A Quantum Theory of Felt Duration

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It's a few minutes before 8 pm and you are running late for tonight's dance show. On your way into the theater, you see your friend Peter just coming out. As you both exchange a few remarks, you ask him how long the show lasted. He says: "I left my watch at home, but it *felt* like it went on for about an hour and a half."

Like Peter, we usually experience events as having particular durations. The experienced duration of an event can come apart from the actual temporal length of the event. That is, there can be illusions of felt duration as the following cases illustrate.

THE SURPRISE PARTY

> Your friends organized a fun surprise party for you. Two hours into the party you look at the watch with astonishment: you can't believe it's that late! *It feels like the party has just started.*

THE BORING MOVIE

> You entered the theater expecting a comedy. The movie turned out to be a flat, silly story, with not much going for it. It's the fourth time you check your watch: you can't believe time is passing so slowly! *What you've experienced as an hour has not really been more than twenty-five minutes.*

The coherence of these and similar cases suggests that there is something that it is like to experience an event as lasting for a particular amount of time. Otherwise it would not make sense to be surprised when you learn that the party or the movie was, respectively, a lot longer or shorter than it *felt*. The subjective sense of duration is captured in everyday expressions like "Time flies when you're having fun" or "A watched pot never boils". In using these expressions, we give voice to the idea that a certain event is *experienced* as taking either a much shorter or longer amount of time than it in fact takes.

My aim in this paper is to offer a novel theory of this phenomenon. More precisely, I aim at offering a theory of our experience of duration according to which the following must be accounted for.

EXPERIENCE OF DURATION Usually, we experience the events we perceive as having durations and this provides the basis for our immediate judgments about the duration of those events.

EXPERIENCE OF DURATION will thus be the datum to be explained.

To appreciate what is at issue, consider denying EXPERIENCE OF DURATION by claiming that we do not really experience the events we perceive as having durations. This would be tantamount to claiming that, with respect to the durations of everyday events like dances, parties, and movie screenings, we are zombie-like. That is, there would be nothing that is what it is like to experience duration. I find this very hard to believe. Indeed, the opposite seems to be the case: it is very unusual to go through an event without *experiencing* it as having some duration or other.

Contrast experiencing the dance show as lasting for about an hour and a half with, upon waking up, *guessing* the duration of your nap by saying the amount of time that first pops into your mind. Or contrast this experience with *estimating* the duration of your nap by looking at the positions of the Sun before and after you sleep. In the former case, you simply find yourself making the judgment; in the latter, you make it on the basis of an inference. In neither case is the judgment based on your *experience* of the nap as having a certain duration.

Throughout the discussion, it will thus be important to keep in mind that EXPERIENCE OF DURATION is not *just* a claim about duration judgments. Instead, it is the claim that we usually *experience* events as having durations and that we form corresponding judgments on the basis of these experiences. In other words, it is usually *because* we experience the event as having a certain duration that we form a judgment about its duration. I will use *felt duration* as a name for the experience of an event as having a certain duration, the what-it's-like to experience it as lasting for a certain amount of time. In THE BORING MOVIE case, I will thus say that while the movie's duration was twenty-five minutes, its felt duration was one hour.

I begin section II by considering proposals from the psychological literature. I then explain why I do not think they can be used as accounts of felt duration that vindicate the datum. My positive account begins in section III. According to the theory I will present, there is a specific duration such that, usually, experiencing an event as having that duration has a particular phenomenal quality, a particular feeling. This is the duration characteristic of what I call *a quantum*. After introducing this idea, section IV puts it to work. I there develop a theory according to which while a quantum provides the basis for our subjective measuring system of duration it also marks a natural division between two distinct ways of experiencing duration, which must be recognized by any adequate theory of felt duration. In developing the positive account, I focus first on the good cases: those in which our experience of the duration of an event is not misleading. In section V, I turn to duration illusions. These come in different types, each requiring its own treatment. I hope to show that the theory offers an interesting and explanatorily powerful way of characterizing our experience of duration. The remainder of this introductory section presents a feature of felt duration that will be relevant throughout the paper.

Short- vs. Long-Lived Events

The duration of an event is the sum of the durations of all its non-overlapping, proper temporal parts or, as I will call them, *slices*. So, while a part of an object and the object can have the same color (if, for example, the object is red all over), a slice of an event and the whole event cannot have the same duration. Furthermore, while one can see the color of an object that is not wholly visible in one glance by seeing just a part of it, one cannot likewise experience the duration of a long-lasting event by experiencing one of its slices.

