Meeting of the Aristotelian Society held at Senate House, University of London, on 22 April 2013 at 5:30 p.m.

XII—Perceiving the Passing of Time

Ian Phillips

Duration distortions familiar from trauma present an apparent counterexample to what we might call the naive view of duration perception. I argue that such distortions constitute a counterexample to naiveté only on the assumption that we perceive duration absolutely. This assumption can seem mandatory if we think of the alternative, relative view as limiting our awareness to the relative durations of *perceptually presented* events. However, once we recognize the constant presence of a stream of *non-perceptual* conscious mental activity, we can provide an attractive, purely relative account of temporal distortions quite consistent with the naive view. I also consider (and reject) a second empirical challenge to the naive view arising from the so-called 'oddball effect'. I conclude by tentatively pointing to further empirical data, traditionally accounted for in terms of an internal clock model of timing, which, I suggest, may be understood more illuminatingly by appeal to the idea that we perceive duration in part relative to concurrent non-perceptual mental activity.

Survivors of life-threatening danger reliably report that the traumatic events which they experienced appeared to last much longer than events of the same objective length in normal conditions: 'time seemed to slow down' for them. As well as being of intrinsic interest, such cases are often said to reveal something about the nature of duration perception in general. In particular, such experiences have been thought, in different ways, to show the untenability of what we might call the naive view of duration perception (§§I–III).

Our experiences of duration during trauma are inconsistent with the naive view only on the assumption that we perceive duration absolutely. The naive view is thus defensible in so far as the content of duration experience is purely relative. The global nature of traumatic temporal distortions may seem to preclude a purely relative account. However, an attractive purely relative account emerges once we recognize that our awareness of relative duration is not limited to the relative durations of *perceptual* events (e.g. that one sound lasted twice as long as another) but includes an awareness of the durations

Proceedings of the Aristotelian Society, Vol. cxiii, *Part* 3
doi: 10.1111/j.1467-9264.2013.00353.x

of perceived events relative to our concurrent *non-perceptual* mental activity. This provides the clue to what is occurring in traumatic time distortions: subjects are experiencing a great deal more non-perceptual mental activity during the crisis events than they would normally experience during a period of matching objective length. I explain how such purely relative experience grounds subjects' initially puzzling reports, both of time slowing down and of their minds speeding up. Such reports, in contrast, present a serious challenge to absolutist accounts of duration perception (§IV).

Having shown how the resultant account of traumatic time distortions is consistent with the naive view and drawn out some further corollaries (§V), I turn briefly to a second objection to the naive view of duration perception arising from the so-called 'oddball effect' (§VI). I conclude by tentatively pointing to a larger body of data traditionally accounted for in terms of an internal clock model of timing which, I suggest, may be more illuminatingly understood by appeal to the idea that we perceive duration in part relative to our concurrent non-perceptual mental activity (§VII).

I

The Naive View. The naive view of duration perception comprises two claims. The first is simply the idea that we are—in some sense—perceptually aware of the durations of events in our environment. As Foster puts it, 'duration and change through time seem to be presented to us with the same phenomenal immediacy as homogeneity and variation of colour' (1982, p. 255). Call this *realism* about perceived duration.[1]

To introduce the second aspect of the naive view of duration perception we need to recognize that temporal experience is a special case of perceptual experience. There is no temptation to think that when we experience a red, round tomato, or a loud, high-pitched

[1] Cf. Dainton (2000, p. 115), who takes realism to be a 'phenomenological constraint' on theorizing in this area, 'an obvious truth', the 'most basic of facts'. For contrastingly sceptical views about realism see Le Poidevin (2007) and Chuard (2011). Note that the concern of these authors—and of the present discussion—is specifically with our *conscious* perceptual experience. Note also that Foster and Dainton, being sense-datum theorists, do not think of the durations immediately presented as being the durations of environmental events, but rather of sense-data. Here, in contrast, I do assume that we are literally perceptually aware (in some sense) of the durations of events in our environment.

Proceedings of the Aristotelian Society, Vol. CXIII, *Part* 3
doi: 10.1111/j.1467-9264.2013.00353.x

sound, that our experience of these objects is itself red and round, or loud and high-pitched. Our experiences, at least in their subjective aspect, do not have colours or shapes, pitches or intensities. On the other hand, our experiences *do* manifestly have temporal properties, being processes or events which persist through time and occur before and after one another. This raises a special question which fails to arise in other cases of perception, namely, how do the temporal properties of experience relate to the temporal properties of what is experienced? Or, in more traditional terminology, how does act time relate to object time?

A traditional, if much maligned, answer to this question is eloquently voiced by Helmholtz, who asserts that the only case in which 'our perceptions can truly correspond with outer reality is that of the time-succession of phenomena' (1867, p. 445; quoted in James 1890, p. 628). 'Events,' says Helmholtz, 'like our perceptions of them, take place in time, so that the time-relations of the latter can furnish a true copy of those of the former.' In the case of duration, the idea would be that if we experience an event as having a certain duration, then our experience itself will persist for a matching period of time. This idea receives support from reflection on our experience. Imagine hearing a singer sustaining a long note. Then ask yourself, how long did your experience of the note itself last? The natural answer is that your experience itself lasted just as long as the note apparently lasted.[2]

There are thus two aspects to our initial intuitive conception of duration perception: *realism*, and what we might call *matching*, the claim that whenever our experience apparently presents us with an event with a certain duration, our experience itself persists for a matching amount of time. Foster also numbers amongst the few explicit exponents of *matching*. As he concludes on the basis of an argument concerning the diachronic structure of auditory awareness, 'we have to take experience to extend over a period of real time in a way which exactly matches the phenomenal period it presents' (Foster 1991, p. 249).[3]

[2] For more on these themes see Phillips (2010; forthcoming a).

[3] Likewise Dainton, in the context of endorsing Foster's overlap model of the diachronic structure of experience, comments, 'even if we draw an awareness–content distinction [which Dainton ultimately rejects] it makes no sense to suppose that an act of awareness can apprehend a content of a greater temporal duration than itself' (2000, p. 180). For discussion of what is fundamentally at work in Foster's argument see Phillips (2010).

Proceedings of the Aristotelian Society, Vol. CXIII, *Part* 3
doi: 10.1111/j.1467-9264.2013.00353.x

Having set out the commitments of the naive view, I now turn to a major challenge it faces.

II

Trouble for Naiveté. Car crash victims, pilots forced to eject from their planes, rock climbers suffering serious falls, and other survivors of life-threatening danger, reliably report that the traumatic events which they experienced appeared to last much longer than events of the same objective length in normal conditions.[4] To see why such cases of 'time seeming to slow down' pose a difficulty for the naive view, consider a simple example. A rock climber falls from a rock face and hits the ground a second later. The climber reports that her one-second fall seemed to last a great deal of time. It is tempting to think of the climber as thus *misperceiving* her fall in the sense of experiencing it as lasting much longer than it in fact did, for instance as taking ten seconds when it in fact took only one. If this is the right way to describe the climber's experience, then, given the naive matching claim above, the climber must enjoy an experience of her fall which itself lasts ten seconds. This is not incoherent, but it is surely not credible (at least in general). As we naturally imagine the case, the rock climber's experience of her fall doesn't continue to unfold for nine seconds after she has hit the ground. Whilst a number of possible ways of accommodating such an extended experience suggest themselves, it is implausible that in every case some such accommodation occurs. Indeed, we naturally think that the climber might be rendered unconscious the moment that she hits the ground, and yet nonetheless experience her fall much as she later reports. It seems then that the naive view cannot provide a plausible account of such experiences in general, and so must be rejected.

[4] See Noyes and Kletti (1976, 1977), Flaherty (1999), Carson (1999), Ursano et al. (1999) and Hancock and Weaver (2005). Such real-life cases have been replicated under experimental conditions, though with obvious ethical constraints. For example, Langer et al. (1961) asked subjects to estimate a five-second interval whilst being moved towards or away from a precipice. Subjects being moved towards judged five seconds over after 3.37 seconds. Subjects being moved away judged it over after 4.22 seconds. This reveals a 20% 'slowing of time' in the more fear-provoking condition. For other quasi-realistic studies see Falk and Bindra (1954) and Watts and Sharrock (1984). For the (similar but less dramatic) effects of mildly fear-provoking stimuli on time perception see Noulhiane et al. (2007), Droit-Volet and Gil (2009), Wittmann et al. (2010) and Tipples (2008, 2011).

