Temporal Binding and the Perception/Cognition Boundary

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Abstract:

Temporal binding occurs when people observe two events that they believe to be causally connected: They underestimate the length of the interval between those two events, when compared with their estimates of the length of intervals between events they believe to be causally unrelated. I discuss temporal binding in the context of Dennett and Kinsbourne's (1992) influential argument levelled at what they call 'Cartesian Materialism'. In particular, I argue that Dennett and Kinsbourne's argument trades on a representational conception of perceptual experience, which blurs the boundary between perception and judgement, and that temporal binding can serve as a case study for developing an alternative, relational, conception of perceptual experience and of its relation to judgement. Based on research on the mechanisms underlying temporal binding, I provide an explanation of the phenomenon in which perception and judgement play clearly distinct roles.

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The term ‘temporal binding’ refers to a subjective shortening of the interval between two events that occurs when these events are believed to stand in a cause-effect relationship to each other. That is to say, for a certain range of intervals between two events, people will judge those two events to occur closer together in time if they believe the first of them to be the cause of the second, in comparison with two events that they believe to be causally unrelated. Such binding was originally thought to occur only in the context of intentional action (Haggard, Clark, & Kalogeras, 2002) – i.e. when the first of the two events is a voluntary movement and the second its consequence – and the effect is therefore also sometimes referred to as ‘intentional binding’. However, binding has since also been demonstrated to occur in scenarios that do not involve intentional action, but only the observation of a mechanically produced cause-effect sequence (Buehner, 2012). Hence, I will use the more neutral terminology.

Cases such as temporal binding, in which people’s judgements about properties of a sequence of events don’t correctly reflect the properties the sequence actually has, have played a prominent role in discussions of consciousness.[1] In particular, such cases stand at the heart of an influential argument put forward by Dennett and Kinsbourne (1992) against a view of consciousness they term Cartesian Materialism and in favour of an alternative view they call the Multiple Drafts Model.[2] The focus in that context has typically been on phenomena other than temporal binding. In what follows, I want to suggest that reflection on the case of temporal binding can help make explicit and undermine a key set of assumptions underlying Dennett and Kinsbourne’s argument. In particular, I argue that their argument rests on

a representational view of perception – that is, a conception of perception on which perceptual experience is construed as something akin to judgement, thus blurring the boundary between perception and cognition. I then use the case of temporal binding to illustrate an alternative, relational, view of perceptual experience, by providing an explanation of temporal binding on which perceptual experience and judgement play two clearly distinct roles.

1. Dennett and Kinsbourne on Cartesian Materialism

Cartesian Materialism is also described by Dennett & Kinsbourne as a view of the mind as a 'Cartesian Theatre'. This metaphor is meant to evoke the idea of a 'stage' on which mental items must appear in order to become conscious, their appearing on this stage constituting them being conscious. Another metaphor they also use for this view is that of a determinate 'finish line' that information must cross to enter consciousness.

The structure of their argument might be summarized in terms of the following *modus tollens*:

(1) If Cartesian Materialism is correct, there are two clearly separable, rival, explanatory hypotheses to account for cases in which people's judgements about a sequence of events differ from how those sequences of events actually unfolded.
(2) No distinction between two such separable explanatory hypotheses can be sustained. The difference between them is a chimera – a "difference that makes no difference".
(3) Therefore, Cartesian Materialism is incorrect.

In order to illustrate the reasoning behind (1) and (2), it might help to consider a relatively basic example, namely metacontrast masking.

In a typical metacontrast masking experiment, participants are first asked to focus spatial attention on a fixation point in the centre of a screen. Following this, after a short delay, a circular target is displayed, typically for approx. 40ms, centred on the same location. Then the screen goes blank again. After a further delay, typically of approx. 20ms, a mask is displayed on the screen, typically again for approx. 40ms. This is again centred on the same spot as the circular target, but consists of a ring, whose inner perimeter is just slightly larger than the circular target was.

