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The Fragmentation of Felt Time

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Consider the following ordinary phenomenon:

> (MUSICAL TRAIN RIDE) It's 7 am as you board your hour-long train ride to work. Today, you came well-prepared to pass the time with a recording of your favorite band, Phish. The song "Runaway Jim" is nearly an hour long—it's the perfect length to keep you entertained the whole ride.[1] You find a good seat, close your eyes, and hit the "play" button. You spend the rest of the journey absorbed in the music. As you arrive at your destination, it feels like no more than twenty minutes have passed since the ride began. You declare your morning commute a success.

This phenomenon is prevalent. Businesses, for example, play music in their stores to make customers feel like less time passes while they shop; similarly, music played for customers on hold makes the wait-time feel as though it passes more quickly. Indeed, consumer behavior research shows not only that an interval of time waiting over the phone feels shorter when listening to music (Guéguen & Jacob, 2002; North & Hargreaves, 1999; Roper & Manela, 2000), but also that the effect is greater when subjects enjoy the music[2] (Cameron et al., 2003; Lopez & Malhotra, 1991; Yalch & Spangenberg, 1990).[3]

Within the psychological literature, cases such as MUSICAL TRAIN RIDE are instances of a general phenomenon known as *the dual task interference effect* (see, e.g., Macar et al., 1994; Brown, 2010; and Zakay et al.,

1. For a recording of a live performance of "Runaway Jim", see Kahn (2018). (You may want to consider your favorite hour-long song instead of this one).
2. This is perhaps why some companies now offer consumers a choice of music to listen to (e.g., pop, jazz, classical) while waiting on the phone.
3. As Yalch & Spangenberg (1990, 60–61) report, "[w]hen shoppers were exposed to music that they normally listen to […] they reported spending less time in the store than they had intended, relative to when they listened to music they do not usually select". This experimental design did not allow for comparisons between felt time and objective time. For a more recent study on the relationship between experiences of music and time that also reviews consumer behavioral findings, see Bailey & Areni (2006). For a recent study on this from the psychological literature, see Droit-Volet et al. (2013).

1983; as well as Hicks et al., 1976 and Phillips, 2012 for a discussion), where subjects engaged in concurrent tasks are observed to judge the duration of intervals to be significantly shorter than they actually are. More specifically, the phenomenon is observed by comparing the duration judgments of subjects engaged *solely* in timing an interval with the duration judgments of subjects engaged in *both* timing the interval *and* performing an additional task, such as sorting a deck of cards by color.[4] When engaged in two concurrent tasks, subjects judge the duration of the interval as significantly shorter. In MUSICAL TRAIN RIDE, the secondary task is listening to "Runaway Jim". Accordingly, your journey feels significantly shorter when you listen to "Runaway Jim" than when you hear no music and focus solely on the trip's duration.

My aim in this paper is to propose a novel account of a subject's temporal experience in instances of the dual task interference effect that allows us to make sense of cases where, as in MUSICAL TRAIN RIDE, the secondary task itself requires experiencing time. In section 1, I argue that the prevailing psychological model and some initially appealing alternative explanations fail at this. In section 2, I put forward a proposal according to which the fragmentation of felt time is what best explains these cases. According to this view, attentive engagement fragments felt time. Instead of experiencing the activity or event we are engaged in as if it is located within a single, unified timeline where other events are also located, one experiences parts of this activity or event as if they were located within a temporally isolated branch or fragment of the main timeline. Phenomenologically, it is as though time passes only in this branch, creating the sensation — upon integration — that less time has passed in the main timeline. In support of this proposal, I draw upon ideas in the empirical literature, and I suggest some underlying neuropsychological mechanisms that might serve to implement the fragmentation model. In section 3, I further develop the model, extending it to cases where thinking about time makes one feel as though *more* of it passes and briefly discussing some of its empirical implications. I end this section by discussing the possibility that an analogous model holds for the case of space. In section 4, I briefly conclude.

4. The dual task interference effect has been mostly studied under a prospective temporal paradigm. For a discussion of the prospective/retrospective paradigms, see footnote 19.

1. Motivating the Search for a New Proposal

Consider first the *attentional model,* the most prominent way in which psychologists account for a subject's temporal experience in instances of the dual task interference effect. This model involves two main claims. The first is that a subject's total attention is distributed between processing temporal and non-temporal information. The second claim holds that as more attention is devoted to processing temporal information, more time is experienced as having passed. Zakay & Block (1997a) explain the attentional model as follows:

> Most theorists think that experienced duration increases when a person allocates more attentional resources to processing temporal information. According to attentional models (e.g., Thomas & Weaver, 1975; Zakay & Block, 1996), a person divides attentional resources between nontemporal (stimulus) and temporal information. Thus, experienced duration should increase if the number of stimuli requiring processing is small, if a processing task is easy, if participants do not need to actively respond to presented information, or if they do not need to divert attention between two sources of stimuli. (Zakay & Block, 1997a, 185, my emphasis)[5]

5. Zakay & Tsal (1989, 209) explain the attentional model as follows:

> Proponents of the attentional approach (e.g., Frankenhaeuser, 1959; Hicks, Miller, Gaes, & Beirman, 1977; Priestly, 1968) view time estimation as a direct function of the amount of attention allocated for processing the passage of time. The more attention is allocated to a cognitive processor of time, the longer duration estimates will be.

See also Block & Zakay (2004), Block et al. (2010), Brown (2010), and Tse (2010).

Applied to MUSICAL TRAIN RIDE, the idea is that your attention during your hour-long ride is coopted to process musical information, leaving little attention to process temporal information. As a result, the train ride feels as though it was only about twenty minutes long. Droit-Volet et al. (2010), for instance, account for their finding that an interval of time filled with music feels shorter than one filled with a neutral (non-musical) sound in precisely this way: "our results show that time flies in the presence of music *because it distracts our attention away from the processing of time*, probably due to music's rich structure or the pleasure produced by listening to it" (Droit-Volet et al., 2010, 231, my emphasis).

To capture the features of the attentional model at the cognitive level, Zakay & Block (1995) proposed to modify what is known as an *internal clock*, a mental counter that accumulates and counts 'ticks' produced while a subject experiences an event. An internal clock delivers as outputs 'duration feels' or 'duration qualia' of increasing lengths.[6] This cognitive mechanism was originally proposed by Creelman (1962) and Treisman (1963), and later developed by Gibbon (1977), Church & Gibbon (1982), and Wearden (1991). Zakay and Block (1995) modified this clock by adding a gate controlled by attention. The gate narrows down when the subject attends to a non-timing task — thereby slowing the flow of ticks into the counter — and widens up again when the subject resumes attention to the timing task. When a secondary task — e.g., listening to music — distracts the subject from keeping track of time, fewer ticks are counted and the subject feels as though less time has passed. This modified clock, known as the *attentional gate clock*, enjoys widespread support.[7]

Despite their predominance, I argue that the attentional model and the corresponding attentional gate clock should be rejected. The main problem is that they cannot explain cases such as MUSICAL TRAIN RIDE where the secondary task — listening to music — itself involves experiencing time. Listening to a piece of music involves, for example, experiencing its sounds and silences — how long they last, how they are temporally ordered. It also involves experiencing its beat and tempo — how the beats slow and how they quicken. But all of this requires experiencing temporal features. Let us express the idea as follows:

> (TEMPORALITY IN MUSIC) Experiencing music requires experiencing temporal features such as duration and temporal order.[8]

In MUSICAL TRAIN RIDE, then, you attentively experience the music. Given TEMPORALITY IN MUSIC, you are thus attentively experiencing temporal features.[9] According to the attentional model, devoting more attentional resources to processing temporal information makes you feel like *more* time has passed. In terms of the attentional gate clock, devoting more attention to time should widen the counter's gate, producing a greater "tick" count. But then you should feel like your train ride took *longer* than usual, which contradicts what MUSICAL TRAIN RIDE states. Hence, on pain of rejecting either TEMPORALITY IN MUSIC or the characterization of your experience given in MUSICAL TRAIN RIDE — either of which, given their strong initial plausibility, would require

6. For a discussion of this model and alternative proposals, see, e,g., Wearden (2003), Buhusi & Meck (2005), and Phillips (2012).

7. Wittman & Meissner (2018, 65), for instance, write: "Its strong heuristic value probably explains why this model is predominantly used in psychology to account for empirical results". For further discussion, see Wearden (2016).

8. Phillips (2014) and Lee (2014) have also noted this. Phillips (2014, 152) writes: "In audition we can simply make no sense of experience without temporally extended contents: sounds (and, I would add, silences) essentially have duration, and all auditory experience is experience of sound (or silence)". Similarly, Lee (2014, 2) claims that "[w]e can't even begin to describe an auditory experience such as an experience of music without supposing that it presents the durations and temporal orders of sounds".

9. Phillips (2012) raised a similar criticism to what I am calling the *attentional model*.

an argument[10] — the attentional model and the attentional gate clock should be resisted.[11]

Let us thus turn to consider ways of accounting for MUSICAL TRAIN RIDE that respect TEMPORALITY IN MUSIC. One proposal is to accept, in accordance with TEMPORALITY IN MUSIC, that attending to the music requires experiencing its temporal features but argue that this experience is heavily distorted. As a result, you experience both your train ride *and* "Runaway Jim" as lasting twenty minutes. The proposal is thus committed to this claim:

> (TIME COMPRESSION) Attending to a piece of music significantly shortens its felt duration.

TIME COMPRESSION, however, seems to recommend that to have a veridical experience of the duration of a piece of music, you are better off *diverting* your attention away from it, since attending to the music significantly shortens its felt duration. But this is absurd — musicians do not need to keep distracting themselves away from a piece of music to gain a better sense of the duration of its different movements. Indeed, TIME COMPRESSION runs contrary to everyday experience, since in ordinary cases like MUSICAL TRAIN RIDE, absorption does not seem to produce a shortened version of "Runaway Jim". We should thus steer away from this proposal.

Another proposal is that MUSICAL TRAIN RIDE is characterized by an experience with an inconsistent content such as this:

> (INCONSISTENT EXPERIENCE) Less than twenty minutes *and* about an hour passed during your train ride.

By claiming that you experienced the train ride as lasting less than twenty minutes, this view can explain, on the one hand, why the trip felt short. In this way, it can make sense of the strong intuition stated in MUSICAL TRAIN RIDE that, while absorbed in the music, your temporal experience is illusory. By claiming that you also felt as though an hour passed during your train ride, this view can explain, on the other hand, why you did not experience "Runaway Jim" as being heavily compressed. In this way, the view can avoid the implausible consequence that musicians need to distract themselves away from a piece of music to get a good sense of its duration — a consequence that, as discussed above, views endorsing TIME COMPRESSION have to accept.