Proceedings of the Aristotelian Society, Vol. CXIII, *Part* 3
doi: 10.1111/j.1467-9264.2013.00353.x

In response, it is insufficient to object to the example's presupposition that we perceive duration relative to a particular metric, namely in seconds. This can be seen by brief consideration of Peacocke's approach to temporal perception, which rejects this presupposition and yet provides no relief for the naive view. Peacocke holds that spatial perception is 'unit-free', as illustrated 'by the fact that when we see a table to have a certain width, we do not see it as having a certain width in inches, say, as opposed to centimetres' (1992, p. 69). He further indicates (2004, p. 67) that he would endorse the analogous claim concerning temporal perception: when we perceive an event as having a certain duration we do not perceive it as having a duration in seconds, say, as opposed to heleks (a Hebrew time unit corresponding to $3\frac{1}{3}$ seconds). Peacocke eliminates units from his canonical specifications of spatial perceptual content by employing 'an ontology of distances such … that there is just one distance which has both the measure of one inch and equally the measure of 2.54 centimetres' (1993, p. 164). By analogy, in the temporal case, he will presumably appeal to an ontology of durations such that there is just one duration which has both the measure of one helek and equally the measure of $3\frac{1}{3}$ seconds.

Consider now our climber. According to a unit-free account of her experience, her experience represents her fall as lasting a duration, *D*. The naive matching claim will thus require that her experience itself have a duration *D*. Yet, in so far as her experience misrepresents the duration of the fall as ten times as long as its actual duration, *D* will have the measure of ten seconds (and, of course, equally that of three heleks). Thus, no progress has been made in avoiding the implausible conclusion that the climber has a ten-second-long experience of her one-second fall. How else then might the naive theorist respond to the alleged counterexample?

III

Memory and Realism. One radical possibility is to deny that such distortions really do occur despite subjects' reports. Such a view is, in fact, not uncommon in the empirical literature. Thus, Stetson, Fiesta and Eagleman (2007, p. 1) offer experimental data in support of the conclusion that 'time-slowing is a function of recollection, not perception', and Gallistel (1996, p. 336) appears to endorse the

Proceedings of the Aristotelian Society, Vol. CXIII, *Part* 3
doi: 10.1111/j.1467-9264.2013.00353.x

more general anti-realist idea that 'duration is not itself a sensible aspect of events' but 'exists only in recollection'.[5] Such views are not lightly dismissed. However, in the present context I offer only three brief remarks. First, Gallistel's apparent anti-realist view that duration 'exists only in recollection' is clearly not an option available to the naive theorist, since it abandons the first realist component of their position. Indeed, Gallistel (1996, p. 336) appears to straightforwardly contradict Foster when he writes that duration is precisely 'not like colour or shape'. Second, in motivating their hypothesis about duration distortions, Stetson, Fiesta and Eagleman commit to a questionable theoretical assumption (namely, that in order for duration distortions to be perceptual, our perception of duration must be a function of sensory resolution), which, in the light of the view of duration perception proposed below, is seen to be non-mandatory.[6]

Finally, however, there is *one* sense in which the naive theorist must agree with views on which duration exists only in recollection. In developing the charge that traumatic duration distortions are a counterexample to naive matching, the discussion of the rock climber above assumed that she experienced the duration of her fall *absolutely*. In the following section, I show how by rejecting this assumption we can provide an account of duration distortions which is entirely consistent with the naive view. Nonetheless, subjects do make absolute duration *judgements*, and understanding these does, I will suggest, require appeal to memory. As a result, the view I defend is limited in its realism: only relative durations are properly thought of as figuring in our conscious perceptual experience; absolute values are confined to memory-based judgements.[7]

[5] Such a view has significant precedent in the philosophical literature. It seems to be a natural consequence of the kind of scepticism about time perception one finds in Reid (1827) and others who follow him (see Prichard 1950; Le Poidevin 2007, p. 99; Chuard 2011). However, Gallistel's discussion is fundamentally targeted at the level of sensory processing, and so leaves open a realist view on which recollection plays a constitutive role in conscious perceptual experience.

[6] For an excellent discussion of Stetson, Fiesta and Eagleman (2007), see Arstila (2012). Arstila defends an account of temporal distortions congenial to that defended here. A key difference is that the present account proposes a general account of duration perception, understanding traumatic time distortions as simply one manifestation of mental activity's role in timing. In contrast, Arstila apparently takes trauma to be a special case. Thus, Arstila explicitly sets aside the vast majority of research on duration estimation, preferring to explain such data in traditional internal clock terms.

[7] Whether one thinks this marks a contrast with colour perception (and so conflicts with Foster's way of expressing realism) depends, of course, on one's view of colour perception.

Proceedings of the Aristotelian Society, Vol. CXIII, *Part* 3
doi: 10.1111/j.1467-9264.2013.00353.x

I now turn to the central project of the paper, namely the development of a purely relative account of duration perception with the resources to account for traumatic duration distortions consistent with the naive view.

IV

A Purely Relative Account of Perceived Duration. The most austere account of perceived duration we might reasonably consider would involve our simply perceiving the relative durations of perceived events. In the simplest cases, both such events will occur close together in time. Thus, we might hear two tones as lasting the same amount of time, or see the first of two visual stimuli presented in brief succession as having a longer duration than the second. A number of questions arise in specifying the precise contents of experience on such a view. One is whether we perceive the *ratios* of durations of events, or whether duration is merely perceived on an interval or ordinal scale (Stevens 1946). Another is whether our awareness of durations is limited to relations between perceived stimuli which are very close together in time, or whether we can perceive durations between events significantly separated in time, or relative to certain abstracted standards (e.g. the average length of recent stimuli). Whatever precisely the answer to these questions, at the heart of such an approach is the denial that we perceive events as having absolute durations.

Such an approach to temporal perception may seem distinctly unpromising in relation to the *global* duration distortions of trauma. For, on the face of it, a purely relative account can at most allow that a *particular* event or set of events be perceived as unfolding more slowly than some other event or set of events. Yet this is not what subjects report in cases where 'time seems to slow down'. Subjects report that their perceptual environments are slowed *as a whole*. As a result, a dilemma presents itself. Either we must embrace absolute durations, and so abandon the naive view (given the challenge developed above), or we must deny that subjects really do experience duration distortions after all, and explain their reports entirely by appeal to memory (as in Stetson, Fiesta and Eagleman 2007, cited above). One might attempt to resist this dilemma by arguing that subjects can be aware of the durations of current crisis

Proceedings of the Aristotelian Society, Vol. CXIII, *Part* 3
doi: 10.1111/j.1467-9264.2013.00353.x

events relative to the durations of just prior events. However, this is unlikely to be an attractive route for the naive theorist to take, since matching will still entail an implausible claim, namely that the experiences during trauma last much longer than the experiences of the comparison events just prior to the trauma.

Fortunately for the naive theorist, there is another way to resist the dilemma. The dilemma seems to arise, I suggest, only because we fail to bear in mind that our conscious lives are not merely perceptual. At least in the case of self-conscious humans, our waking consciousness is replete with *non-perceptual* mental activity: thinking, imagining, remembering. Indeed, such activity is arguably an essential element of waking consciousness. Moreover, non-perceptual mental activity, no less than perceptual experience, manifestly has temporal features: it too is constituted of events and processes which unfold in time and occur before and after one another. Consequently, such activity provides an ever-present reference stream against which to measure the rates and durations of events in our perceived environments.[8]

In this light, the minimal account of perceived duration suggested at the beginning of the section is revealed to be too austere. As well as perceiving the relative durations of *perceptual* events, we are (arguably of necessity in wakeful consciousness) aware of the durations of environmental events relative to the non-perceptual conscious activity that occurs between their onset and offset. We can now also see how to avoid the dilemma posed by the global nature of duration distortions. It can be avoided in so far as what is happening during crashes, frights and falls involves a relative increase in the rate of non-perceptual mental activity. Such an increase in non-perceptual mental activity will mark a dramatic, though purely relational, difference between our 'normal' experience of a one-second-long event and our experience of a one-second-long event in trauma.