Consider the dance show. If the curtain is red all over, by sneaking into the theater and seeing a bit of the curtain Peter could get to see the color of the curtain. He could not, however, experience the duration of the whole dance by sticking his head into the theater and experiencing the duration of one of the dancer's pirouettes. For this, he needs to patiently stay in the theater and experience many more bits of the show. This suggests that if he experiences the duration of the whole dance at all, he experiences it differently

from the way he experiences the duration of shorter-lived events whose duration he can take in at one glance.

This idea has been well acknowledged within the psychological literature, where it has been widely held that the way in which we experience durations at the millisecond level is not the way in which we experience durations within the second-and-above range.[1] This literature has been mainly concerned with studying intervals between 100 milliseconds and a few seconds. The difference is sometimes stated as one between *sensing* and *cognizing* duration.[2]

Let a *short-lived* event be one whose duration can be taken in with one single act of looking, smelling, touching, tasting, or hearing and assume that these fall, roughly, within the milliseconds to a few seconds range. Let a *long-lived* event be one whose duration is too long to be taken in this way; let's assume that they last for at least more than a few seconds. The idea that we experience the duration of short- and long-lived events in different ways will be a premise throughout this discussion.

II.
Psychological Models

In this section, I discuss three models proposed in the experimental psychological literature: a sub-personal pacemaker and two state-dependent models, one based on attention and the other on levels of neural energy. Despite their differences, they all share a single strategy commonly appealed to in this literature. After presenting the models and

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[1] As the discussion in section III will illustrate, the distinction between experiencing durations from the millisecond to second range and experiencing longer durations is also supported by phenomenological considerations.

[2] In his literature review, Grondin, for instance, writes:

> Many researchers in the field of time perception—mainly those adopting a neuroscientific perspective […]—have emphasized a distinction between intervals above and below 1 sec (Penney & Vaitilingam, 2008). *This distinction is based on differential pharmacological effects* (Rammsayer, 2008) *and on the fact that the processing of smaller intervals is sensory based, or benefits from some automatic processing, whereas the processing of longer intervals requires the support of cognitive resources […]*. (Grondin, 2010, 564, my emphasis).

Eagleman and Pariyadath make the same point in the following passage of the paper where they propose the neural energy model that will be discussed in the following section:

> We focus here on timing mechanisms that underlie judgments at the 'automatic' or 'direct sensation' time scale, i.e. on the scale of tens to hundreds of milliseconds (*timing of longer scales, such as seconds and minutes and months are categorized as 'cognitive' and appear to be underpinned by entirely different neural mechanisms* […]). (Eagleman and Pariyadath, 2009, 1841, my emphasis).

explaining this strategy, I go on to say why, even if each model could overcome the empirical difficulties it faces, none could serve as an account of felt duration that vindicates the datum. I finally suggest, however, that some features of these models could be taken up as insights in a theory of felt duration.

Two clarifications are in order. First, the models are targeted at short-lived events and thus, if correct, would have to be supplemented with a corresponding model for long-lived events. Second, sometimes these models are presented as accounting for duration experiences. Other times, however, they are presented as accounting only for duration judgments.[3] Despite this, since our interest is in felt duration, I will understand them as models of our experiences of duration *whether or not this is how they were intended by their proponents*. So even when I think that many times the models *are* intended as accounts of our experiences of duration, my discussion is not aimed at showing that they are right or wrong as they were proposed: I am not concerned with exegetical matters. The question instead is whether or not they *could* be offered as explanations of felt duration that do justice to the datum. My claim is that they could not. I also hope the discussion sheds light on what we should expect from a theory of felt duration.

Sub-Personal Pacemakers

Prominent within the psychological literature are what I call *sub-personal pacemakers*.[4] The idea is that some brain process is responsible for generating 'ticks' at a roughly constant rate. The 'ticks' produced during the presence of a stimulus are accumulated and counted. The number of 'ticks' thus collected determines how long the stimulus is experienced as lasting. In these models, the 'ticks' are only sub-personally available.