Contrast, however, your temporal experience upon the train's arrival with a typical instance of an inconsistent experience, such as the waterfall illusion. After seeing a waterfall for a little and then gazing over at a stationary object, the object appears to be moving. Yet it *also* appears to remain still. Crucially, *both appearances are readily available to the subject undergoing the illusion*.[12] This is not what happens in MUSICAL TRAIN RIDE: if, as the train arrives at your destination, I ask you how long it felt like the ride lasted, your reply is not that it seemed to last about twenty minutes and that, oddly enough, it also seemed to last about an hour. Instead, you only report that it seemed to last about twenty minutes (though you deny that "Runaway Jim" sounded grossly compressed). This is further revealed by your bafflement upon looking at your watch and learning that your train ride lasted about an hour. You are baffled because what you *learn* about how long the trip lasted is contrary to how long you *felt* like it lasted. But then your temporal experience in MUSICAL TRAIN RIDE does not seem to have an apparently inconsistent content. We can therefore also set this proposal aside.

10. The problem, then, with attentional models in general, and the account of Droit-Volet et al. (2010) on their finding in particular, is that they assume without argument that listening to music does not require experiencing time. On this, see also Phillips (2014).

11. Views such as Lockwood's (2005) and Merino-Rajme's (2014), according to which we do not experience time while having fun, similarly fail to account for MUSICAL TRAIN RIDE: Listening to music can be lots of fun, and given TEMPORALITY IN MUSIC, it also involves experiencing time.

12. Check it out for yourself if you haven't done so: http://www.michaelbach.de/ot/mot-adapt/index.html

Finally, one could reject TEMPORALITY IN MUSIC and hold that:

> (RELATIVE DURATION) A musical experience involves experiencing only the *relative* durations of its various parts with respect to one another.

On this view, we account for MUSICAL TRAIN RIDE by claiming that although the perceived duration of the ride as lasting twenty minutes is indeed illusory, this does not affect the listening experience itself, since, by and large, the relative temporal relations that hold amongst the various bits of "Runaway Jim" are still experienced correctly.

Experiencing a song, however, involves more than experiencing the durations of its various sounds relative to each other. It also involves, at least, experiencing these durations relative to something that remains constant when the song is compressed or stretched out in time.[13] For otherwise you would notice no difference between listening to "Runaway Jim" and listening to a slowed down or a sped up version of it — versions where the durations of its sounds are, say, doubled up or compressed by half while their relative durations are held constant.[14] Yet listening to an hour-long piece of music and listening to a fifteen-minute compressed version of it feel very different: The former feels longer than the latter.

None of this implies that your experience of a piece of music must be completely veridical or that there can be no systematic duration illusions. Rather, the claim is that if, for instance, you are engaged in listening to an hour-long song, your experience should allow you to

13. For some proposals along these lines, see Lockwood (2005), Phillips (2013), and Merino-Rajme (2014).

14. This is consistent with the possibility that, if the whole world — yourself included — slowed down or sped up, you may notice no difference between the correspondingly slowed down or sped up version of "Runaway Jim". (For a defense of such a view — known as temporal functionalism — according to which we could not have systematic temporal illusions such that, say, a minute, a second, or an hour feels like it takes, e.g., twice or half as long as it actually feels like it takes, see Chalmers, 2019). What I aim to rule out above is that experiencing "Runaway Jim" involves *only* experiencing the relative durations of its various sounds with respect to one another.

appreciate its duration as being significantly longer than, say, the duration of a fifteen-minute version of this song, given that you also attentively listened to this shorter version. In particular, if you attentively listen to a fifteen-minute compressed version of the hour-long song you have just heard, your experiences should allow you to appreciate that the fifteen-minute version is much shorter than the hour-long version. But this is incompatible with RELATIVE DURATION.

In the rest of this paper, I develop a novel proposal that avoids these problems and illuminates interesting aspects of our temporal experience.

2. The Proposal: Fragmented Felt Time

2.1 Preliminaries

Before we begin, allow me to make a few points about the scope and focus of the paper, as well as the terminology that it employs. This paper focuses on experiences of events longer than a few seconds and up to a few hours, such as dinners, meetings, and short commutes. I call these *long-lived events*. Significantly shorter and longer events are out of the scope of this discussion. This constraint is consistent with the wide agreement within the neuropsychological literature that our experiences of intervals of time of about less than a second long and those of longer intervals are underpinned by different mechanisms. For explicit statements of this agreement, see, for instance, Grondin (2010) and Eagleman & Pariyadath (2009).

In regard to terminology, I characterize duration experiences throughout this paper as though they were given in seconds, minutes, and hours. This is unrealistic. It is more plausible to think that we experience the durations of long-lived events either in terms of some subjective unit of time[15] or in a unit-free way,[16] and that we later learn to express the content of such experiences in terms of seconds, minutes, and hours. Thus, when I write that it felt to you as though the

15. For some proposals, see Phillips (2012 and 2013), Merino-Rajme (2014), and Lockwood (2005).

16. See Peacocke (1986). Thanks to Geoffrey Lee for a discussion on this.

dinner took two hours, what I mean is that your sense of the duration of the dinner is best expressed — so you have learned — by saying that it feels like the dinner took two hours.[17]

I will also distinguish the temporal experiences we have *while* experiencing an event and the corresponding immediate judgments (i.e., judgments based solely on those temporal experiences) from the memories that we may *later* have regarding the event's duration and the corresponding immediate judgments. For example, a fun, three-hour party may feel to you as though it lasts less than an hour, and yet the next day, as you go over the prior evening's events "in your mind", you find yourself thinking that the party lasted quite a while. William James famously noted the mismatch between time experienced and time remembered when he wrote: "In general, a time interval filled with varied and interesting experiences seems short *in passing*, but long *as we look back*".[18] In this discussion, I will be concerned solely with the former experiences and corresponding immediate judgments, not with the latter memories and corresponding immediate judgments. Using James's terminology, our discussion concerns the experiences of time "in passing" and not "as we look back". Within the psychological literature, prospective and retrospective experimental paradigms, introduced by Hicks et al. (1976), have been used as a proxy for James's notions.[19]

Moreover, I present the discussion at the phenomenological level: It concerns the "what it is like" to experience a certain amount of time as having passed. Indeed, I assume here that cases like MUSICAL TRAIN RIDE concern temporal experiences and not just their corresponding immediate judgments. In support of this assumption, consider the fact that in MUSICAL TRAIN RIDE, after acknowledging — perhaps based on looking at a properly functioning watch — that the ride was an hour long, one still feels as if it took no more than twenty minutes. In other words, the twenty-minute felt duration persists despite the formation of an explicit belief that the ride took about an hour. Cases such as

17. The idea that duration is not experienced in objective units may partly explain why it takes children many years to successfully express their sense of time in conventional units such as minutes and hours, despite using duration words as early as during their preschool years (see Tillman & Barner, 2015). Thanks to Bernard Kobes for the reference.

18. James (1952, 408, my emphasis).

19. On this, Zakay & Block (1997a, 184–185) write (see also Grondin, 2010):

> A more common way to test James's distinction is by comparing duration estimates in what researchers now call the prospective paradigm and the retrospective paradigm. *In the prospective paradigm, participants know in advance that they will be asked to judge the duration of a time period. In the retrospective paradigm, participants do not know until after a time period that they are being asked to judge its duration.* In both cases, of course, participants experience a time period in passing. The way in which they experience it and the various cognitive processes involved may nevertheless differ between the two paradigms. In the prospective paradigm, a person may intentionally encode temporal information as an integral part of the experience of the time period. This is partly why Block (1990) and others have used the term *experienced duration* to refer to the prospective paradigm. In the retrospective paradigm, a person may incidentally encode temporal information, and whatever information is relevant may be retrieved from memory later. Hence, the term *remembered duration* refers to the retrospective paradigm. (My emphasis.)

A number of studies have found the effect James noted when comparing experiments using prospective and retrospective paradigms. For instance, increasing the difficulty of a task has opposite effects on prospective and retrospective timing: More difficulty yields shorter prospective durations, but longer retrospective durations (see, for instance, Block et al., 2010).

While I agree that the prospective and retrospective paradigms serve to elucidate some aspects of James's distinction, there are also reasons to be wary about equating both distinctions. First, as noted by Zakay and Block in the quote above, on a prospective paradigm, one knows in advance that one will be asked to judge a duration. This knowledge — which might have effects on the temporal experience — need not be present in an experience of time in passing. Second, the prospective/retrospective terminology is misleading, as in both cases the duration judgement comes after the relevant period of time has elapsed (how else could the whole duration be experienced and judged?) (*cfr.* Wearden, 2016, 118). In this sense, both judgments count as retrospective. Third, as Wearden (2016, 118) also points out:

> The term 'remembered duration' as a substitute for retrospective timing is […] less than ideal, as memory for the duration of stimuli and other events can be the focus of interest even in a study involving prospective timing […] Likewise, the term 'experienced duration' for prospective timing carries with it the implication that duration is not experienced at all when individuals are not alerted that it is a feature of the task, which is surely false.

Thanks to an anonymous referee for prompting me to discuss this.

this — where one maintains two mental states with blatantly inconsistent contents, even after explicitly acknowledging the inconsistency — strongly indicate that one of the two mental states is *not* a belief. Note, however, that even if you object that we do not experience the duration of long-lived events, and instead you think that we form only immediate judgments about their durations, it remains to account for these judgments. But the same kind of problems raised for the proposals discussed above would arise again for versions of these proposals presented solely in terms of immediate temporal judgments. Hence, even if I here assume that we have temporal experiences, one could reject this assumption and still embrace the proposed account as a model of the corresponding immediate temporal judgments.[20]

Finally, the fragmentation model that I will propose is not intended as an account of *every* temporal experience of long-lived events. Rather, this model is compatible with there being other factors, not here discussed, that also play a relevant role in accounting for our temporal experiences and generate temporal illusions.[21] The targets of this model are cases similar to musical train ride; the proposal should be understood as part of a larger, multi-factored, non-monolithic account. The idea that there is no one, simple model of temporal experience that accounts for all cases is widespread amongst psychologists. For an explicit expression of this, see — for instance — Sanders (2015).[22]

20. In other words, though I assume that musical experiences involve genuine experiences of duration and temporal order, I do not intend to be arguing against a Humean view on which our musical experiences involve only a succession of non-temporal sensory experiences accompanied by memories and judgments about duration and order. For, as I note in the main text, the Humean still needs to account for those memories and temporal judgments. Thanks to Philippe Chuard for a prompting me to clarify this, as well as for many other helpful comments on this paper.