That such an increase in mental activity does occur in traumatic time distortions is strongly evidenced by the anecdotal data. Noyes

[8] Cf. Paul's remark, 'if we were in an entirely static environment where there were no contrasts between property instances (this would have to include no contrasts with respect to properties of my thoughts), then it would seem to us as though time were standing still' (2010, p. 355). Paul is absolutely right to recognize the need to eliminate changes in our thoughts in order to prevent awareness of the passage of time. However, it is plausible to think that if we did eliminate such changes, we would simply be eliminating conscious experience altogether. If that is right, there is no possibility of time ever *seeming* to stand still (cf. O'Shaughnessy 2000).

Proceedings of the Aristotelian Society, Vol. cxiii, *Part* 3
doi: 10.1111/j.1467-9264.2013.00353.x

and Kletti provide a rich supply, of which the following are representative.

> My mind speeded up. Time seemed drawn out. It seemed like five minutes before the car came to a stop when, in reality, it was only a matter of a few seconds … My mind was working rapidly and reviewed information from driver's education that might bear on what I should do to save myself. (Noyes and Kletti 1977, p. 376)
>
> I started seeing good and bad things in my life … scenes that flashed rapidly before my eyes like lantern slides shown in rapid succession. … I don't remember how many there were but, from the moment I saw the accident about to happen, it seemed like I waited forever for the impact. (p. 377)
>
> As the time in which everything happening seemed to slow down, my thoughts speeded up. (p. 378)
>
> My thinking processes increased at an incredible rate so that my movements, in relation to them, seemed extremely slow. (p. 378)

In each of these cases, as Noyes and Kletti bring out, a striking and evidently subjectively central aspect of the subject's overall experience is the connection between the perceived rates and durations of environmental events, and the rate of internal conscious processes of thought, imagination and recollection. This connection emerges clearly in the statistical data: of the subjects Noyes and Kletti interviewed who believed they were about to die, 78% reported 'altered passage of time' (almost without exception a slowing); 68% reported 'increased speed of thoughts'.

The anecdotal data support the idea that what is happening in trauma is a result of our awareness of the durations of environmental events being (in part) relative to our non-perceptual mental activity. According to this hypothesis, what subjects are reporting in terms of 'time slowing down' are experiences in which an unusually large amount of non-perceptual mental activity occurs within a certain objective period: much more activity than would normally occur during such a period.[9]

[9] See further Noyes and Kletti (1976) and Flaherty (1999), which also makes the connection with mental activity explicit. One of the subjects Flaherty quotes is Charles Darwin, who recalls a childhood fall as follows: 'the number of thoughts which passed through my mind during this very short, but sudden and wholly unexpected fall, was astonishing' (Darwin 1887, vol.1, p. 29; quoted in Flaherty 1999, p. 75). Closely related suggestions can also be found in Sierra (2009, p. 36) and, especially, Arstila (2012).

Proceedings of the Aristotelian Society, Vol. CXIII, *Part* 3
doi: 10.1111/j.1467-9264.2013.00353.x

It is natural to object at this point that the reports which subjects are giving are *absolute* judgements. On the one hand, events in subjects' perceived environments (including, in some cases, their own bodily movements) are judged to be absolutely slowed down. On the other hand, subjects' thinking processes (what I am labelling 'non-perceptual mental activity') are judged to be absolutely sped up. These absolute judgements might seem to provide support for a view on which temporal properties are, after all, perceived absolutely, and so to tell against the naive view. In contrast, according to the view on offer, experience only provides us with relative durations, and in the case in point only information concerning how many non-perceptual events occur whilst some perceived event occurs. A clear challenge for this view is to explain why subjects make such absolute judgements.

Before meeting that challenge, it is worth noting that the dual nature of the judgements which subjects are making does not in fact support an absolute view. Indeed, on reflection, they can be seen to present the absolutist with a serious difficulty. On the one hand, if subjects' experiences in trauma really do present them, absolutely, with a slowed-down world, then it is extremely hard to understand why subjects do not simply report themselves as thinking at their normal rate. In other words, it is obscure why subjects *also* judge that their thinking processes are sped up, in addition to reporting the world to be slowed down. On the other hand, if subjects' experiences present them with a world unfolding at its usual rate but over a period in which their thinking is (absolutely) sped up, it is obscure why subjects additionally report the world to be slowed down, as opposed to simply recording that their thinking is much more rapid than usual. As we have seen, however, subjects *both* report that their environment is slowed down *and* (in almost the same breath) that their minds are sped up. The fact that subjects make both these absolute judgements suggests than what underlies them is not absolute, but rather neutral, purely relative perception.

Even accepting that subjects' judgements motivate a purely relative account of experienced duration, we still need an account of why subjects make dual absolute judgements, rather than simply making a single neutral relative judgement. The answer, I suggest, lies in the ways in which subjects ordinarily ground absolute duration judgements in a combination of perception and memory. In forming a judgement about the absolute duration of some event in

Proceedings of the Aristotelian Society, Vol. CXIII, *Part* 3
doi: 10.1111/j.1467-9264.2013.00353.x

the world or of some flow of mental activity, subjects naturally reach for a reference measure: a stored, learned representation of how much change one can expect in one's environment or mind over a given period (say, a second). In the normal case, where there is no unusual discrepancy between the rate of one's mind or world, either reference will serve, and so there is every reason to think that *both* ways of making such judgements are instinctive for us.

The dual nature of subjects' judgements in trauma can then be understood as a result of these two instinctive procedures for making absolute judgements on the basis of purely relative experience coming apart in an abnormal case where the pace of mental activity occurs at a much faster than normal rate. Here the choice of reference measure makes a dramatic difference. On the one hand, subjects can exploit their stored knowledge of how much mental activity typically occurs during a second. They will then implicitly treat their mental activity as proceeding at its normal tempo, and in consequence judge their environment to be slowed down. On the other hand, subjects can exploit their stored knowledge of how much environmental change typically occurs over a second. They will then implicitly treat their environment as running at its normal tempo, and in consequence judge their minds sped up.

Of course subjects (psychopathology aside) will, on reflection, acknowledge that it is their minds which were sped up and not the world which was slowed down. This will then be their final considered judgement as to the facts. But this is no reason for them not to express their experience in the Janus-faced manner they do. This simply reflects their usual practice of judging durations on the basis of purely relative perception, a practice which here produces divergent answers.

V

Corollaries. According to the account of the previous section our experience only provides us with relative durations. In cases of trauma, we are aware of a great deal of non-perceptual mental activity occurring during the crisis events. Experience itself gives us no more than that. Nonetheless, as just explained, such experiences are naturally reported both as cases of time slowing down and our minds speeding up.

Proceedings of the Aristotelian Society, Vol. CXIII, *Part* 3
doi: 10.1111/j.1467-9264.2013.00353.x

Given our initial concerns, the most important corollary of the above approach is that our experiences of duration during trauma no longer pose any threat to the naive view. The rock climber's experience of her fall is of an event which lasts the same amount of time as a certain amount of mental activity. According to naive matching, whenever an experience presents an event with a certain apparent duration, the experience itself must persist for a matching amount of time. In this case, the climber's experience presents her with a fall-event as apparently having the same duration as a great deal of mental activity. The experience itself must therefore *actually* last for a period of time during which a great deal of mental activity occurs. Yet this is quite unproblematic. For the experience can do so without continuing on after the climber has hit the ground. Nothing prevents the experience lasting just one second, so long as it is a second during which a great deal of mental activity occurs. And that is precisely what is occurring according to the hypothesis at hand.

A further corollary of the current approach is that our experiences of duration in trauma are not strictly speaking illusions. Our climber may make a mistaken judgement about the duration of her fall, but her experience does not present the fall other than as occurring over a period during which a great deal of mental activity occurs—and that is precisely what it does. The present account does nonetheless allow for duration illusions in other cases. For instance, lightning strikes last only around fifty microseconds, yet, due to visible persistence (Coltheart 1980), the lightning arguably appears to last for a duration similar to much longer events, say the sound of a heartbeat. Here, then, we can genuinely misperceive the lightning strike and the sound of the heartbeat as equidurational. Plausibly we can also misperceive the relative durations of the lightning and an event, say a fleeting image, in our non-perceptual consciousness.