Consider one of these models, an *information pacemaker*. According to this, the brain's rate of information processing is what generates the 'ticks'. When a fixed amount of information is processed a 'tick' is produced. By counting the 'ticks' accumulated in the presence of a stimulus and assuming that the brain's information processing rate is

[3] Most of the times the discussions go back and forth between talking of subjective duration, experiencing duration, appearing duration, estimated duration, and judged duration.
[4] See, for instance, (Treisman, 1963) and more recently (Tse *et al.*, 2004) and (Ulrich *et al.* 2006).

roughly constant, the pacemaker can determine the amount of time the stimulus was presented. Duration illusions are explained by arguing that factors like attention or emotion affect the brain's rate of information processing. Attending to a stimulus would, for example, increase the amount of information processed, which would then cause the pacemaker to accumulate more 'ticks'. This would result in an experience of the stimulus as lasting longer.[5]

Against this model, it has been claimed that our brains process different types of information at different rates.[6] For example, the processing rates for signals from different sensory modalities differ: it takes longer to process visual information than auditory information. Despite this, auditory and visual signals received within a short time window (approximately 80 ms) are experienced as in synchrony. For instance, if you utter some words in front of me, I process the visual and the auditory signals at different rates but experience the movements of your lips and the sounds you produce as in synchrony.[7]

One might think that the reason for this is that the amount of information processed that counts as a tick varies across modalities. Thus, instead of a single pacemaker, what is needed is one *per sensory modality*, with the amount of information processed that counts as a tick varying for each.[8] According to some studies, however, the felt duration of a stimulus from one sensory modality can affect the duration that a stimulus from a different modality is experienced as having.[9] For the model to account for cross-modal effects like this, the various pacemakers would have to interact in

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[5] Tse *et al.* explain that "[i]f attending to a stimulus boosts information processing of that stimulus, the counter would count more units, and subjective time would expand." (Tse *et al.*, 2004, 1172).

[6] See Eagleman et al. (2005, p. 10371). This point is nicely made in Eagleman's essay *Brain Time* on his website, http://eaglemanlab.net/time (accessed on Sept. 25th, 2012). The example is also taken from this essay.

[7] As Eagleman points out, this is why sounds and not light flashes are used as the *go* signals in short distance running competitions: our reaction is faster in the former case. Cf. Eagleman (2005) and http://eaglemanlab.net/time (accessed on Sept. 25th, 2012). The example is taken from his essay *Brain Time*, found in this website. On the timing studies, Eagleman refers back to Di Lollo, (1977). In Eagleman and Pariyadath (2009), it is also argued that sub-personal pacemaker models for short-lived events have not found support from neurophysiology studies.

[8] A proposal similar to this is mentioned in van Wassenhove et al. (2008, p. 1).

[9] In one of these studies, van Wassenhove et al. (2008) aimed at testing whether the stimuli from one sensory modality could affect the duration judgments of a different modality. As they write, the results suggest "the existence of multisensory interactions in the perception of duration and, importantly, […] that *vision can modify auditory temporal perception* in a pure timing task." van Wassenhove et al. (2008, p. 1, my emphasis).

complicated ways. This has been taken to cast some doubt on sub-personal pacemakers and motivated the proposal of alternative models.[10]

State-Dependent Models

State-dependent models have been proposed as an alternative to sub-personal pacemakers. According to these models, there is no need for a counter: features of the patterns of our neural states can directly determine the felt duration of the short-lived event that serves as the stimulus.[11] To illustrate, consider an attention-based model. According to this, the features of our neural states encoding the level of attention that is directed towards the stimulus are what determine the felt duration for that stimulus.[12]

Attention-based models were thought to offer an attractive explanation of a commonly discussed phenomenon within this literature, the oddball effect. When a novel stimulus, the 'oddball', is presented in a sequence of repetitions of a different stimulus, it is experienced as taking more time than any of the repeated stimuli, even when they all have the same objective duration.[13] The proposed explanation is that the novelty of the oddball attracts more attention. If the level of attention directed towards an object is what determines its felt duration, this would explain why the oddball appears to last longer. Some experimental results, however, tell against this. For if felt duration is determined solely by those features encoding the levels of attention then, contrary to what has been observed, the felt duration of the oddball should increase if the oddball is more attention-grabbing, for example, if it is a tarantula as opposed to a shoe.[14] Despite this, the two stimuli have the same felt duration.[15]