21. Emotions, for instance, are also thought to play an important role in generating duration illusions. For a general discussion, see, e.g., Grondin (2010, 566–567) and Wearden (2016, chapter 5).

22. See also Zakay & Block (1997b), though note that they are discussing temporal experiences over relatively shorter durations.

2.2 Experiencing Internal Time

Let us begin by asking how it is that we experience a long-lived event *as* a long-lived event. In other words, how is it that we experience events such as songs, train rides, and dinner parties — events too long-lived to be experienced "at once" — as long-lived events rather than as, say, a disconnected series of short-lived events?

Long-lived events are composed of short-lived events that we can take in "at once" — e.g., a trumpet sound, a change of traffic light, or the movement of someone's lips as they speak a few words. Given this, we may ask instead: How is a short-lived event experienced as part of a long-lived event rather than as temporally isolated from everything else? How is the short-lived sound of a trumpet heard as part of a long-lived sonata?

On my view, the best way to answer this question is by thinking of the experience of a short-lived event (e.g., a trumpet sound) as something that is already embedded in the (ever changing) mental representation of a long-lived event (e.g., the sonata).[23] This mental representation — or mental timeline, as I will also call it — has two main functions. First, it keeps track of the temporal features of the long-lived event. For example, as one experiences a short-lived event, the length of the long-lived event's mental timeline that this short-lived event is experienced as composing increases. Second, this mental timeline affects one's experience of the short-lived event itself: It allows one to experience the short-lived event as being temporally related to the long-lived event represented by the timeline. In particular, it allows one to experience the short-lived event as increasing the duration of the long-lived event it is experienced to compose. When this happens, I will say that one experiences time *as passing for the long-lived event*. Figure 1 below illustrates this in a case where all one experiences is "Runaway Jim".

23. See also Merino-Rajme (2014).

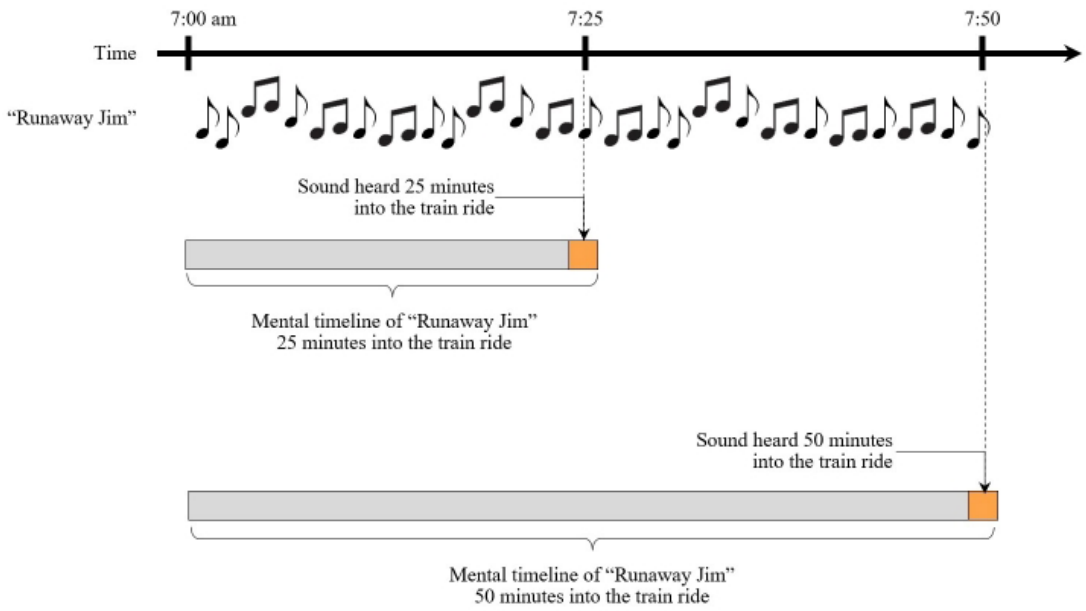

Figure 1. Mental timeline formed while listening to "Runaway Jim".

As one listens to "Runaway Jim", one forms and continues to update a mental timeline that captures the song's evolving temporal features. In particular, as one continues to listen to the short-lived sounds of "Runaway Jim", the length of the timeline of "Runaway Jim" increases. This growing timeline, in turn, allows one to hear the sounds played at 7:25 am as increasing the duration of a 25-minute song and those played at 7:50 am — when the timeline, let's assume, has doubled up — as increasing the duration of a 50-minute song. In this way, as one listens to the short-lived sounds of "Runaway Jim", one experiences time as passing for "Runaway Jim".

One might be tempted to object that a long-lived event, precisely because it is too long-lived to be perceptually available in the way in which a short-lived event is, cannot make a difference to a subject's overall experience. This temptation, however, should be resisted. Ordinarily, objects — or parts of them that are occluded, missing, or out-of-sight — can make a difference to our perceptual experience. This well-known phenomenon is called *amodal completion*. Canonical examples are seeing a chair across the room *as having a back*, even if the back is out-of-sight, or seeing the chair *as having four legs*, even if one of the legs is occluded or missing from the subject's perspective.[24] Similarly, a short-lived sound can be heard as being temporally related to a song, even if the whole song is out of one's current perceptual ken.[25] In other words, just as an out-of-sight part of the chair can amodally complete a subject's experience of the chair, the temporal features of a long-lived event that are out of our perceptual ken can amodally complete a subject's experience of a short-lived event.

The view so far sketched presupposes that subjects individuate or parse out long-lived events, an assumption that has been empirically supported by recent work. For instance, Zacks et al. (2007) propose what they call *event segmentation theory* (or *EST*), according to which "the perception of boundaries between events arises from ongoing perceptual processing and regulates attention and memory" (Zacks et al., 2007, 273). The events in EST span "from a few seconds to tens of minutes" (276) and, as with train rides, can be socially constructed: "The perception of events depends both on sensory cues and knowledge

24. The chair's back may be further presented as having the same color and texture as the rest of the chair. For other examples, consider seeing a rabbit as having two ears, even if one is blocked by a tree from one's viewpoint, or the Kanizsa triangle. For a discussion of the latter, see, e.g., Davis & Driver (1998).

25. A wide range of views on amodal completion are compatible with these characterizations. See, e.g., Gibson (1972); Nöe (2004); Nanay (2009); and Briscoe (2011). As noted in section 2.1, while I favor characterizing these cases in experiential terms, the discussion can be recast merely in terms of immediate temporal judgments alone, so it would be compatible even with views that attempt to account for amodal completion purely in terms of perceptual judgments.

structures that represent previously learned information about event parts and inferences about actors' goals and plans" (273). Zacks et al. (2007) provide a number of studies on long-term memory and learning procedures to support EST, and offer neurophysiological data suggesting that the representations of such events are implemented in the prefrontal cortex (*cfr.* Zacks et al., 2007, 273). More recently, Baldassano et al. (2017) have further supported EST by developing a model that identifies parsed events "directly from fMRI activity patterns across multiple timescales and datasets" (Baldasanno et al., 2017, 711). The model was tested "by fitting it to fMRI data collected while subjects watched a 50-min movie (Chen et al., 2017) and then assessing how well the learned event structure explained the activity patterns of a held-out subject" (Baldassano et al., 2017, 712). It was found that "event boundaries during perception can be identified from cortical activity patterns" (712). Their work also shows that the chunking of events takes place at different timescales and is hierarchically organized (on this, see also Kurby & Zacks, 2008 and Zacks et al., 2001).[26]

Even if we parse out long-lived events, is it plausible to claim that *past* information about them (which has already been collected and stored) affects how information that is *currently* being received is processed, such that, in our case, past information about a long-lived event's temporal features affects how we experience an occurrent short-lived event? There is recent evidence showing that past information indeed plays a role in current information processing. For instance, Hasson et al. (2015) report neural imaging experiments that — contra the traditional view — provide evidence for a kind of memory, which they refer to as *process memory*, that is not located in an encapsulated store or "segregated from ongoing neural processes", but is rather constantly used in processing of "incoming information in the present moment" (Hasson et al., 2015, 306).[27] Their results fit well with the findings by Baldassano et al. (2017) mentioned earlier that the parsing of long-lived events takes place at different timescales and is hierarchically organized.[28] Further, by analyzing neural responses through fMRI, Hasson et al. (2015) were able to determine the timescale of the information used by process memory in real time (Hasson et al., 2015, 307–308). I will return to discuss these studies in section 3.2, where I propose ways of testing my proposal.

Moreover, the idea that the *temporal* information — as opposed to some other kind of information — of a long-lived event can affect the current experience of a short-lived event also fits well with recent empirical findings. Consider first the spatial analogue of this idea, namely, that the spatial information of a larger, out-of-sight space — e.g., a university campus, a forest, or a city area too large to be wholly perceived from the smaller location where the subject is situated — can affect your current experience of a local space — e.g., a classroom, a tree, or a city corner. Both the spatial and the temporal versions of this idea require that there be a way of coupling the current perception of the local (spatial or temporal) environment with the mental map or timeline of the broader environment, so that the subject can orient themself and navigate that environment in real time. A body of research in neuroscience has identified just this (*cfr.* Eichenbaum, 2014 and Shapiro et al., 2007): In the case of space, a group of cells in the hippocampus known as *place cells* fire when the subject sees themselves as occupying a

26. Many thanks to Jorge Morales for a helpful discussion on this and subsequent sections where I discuss the empirical literature, as well as for suggesting references to some of the empirical studies I cite.

27. EST also supports the idea that our representations of long-lived events affect our current perceptions: "Perceptual processing is guided by a set of representations called *event models* that bias processing in the perceptual stream" (Zacks et al., 2007, 274).