In a recent discussion, Peacocke asks us to consider 'Speeded-Up Earth, on which everything happens twice as fast as it does on actual earth' (Peacocke 2013, p. 322). On the present approach, Oscar and Fast Oscar, his counterpart on Speeded-Up Earth, will be phenomenal twins: their subjective lives in respect of their awareness of duration will be identical.[10] Speeded-Up Earth is the temporal coun-

[10] Peacocke appeals to Speeded-Up Earth to make the opposite point. Chalmers (2013, p. 355) replies by expressing sympathy with the present view that 'temporal experience is

Proceedings of the Aristotelian Society, Vol. CXIII, *Part* 3
doi: 10.1111/j.1467-9264.2013.00353.x

terpart of Thompson's Doubled Earth where everything is twice as big (Thompson 2010). Thompson argues that Oscar and Big Oscar, his Doubled Earth counterpart, are phenomenal twins. Thompson's case prompts us to ask whether we can find a spatial counterpart to traumatic time distortions. The most natural way of doing so is to consider accounts of size perception according to which we perceive the sizes of objects in our environments relative to (aspects of) our own body's size (see, for example, Wraga 1999, who emphasizes our effective eye height). Such views not only predict Thompson's intuition about Doubled Earth, they also predict the spatial analogue of distorted experiences of duration in trauma. For instance, imagine Alice in Wonderland's experience on following the bottle's 'DRINK ME' instruction, and so shrinking to a fraction of her usual size. Assuming a body-relative account of size perception, Alice will now perceive the table before her as vast relative to her body size, and conversely her own body as tiny relative to the table.[11]

VI

The Oddball Effect. Duration distortions in trauma are not the only alleged counterexamples which the naive view of duration faces. Another case claimed to conflict with naive matching is the so-called 'oddball effect'. In the relevant experimental set-up, subjects have to detect and respond to a statistically unlikely stimulus (the oddball) embedded in a series of otherwise identical repeated stimuli (the standards). For example, subjects might have to respond to a red circle presented in the middle of a train of black circles. In a case where each black circle is presented for 1050 ms with approximately similar gaps between stimuli, the red circle appears equidurational with the black circles when presented for only 800 ms (Tse et al.

best regarded as constitutively involving the representation of relative times rather than absolute times'. For earlier discussion of such cases see Lee (2009) and Phillips (2009, ch. 1). As emphasized to me by Geoff Lee, cases of gradual speeding up without loss of consciousness need more careful consideration.

[11] Since our bodies do not in fact grow and shrink in these dramatic ways, actual cases of such distortions are plausibly limited to cases where psychopathology or clever experimental manipulation leads to a false awareness of a change in our body size. See, for example, Todd (1955) on 'Alice in Wonderland' syndrome, and the body-swap illusions explored by Linkenauger et al. (2010) and van der Hoort et al. (2011).

Proceedings of the Aristotelian Society, Vol. CXIII, *Part* 3
doi: 10.1111/j.1467-9264.2013.00353.x

2004; for a wide-ranging review see Eagleman 2008).[12] More generally, oddball stimuli appear equidurational with non-oddball standards which are objectively 20–50% longer.

According to Lee,

> These examples provide counterexamples to [naive matching], provided they involve an experience lasting less time than it presents a stimulus as lasting—in other words, provided the dilation of subjective duration is not accompanied by a corresponding dilation of the objective duration of the experience. … [I]t would be very strange to hold that it must be the case that the subject's experience of e.g. the oddball is objectively longer than her experience of the other stimuli, even if the stimuli themselves have the same duration. Assuming the oddball stimulus appears to last longer than it really does, if this claim were correct, it seems that the subject's experience of each of the stimuli that occur after the oddball would have to lag behind in order to fit the longer experience of the oddball into the stream of consciousness. With enough oddballs we could make each experience lag behind its stimulus any amount we chose! (Lee 2009, ch. 1)

How should the naive theorist respond to this challenge?

Tse et al. (2004) begin their original paper on the oddball effect by suggesting that the effect is similar to (if less dramatic than) the temporal distortions of trauma. As such, the naive theorist might attempt to apply the style of response developed above. The oddball effect would then be accounted for in terms of a spike in non-perceptual mental activity swiftly precipitated by the unexpected oddball stimulus. Subjects' judgements would then be understood as tracking the fact that the same amount of mental activity occurred during the unexpected 800 ms red disc as during an average 1050 ms black standard.[13] Although this account is certainly wor-

[12] More precisely, what is determined is the 'point of subjective equality' (PSE), defined as the point at which subjects respond that the oddball appears longer (as opposed to shorter) than the common duration of the standard stimuli 50% of the time. With a common duration of the standard stimuli of 1050 ms, the PSE occurs with an oddball duration of 800 ms. It is a nice question precisely what comparison subjects are making in offering this judgement. They are told that the standards are of constant duration and encouraged to use previous and immediately subsequent stimuli in making their decision. Even so, it is unlikely that all the standard stimuli are given equal weight in making the relevant appearance judgement.

[13] Note that some oddballs do plausibly elicit fear responses and so may indeed be thought of as closely connected to the effects of fear and threat found in traumatic time distortions. See here Wittmann et al. (2010) on the effects of looming (but not receding) oddballs which they think of as 'experienced as posing a "threat"' (p. 8, citing Schiff et al. 1962; see also van Wassenhove et al. 2008).

Proceedings of the Aristotelian Society, Vol. CXIII, *Part* 3
doi: 10.1111/j.1467-9264.2013.00353.x

thy of investigation, it is not clear that any appeal to mental activity is necessary to reconcile the oddball effect with the naive view. The reason, as I now argue, is that the effect only provides a counterexample to the naive view given two further background assumptions, both of which we have reason to question.

To focus discussion, consider the simple case in which a red oddball *O* (objective duration 800 ms) is presented in a train of standard stimuli S_i (objective durations all 1050 ms). What is not in dispute are two facts: (a) that in such a set-up *O looks* equidurational with the S_i; and (b) that *O* is *not* equidurational with the S_i (its duration is 250 ms, almost a quarter, shorter). These facts generate a difficulty for naive matching given two assumptions.

The first assumption is that it is legitimate to move from the undoubted fact (a) that *O looks* equidurational with the S_i, to the claim that subjects *misperceive* the oddball as equidurational with the S_i. Given this assumption together with naive matching, we will be forced to conclude that there is an objective equality of duration between our experience of *O* and the average length of our experiences of the S_i. The second assumption is that our experiences of the S_i all have roughly the same durations as the S_i themselves. Given this second assumption, the conclusion just obtained entails that the experience of *O* must be significantly *longer* than *O*'s actual duration, and in a way that is not compensated for by any contraction of surrounding experiences. As Lee presses, this result has the uncomfortable consequence that a lag is required to accommodate the oddball experience.

Lee's uncomfortable consequence can be avoided by rejecting either of the two assumptions just identified. The most obvious assumption to reject is the second. For even assuming that subjects do misperceive *O* as equidurational with the S_i, neither Lee nor Tse et al. give us any reason to suppose that this relative misperception is due to 'expansion' of the oddball experience relative to the oddball's objective duration. On one popular alternative picture proposed by Pariyadath and Eagleman (2007), it is rather that our experiences of the repeated S_i become increasingly shorter than the stimuli of which they are experiences due to 'repetition suppression'. This proposal suffices to explain the supposed relative misperception of durational equality between *O* and the S_i without entailing that the experience of *O* lasts any longer than *O* itself, and so without requiring any lag. Given the fact that attentional effects in general in-

Proceedings of the Aristotelian Society, Vol. CXIII, *Part* 3
doi: 10.1111/j.1467-9264.2013.00353.x

volve both enhancement and suppression, a mixed view is tempting, on which our experience of the oddball is somewhat expanded and our experience of the standards somewhat contracted. No uncomfortable lag is required on this mixed picture either, since the expansion and contractions will plausibly equal out.