The typical finding in experiments involving such an arrangement of stimuli is that participants report only seeing the mask – i.e., the ring – appearing briefly on an otherwise blank screen. That is, they don't report seeing the circular target that precedes the ring. Yet, in a control experiment in which only that target is displayed, for the same amount of time, but not followed by the ring, participants do report seeing the target. It is in this way that, in metacontrast masking, a temporally later stimulus influences people's awareness of an earlier stimulus.

How might metacontrast masking be explained? It is natural to think that it could be either a misremembering effect or a misperception effect – an idea Dennett and Kinsbourne flesh out by distinguishing between what look like two rival explanatory models, which they label 'Orwellian' and 'Stalinesque', respectively. As they put it, the Orwellian model would have it that "[s]ubjects are indeed conscious of the first stimulus […] but their memory of this conscious experience is almost entirely obliterated by the second stimulus" (Dennett & Kinsbourne, 1992, p. 193). By contrast, the Stalinesque model would have it that "the second stimulus somehow

prevents conscious experience of the first stimulus (it somehow waylays the first stimulus on its way to consciousness). The first stimulus never gets to play on the stage of consciousness" (ibid.).

As the last sentence indicates, Dennett and Kinsbourne interpret the idea that there are two clearly distinguishable rival explanatory hypotheses at issue here to be a symptom of an implicit adoption of a 'Cartesian Theatre' view of the mind, and they think that it needs to be abandoned along with that view. As they argue,

> [b]oth […] models can deftly account for all the data […]. They agree about just where in the brain the mistaken content enters the causal pathways; […] they [also] both account for the subjective data – whatever is obtainable 'from the first-person perspective' – because they agree about how it ought to 'feel' to subjects: Subjects should be unable to tell the difference between misbegotten experiences and immediately misremembered experiences. So, in spite of first appearances, there is really only a verbal difference between the two theories. They tell exactly the same story except for where they place a mythical Great Divide, a point in time (and hence a place in space) whose fine-grained location is nothing that subjects can help them locate, and whose location is also neutral with regard to all other features of their theories. This is a difference that makes no difference. (Dennett & Kinsbourne, 1992, p. 193f.)

Existing critiques of Dennett and Kinsbourne's argument have typically either focused on whether, contrary to them, there may not in fact be empirical ways to distinguish between the Orwellian and the Stalinesque model, or they have granted

that there may not be, but argued that the implied inference from this to the claim that the very idea of such a distinction needs to be rejected is unjustifiably verificationist. My argument will take a somewhat different route. Before setting it out, though, it is worth saying a few words about the model of consciousness advocated by Dennett and Kinsbourne themselves, and isolating in particular one crucial feature of it, which, I will argue, plays a key background role in their argument. Here is their own description of that model, which they call the Multiple Drafts Model:

> All perceptual operations, and indeed all operations of thought and action, are accomplished by multi-track processes of interpretation and elaboration that occur over hundreds of milliseconds, during which time various additions, incorporations, emendations, and overwritings of content can occur, in various orders. Feature-detections or discriminations *have to be made only once*. That is, once a localized, specialized "observation" has been made, the information content thus fixed does not have to be sent somewhere else to be *re*discriminated by some "master" discriminator. In other words, it does not lead to a re-presentation of the already discriminated feature for the benefit of the audience in the Cartesian Theater. […] These spatially and temporally distributed content-fixations are themselves precisely locatable in both space and time, but their onsets do *not* mark the onset of awareness of their content. (Dennett & Kinsbourne, 1992, p. 185)

The particular feature of this picture I want to highlight is that it explains the operation of the brain in terms of the activity of multiple distinct pieces of mental machinery which, at a high enough level of abstraction, can all be described as

performing the same general set of functions, which Dennett and Kinsbourne variously describe as ‘content-fixing’, ‘interpreting’ or ‘editing’ (compare also the metaphor of producing multiple drafts). This basic underlying assumption is not just involved in Dennett and Kinsbourne’s own Multiple Drafts Model. It also seems to be in play in the way they construe the Orwellian and Stalinesque models of consciousness. Only, the Orwellian and Stalinesque model, as they see it, also involve an additional (unwarranted) assumption, as indicated in the passage quoted above, of the same input going through a sequence of different such content-fixings with a step in it at which the relevant content becomes conscious, so that we can ask, with respect to a particular content, whether it was ever conscious, or whether it was ‘edited out’ before reaching consciousness.