28. They write:

> In this framework, we emphasize that traces of past information should not be segregated from ongoing neural processes. To dissociate our notion of memory from the traditional notion of encapsulated memory stores, we will use the term 'process memory' throughout the paper. *We use the term process memory, in a broad sense, to mean active traces of past information that are used by a neural circuit to process incoming information in the present moment. Furthermore, we argue for a hierarchical organization of process memory, in which the timescale of memory-dependent processing gradually increases from early sensory areas to high-order areas*. (Hasson et al., 2015, 306, my emphasis)

landmark within a larger, structured space — e.g., when they see themselves as crossing the entrance of a campus building (Eichenbaum, 2014, 732). Time cells — the temporal analogues of place cells — were subsequently identified. Eichenbaum reported this by noting that "in addition to place cells, which fire when rats are in a particular location in a spatially structured environment, the hippocampus contains time cells, which fire at particular moments in a temporally structured period." (Eichenbaum, 2014, 742, my emphasis). Interestingly, it was also found that "[p]lace cells and time cells are the same neurons, so many of these cells encode both spatial and temporal dimensions" (Eichenbaum, 2014, 742, my emphasis), which supports treating the spatial and the temporal cases alike.[29]

Before moving on, let me introduce some terminology that will serve to delineate the model I have been developing. I will say that a subject experiences the *internal time* of a long-lived event whenever they experience a short-lived event as temporally related to the long-lived event it composes. When this is the case, I will also say that it feels as though the short-lived event partakes in the *internal time* of the long-lived event it composes. Thus, in addition to saying that it feels to you as though time passes for "Runaway Jim", in the case depicted in Figure 1, I will also say that you experience the internal time of "Runaway Jim" and that it feels to you as though, e.g., the trumpet sound at 7:25 am partakes in the internal time of "Runaway Jim".

There is more to our temporal experience, however, than simply experiencing a short-lived event as partaking in the internal time of the long-lived event that the short-lived event is experienced as composing. We can also experience a short-lived event as partaking in external time, as I now turn to explain.

29. On this, see also Buonomano (2017, 189–190). The discussion also assumes that we form mental timelines of long-lived events. For empirical support of this, see also Bonato et al. (2012) and Buonomano (2017, chapter 11).

2.3 Experiencing External Time

If we were limited to experiencing only the internal time of long-lived events, such events would feel to us like temporally isolated realities. Going about one's day, for example, would feel like "world-hopping" — like constantly hopping from one world to another, the former vanishing just as the latter starts afresh. But of course, this is not how it feels to go from a work meeting to a dinner party to your commute back home. Rather, we regularly experience short-lived events as temporally related to *more* than one long-lived event — that is, we experience them as taking place within a wider temporal horizon that includes other long-lived events.

For example, sipping your morning coffee may feel not only as being *part of* your breakfast but also as happening *before* your commute to work and *after* your early workout. Similarly, you may experience fastening your seatbelt not only as taking place at the end of a long, delayed flight but also as happening *while* the conference starts without you. Or, to return to our example, you may hear the trumpet sound not only as composing "Runaway Jim", but also *as taking place while* you commute to work, *before* your meeting, and *after* your workout. In this way, temporal relations to other long-lived events regularly feature in our everyday experiences of short-lived events. In this sense, our experience of a short-lived event transcends the temporal boundaries of, e.g., the breakfast, the flight, or the song they compose, allowing us to experience them as within a wider, overarching temporal horizon that includes other long-lived events.

To talk about this way of experiencing a short-lived event, and to distinguish it from *internal time* as discussed in the last section, I will say that we experience a short-lived event in *external time* whenever we experience it as temporally related to *more* than one long-lived event. In contrast, recall that we experience a short-lived event in internal time whenever we experience it as temporally related to *only* one long-lived event it composes (i.e., merely as composing one long-lived

event).[30] Correspondingly, and respectively, I will also say that it feels as though a short-lived event partakes in external time or internal time and will describe a subject as experiencing external or internal time.

Let us return now to the framework introduced in the last section for explaining the experience of internal time and extend it to the experience of external time. We said above that we experience a short-lived event in internal time when we experience it as part of a long-lived event that we have represented through a mental timeline. Extending this model now to external time, we experience a short-lived event in external time when we experience it as temporally related to more than one long-lived event. In this case, the individual long-lived events are represented by simple mental timelines, and their temporal relations are represented by interconnections between these individual timelines, resulting in a larger, more complex timeline. As we experience a short-lived event in external time, all temporally related timelines are updated. This, in turn, affects the overall experience of the short-lived event itself: In particular, time feels as passing for *various* long-lived events experienced as temporally related to the short-lived event.

Figure 2 illustrates the difference between experiencing a short-lived event in external time versus experiencing it only in internal time. The figure depicts an experience of taking two distinct sips of coffee (highlighted in bolded orange) at two distinct moments during your breakfast. It is assumed that the breakfast takes place while you are in flight, having completed a workout earlier that morning before heading to the airport and boarding the plane.

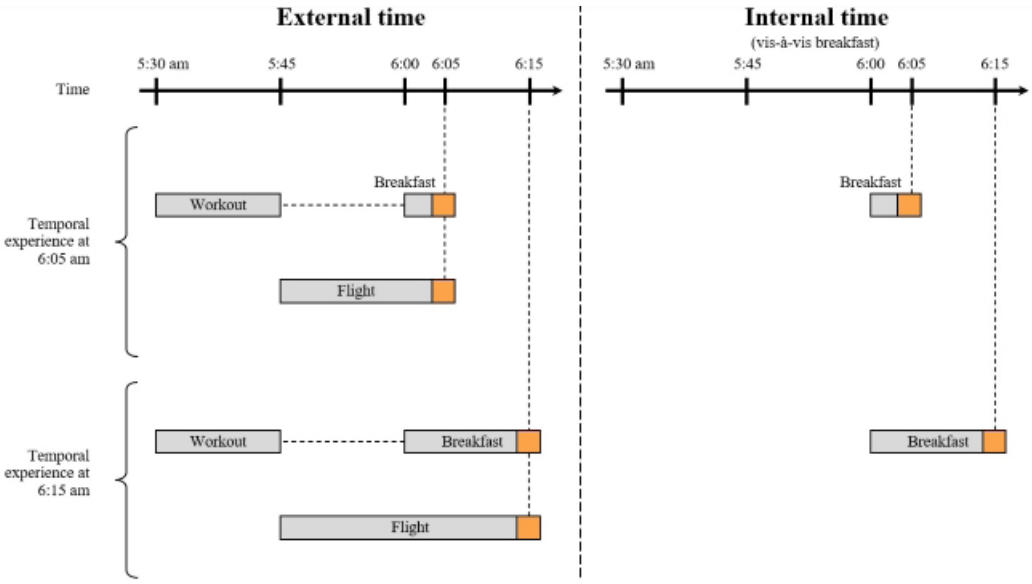

Figure 2 Experiencing a short-lived event as partaking in external time (left) vs. experiencing it only as partaking in internal time (right)

As shown on the left, as you sip your coffee at 6:05 am, you feel the duration of your breakfast and of your flight increasing, while your morning workout recedes in time. By 6:15 am, the mental timelines of all three events have been updated: At this later time, the duration of both your breakfast and your flight feel longer, and your workout is experienced as being even further away in time. The right side depicts the contrasting situation, where you experience time only as passing for your breakfast. As before, at 6:15 am, it feels like your breakfast lasted about fifteen minutes, three times as long as it felt at 6:05 am. In this case, however, only the breakfast's timeline is updated, since here, drinking the coffee is not experienced as temporally related to any other long-lived event.

30. This characterization is rough. For one thing, it doesn't distinguish between experiencing a short-lived event as partaking in external time and experiencing it as merely partaking in the internal time of two different long-lived events — e.g., you might be absorbed in listening to music and in painting. This rough characterization, however, suffices to convey the main idea behind the model in a simpler way. The model, of course, allows for further refinements that would distinguish between more complex cases.

However, it is not an all-or-nothing matter whether we experience the short-lived events of a long-lived event as partaking in external time or only as partaking in the internal time of this long-lived event. Some short-lived events are experienced as partaking in external time, while others are experienced only as partaking in the internal time of the long-lived event. I will turn now to suggest that attention plays a crucial role in modulating this dynamic.

2.4 The Core of the Proposal: Attention Fragments Felt Time

In experiencing a long-lived event, we go back and forth between experiencing its short-lived events only as partaking in internal time and experiencing them also as partaking in external time. We thus go back and forth between only experiencing time as passing for the long-lived event that the short-lived event is experienced as composing, and also experiencing time as passing for other long-lived events that we experience as temporally related to the short-lived event. Importantly, this back-and-forth is driven by attention, so that:

> (FRAGMENTATION) When our attention is directed towards a long-lived event, we experience its short-lived events only as partaking in the internal time of the long-lived event. Otherwise, we also experience its short-lived events as partaking in external time.[31]

31. FRAGMENTATION is an idealized thesis since it does not consider (1) that attention comes in degrees (e.g., we may pay more or less attention to a long-lived event), and (2) that the effects of attention may be probabilistic (e.g., attention may merely raise the probability of experiencing an event only as partaking in internal time). The following thesis is thus more plausible.

    > (FRAGMENTATION*) The more attention we direct towards a long-lived event, the more likely it is that we experience its short-lived events only as partaking in the internal time of the long-lived event. The less attention we direct towards a long-lived event, the more likely it is that we experience its short-lived events also as partaking in external time.

    Still, I articulate the view in terms of FRAGMENTATION to allow for a simpler presentation and discussion of its underlying idea. Once the view has been presented, it is easy to see how analogous considerations hold for FRAGMENTATION*. Thanks to an anonymous referee for prompting me to clarify this.

Consequently, when our attention is directed towards a long-lived event, we only experience time as passing for this long-lived event. Otherwise, we experience time also as passing for other long-lived events experienced as temporally related to the long-lived event.

Focusing our attention on a long-lived event thus fragments our sense of time. As we direct our attention towards a long-lived event, its short-lived events go from being experienced as part of a wider temporal horizon where other long-lived events are also located to being experienced as temporally isolated from them.

I now turn to explain how FRAGMENTATION accounts for temporal experiences as in MUSICAL TRAIN RIDE, further defending and elaborating my view.