There is also reason to question the first assumption, namely, that because *O looks* equidurational with the S_i to subjects in the relevant context, subjects *misperceive O* as equidurational with the S_i. A reason for questioning this assumption is that it is natural to assimilate the oddball effect to other attentional effects where transient attention alters the way in which a perceived stimulus dimension appears (e.g. Carrasco et al. 2004; Carrasco 2011; cf. Tse et al. 2004, 2010). At least in these other cases, it is not at all obvious that the presence or absence of attention should be thought of as generating an illusion (cf. Block 2010).

In all these attentional effects subjects are asked to make an appearance judgement, as opposed to a judgement about the objective durations of the stimuli. In Tse et al.'s oddball experiment, subjects are told to respond '"longer" if the oddball *appeared* to last longer than the standards and "shorter" if it *appeared* not to last as long as the standards' (2004, p. 1173; my emphasis). Now, in general, that a stimulus appears or looks *F* to a subject, does not entail that the subject is misperceiving the stimulus as being *F*. For instance, we can agree that when viewed at an angle a circular coin *looks* elliptical without thinking that we misperceive the coin as elliptical. More positively, the coin's looking elliptical seems consistent here with its circularity nonetheless being an object of awareness for us. Imagine, then, an experiment in which subjects are presented, over a series of trials, with a tilted (circular) coin paired with untilted ellipses of varying eccentricity. In each trial subjects are asked to judge whether the coin looks more or less eccentric than the paired ellipse. On the basis of such judgements we can establish a point of subjective equality (PSE): an eccentricity at which subjects say 'more eccentric' 50% of the time. Plausibly this eccentricity will be non-zero. But crucially, given our earlier verdict that seeing a coin at an angle need not involve any illusion and is consistent with seeing the coin's circularity, this finding will not show that the coin is *misperceived* as having a non-zero eccentricity.

We can reject the first assumption by thinking of the oddball effect in like manner, albeit as an attentional as opposed to perspecti-

Proceedings of the Aristotelian Society, Vol. CXIII, *Part* 3
doi: 10.1111/j.1467-9264.2013.00353.x

val effect. So conceived, the fact that subjects naturally make appearance judgements to the effect that the oddball appears equidurational with objectively longer oddballs does not establish that they are misperceiving the oddball. The relevant data do not show that subjects do not perceive the oddball's actual duration relative to the S_i. Assessment of whether this account can be sustained requires a much fuller treatment of the content and basis of the relevant 'looks' judgements than I can offer here.[14] My point here is only that, independent of considerations about the role of mental activity, we should not unquestioningly accept that the oddball effect is an illusion. And, if it is not an illusion, then it does not even pose a prima facie challenge to naive matching.

Clearly all these suggestions, like the claims elsewhere in this paper, are matters for further philosophical and empirical investigation. Moreover, there are doubtless other potential concerns for the naive view to consider: each in its own terms.[15] Nonetheless, thus far, we have found no compelling reason to relinquish the naive view. In what remains, I turn to a consideration of a larger body of empirical data traditionally accounted for in terms of an internal clock model of timing. I make two suggestions. First, that such data may in fact provide further evidence of the role of mental activity in our awareness of duration. Second, that the mental activity hypothesis is explanatorily superior to a traditional internal clock model in accounting for the adaptive value of time distortions.

VII

Fear, Fever, Pharmacology and Flicker. There are two main strands to the empirical literature on duration perception. One is largely concerned with dual-task paradigms, findings from which motivate so-called attentional approaches to timing. I discuss these in relation to the present hypothesis elsewhere.[16] The second strand, which I

[14] For sustained defence of just such an account, see Martin (2010). My comments in relation to the assumption here are greatly indebted to Martin's work in this paper, and as developed and applied to Carrasco-type cases in more recent and as yet unpublished work.

[15] Watzl (2012) argues that so-called 'motion silencing' provide a counterexample to naive matching. I dispute this claim in Phillips (forthcoming b).

[16] See Phillips (2012), where I propose that ubiquitous but obscure explanatory appeals to 'attention to the passage of time' may best be understood in terms of the role of mental activity in timing.

Proceedings of the Aristotelian Society, Vol. CXIII, *Part* 3
doi: 10.1111/j.1467-9264.2013.00353.x

pursue in what follows, concerns data typically accounted for in terms of an internal clock model of timing. This body of data relates to the effects of various interventions on duration judgements. In particular, the effects of emotional stimuli, of raising and lowering body temperature, of dopaminergic drugs, and of exposing subjects to repetitive visual or auditory simulation. In short: fear, fever, pharmacology and flicker.

The basic effect of fear on timing has already been noted. In general, fear increases the apparent length of an interval or stimulus relative to a control.[17] The effect of body temperature on the apparent passage of time was the focus of the earliest studies in support of an internal clock model (François 1927; Hoagland 1933). Experimenting on his fevered wife, Hoagland found that increases in body temperature slowed her sense of the passage of time: events seemed to take longer than they usually did. The subsequent literature (reviewed in Wearden and Penton-Voak 1995) finds the same basic effect: increased body temperature leads to increased time estimation; decreased body temperature leads to decreased time estimation.[18] In short: external events seem slower when you're hot, and faster when you're cold. The standard finding from animal and human drug studies is that dopamine agonists (e.g. cocaine, methamphetamine and caffeine) lead to intervals being overestimated, whereas dopamine antagonists (e.g. anti-psychotics like haloperidol) lead to intervals being underestimated.[19] Finally, an important psychophysical technique in the timing literature involves preceding or accompanying stimuli with a train of repetitive stimulation (periodic clicks or flashes). Such stimuli are then perceived as if their duration is increased compared to a silent or white-noise control (Treisman et al. 1990; Penton-Voak et al. 1996).

Such data have been a central source of support for internal clock models of time perception, and such models remain highly influential in no small part because of their capacity to provide a simple and unified explanation of the effects of these various interventions

[17] For the complex effects of other emotions see, for instance, Droit-Volet and Meck (2007).

[18] Unsurprisingly, these effects only obtain within limits; for example, they break down with extreme fever, and are subject to various caveats: for instance, cold shock has the same effect as raising body temperature (Wearden and Penton-Voak 1995, p. 137; see Fox et al. 1967 and Lockhart 1967).

[19] See, for example, Meck (1996, 2005), Coull et al. (2011), Maricq et al. (1981), Matell et al. (2004), MacDonald and Meck (2005), Drew et al. (2003), Buhusi and Meck (2002) and Cevik (2003).

Proceedings of the Aristotelian Society, Vol. CXIII, *Part* 3
doi: 10.1111/j.1467-9264.2013.00353.x

on timing.[20] The core idea behind an internal clock model is that each of us is equipped with an internal clock or pacemaker whose function is to produce regular or random pulses.[21] The perceived duration of an event or interval is then modelled as an increasing function of the number of pulses accumulated during the event or interval. On a very simple model we can think of judgements of metric duration (e.g. 'that event lasted one second') as based on a comparison between the number of accumulated pulses and a reference memory which represents how many pulses are normally associated with a one-second period (see fig. 1).

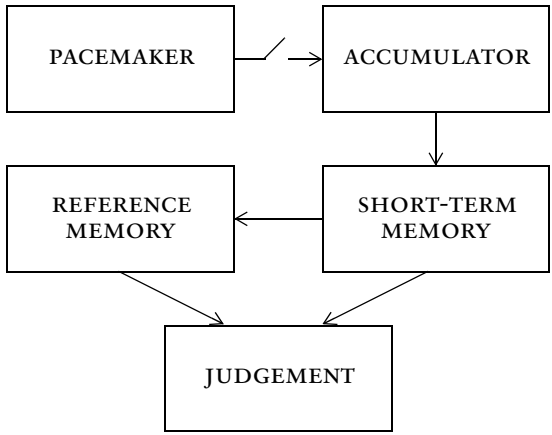

Figure 1 A Simplified Internal Clock Model of Timing; cf. Gibbon et al. (1984)

The internal clock model has a straightforward explanation of the effects of the varied interventions noted above: such interventions directly modulate the rate of the pacemaker, and so lead to a greater (or fewer) number of pulses being accumulated during the relevant interval. Thus whether you frighten someone, increase their body

[20] As Droit-Volet and Gil (2009, p. 1944) put it, 'the internal clock model remains the dominant theoretical model of time because it permits an excellent description of a wide range of experimental results across many paradigms'.