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[10] Cf. van Wassenhove et al. (2008, especially p. 8).
[11] See, for instance, Ivry and Schlerf (2008) and Karmarkar and Buonomano (2007). For a discussion of these models, see also Grondin (2010, pp. 567-568).
[12] Cf. Grondin (2010, pp. 565-568) and Eagleman and Pariyadath (2009).
[13] See, for instance, Pariyadath and Eagleman (2007), Eagleman and Pariyadath (2009), and Tse et al. (2004).
[14] See Pariyadath and Eagleman (2007) and Eagleman and Pariyadath (2009). As they argue, the experiments also tell against the hypothesis that the saliency of the object is what is relevant. The example is taken from Eagleman and Pariyadath (2009).
[15] In the case of an information pacemaker, since attention need not be the only factor affecting the pacemaker's rate of information processing, it can be claimed that different factors are involved in different cases. For example, in Tse et al. (2004) it is argued that the oddball causes an increase in *arousal* that raises the rate of information processing. A consistent account of what are the relevant factors affecting the pacemaker and how they interact would still be needed.

A different, though related, proposal holds that what determines felt duration is not the level of attention encoded in the neural state but *the amount of neural energy* involved in experiencing the stimulus.[16] According to this proposal, it is the unpredictability of the stimuli, something shared by the shoe and the tarantula, that explains why they both have the same felt duration.[17] Because the oddball is less predictable than the repeated stimuli, more neural energy is involved in seeing it and thus it is experienced as lasting longer.

The predictability of the object, however, cannot be the only factor determining the level of neural energy. For then, given that looming and receding oddballs are equally unpredictable, they should be experienced as having the same durations.[18] However, a looming oddball presented in a train of steady stimuli appears to last longer than a receding oddball, even if they all have the same objective duration.[19] This model would thus need to explain which further factors are involved and just how they interact to produce the required effects on the levels of neural energy. An account of exactly which neural responses involved are relevant would also be needed.[20] Other models explore the idea that the emotional level involved in the experience is what is crucial.[21] Levels of arousal and the saliency of the object have also been thought to be relevant.[22]

All of these proposals share the same strategy: a certain factor—be it the amount of information processed, the level of attention encoded in a neural state, or the amount of neural energy involved in experiencing the stimulus—is either an input, an output, or a

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[16] As explained by Eagleman and Pariyadath (2009), the idea is, roughly, that the felt duration of a stimulus reflects the size of the corresponding neural response.
[17] Eagleman and Pariyadath (2009).
[18] See van Wassenhove et al. (2008).
[19] In van Wassenhove et al. (2008, pp. 6-7) it is reported that: "[S]ubjective time dilation was consistently found in auditory, visual and auditory-visual presentations for a visual stimulus increasing in size, and an auditory event increasing in frequency (Loom experiment). […]Second, a decrease in visual size and auditory frequency (Recede experiment) did not lead to significant distortions of subjective time." They also reported that "a looming disc embedded in a series of steady discs led to time dilation, whereas a steady disc embedded in a series of looming discs led to time compression" van Wassenhove et al. (2008, p. 1). They suggest that the *saliency* of the object is the major factor affecting felt duration.
[20] Eagleman and Pariyadath acknowledge this. See Eagleman and Pariyadath, (2009, pp.1846-1847). Other problems raised for state-dependent models is how they can work in noisy environments and how the dynamics of the neural patterns could speed up or slow down in cases of duration illusions. Cf. Eagleman and Pariyadath, (2009).
[21] On this, see the section on emotions in Grondin, (2010, pp. 566-567).
[22] van Wassenhove et al, (2008).

feature of a sub-personal mechanism. Each of these factors is different from, but thought to be strongly correlated with, the duration of the stimulus.

One advantage of this strategy is that it allows for an easy explanation of duration illusions: cases in which, as we have seen, the stimulus is experienced as lasting more or less time than it actually lasts. Indeed, the accounts are tailor-made for this. Since according to these models what determines the duration experienced is a factor distinct from but correlated with the duration of the stimulus, they can explain the illusions by offering a plausible explanation of why this factor and the duration of the stimulus come apart.

The main problem with these models, however, is that *no features of our experiences get to play any role in them*. This raises the following questions: how could any of these mechanisms account for what *felt* duration is, of what is characteristic of *experiencing* duration? Also, why would the experience determined by any of these mechanisms be an experience *of the duration of the stimulus* as opposed to an experience of the level of attention directed towards the stimulus, the amount of neural energy devoted to experiencing it, or whatever else is taken to be correlated with the duration of the stimulus? Moreover, why do any of these mechanisms determine *any experience at all* as opposed to only a duration judgment? Nothing in these proposals allows us to give answers to these questions.