2.5 How fragmentation Accounts for MUSICAL TRAIN RIDE

As the train departs, you start listening to "Runaway Jim". At this point, you are not yet absorbed by the music, and so according to FRAGMENTATION, you experience the song's first short-lived sounds as partaking in external time. In particular, you experience them as part of "Runaway Jim" and as happening during your train ride (you may also experience them as happening after your breakfast, before your meeting, etc., but we will disregard these to simplify the discussion). In this way, you experience time as passing for "Runaway Jim" *and* for the train ride, increasing the duration of both timelines by the same amount. A bit later, you become absorbed in the music and remain so for most of the trip. According to FRAGMENTATION, the effect of your absorption is to temporally isolate your experience of "Runaway Jim" from every other event. While absorbed in the music, it feels to you as though time passes only for "Runaway Jim", and only its timeline increases. Every now and then, however, your attention drifts away from the music. You begin to wonder where you are on the journey, let's say, or you become distracted by another passenger. During these moments, it again feels as though time passes for both "Runaway Jim" and the train ride, increasing the length of both timelines. Still, the overall effect of spending most of the train ride absorbed in the music

is that the timeline of "Runaway Jim" becomes much longer than the timeline of the train ride. Consequently, it feels as though more time has passed for "Runaway Jim" than for the train ride. By 8 am, it feels as though twenty minutes have passed for the train ride while an hour has passed for "Runaway Jim". Had you experienced more sounds as though they were played during the train ride, the timeline of the train ride would have been longer. In this way, it would have felt to you as though the train ride lasted more time. Conversely, had you been absorbed in "Runaway Jim" even longer, experiencing still fewer of its sounds as though they were played during your train ride, the timeline of the train ride would have been shorter. In this way, it would have felt to you as though the train ride lasted even less time.[32] Figure 3 (see page 14) illustrates the effect of FRAGMENTATION on your temporal experience during MUSICAL TRAIN RIDE.

The rows represent your temporal experience at different moments. The gray rectangles around musical notes represent sounds experienced while not fully absorbed in "Runaway Jim", while the orange ovals represent sounds experienced while fully absorbed in it. The thick horizontal lines on each row represent mental timelines: The orange ones stand for "Runaway Jim", and the gray ones stand for the train ride; their lengths represent felt durations. The bolded squares at the end of each rectangle represent the experience of the short-lived event occurring at that time. The dashed, vertical lines connect a short-lived sound to the mental timeline(s) that affect(s) how you experience that short-lived sound. For example, the first row indicates that you experience the sounds played shortly after 7 am — while you are not yet fully absorbed in "Runaway Jim" — as temporally related to both the train ride and "Runaway Jim", and that you experience both events as having similarly short durations. In contrast, the third row indicates that you experience the sounds played later — while fully absorbed in "Runaway Jim" — only as partaking in the internal time of "Runaway Jim", and that, corresponding to this, the felt duration of "Runaway Jim" is longer.

As a whole, the figure illustrates that becoming absorbed in the music has the effect of detaching your experience from external time. As we have seen, while not absorbed in the music, its short-lived sounds are experienced in external time: They are experienced as part of a wider, more complex timeline that includes not only the timeline of "Runaway Jim", but also the timeline of the train ride. The figure depicts this with a vertical, dashed line that connects the short-lived event to more than one timeline (see lines 1, 2, 4, 6, 9, 12, 13, and 14).[33] By contrast, as you become absorbed in the music, its short-lived sounds are experienced only as partaking in internal time. The figure depicts this with a dashed line that connects the short-lived events to only one timeline — that of "Runaway Jim" — illustrating that the timeline of "Runaway Jim" becomes detached or fragmented from external time (see lines 3, 5, 7, 8, 10, and 11).

Note also that the figure represents the timeline of the train ride using disjointed segments connected by a dashed, horizontal line. The space between segments represents periods of objective time during which one is absorbed in the music. The dashed line connecting these segments indicates that, despite being objectively disjointed, we experience the separated segments of the train ride as continuous. Indeed, as discussed in the section on internal time above, when we are absorbed in experiencing a long-lived event, other long-lived events do not feature in our experience, and so we do not experience these events as ending, or as anything else for that matter. Rather, in cases of absorption, our experience of other long-lived events is, as it were, suspended. For example, when you become absorbed in "Runaway

32. Note that EST leaves open the possibility that various events are tracked simultaneously. It is thus compatible with the proposed model:

> In addition to simultaneous parsing on multiple timescales, *it is possible that event segmentation sometimes tracks simultaneous activities in parallel.* For example, when attending a child's birthday party, one might simultaneously segment the actions of children playing a birthday game and those of parents having a conversation at the same time. (Zacks et al., 2007, 276)

33. To simplify the exposition, the figure includes only two timelines (the timeline of "Runaway Jim" and the timeline of the train), but a more realistic depiction may include more.

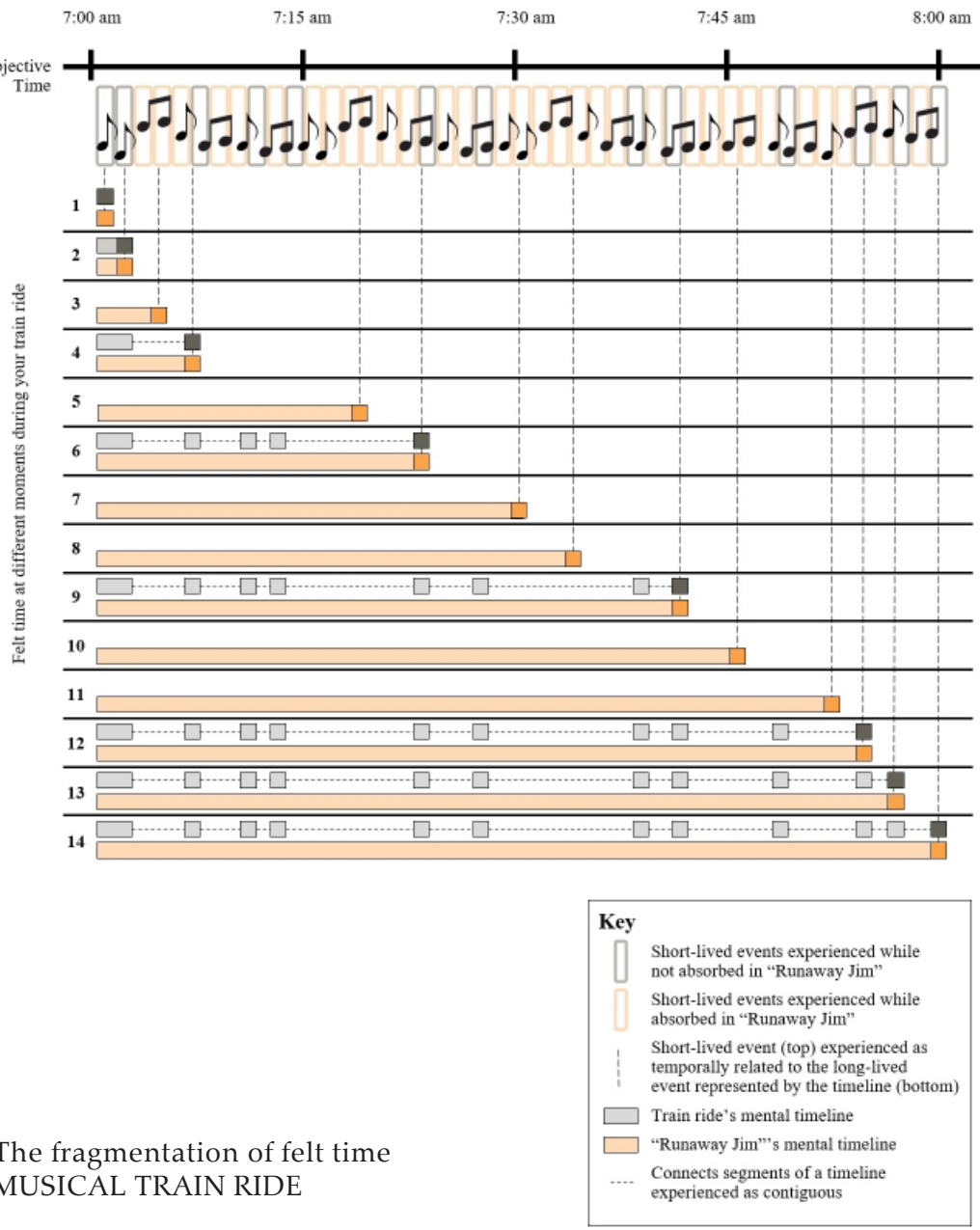

Figure 3. The fragmentation of felt time in MUSICAL TRAIN RIDE

Jim", it does not feel to you as though the train has stopped moving. Also, it does not feel to you as though the train ride restarts as your attention drifts away from the music — it rather feels as though the train smoothly continues its journey.

Lastly, the figure shows the cumulative effect of being absorbed in the music for most to your trip. In section 2.2, above, I argued that experiencing a long-lived event such as "Runaway Jim" involves experiencing its short-lived events, its sounds, as temporally related to the long-lived event itself, i.e., the song. I also said that we do this by forming a mental timeline of the song that increases as we continue to hear its short-lived events, the sounds, as temporally related to it. This, I argued, is what it means to experience time as passing for "Runaway Jim", or what I called the internal time of "Runaway Jim". In section 2.3, I went on to argue that this process continues not only while absorbed in "Runaway Jim", but also for those periods of distraction during which we experience its sounds as also temporally related to other long-lived events (in our case, to the train ride) — what I called experiencing "Runaway Jim" in external time. In short, I argued that when we are listening to "Runaway Jim" (whether fully absorbed or not), we continue to increase its timeline, and so it feels as though more and more time passes for it. In the figure, we can see this cumulative effect as the timeline for "Runaway Jim" increases as we move down each row. Contrast this with what happens to the timeline of the train ride. Unlike the timeline for "Runaway Jim", the timeline for the train ride is not constantly being updated. The reason for this is that not all sounds are experienced as temporally related to the train ride. What results, over time, is that the timeline for "Runaway Jim" becomes increasingly longer than that of the train ride, and their felt durations differ accordingly. One can see this represented in the figure by comparing the progression of both timelines as one moves down each row. In rows 3, 5, 7, 8, 10 and 11, when you are fully absorbed in the music, it does not feel as though time passes for the train ride (as discussed above, the train ride is not at all part of your experience during these times). Accordingly, the timeline for the train ride does not increase during these times. But then, by the time the sounds of the music are experienced as temporally related to both timelines — as, i.e., in rows 4, 6, 9, 11, 12, 13, and 14 — the timeline of "Runaway Jim" is longer than the timeline of the train ride. As shown in the last rows, by the end of the trip, the timeline for "Runaway Jim" is much longer than that of the train ride.

Let me now turn to explain how this proposal avoids the pitfalls of the views previously discussed. To begin with, the view embraces the plausible claim, discussed earlier, that listening to music requires experiencing temporal features (TEMPORALITY IN MUSIC), for it proposes a model according to which we get to experience a long-lived piece of music by representing its temporal features in a mental timeline and allowing these features to affect our experience of the music's short-lived sounds. In doing so, unlike the attentional model, this view accounts for instances of the dual task interference effect where the secondary task is listening to music without making the implausible claim that, as Droit-Volet et al. (2010, 231) put it earlier, listening to music "distracts our attention away from the processing of time". Instead, the model appeals to the fragmentation of the mental timelines to account for our sense of duration of the two tasks involved.