[21] Early clock models were developed in Creelman (1962) and Treisman (1963). The most influential model is scalar timing (or expectancy) theory (SET) due to Gibbon (1977), developed in Gibbon et al. (1984), and applied to human timing in, for example, Wearden (1991). For reviews of the development and controversies surrounding such models see, for instance, Wearden (2001, 2003).

Proceedings of the Aristotelian Society, Vol. CXIII, *Part* 3
doi: 10.1111/j.1467-9264.2013.00353.x

temperature, give them a dopamine agonist, or stimulate them with repetitive clicks or lights, you affect their time perception in the same basic way, by increasing the rate of their pacemaker and thereby causing them to overestimate how much time has passed. In this way, the internal clock model unifies a disparate set of data, proposing a common mechanism by which these heterogeneous interventions affect duration judgements, namely, by affecting the rate of pulse production.

Might the hypothesis that mental activity provides a measure of perceived duration be able to explain the effects just described? It could in so far as fear, fever, pharmacology and flicker modulate mental activity in ways which parallel their alleged effects on a hypothetical internal clock. Establishing that this is the case is of course a matter for substantial empirical investigation, but I do want to suggest that the hypothesis is worthy of serious consideration. Consider, for instance, what we know about the effects of body temperature on cognition: raising body temperature increases alertness and enhances cognitive function on a range of likely measures (e.g. Wright et al. 2002). Likewise, it hardly needs saying that dopamine agonists such as amphetamines increase alertness and heighten cognitive function (e.g. Ballas et al. 2009), whereas anti-psychotics reduce alertness, 'blunting cognition' (e.g. Nasrallah and Tandon 2009). More intriguingly, Jones et al. (2011) found that 'response times on [an] arithmetic task were significantly reduced by [repetitive] clicks' in contrast to a white noise control condition which also has no effect on timing.[22] Collectively, such findings should encourage us to take seriously the hypothesis that variation in duration judgements due to a wide range of interventions may be the result of variation in concurrent mental activity relative to which we measure the durations of environmental events.

The investigation of this hypothesis presents a large empirical challenge. For whilst it is undoubtedly possible to measure the effects of a given intervention using a standardized cognitive test (for example, a working memory task such as a basic arithmetic test or the Digit Symbol Substitution Test standardly used to diagnose concussion, or a vigilance test such as the Psychomotor Vigilance Task), we cannot straightforwardly associate increased performance on

[22] Jones et al. also found improvements in a traditional working memory paradigm in the click condition.

Proceedings of the Aristotelian Society, Vol. cxiii, *Part* 3
doi: 10.1111/j.1467-9264.2013.00353.x

such measures with greater speed of mental activity. Certainly, there is an intuitive connection.[23] But it is plausible that in some situations, greater speed of mental activity may be detrimental to cognitive performance, for example during episodes of extreme anxiety or mania. The empirical challenge then is to draw on subjective reports, objective behavioural measures, and possibly also physiological measures (such as activity in the frontal lobes, heart rate, skin conductance and pupil dilation) to establish the exact relationship between rate of mental activity and judgements of elapsed time, and not simply to rely on standardized cognitive test scores as proxies for mental activity.

By way of further motivating that inquiry, I want to end by advertising a potential explanatory advantage of a mental activity based approach over a traditional internal clock account. The advantage arises in explaining the adaptive value of temporal distortions. Theorists in the time perception literature often claim that temporal distortions are adaptive. Thus, commenting on evidence which shows that subjects overestimate time in a stressful situation,[24] Hancock and Weaver comment, 'Phenomenologically, time slowed down in the stressful condition.... this represents an adaptive and appropriate response' (2005, p. 198).[25] Internal clock theorists offer an explanation along the following lines:

> [W]hen a subject is confronted with a threatening event, the internal clock runs faster under the influence of dopamine, and the preparation for action is quicker. By modifying the perception of time, the internal clock ensures the survival of the organism in urgent situations. (Droit-Volet and Gil 2009, p. 1946)

The explanation appears to be the following. Threat-evoked fear leads to a spike in dopamine levels, which in turn increases the rate of the internal clock. This is the basis of subjective time expansion, and this is said to mean that subjects are more quickly able to prepare for action. As one neurophilosophy blog put it, 'In such a situation, an illusion of time dilation could facilitate an effective escape'.[26]

[23] For example, in a classic study, Kleitman (1934, p. 501) explicitly connects increases in body temperature with increase in the 'speed of thinking' on the assumption that reaction time correlates with speed of thought.

[24] In Langer et al. (1961), mentioned above.

[25] Cf. Carson (1999) and Tipples (2011).

[26] 'Does Time Dilate During a Threatening Situation'.

Proceedings of the Aristotelian Society, Vol. CXIII, *Part* 3
doi: 10.1111/j.1467-9264.2013.00353.x

However, on reflection, there is something very puzzling about this explanation. Imagine that you are a caveman or -woman on the veldt. Scanning the horizon, you spot a sabre-toothed tiger heading your way. Then suddenly the world around you seems to slow down and the tiger appears to be running more slowly. How is this helpful? The tiger is not actually running any more slowly. And the illusion of time being drawn out gives you no extra seconds in which to flee.

We get a much more satisfactory explanation of what is going on if we consider how things look on a mental activity picture. Here the effect of the fear-based dopamine spike is to speed mental activity. That, in and of itself, is an adaptive response. Assuming your mental activity remains ordered and under your control (e.g. you do not panic or become manic), its increased rate means that in the same limited time span you are more quickly able to plan action. On the veldt, you can more quickly think where to run or hide from the tiger, or how to scare it off.[27] The fact that one's perceived environment appears slowed is a result of this increase in mental activity, and in that derivative sense (and that sense alone) temporal expansion is adaptive.

VIII

Conclusion. Duration distortions familiar from trauma threaten our naive commitments concerning duration perception only on the assumption that we perceive duration absolutely. By way of antidote, I showed how a purely relative account of perceived duration could make sense of duration distortions by appeal to the idea that duration is in part perceived relative to concurrent non-perceptual mental activity. I argued that this account is better placed than absolutist accounts to explain subjects' puzzling anecdotal reports of both the world slowing down and of their minds speeding up. Finally, I suggested that recognizing the role of mental activity in timing may help explain the effects of a wide range of interventions on our experience of the passing of time.[28]

[27] Tellingly, many anecdotal reports of subjects in life-threatening situations explicitly attribute their survival to their amazing capacities to think what to do or to recall relevant information in a very short space of time.

[28] I am grateful to audiences in Cardiff, Edinburgh, Glasgow, Oxford, Reading and Toronto, and especially to the audience at the Aristotelian Society. Of the many helpful questions and

Proceedings of the Aristotelian Society, Vol. CXIII, *Part* 3
doi: 10.1111/j.1467-9264.2013.00353.x

St Anne's College
University of Oxford
Oxford OX2 6HS
UK
ian.phillips@st-annes.ox.ac.uk

References

Arstila, Valtteri 2012: 'Time Slows Down During Accidents'. *Frontiers in Psychology: Theoretical and Philosophical Psychology*, 3:196, pp. 1–10. doi: 10.3389/fpsyg.2012.00196.

Ballas, Christos A., Dwight L. Evans and David F. Dinges 2009: 'Psychostimulants and Wakefulness-Promoting Agents'. In Schatzberg and Nemeroff 2009, pp. 843–60.

Block, Ned 2010: 'Attention and Mental Paint'. *Philosophical Issues*, 20, pp. 23–63.

Buhusi, Catalin V., and Warren H. Meck 2002: 'Differential Effects of Methamphetamine and Haloperidol on the Control of an Internal Clock'. *Behavioral Neuroscience*, 116(2), pp. 291–7.

Carrasco, Marisa 2011: 'Visual Attention: The Past 25 Years'. *Vision Research*, 51(13), pp. 1484–1525.

——Sam Ling and Sarah Read 2004: 'Attention Alters Appearance'. *Nature Neuroscience*, 7(3), pp. 308–13.

Carson, Douglas M. 1999: 'Temporal Distortions and the Ejection Decision'. *Flying Safety*, 55(6), pp. 4–7.

Çevik, Münire Özlem 2003: 'Effects of Methamphetamine on Duration Discrimination'. *Behavioral Neuroscience*, 117(4), pp. 774–84.