Because the theories offer no reasons to think that the mechanisms proposed ground our experiences of duration as opposed to either the duration judgments directly or an experience of something else that generates them, *these same theories can and have been offered as accounts of duration judgments that deny or remain silent about there being corresponding duration experiences.* This is bad news for someone trying to vindicate the datum. For in reporting that the stimulus was experienced as having a certain duration the subject could turn out to be either like someone guessing the duration of her nap by saying the number that first pops into her mind or like someone estimating it based on the positions of the Sun. In either case, the theories that are supposed to account for our experience of duration would have us be, relative to the duration of the stimulus, zombie-like. For this reason, none of these can be the complete explanation of the intuition that I judge the oddball to last longer than the repeated stimuli *because of*

what I saw, as opposed to because my brain operates in such and such ways.

One moral of this discussion is that the account of felt duration we are looking for should be distinguished from accounts of the organism's sub-personal mechanisms for keeping track of time. While these have various effects on a wide variety of processes of our bodies (e.g. neuron-firing, enzyme and hormonal production, pregnancy) and some may or may not be what underlie our experiences of events as having durations, in so far as they do not involve our experiences, they will be of no interest to us here. If the datum is true, there should be a way of explaining what *felt duration* is; that is, a way of characterizing just how we experience events as having different and yet comparable durations.

What we want then is a theory that characterizes what felt duration is, what is distinctive about it, and which can explain how in certain temporal illusions felt duration can radically diverge from real duration. This theory should explain how features of our experiences are relevant in giving rise to different duration judgments. Some of the factors already discussed such as attention or emotion might still have a role to play in such a theory. They could affect the *experiential features* that give rise to an overall experience of an event as lasting for a particular amount of time. In the rest of the paper, I aim at offering a theory of this form.

Crucial to this theory will be the idea that there is a specific duration such that, usually, experiencing an event as having that duration has a particular phenomenal quality, a particular feeling. This duration is the duration characteristic of what I call *a quantum*: the longest-lived temporal slice of a situation that is normally experienced as a 'tightly unified' whole. My hypothesis is that although the temporal length of particular quanta can vary, typically they have roughly the same duration. Characteristically, they last for less than a couple of seconds.

Think of hearing an arpeggio. Each note is played and heard as being played at a different time; still, the arpeggio is experienced as a whole. Or think of seeing a dancer make a pirouette. While the pirouette takes some time, it is seen as one cohesive movement. Or think of going through a syllogistic inference 'in one's mind'. The premises and the conclusion are experienced as mutually holding each other into a compact whole. Each of these exhibits a tight kind of unity not found across longer-lived

conscious episodes. Contrast the feeling of unity in each of these cases with the lack of it in, for example, the hearing of a whole symphony, or the seeing of the whole dance, or the going through the argument of a long paper. The felt unity featured in the first three cases is what characterizes experiencing a quantum.

In the next section, I aim to make this idea clear. This is important because as we will see in section IV, we experience the durations of other events in terms of quanta.

III.

The Basic Unit: A Quantum

Consider the following.

THE BERLIN WALL

> Take some position such that, by standing on it and directly facing the Berlin Wall, one can take a good look at a small, colorful section of it. From this position, the paintings on the bricks are plainly visible and nothing other than this part of the wall is visible: one does not, for instance, also see a bit of the ground. Let this position be *the spot*. Consider someone, some years ago, standing at the spot and staring directly at the wall. Let her be *the viewer*.

By standing at the spot and looking straight, the viewer sees the colors, sizes, shapes, and other visible qualities of a part of the wall. She does not, for instance, see the whole wall at once, or as I will say, *in one glance*.

It is important to distinguish the qualities seen in a glance from the glance itself. Suppose all one sees in a glance is white. Seeing white is different from white. Seeing white is a visual experience of white. White, however, is the quality being seen, something that might or might not be seen on a given occasion. More generally, the experiencing (visually or otherwise) of a quality and the quality experienced are distinct. I will also refer to the qualities of an object—items like the particular whiteness or roundedness of this or that figure on the wall—as its *features*.[23]

[23] *Qualities* or *features*, thus, refer to particular items like the redness or roundedness of this or that figure on the Berlin Wall. The notions are intended to be non-committal as to what is the best metaphysical way of characterizing these items.