Unlike views committed to TIME COMPRESSION, which says that attending to a piece of music significantly shortens its felt duration, this proposal can hold that it felt to you as though the train ride lasted twenty minutes without holding that it also felt to you as though "Runaway Jim" lasted only this much. For while both events occurred together and took roughly the same amount of objective time, on my view, most of the short-lived sounds of "Runaway Jim" are not experienced as taking place during the train ride, and this allows their felt durations to come apart.

It is also because the felt duration of "Runaway Jim" can come apart from that of the train ride that this view can account for your temporal experience of "Runaway Jim" without embracing RELATIVE DURATION, which — as discussed in section 1 — implausibly implies that we could not perceptually distinguish a twenty-minute version of a piece

of music from a five-minute version of it that preserves the temporal structure of the original piece.

Finally, recall that according to MUSICAL TRAIN RIDE, the following three claims are true:

(a) It feels like the train ride takes about twenty minutes;

(b) It feels like "Runaway Jim" takes about an hour; and

(c) It feels like "Runaway Jim" and the train ride begin and end at the same time.

One might try to account for all these claims by holding that the content of your temporal experience during MUSICAL TRAIN RIDE is inconsistent (INCONSISTENT EXPERIENCE). Yet, as I argued in section 1, the subject does not seem to be (at least immediately) aware of having an experience with an inconsistent content. By embracing the proposed fragmentation model, however, one can account for (a), (b), and (c) without having to claim that the subject has an experience with an inconsistent content that is readily available to her. We can see this by first imagining the following: Suppose that each time you become absorbed in the music, you enter an alternative reality where "Runaway Jim" seamlessly continues to play — i.e., the music follows you to this world. Suppose also that nothing else happens in this other world: It is composed of nothing other than your isolated absorption in the music. Imagine also that each time your attention drifts away and you lose absorption in the music, you return to the original world just as easily as you left it, and that, as before, the music follows you — i.e., as you return to your seat in the original world, "Runaway Jim" seamlessly continues to play. Finally, suppose that all along, as you shift to and from the original world, you keep track of the durations of the train ride and the music by forming corresponding timelines that allow you to experience their durations. Figure 4 below illustrates this.

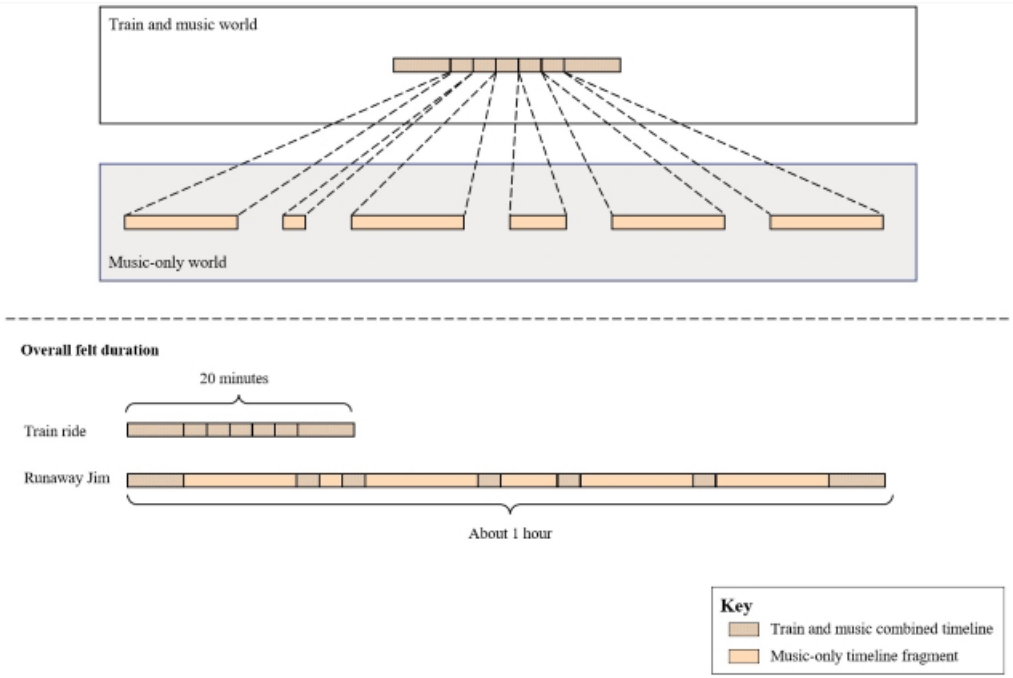

Figure 4. Experiencing parts of "Runaway Jim" as if played in an alternative reality

The gray and orange striped rectangles represent the timeline you form at "train and music world". The solid orange rectangles represent the various segments you form at the "music-only world". The dashed lines represent that the music smoothly continues as you move from one world to the other. The lower part of the figure represents the overall duration for the train ride and for the music according to these timelines. More specifically, the length of the top timeline represents overall felt duration for the train ride (twenty minutes), while the length of the bottom line represents overall felt duration for the train ride (an hour). The greater length of the bottom timeline results from

inserting the isolated fragments for the "music-only world" into the "train and music" timeline at the intersections indicated by the dashed lines. In this way, the figure shows that while both the music and the train ride begin and end at the same time, their durations are distinct, and this is reflected in your experience.

Now, while the depicted situation may turn out to be inconsistent — for example, it may not be possible for you and the very same piece of music to pop in and out of spatio-temporally isolated worlds — such inconsistency is not readily available to the subject. For the facts about the nature of trans-world identity that would give rise to the alleged inconsistency are not apparent from the phenomenology — they require sophisticated arguments. Thus, the subject may at least have an experience that consistently features (a), (b), and (c) above. Now, while the metaphysics in MUSICAL TRAIN RIDE are clearly not such as depicted in the imagined scenario above — you do not pop in and out of spatio-temporally isolated worlds as you ride the train to work — they could still represent how the subject (consistently) experiences them to be.[34]

Still, one might object that according to MUSICAL TRAIN RIDE, it feels to you as though your train ride lasted twenty minutes *and* you also take yourself to have heard all of "Runaway Jim" while riding the train. Thus (so goes the objection), there is no way to explain that "Runaway Jim" lasted for about an hour without holding that there is a patent inconsistency in your experience and, thereby, endorsing INCONSISTENT CONTENT.

34. Here is a different way of making this point. According to my proposal, the subject has two distinct timelines for the same period of objective time, one for the train ride and the music and the other solely for the music. When we use the former timeline, we determine one duration. When we use the latter timeline, we determine a longer duration. If, instead of hopping between worlds, these timelines reflect what is going on in one and the same world, they are inconsistent with one another. This inconsistency, however, is not readily apparent to the subject while she is having the experience, since, at any given time, she normally uses only one of these timelines to determine her experience of the duration of this period of time. Thanks to an anonymous referee for suggesting this way of making the point.

In reply, note that while you may well *believe* that you heard the whole of "Runaway Jim" while riding the train, this is not how you *experience* it. As depicted in Figures 3 and 4, above, most of the sounds of "Runaway Jim" are not experienced as temporally related to the train ride or to any other event external to "Runaway Jim". Thus, you can have an experience with features (a), (b), and (c) above that, at least, appears to be consistent.[35]

One might further object that the above reply makes a false assumption, namely that the relation 'is experienced as temporally related to' is not transitive, since it assumes that for events A, B, and C, it is possible that A is experienced as temporally related to B, B is experienced as temporally related to C, but A is not experienced as temporally related to C.[36] In reply, first note that it may be tempting to think that the relation 'is experienced as temporally related to' is transitive on the grounds that the relation 'is temporally related to' *is* transitive. But from the fact that relation X is transitive, it does not follow that the relation *experienced as X* is also transitive. Consider, for example, the relation 'is the same color as'. While this relation is transitive, it is

35. Compare this with an instance of the Müller-Lyer illusion where you yourself draw the lines. In this case, you may *be certain* that both lines are of equal length. Still, one of them *looks* longer than the other. As in MUSICAL TRAIN RIDE, this version of the Müller-Lyer illusion involves a clash between the content of your belief (that the lines are of equal length) and the content of your experience (that one is longer than the other). Still, in both cases, the content of your experience itself is consistent (at least as the case has been described; I leave open the possibility of alternative accounts of the Müller-Lyer illusion). There are, however, important disanalogies between both cases. For one thing, in the case of the Müller-Lyer illusion, the full length of the lines falls within your visual field, whereas in MUSICAL TRAIN RIDE, "Runaway Jim" is a long-lived event and hence falls outside of what we may call your "immediate temporal field" (what many people think of as "the specious present", which does not last more than a couple seconds). For another, in the case of the Müller-Lyer illusion, you need not see both lines as aligning on the extremes, whereas in MUSICAL TRAIN RIDE, the fact that both events begin and end at the same times figures in the content of your experience. For these and other reasons, I don't think the cases should be treated in the same way. Thanks to Laurie Paul for suggesting that I compare MUSICAL TRAIN RIDE with the Müller-Lyer illusion.

36. Thanks to an anonymous referee for prompting me to say more about this.

far from obvious that 'is experienced as the same color as' (or 'looks to be the same color as') is also transitive. Indeed, Nelson Goodman (1951) argued that rejecting the transitivity of this relation is key to solving the phenomenal sorites paradox, and nothing in his argument required rejecting the transitivity of the relation 'is the same color as'.[37] But then, that the relation 'is temporally related to' is transitive is not enough to conclude that the relation 'is experienced as temporally related to' is also transitive.

In fact, we have good reason to deny that 'is experienced as temporally related to' is transitive, since to hold otherwise flies in the face of the phenomenology. To illustrate, suppose that while enjoying your morning coffee (event A), you hear the bell of the train station ringing (event B), which prompts you to finish up your coffee and rush towards the train's entrance. Suppose further that as you return home in the evening, you again hear the train station bell ring (event C) and that you experience this ring as taking place *later* than the bell ring you heard that morning. So far, A and B have been experienced as simultaneous, and C has been experienced as later than B. It is clear, though, that in experiencing C as later than B, you do not also need to experience C as later than A; indeed, A may not figure in the content of your evening experience at all. That is, when your experience presents the evening bell sound as occurring later than the morning bell sound, it need not also present again your morning coffee. Note further that, since we are constantly experiencing events as temporally related to other events, if the relation 'is experienced as temporally related to' were transitive, the contents of our experiences would quickly become bloated, filled with lots of inconsequential events experienced earlier. But the contents of our experiences are not so bloated. Thus, the objection fails. It is possible to suppose, as my account does (and as depicted in Figure 3), that you experience the train starting to move and the initial, distinctive sounds of "Runaway Jim" as taking place simultaneously (rows 1 and 2), and also that you experience the later sounds of "Runaway Jim" as temporally related to these earlier sounds without experiencing them as temporally related to the train ride starting to move (rows 3, 5, 7, 8, 10, and 11).