Chalmers, David J. 2013: 'The Contents of Consciousness: Reply to Hellie, Peacocke and Siegel'. *Analysis*, 73(2), pp. 345–68.

Chuard, Philippe 2011: 'Temporal Experiences and Their Parts'. *Philosophers' Imprint*, 11(11), pp. 1–28. www.philosophersimprint.org/011011/.

Coltheart, Max 1980: 'Iconic Memory and Visible Persistence'. *Perception and Psychophysics*, 27(3), pp. 183–228.

Coull, Jennifer T., Ruey-Kuang Cheng and Warren H. Meck 2011: 'Neuroanatomical and Neurochemical Substrates of Timing'. *Neuropsychopharmacology*, 36(1), pp. 3–25.

comments on those occasions, I gratefully recall those from Tim Bayne, Emma Borg, Bill Brewer, Derek Brown, Kevin Connolly, Cian Dorr, Craig French, Anil Gomes, John Hawthorne, Liz Irvine, Nick Jones, Guy Kahane, Geoff Lee, Hemdat Lerman, Fiona Macpherson, Rory Madden, Mike Martin, Lucy O'Brien, Samir Okasha, David Papineau, Sean Power, Nick Shea, Matt Soteriou, Maja Spener, James Stazicker, Scott Sturgeon and Lee Walters. Apologies to all those I have forgotten. As ever, special thanks to Hanna Pickard.

doi: 10.1111/j.1467-9264.2013.00353.x

Creelman, C. Douglas 1962: 'Human Discrimination of Auditory Duration'. *Journal of the Acoustical Society of America*, 34, pp. 582–93.
Dainton, Barry 2000: *Stream of Consciousness: Unity and Continuity in Conscious Experience*. London: Routledge. Rev. edn., 2006.
Darwin, Charles 1887: *The Life and Letters of Charles Darwin*, ed. Francis Darwin. 2 vols. New York: Basic Books, 1959.
'Does Time Dilate During a Threatening Situation?'. *Neurophilosophy* blog. http://scienceblogs.com/neurophilosophy/2010/01/23/is-time-dilated-during-a-threatening-situation/. Accessed 22 March 2013.
Drew, Michael R., Stephen Fairhurst, Chara Malapani, Jon C. Horvitz and Peter D. Balsam 2003: 'Effects of Dopamine Antagonists on the Timing of Two Intervals'. *Pharmacology, Biochemistry and Behavior*, 75, pp. 9–15.
Droit-Volet, Sylvie, and Sandrine Gil 2009: 'The Time-Emotion Paradox'. *Philosophical Transactions of the Royal Society* B, 364, pp. 1943–53.
Droit-Volet, Sylvie, and Warren H. Meck 2007: 'How Emotions Colour Our Perception of Time'. *Trends in Cognitive Sciences*, 11(12), pp. 504–13.
Eagleman, David M. 2008: 'Human Time Perception and its Illusions'. *Current Opinion in Neurobiology*, 18(2), pp. 131–6.
Falk, John L., and Dalbir Bindra 1954: 'Judgment of Time as a Function of Serial Position and Stress'. *Journal of Experimental Psychology*, 47(4), pp. 327–31.
Flaherty, Michael G. 1999: *A Watched Pot: How We Experience Time*. New York and London: New York University Press.
Foster, John 1982: *The Case for Idealism*. London: Routledge and Kegan Paul.
——1991: *The Immaterial Self: A Defence of the Cartesian Dualist Conception of the Mind*. London: Routledge.
Fox, R. H., Pamela A. Bradbury, I. F. G. Hampton and C. F. Legg 1967: 'Time Judgment and Body Temperature'. *Journal of Experimental Psychology*, 75(1), pp. 88–96.
François, Marcel 1927: 'Contributions à l'étude du sens du temps: La température interne comme facteur de variation de l'appréciation subjective des durées'. *L'Année Psychologique*, 27, pp. 186–204.
Gallistel, C. Randy 1996: 'The Perception of Time'. In Kathleen Akins (ed.), *Perception*, pp. 317–39. Oxford: Oxford University Press.
Gibbon, John 1977: 'Scalar Expectancy Theory and Weber's Law in Animal Timing'. *Psychological Review*, 84(3), pp. 279–325.
——Russell M. Church and Warren H. Meck 1984: 'Scalar Timing in Memory'. In John Gibbon and Lorraine G. Allan (eds.), *Timing and Time Perception, Annals of the New York Academy of Sciences*, vol. 423, pp. 52–77. New York: New York Academy of Sciences.
Hancock, P. A., and J. L. Weaver. 2005: 'On Time Distortions Under Stress'. *Theoretical Issues in Ergonomics Science*, 6(2), pp. 193–211.

Proceedings of the Aristotelian Society, Vol. CXIII, *Part* 3
doi: 10.1111/j.1467-9264.2013.00353.x

Helmholtz, Hermann von 1867: *Treatise on Physiological Optics*, ed. and trans. James P. C. Southall. 3 vols. New York: Dover Books, 1925.
Hoagland, Hudson 1933: 'The Physiological Control of Judgments of Duration: Evidence for a Chemical Clock'. *Journal of General Psychology*, 9, pp. 267–87.
James, Willam 1890: *The Principles of Psychology*. New York: Henry Holt.
Jones, Luke A., Clare S. Allely and J. H. Wearden 2011: 'Click Trains and the Rate of Information Processing: Does "Speeding Up" Subjective Time Make Other Psychological Processes Run Faster?'. *Quarterly Journal of Experimental Psychology*, 64(2), pp. 363–80.
Kleitman, N., S. Titelbaum and P. Feiveson 1938: 'The Effect of Body Temperature on Reaction Time'. *American Journal of Physiology*, 121, pp. 495–501.
Langer, Jonas, Seymour Wapner and Heinz Werner 1961: 'The Effect of Danger upon the Experience of Time'. *American Journal of Psychology*, 74, pp. 94–7.
Le Poidevin, Robin 2007: *The Images of Time: An essay on Temporal Representation*. Oxford: Oxford University Press.
Lee, Geoffrey 2009: *Consciousness and the Passing of Time*. Ph.D. Thesis, New York University.
Linkenauger, Sally A., Veronica Ramenzoni and Dennis R. Proffitt 2010: 'Illusory Shrinkage and Growth: Body-Based Rescaling Affects the Perception of Size'. *Psychological Science*, 21(9), pp. 1318–25.
Lockhart, John M. 1967: 'Ambient Temperature and Time Estimation'. *Journal of Experimental Psychology*, 73(2), pp. 286–91.
MacDonald, Christopher J., and Warren H. Meck 2005: 'Differential Effects of Clozapine and Haloperidol on Interval Timing in the Supraseconds Range'. *Psychopharmacology (Berl.)*, 182, pp. 232–44.
Maricq, Andres V., Seth Roberts and Russell M. Church 1981: 'Methamphetamine and Time Estimation'. *Journal of Experimental Psychology: Animal and Behavioral Processes*, 7(1), pp. 18–30.
Martin, M. G. F. 2010: 'What's in a Look?'. In Bence Nanay (ed.), *Perceiving the World*. Oxford: Oxford University Press.
Matell, Matthew S., George R. King and Warren H. Meck 2004: 'Differential Adjustment of Interval Timing by the Chronic Administration of Intermittent or Continuous Cocaine'. *Behavioral Neuroscience*, 118(1), pp. 150–6.
Meck, Warren H. 1996: 'Neuropharmacology of Timing and Time Perception'. *Cognitive Brain Research*, 3, pp. 227–42.
——2005: 'Neuropsychology of Timing and Time Perception'. *Brain and Cognition*, 58(1), pp. 1–8.
Nasrallah, Henry A., and Rajiv Tandon 2009: 'Classic Antipsychotic Medications'. In Schatzberg and Nemeroff 2009, pp. 533–54.

Proceedings of the Aristotelian Society, Vol. CXIII, *Part* 3
doi: 10.1111/j.1467-9264.2013.00353.x

Noulhiane, Marion, Nathalie Mella, S. Samson, R. Ragot and V. Pouthas 2007: 'How Emotional Auditory Stimuli Modulate Time Perception'. *Emotion*, 7(4), pp. 697–704.