The passage quoted above is meant as a description of brain functioning. Note, however, that, as a consequence of construing the basic mental operation as one of content-fixing, this is a view on which perception itself also becomes conceived of in terms of this notion. Consider, for instance, how this approach would construe an ‘Orwellian’ explanation of metacontrast masking: On such an explanation, at the onset of perceptual consciousness corresponding to the time when the target circle was displayed, the observer is in a state with a representational content in which that circle figures – meaning that she is perceptually conscious of the circle. Yet, subsequently, this content is not retained in memory, but is instead converted to one in which the circle does not figure.

Such a view, which conceives of perceptual experience as the upshot of, and as itself a matter of, ‘content-fixing’, essentially construes perception as something akin to judgement – the arriving at a representation of things as being a certain way. This is true as much of Dennett and Kinsbourne’s own Multiple Drafts Model as it is

of the Orwellian and Stalinesque models, as characterized by them. The crucial difference between their model and the others lies just in the fact that, on the Multiple Drafts Model, the representational content conscious experience is assumed to possess is not fixed at an arbitrarily fine-grained temporal level. As mentioned before, on that model, "various additions, incorporations, emendations, and overwritings of content" (Dennett & Kinsbourne, 1992, p. 185) can occur over hundreds of milliseconds after a stimulus is first received by a sensory receptor, and none of them individually, Dennett and Kinsbourne think, should be identified with 'the point' at which the subject becomes conscious of the stimulus (or fails to do so). It is only of that period as a whole that we can say that it constituted the subject's either being conscious of the stimulus or not, where this is construed as the subject being in a state with a certain representational content.

I now want to turn to the case of temporal binding – another phenomenon that involves people making erroneous judgements about a property of a sequence of events. As I will suggest, the case of temporal binding can serve to illustrate an alternative, quite different conception of perceptual experience, which gives perceptual experience and judgement two quite distinct roles. Specifically, this conception allows us to give an explanation of temporal binding that locates the phenomenon firmly on the level of judgement, rather than perception, but an explanation that differs in crucial ways from the Orwellian model, as envisaged by Dennett and Kinsbourne.

3. Temporal binding

A typical experiment to study temporal binding involves comparing participants' responses across two types of trials, often referred to as *causal trials* and *non-causal*

trials, respectively. In each type of trial, participants are asked to make a judgement about the length of an interval between two events (or about the timing of the events). The two types of trial differ in that, in causal trials, there is a plausible causal connection between the relevant events (the first of which is often an action carried out by the participant him- or herself), whereas in non-causal trials, it is not plausible that the first event is the cause of the second. What is taken as a measure of temporal binding is the extent to which the interval between the two events in causal trials is judged to be shorter when compared with the interval between the two events in non-causal trials (in cases where these intervals were in fact of the same length).

There is some evidence that temporal binding is due to a slowing down of the pacemaker in an 'internal clock' used to time events. Models of timing postulating such an internal clock conceive of it as consisting in a pacemaker that emits pulses at a certain rate, which are then accumulated in an accumulator (Gibbon, Church, & Meck, 1984; Wearden, 2001). For a given interval, the stimulus at the onset of that interval causes a switch between the pacemaker and the accumulator to close, so that the latter starts accumulating pulses, until the stimulus at the offset of the interval causes the switch between the pacemaker and the accumulator to open again. Because temporal judgements are based on the number of pulses accumulated in the accumulator, they will be affected by a change in the rate at which the pacemaker emits such pulses. Increases in the rate of pulses will cause the interval to be judged to be longer, and decreases in the rate with cause it to be judged to be shorter.