37. As Delia Graff Fara notes, the intransitivity of this relation has been "widely regarded among philosophers as itself uncontroversial" (2001, 905). Of course, Fara went on to forcefully argue that 'looks to be the same color as' is indeed transitive, developing her own solution to the phenomenal sorites paradox. (For arguments against Fara, see Chuard, 2010 and Phillips, 2011.) What is important for the point being raised here is not whether 'looks to be the same color as' is indeed transitive or not, but rather that showing this requires much more than merely noting that 'is the same color as' is transitive.

2.6 Cognitive Implementation of the Model

Turning now to the cognitive level, I propose a modification to Zakay and Block's (1995) attentional gate clock discussed above that, unlike their model, can be used to implement the phenomenal temporal fragmentation that accounts for your temporal experience in MUSICAL TRAIN RIDE.

First, let an internal clock have an "event file" or "event-index" for each long-lived event represented in a mental timeline. Second, as the clock counts a "tick", let it file or index this "tick" to one or various long-lived events. Finally, let attention control the filing/indexing as follows: Each "tick" is filed/indexed only to those long-lived events whose temporal relations one is attending to when the "tick" is produced. In this way, the filing/indexing of each "tick" reflects the temporal relations to which one is attending when the "tick" is produced.[38] For example, a "tick" produced while your attention is focused on experiencing a short-lived sound as temporally related to both "Runaway Jim" *and* the train ride will be filed/indexed to both of these long-lived events, with the result that the total "tick"-count for each event increases. By contrast, if instead you are absorbed in the music when the "tick" is produced, such that you experience the short-lived sound as temporally related to "Runaway Jim" alone, the "tick" will be filed/indexed only to "Runaway Jim", and only its "tick"-count increases. This modification to the attentional gate clock delivers the right result. For

38. Alternatively, we could model this by means of various counters, one for each long-lived event, working at the same time and capable of using (at least some of) the same "ticks" as inputs.

in MUSICAL TRAIN RIDE, most of the train ride is spent absorbed in the music, and so as time goes by, a greater number of "ticks" accumulate for "Runaway Jim" than for the train ride. Now, since the "tick"-count for a long-term event determines its felt duration, the internal clock model, so modified, successfully delivers a long felt duration for "Runaway Jim" — viz., an hour — and a shorter felt duration for the train ride—viz., twenty minutes.[39]

Note that on Zakay and Block's attentional gate clock, "ticks" are lost when attention is focused on the internal temporal structure of the music. For this reason, their attentional gate clock cannot explain how the subject can experience the duration of "Runaway Jim", despite explaining the subject's feeling that the train ride flew by. More generally, as it stands, the attentional gate clock model cannot account for cases of the dual task interference effect where the secondary task involves experiencing time. On the modified proposal above, however, the "ticks" are not lost: They are still counted, *though only towards the long-lived event one is attending to* (in our case, "Runaway Jim"; they are dropped from the train ride timeline). By introducing an attention-guided function that files/indexes "ticks" to the long-lived events one is attending to, this modified version of the attentional gate clock can account for differences in felt duration even in cases where the events implicated take the same amount of objective time. In this way, instances of the dual task interference effect where, as in MUSICAL TRAIN RIDE, the secondary task also requires experiencing time can be accounted for.[40]

39. One could modify the model to account for partial attention so that when the subject is *partially* absorbed in a long-lived event, it still feels to her as though the short-lived events that compose this long-lived event are temporally related to other long-lived events. According to this modification, the subject would be more likely to undercount the short-lived events of the long-lived event she is less focused on, and hence, over time, she would end up feeling as though this long-lived event had a shorter duration.

40. One might object that since the event *listening to "Runaway Jim"* is part of the event TRAIN RIDE, the "tick"-count for the train ride should be at least as much as that for "Runaway Jim". But if so, the model cannot in fact explain the shorter felt duration of the train ride. The reply to this objection is that while it is objectively true that the event *listening to "Runaway Jim"* is part of the event TRAIN RIDE, this is not how you experience these events. As discussed in the text, while absorbed in the music, the short-lived events of "Runaway Jim" are not presented as temporally related to the train ride (or any other external event). The modified clock model I have proposed implements this experience by indexing the "ticks" produced while you are absorbed in the music *only* to "Runaway Jim", thereby delivering a larger "tick" count — and a longer duration feel — for "Runaway Jim" than for the train ride. Thanks to an anonymous referee for prompting me to clarify this.

3. Further Developments, Implications, and Extensions of the Model

3.1 Feature-Based Attention[41]

I have proposed that when absorbed in "Runaway Jim", you experience its sounds in temporal relation to it alone, and that this fragments your temporal experience. Could absorption have such effect on your experience? What attentional mechanism might be responsible for this?

Research on attention — mostly carried out in vision — has revealed that we can focus our attention not only on objects and on localized spatial regions, but also on specific *features* of the scene we are looking at, such as color, direction of motion, and orientation (*cfr.* Treue and Martínez-Trujillo, 2007; Maunsell and Treue, 2006; Treue and Katzner, 2007; and Freiwald, 2007; for a helpful review, see Carrasco, 2001). As with spatial- and object-directed attention, feature-based attention enhances the strength of the feature attended to at the expense of weakening the strength of other less relevant features. This type of attention is relevant in searching tasks.

Suppose you are looking for a blue t-shirt in your messy room. Attending to blueness enhances the blue elements within your visual field and weakens other elements such as shape, orientation, and other colors. Put differently, a concept such as *blueness* can be used by attention to magnify a certain feature in the visual field — i.e., blueness — at the cost of weakening other features irrelevant to this task.

As we have seen, listening to music involves attending to its temporal relations, and more specifically, being absorbed in a piece of music involves attending to its internal temporal relations alone. Suppose,

41. Thanks to Ned Block for a helpful discussion on this section and for drawing my attention to some of the empirical literature I cite below.

then, that when we become absorbed in "Runaway Jim", we do so by employing the concept *temporal-relations-internal-to-"Runaway Jim"*, which has the effect of enhancing these temporal relations at the expense of weakening other features irrelevant to the task, including the temporal relations that obtain between the sounds of "Runaway Jim" and external events such as the train ride, an upcoming meeting, and an earlier workout.[42] If so, feature-based attention could serve as the attentional mechanism that drives the temporal fragmentation characteristic of MUSICAL TRAIN RIDE.[43]

Inattentional blindness, the phenomenon where salient events go unperceived when unattended to (Mack and Rock, 1998; Most et al., 2005; Neisser and Becklen, 1975), can further explain why it is that when you are absorbed in the music, you do not *experience* the short-lived sounds of "Runaway Jim" as partaking in external time. For if attending closely to the internal temporal relations of "Runaway Jim" causes inattention to its external temporal relations, then, assuming this is an instance of inattentional blindness, the external temporal relations would not just be unattended to, but also unperceived.[44] In other words, focusing on the internal temporal relations of "Runaway Jim" makes one fail to experience its external temporal relations in much the same way that attending to a basketball match makes one fail to see the gorilla passing at the center of one's visual field (Simons and Chabris, 1999).[45]

3.2 Testing the Model

The research on process memory mentioned earlier suggests a way of testing the model. Recall that process memory is a type of memory that enables integration of past information in current information processing. Recall also that, as shown by Hasson et al. (2015), it is possible to determine the timescale of the information used by mapping its distinctive neural markers.[46] Given this, we should expect that when a subject is absorbed in a long-lived event, the strongest neural markers will be those that correspond to timescales of equal or lesser duration than the attended long-lived event, while neural markers for the longer timescales will be weaker or nonexistent. Conversely, when the subject is not absorbed, neural markers for the longer timescales will be relatively stronger.

For example, consider a case like MUSICAL TRAIN RIDE, but where a two-minute song is played at the end of a ten-minute train ride. When the music is playing and the subject is absorbed in it, we should expect

42. One may object that while this model serves to account for cases such as MUSICAL TRAIN RIDE, other cases are not so easily explained. For instance, when absorbed in experiencing pain, time seems to take longer. Let me say two things about pain cases. First, it is not clear that time seems to take longer during a painful experience. Thorn and Lee Hansell (1993) and Isler et al. (1987), for instance, suggest that, while in pain, subjects judge the duration of a time interval to be shorter than do subjects in the same condition but undergoing no pain. Second, it is likely that in such cases, factors other than attention (e.g., emotions) also play a relevant role in accounting for the subject's temporal experience. As noted earlier, at the end of section 2.1, my account does not attempt to capture the effects of all the factors, and the relations between them, that one would have to consider in giving a more comprehensive account of temporal experience.

43. Instead of feature-based attention, one could appeal to object-based attention, taking "Runaway Jim" as the attended object. But since "Runaway Jim" is too long-lived to be directly perceived — its boundaries lie outside of the immediate perceptual field — it will perhaps seem more natural to individuate it by attending to one of its unifying features, hence the appeal here to feature-based attention. For some studies suggesting that feature-based attention plays an important role in temporal experience, see, for instance, Macar et al. (1994) and Coull (2004). Thanks to E. J. Green for suggesting that I also consider object-based attention.

44. Note that on Zakay and Block's attentional gate clock discussed in sections 1 and 2.6, attention to time is also needed to *experience* — rather than to merely *notice* — time.

45. Alternatively, one may opt for a variation of the proposed model according to which, when absorbed in the music, one still experiences the temporal relations between the short-lived sounds of "Runaway Jim" and external long-lived events but fails to *notice* them. In this case, attention would produce a fragmentation of *noticed* time rather than of *felt* time.

46. Hasson and collaborators distinguished three different timescales: a short one (e.g., 10s to 100s of milliseconds), a medium one (e.g., several seconds), and a long one (e.g., 10s to 100s of seconds) (Hasson et al., 2015, 307). Testing the model in the way I have suggested would require either adapting the experimental case to these timescales or finding neural markers that make finer distinctions within the long timescale.

to find that neural markers for timescales equal to or less than two minutes are stronger than neural markers for longer timescales. If the experimental setting also ensures that during the first eight minutes, no music is played and nothing absorbs the subject's attention — e.g., there are no interesting conversations, no colorful views, and the environment is unconducive to deep thinking — then, during at least the last half of this eight-minute period, neural markers corresponding to timescales above two minutes should be more prominent, since the subject would be keeping track of the duration of the train ride (and of how it is temporally related to other salient long-lived events).