Noyes, Russell, Jr., and Roy Kletti 1976: 'Depersonalization in the Face of Life-Threatening Danger: A Description'. *Psychiatry*, 39(1), pp. 19–27.

——1977: 'Depersonalization in Response to Life-Threatening Danger'. *Comprehensive Psychiatry*, 18(4), pp. 375–84.

O'Shaughnessy, Brian 2000: *Consciousness and the World*. Oxford: Oxford University Press.

Pariyadath, Vani, and David Eagleman 2007: 'The Effect of Predictability on Subjective Duration'. *PLoS ONE*, 2(11), e1264. doi: 10.1371/journal.pone.0001264.

Paul, L. A. 2010: 'Temporal Experience'. *Journal of Philosophy*, 107(7), pp. 333–59.

Peacocke, Christopher 1992: *A Study of Concepts*. Cambridge, MA: MIT Press.

——1993: 'Intuitive Mechanics, Psychological Reality and the Idea of a Material Object'. In Naomi Eilan, Rosaleen McCarthy and Bill Brewer (eds.), *Spatial Representation: Problems in Philosophy and Psychology*. Oxford: Oxford University Press.

——2004: *The Realm of Reason*. Oxford: Oxford University Press.

——2013: 'Phenomenal Content, Space, and the Subject of Consciousness'. *Analysis*, 73(2), pp. 320–9.

Penton-Voak, I. S., Hannah Edwards, Andrew Percival and J. H. Wearden 1996: 'Speeding Up an Internal Clock in Humans? Effects of Click Trains on Subjective Duration'. *Journal of Experimental Psychology: Animal and Behavioural Processes*, 22(3), pp. 307–20.

Phillips, Ian 2009: *Experience and Time*. Ph.D. Thesis, University College London.

——2010: 'Perceiving Temporal Properties'. *European Journal of Philosophy*, 18(2), pp. 176–202.

——2012: 'Attention to the Passage of Time'. *Philosophical Perspectives*, 26(1): *Philosophy of Mind*, pp. 277–308.

——forthcoming a: 'The Temporal Structure of Experience'. In Dan Lloyd and Valtteri Arstila (eds.), *Subjective Time: The Philosophy, Psychology, and Neuroscience of Temporality*. Cambridge, MA: MIT Press.

——forthcoming b: 'Breaking the Silence: Motion Silencing and Experience of Change'. To appear in *Philosophical Studies*.

Prichard, H. A. 1950: 'The Apprehension of Time'. In his *Knowledge and Perception*, pp. 47–51. Oxford: Clarendon Press.

Reid, Thomas 1827: *Essays on the Powers of the Human Mind; to which are added, An Essay on Quantity, and An Analysis of Aristotle's Logic*. London: Thomas Davison.

Proceedings of the Aristotelian Society, Vol. CXIII, *Part* 3
doi: 10.1111/j.1467-9264.2013.00353.x

Schatzberg, Alan F., and Charles B. Nemeroff (eds.) 2009: *The American Psychiatric Publishing Textbook of Psychopharmacology*, 4th edn. Arlington, VA: American Psychiatric Publishing.

Schiff, William, James A. Caviness and James J. Gibson 1962: 'Persistent Fear Responses in Rhesus Monkeys to the Optical Stimulus of "Looming"'. *Science*, 136, pp. 982–3.

Sierra, Mauricio 2009: *Depersonalization: A New Look at a Neglected Syndrome*. Cambridge: Cambridge University Press.

Stetson Chess, Matthew P. Fiesta and David M. Eagleman 2007: 'Does Time Really Slow Down During a Frightening Event?'. *PLoS ONE*, 2(12), e1295. doi: 10.1371/journal.pone.0001295.

Stevens, S. S. 1946: 'On the Theory of Scales of Measurement'. *Science*, 103, pp. 677–80.

Thompson, Brad 2010: 'The Spatial Content of Experience'. *Philosophy and Phenomenological Research*, 81(1), pp. 146–84.

Tipples, Jason 2008: 'Negative Emotionality Influences the Effects of Emotion on Time Perception'. *Emotion*, 8(1), pp. 127–31.

——2011: 'When Time Stands Still: Fear-Specific Modulation of Temporal Bias Due to Threat'. *Emotion*, 11(1), pp. 74–80.

Todd, J. 1955: 'The Syndrome of Alice in Wonderland'. *Canadian Medical Association Journal*, 73, pp. 701–4.

Treisman, Michel 1963: 'Temporal Discrimination and the Indifference Interval: Implications for a Model of the "Internal Clock"'. *Psychological Monographs: General and Applied*, 77(13), pp. 1–31.

——Andrew Faulkner, Peter L. N. Naish and David Brogan 1990: 'The Internal Clock: Evidence for a Temporal Oscillator Underlying Time Perception with some Estimates of its Characteristic Frequency'. *Perception*, 19(6), pp. 705–43.

Tse, Peter Ulric 2010: 'Attention Underlies Subjective Temporal Expansion'. In Anna C. Nobre and Jennifer T. Coull (eds.), *Attention and Time*, pp. 137–50. Oxford: Oxford University Press.

——James Intriligator, Josée Rivest and Patrick Cavanagh 2004: 'Attention and the Subjective Expansion of Time'. *Perception and Psychophysics*, 66(7), pp. 1171–89.

Ursano, Robert J., Carol S. Fullerton, Richard S. Epstein, Brian Crowley, Kelley Vance, Tzu-Cheg Kao and Andrew Baum 1999: 'Peritraumatic Dissociation and Posttraumatic Stress Disorder Following Motor Vehicle Accidents'. *American Journal of Psychiatry*, 156(11), pp. 1808–10.

van der Hoort, Björn, Arvid Guterstam and H. Henrik Ehrsson 2011: 'Being Barbie: The Size of One's Own Body Determines the Perceived Size of the World'. *PLoS ONE*, 6(5), pp. 1–10. doi: 10.1371/journal.pone.0020195.

van Wassenhove, Virginie, Dean V. Buonomano, Shinsuke Shimojo and Ladan Shams 2008: 'Distortions of Subjective Time Perception Within

doi: 10.1111/j.1467-9264.2013.00353.x

and Across Senses'. *PLoS ONE*, 3(1), e1437. doi: 10.1371/journal.pone.0001437.

Watts, Fraser N., and Robert Sharrock 1984: 'Fear and Time Estimation'. *Perceptual and Motor Skills*, 59(2), pp. 597–8.

Watzl, Sebastian 2012: 'Silencing the Experience of Change'. *Philosophical Studies*. doi: 10.1007/s11098-2012-0005-6.

Wearden, J. H. 1991: 'Do Humans Possess an Internal Clock with Scalar Timing Properties?'. *Learning and Motivation*, 22, pp. 59–83.

——2001: 'Internal Clocks and the Representation of Time'. In Christoph Hoerl and Teresa McCormack (eds.), *Time and Memory: Issues in Philosophy and Psychology*, pp. 37–58. Oxford: Oxford University Press.

——2003: 'Applying the Scalar Timing Model to Human Time Psychology: Progress and Challenges'. In Hede Helfrich (ed.), *Time and Mind* II: *Information processing Perspectives*, pp. 21–39. Gottingen: Hogrefe and Huber.

——and I. S. Penton-Voak 1995: 'Feeling the Heat: Body Temperature and the Rate of Subjective Time, Revisited'. *Quarterly Journal of Experimental Psychology*, 48B(2), pp. 129–41.

Wittmann, Marc, Virginie van Wassenhove, A. D. (Bud) Craig and Martin P. Paulus 2010: 'The Neural Substrates of Subjective Time Dilation'. *Frontiers in Human Neuroscience*, 4(2), pp. 1–9.

Wraga, Maryjane 1999: 'Using Eye Height in Different Postures to Scale the Heights of Objects'. *Journal of Experimental Psychology: Human Perception and Performance*, 25(2), pp. 518–30.

Wright, Kenneth P., Jr., Joseph T. Hull and Charles A. Czeisler 2002: 'Relationship Between Alertness, Performance, and Body Temperature in Humans'. *American Journal of Physiology: Regulatory, Integrative and Comparative Physiology*, 283(6), R1370–7.

Proceedings of the Aristotelian Society, Vol. CXIII, *Part* 3
doi: 10.1111/j.1467-9264.2013.00353.x