Evidence that temporal binding may be due to a pacemaker slowing down during causal trials has been reported by Humphreys and Buehner (2009).[3] In an interval estimation paradigm, they used causal trials in which participants had to press a button at a time of their own choosing, which was then followed, after a set interval,

by a tone. They compared this with participants' performance in noncausal trials in which they simply heard a click, which was then again followed, after a set interval, by a tone. (The click was a recording of the noise made by the button press on causal trials.) After each individual trial, participants had to estimate the length of the relevant interval. As expected, Humphreys and Buehner found temporal binding: Participants judged interevent intervals in causal trials to be shorter than corresponding interevent intervals in noncausal trials. However, they also found a difference in the slopes at which interval estimates increased with an increase in the length of the actually presented interval, with the slope for causal trials being shallower than that for noncausal trials. As Humphreys and Buehner point out, such a difference in slopes is a trademark signature of different pacemaker speeds.

How exactly should we interpret an account of temporal binding in terms of a slowed down pacemaker? On the pacemaker-accumulator model, judgements about intervals are based on the pulses accumulated in the accumulator during those intervals. If, during causal trials, the pacemaker slows down, fewer pulses will be accumulated in the accumulator. As a consequence, intervals presented in those trials will thus be judged as being shorter when compared with corresponding intervals in noncausal trials because the latter involve no slowing down of the pacemaker. This explains the discrepancy of judgements in the causal and noncausal trials measured in temporal binding experiments.

4. 'Content-fixing' again.

Note that the explanation of temporal binding just sketched locates the phenomenon firmly on the level of judgement. As far as perception is concerned, there is nothing in this explanation that suggests anything other than that participants are perceptually

aware of the events as they happen. Indeed, their being thus aware of the events is plausibly what underpins the operation of the switch connecting the pacemaker and the accumulator. That is to say, the switch is closed when participants experience the first event and the switch is opened again when they experience the second event (see also Arstila, 2017). Moreover, if the participants experience the stimulus events as they happen, there is also a natural sense in which it is the case that they perceive the actual interval between them.

On the account of temporal binding I have just sketched, participants are thus, in the causal condition, first perceptually conscious of the relevant events and of the actual interval between them, but when subsequently being asked to make a judgement about that interval, they underestimate it. On the face of it, this might look like a version of what Dennett and Kinsbourne call an Orwellian account. However, there are reasons for thinking that it would be a mischaracterization of the account to give it that label.

I said earlier that one assumption made by Dennett and Kinsbourne that plays a crucial role in their argument is that perception is the upshot of, and indeed itself a matter of, 'content-fixing'. An Orwellian account of temporal binding, as they conceive of it, would have it that, in causal trials, one first has a perceptual experience with a representational content that represents the interevent interval to have the length it actually has, but that this then gets transformed into a content that represents the interval to be shorter than it actually is.

I suggest that the account of temporal binding I have offered should not be understood in this way. In particular, nothing in that account commits us to thinking of perception as the upshot of 'content-fixing', and thus as something that itself has a representational content that represents things as being one way or another. Rather,

we can think of the role of perceptual experience here as simply that of putting participants into contact with the relevant stimulus events themselves – something that is a precondition of the interval between them having an impact on the participants' cognition. It is in this sense that the events as they happen themselves figure in the participants' perceptual experience. Similarly, as I said, we can think of participants as being perceptually aware of the interevent interval simply in virtue of their being aware of the relevant two events as they happen. This is different from their forming a representation of that interval as being of a certain length that is then later overwritten by a different representation of it as being of a shorter length, as an Orwellian account, as conceived of by Dennett and Kinsbourne, would have it. Rather, the point at which a representation of that interval is formed is the point at which participants use the number of accumulated pulses to make a judgement about that interval.