3.3 Thinking about Time

Besides MUSICAL TRAIN RIDE, the proposed model can account for the converse phenomenon: cases where thinking about time makes it feel as though more time has passed.

If, for example, while waiting at a bus stop, you continue thinking that the bus is late, the bus delay will feel longer than if you had you spent those five minutes focused on chatting with a bystander or reading the newspaper. Similarly, the train ride will feel much longer if, instead of immersing yourself in music, you spend the whole ride wondering how long it will take to reach your destination. How could merely *thinking* about time in this way have such effects on your experience?

As you focus on how the long-lived event you are currently experiencing is temporally related to other long-lived events in external time, the temporal relations between these long-lived events become more salient and their import on your experience is enhanced. For example, in the bus scenario just given, if you keep thinking that the bus is delayed as you try to read the newspaper, you will experience the short-lived events of reading the newspaper as simultaneous to the bus delay. The effect of this is experiencing time as passing for both events: your reading the newspaper and the bus delay. Consequently, the size of both mental timelines increases. But then, the more you think about the temporal relations that hold between your reading the newspaper and the bus delay, the longer the bus delay will feel like it is taking. Thus, constantly thinking about the temporal relations that hold between the event you are currently experiencing (e.g., reading the newspaper) and other long-lived events in external time (e.g., the bus delay) has the reverse effect of becoming absorbed in the music: It serves to experientially *integrate* the mental timelines of the various long-lived events, making it feel as though time passes for all of them.[47]

The above discussion implies that there is an upper limit to the effect that thinking about time has on the felt duration of any given event. This upper limit would be reached when every bit of a long-lived event is experienced as temporally related to another long-lived event in external time. In the above example, this would happen when every short-lived event of reading the newspaper is experienced as taking place while the bus is delayed. One would then experience complete temporal unity, in the sense that one would experience both events as thoroughly integrated into a single timeline.[48] Having such an experience may turn out to be practically impossible, since it would require having no distractions *at all* from attending to the temporal relations between the short-lived events of one long-lived event and other event(s) in external time. Still, one should expect that, at some point, the impact on felt duration of devoting more attention to these temporal relations will decrease in significance. While this strikes me as a plausible result, determining whether it obtains is ultimately an empirical question. Its exploration may lead to further ways of assessing the model.

Let me close by briefly exploring the plausibility of an analogous phenomenon in the case of space, that is, the idea that felt space can be fragmented.

47. Not all ways of thinking about time have the effect of increasing felt duration. For example, if during your train ride you become absorbed in trying to understand how time is related to space according to the general theory of relativity, or in ascertaining the best metaphysical theory of time, it will feel as though the train ride went by faster than usual (just as when you become absorbed in listening to "Runaway Jim").

48. Thanks to an anonymous referee for pointing this out.

3.4 Felt Space, Fragmented?

Is it plausible that paying close attention to the spatial relations of a larger, partly out-of-sight object has the effect of fragmenting felt space, just in the way that, as I have argued, absorption fragments felt time? That is, is it plausible that in paying close attention to spatial relations, we experience parts of the large object as spatially isolated from every other object, just as, in the case of time, we experience parts of a long-lived event as temporally isolated from every other event?[49] Let me share some thoughts that lend initial plausibility to the idea that felt space can be fragmented.

Consider the following.

> MURAL There is a quarter-mile-long mural painted on a long wall at your university campus. You know that walking along the mural leads directly to the main library. As you walk by the mural's initial images, you feel like you are approaching the library. But the mural is fascinating, and so as you walk further, you become completely taken in by it. As you continue attending to the mural while you walk, it no longer feels as though you are walking toward the library — as far as your experience goes, the mural could be anywhere! Then, as you proceed to view the mural's final images, you catch a glimpse of the library's entrance. This throws you off, since it doesn't feel like you walked *that* far.

We can contrast this case with one where you find the mural utterly boring. As you walk alongside the wall, you keep wondering how much further away the end is. In this case, you are not at all surprised when you see the entrance to the library: Every step has felt as though it's taking you closer to it. Note also that — in analogy with TEMPORALITY IN MUSIC — appreciating the mural requires experiencing its spatial features — the spatial configuration of its various figures, colors, textures, etc.[50] But then, it is at least phenomenologically plausible that we have here a form of spatial fragmentation that is analogous to the temporal fragmentation proposed in MUSICAL TRAIN RIDE. While you are attentively experiencing the mural's internal space, you do not experience the mural as integrated into the larger, external spatial environment.[51]

Moreover, there is empirical evidence supporting the idea that felt space can become fragmented. For example, Wang and Brockmole (2003, 398) argue that "[s]ubjects can acquire new spatial representations easily without integrating them into their existing spatial knowledge system". They go as far as to suggest that "this fragmentation may be the primary property of the human spatial navigation system" (Wang & Brockmole, 2003, 403). They studied how a subject's mental map of a newly encountered space — in this case, their lab — relates to the mental map the subject has previously formed of the larger out-of-sight space where the newly encountered space is embedded — in this case, the university campus traversed to arrive to the lab. Was their mental map of the lab integrated with their mental

49. Thanks to an anonymous referee for prompting me to discuss this.

50. The following supports the idea that, as in the temporal case, in the spatial case we are also dealing with a genuine experiential — as opposed to merely cognitive — phenomenon. Think, for example, of cases where you know — maybe because you are looking at your well-functioning GPS — that your friend's house is a few blocks to your right. Yet, as you turn right, and even as you get a glimpse of her front door, it may still feel to you as though her house is to your left — you simply can't shake off the feeling of walking in the wrong direction! This would make no sense if there were no such thing as what it is like to feel like something is spatially related in this or that way with respect to a larger environment that is not directly perceptually accessible to you, over and above simply believing that it is so. Or think of "blindly" following your GPS in trying to reach a destination: While you may know where the place you are currently at lies in respect to your desired destination — e.g., you see the path between the two places clearly marked on the map displayed on your GPS — you may not feel as though what you see is to your right or to your left. Without your GPS, your sense of location would not help you find your way. For some empirical studies on spatial navigation of out-of-sight environments, see, for instance, Golledge (1999), Carlson et al. (2010), and Wang & Brockmole (2003).

51. Note that spatial and temporal relations need not be the only things that drop out of your experience while absorbed — you might also momentarily lose awareness of your hunger or of your tired feet.

map of the university campus? Their results show that "subjects greatly misaligned their representation of the campus with its actual spatial layout" and that they "did not establish the link between the new environment and their existing knowledge of the campus, despite their direct navigation from campus to the room" (Wang & Brockmole, 2003, 400). Their results challenge traditional views (*cfr*. Stevens & Coupe, 1978) according to which spatial hierarchical representations are always integrated: "In our navigation task, subjects failed to establish the directional link between different 'units'; therefore, they constantly lost track of one environment when they reoriented themselves to the other one" (Wang & Brockmole, 2003, 403). As they further note, this does not suggest

> *that fragments of spatial knowledge can never be combined or integrated*. Studies have shown that, under some conditions, new spatial knowledge is encoded in correct relationship to existing knowledge when common landmarks are available (e.g., Golledge, Ruggles, Pellegrino, & Gale, 1993; Montello & Pick, 1993). It is also easily conceivable that some levels of integration of spatial information will occur during repeated navigation, although sometimes the limitation can be quite profound (e.g., Brockmole & Wang, 2002; Moeser, 1988). (Wang & Brockmole, 2003, 403, my emphasis).

It remains to be established whether this spatial fragmentation is driven by attention in a way analogous to what has been here proposed for the temporal case. To test this, one could modify Wang and Brockmole's experimental setting so that it comes closer to MURAL: There could be a large, attention-grabbing object (e.g., a mural) across the university campus that the subjects traverse, and the experimenters could test whether this makes it more or less likely that the subjects feel as though the large object is spatially isolated from the university campus in which it is embedded. If spatial fragmentation is driven by attention, one would expect that — *ceteris paribus* — this would be so.[52]

4. Conclusion

I have offered a novel way of thinking about the long-suspected connection between attention and temporal experience. On this view, attention temporally isolates or fragments the attended event from external time — that is, from the wider, temporal horizon where other events are located. One then experiences time only as passing in this branch, creating the sensation — upon reintegration — that less external time has passed. I have also suggested how the reintegration of felt time may be driven by thought. Against competing, influential accounts, I have argued that this view succeeds in explaining familiar temporal experiences that the competing views leave unexplained. Along the way, a number of objections have been considered and responded to. I have also shown that current empirical findings fit well with the key assumptions of this model, and I have suggested ways to empirically test it.[53*]

52. The experimental design would have to control for any interactions between our spatial and temporal representations in cases like this. Note also that, as with the temporal case, one may here opt for a modified version of the view, where the subject would still experience the object as spatially related to objects in external space but fail to notice these relations.

53. * I have benefitted from presenting this paper in many venues. For helpful discussions, thank you to the organizers and participants of: Metaphysics Ranch Conference (2015); AAMPh Syracuse (2016); UCLA Colloquium Talk (2015); Laurie Paul's UNC Chapel Hill Graduate Seminar *Experience, Time, and Self* (2015); *Symposium on the Experience of Time* at the Central APA (2015); *Time and Causation Workshop* at Cologne (2015); SPAWN on Consciousness at Syracuse (2015); ASU WIP (2015); Mentoring Women in Philosophy Workshop at UM-Amherst (2015); *Temporal Experience Workshop* at Sydney University (2015); UNAM (2015); *Midsummer Philosophy Conference* at Cambridge (2016); MIT WIP (2017); and UNCUT II at Chapel Hill (2019). For helpful comments on earlier versions of this paper, special thanks to: John Campbell, Enrique Chávez-Arvizu, Philippe Chuard, Alison Fernandez, André Gallois, Geoffrey Lee, Jorge Morales, and Robin Zheng. For useful feedback and discussion, many thanks also to Ya'ir Aizenman, Elizabeth Barnes, Ned Block, Brookes Brown, Alex Byrne, Dave Chalmers, Alejandro Correa, Nina Emery, Maite Ezcurdia, E. J. Green, Mark Johnston, Boris Kment, Bernard Kobes, Sarah-Jane

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