relations, is well-known and simply stated. You say to me ‘Eric has crashed the party’. What makes this true? Not Eric, for his existence is perfectly compatible with the falsehood of your remark. Nor any intrinsic property of Eric’s, for first this property needs to be attached to Eric in some way, and second, none of his intrinsic properties could constitute the property of crashing a party. Some relation between Eric, a spatial location and perhaps other particulars, then? No, because the relation by itself cannot make your remark true independently of the relation, since your remark was specifically about Eric. But then a mere collection consisting of Eric, his intrinsic properties, other particulars, and the relations between all these cannot make your remark true either: they have to be combined in some way. That is, your remark can only be made true by some *structured combination* of particulars, properties and

relations, and this structured combination all folk (well, some folk) call a *fact*. One might resist this by introducing *events* as truth-makers. In this case, the event of Eric's crashing the party. But there are many truths for which events are clearly ill-suited to be the truth-makers. Suppose you had said 'Eric *hasn't* crashed the party'? What event could possibly make this true? Here, perhaps, one could say that the remark has no truth-maker, but is true simply in virtue of the absence of a truth-maker for its negation, namely, 'Eric has crashed the party'. But this strategy only works, if at all, for negative statements. Some statements appear to ascribe properties to events: 'Eric's crashing the party last night was so embarrassing'. The event of Eric's crashing the party is certainly not sufficient by itself to make that statement true, for the statement is to do with the effect of his behaviour on me. If the event appears in the truth-maker at all, it is only as part of some structured combination—a fact, in other words. At any rate, so it can plausibly be argued. I need take no view on the matter here.

[10] For a summary and discussion of the evidence for backwards time referral, see Libet (1981). One rather striking case he reported was as follows. Tingling sensations in the hand can be produced in two ways: by electrical stimulation of the hand itself, or of the appropriate part of the somatosensory cortex. The latter, in effect, mimics the later stages of the neural events associated with hand stimulation, and so, one might expect, should lead more quickly to the perceived sensation. In one experiment, the subject's left cortex was stimulated before the left hand was stimulated. The former led to a sensation in the right hand, but this was reported as occurring *after* the sensation in the left hand.

For a discussion of this, and other intriguing cases, including the 'cutaneous rabbit' and the 'precognitive carousel', see Chapter 12 of Dennett (1991), which also presents a content-sensitivity model of order perception.

[11] Since he thinks there is a particular problem in the case of time, it is likely that Augustine was assuming ordinary perception to be simultaneous with its objects. However, the finite speeds of light and sound mean that there is always a gap, however small, between any given state of affairs and our perception of it. Reflection on this (now familiar) fact would, on the basis of his reasoning in the temporal case, have led

Augustine to a comprehensive idealism.

[12] C.f. Graham Nerlich's introduction of 'geometrical explanation', which is a non-causal explanation of the behaviour of moving objects in terms of the geometrical properties of space (Nerlich (1994)).

[13] Since simultaneity is reflexive, the analysis defines the order of events that are themselves the causal relata.

[14] Of course, on the causal analysis, an event cannot be exactly simultaneous with the perception that it causes.

[15] The following difficulty arises for the version of the causal analysis presented here. Suppose  $a$  to be a cause of  $b$ , and  $c$  a cause of  $d$ . There are no causal connections between the  $a$ - $b$  pair on the one hand and the  $c$ - $d$  pair on the other.  $a$  is simultaneous with  $d$ , and  $b$  is simultaneous with  $c$ . It would follow, from the causal analysis, both that  $a$  is earlier than  $b$  (because simultaneous with a cause of something that is simultaneous with  $b$ ) and that  $b$  is earlier than  $a$  (because simultaneous with a cause of something that is simultaneous with  $a$ ). We could simply accept this consequence, but deny that it constitutes a contradiction, on the grounds that time order is merely local to a causally isolated system. Time order may run in opposite directions in different parts of the universe. This does not entirely dispose of the problem, however, because we cannot rule out the possibility that such regions will come into contact. What is to prevent the following situation:  $a$  is a cause of  $b$ ,  $b$  is a cause of  $c$ , and  $c$  is simultaneous with  $a$ ? One, not obviously question-begging, way of outlawing this kind of case is to introduce the following principle: where, for any causally related items,  $x$ ,  $y$  and  $z$ ,  $y$  is causally between  $x$  and  $z$ , it is also temporally between those items. The various difficulties for causal analyses of time order, and possible responses to them, are discussed in Le Poidevin (2003), Chapter 12.

[16] For a survey of the various options, and their shortcomings, see Tooley (1997), Chapter 6.

[17] See Le Poidevin (1999) for further discussion of this.

[18] See Mellor (1998) for a defence of (one version of) the B-theory of time. Moore (2001) explores the variety of issues at stake in debates between B-theorists and defenders of the A-series.

[19] This is one way of articulating the ‘argument from queerness’ against objective moral properties, on which see Mackie (1977), Chapter 1. On the problem as it arises for numbers and similar abstract objects, see Hale (1987), Chapter 4.

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