The conception of perceptual experience at issue here, that I am contrasting with Dennett and Kinsbourne's conception of perception as the upshot of 'content fixing', is sometimes referred to as the relational view of experience, as opposed to a representational view of experience.[4] Travis describes it at one point as follows:

> *[P]erception*, as such, simply places our surroundings in view; affords us awareness of them. There is no commitment to their *being* one way or another. It confronts us with what is there, so that, by attending, noting, recognizing, and otherwise exercising what capacities we have, *we* may, in some respect or other, make out what is there for what it is – or again, fail to. (Travis, 2004, p. 65, emphases in original)

It is by adopting a relational view of perception along these lines, I want to suggest, that we can avoid the conception of the mind as a Cartesian Theatre, whilst at the same time hanging on to the idea of a clear difference between perception and cognition. Take again the case of temporal binding. The relationalist can, of course, allow that there are a number of things that have to happen in participants' brains in order for them to perceive the interevent interval in a typical temporal binding experiment. But just like Dennett and Kinsbourne, the relationalist will consider it a mistake to identify one of these brain events with the state of being perceptually conscious of the interval, in a way that would allow for raising the question as to what length that interval is represented as having by that state.[5] Rather, what the relevant events in the brain do is enabling the interval itself to have an influence on the participants' cognition, by putting those participants into the relation of awareness to that interval.

The relational view of experience is sometimes criticised as leaving obscure the relationship between perception and judgement.[6] It should be clear, though, that this is not a criticism that can be levelled at the account of temporal binding I have given. As I said, participant's perceptual experience of the two events in the causal and noncausal trials can be seen to play a clear causal role in the operation of the internal clock: It allows the operation of the switch that determines the onset and offset of the interval during which pulses are accumulated in the accumulator to be governed by these events themselves. In this way, perceptual experience grounds the ability to make judgements about the interval between the events based on these accumulated pulses. In Travis's words, this is how, by confronting us with what is there – the events – perceptual experience enables us to make out the interevent

interval for what it is – or sometimes for a different, shorter, interval, as it happens in the case of temporal binding.

Conclusion

I have argued that Dennett and Kinsbourne's argument trades crucially on the idea of 'context fixing' as the basic mental operation. This idea also leads them to adopt a view of perceptual experience as the forming of a representation, thus blurring the boundary between perception and judgement. What I have argued, in effect, is that it is this assumption that we should reject. I have tried to show how adopting instead a relational view of perceptual experience lets us provide an explanation of temporal binding that invokes neither what Dennett and Kinsbourne call an Orwellian nor a Stalinesque explanation of temporal binding, but one which can nevertheless deliver a clear verdict as to whether such binding should be seen as being a matter of faulty perception or mistaken judgement.[7]

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[1] I avoid using the term 'temporal illusions' here because the term 'illusion' typically carries with it the more specific implication that things are not *perceptually experienced* to be the way they really are. To describe temporal binding as a temporal illusion would therefore prejudge one of the key issues at stake in what follows – which is whether temporal binding is a matter of faulty perception or whether it is a matter of erroneous judgement.

[2] See also Dennett (1991). For discussion, see, e.g., Akins (1996), and Shoemaker (1993).

[3] This is likely to be only one element in temporal binding, and is likely to occur only in context in which participants do not only observe the cause but, at that time, also already expect the effect to happen. (Otherwise it is difficult to see what could trigger the relevant slowing down of the pacemaker during the interevent interval.) For the purposes of this essay, this is the case I will focus on.

[4] The particular account I have given of temporal binding does not straightforwardly generalize to other postdiction effects, but these too might be explained in ways compatible with a relational view of experience. For instance, in Hoerl (2015) I give an account of apparent motion that is compatible with a relational view (which could also be extended to the case of metacontrast masking, as discussed in section 1). This account makes use of the idea that temporal experience is not, as Soteriou (2013, p. 104) puts it, homogeneous down to instants. An earlier version of something like that idea already figures in Shoemaker's (1993) response to Dennett.

[5] On related issues, see also Soteriou (2013, pp. 145ff.)

[6] Questions have also been raised, however, about the way this relationship is construed on the alternative representational view of experience. On it, making a judgement based on a perceptual experience is conceived of a transition between one representational state and another akin to the drawing of an inference. Yet, this arguably leaves out the more fundamental sense in which perception provides us with a grasp of what it is our judgements are about in the first place.

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