Typically, however, we do not just experience in one glance one quality but many. In one glance from the spot, for instance, the viewer can experience the various colors, sizes, and shapes of that part of the wall. We should also then distinguish the *act of experiencing* a collection of qualities—in this case, the glance—from the *collection of qualities* being experienced. A *glance* thus is a single act of visually experiencing some part of the scene before one; an act of seeing. Let *a look* be a collection of qualities that can be seen in one glance.[24] [25]

Importantly, the qualities experienced in a glance, those that constitute the corresponding look, are not experienced as being unrelated to each other. Rather, they are experienced as composing a tight unity. They are all presented as being there together, as forming a cohesive, interrelated whole. Contrast the felt unity in the qualities of the section of the wall seen from the spot with the lack of it in the qualities seen through a journey of walking along the whole of the Berlin Wall while viewing all the graffiti painted on it.

To illustrate, consider again the look of the wall taken in by the viewer from the spot and imagine it has a red speck and a blue spot in its right and left extremes, respectively, as depicted in figure 1.

[24] The idea of *a look* captures one of the senses in which we commonly use the phrase "a way something looks". What we refer to with this phrase is to the particular look that the thing or, more generally, the situation encountered has under those specific conditions: from a certain distance, at a certain temperature, when having a dark background, etc. Under different conditions, a particular thing or situation might exhibit different qualities, and hence, under different conditions, the situation can have different looks. When, for instance, you say that the way the sunset looked yesterday made you think of the beach, you would be expressing the idea that the collection of qualities exhibited by yesterday's sunset made you think of the beach.

[25] Not all the qualities of an object or situation need to be part of its look. Objects might have qualities that we might not be able to experience. We must then distinguish the look of a thing or situation, which includes only those qualities *that can be taken in by a glance*, from the collection of *all* of its qualities.

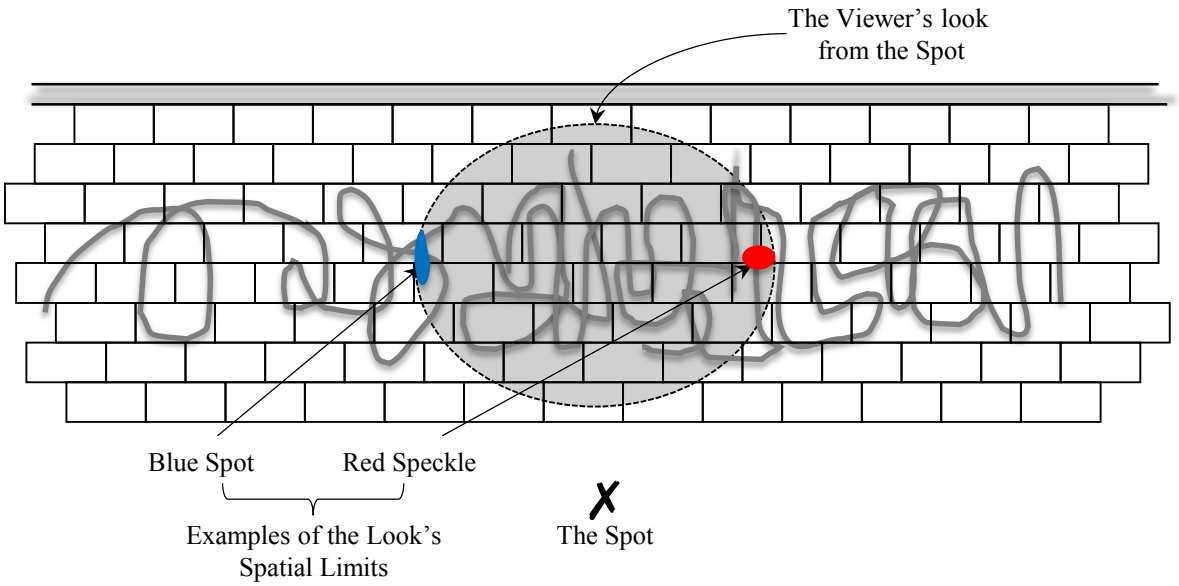

Figure 1. *The Berlin Wall*

Suppose now that we extend the sides of this look one foot on each side. We can imagine a creature that could take in this slightly wider look from the spot. By doing this over and again, we can form a series that begins with the viewer and ends with a creature that could see the whole wall from the spot. Figure 2 depicts some of these looks.

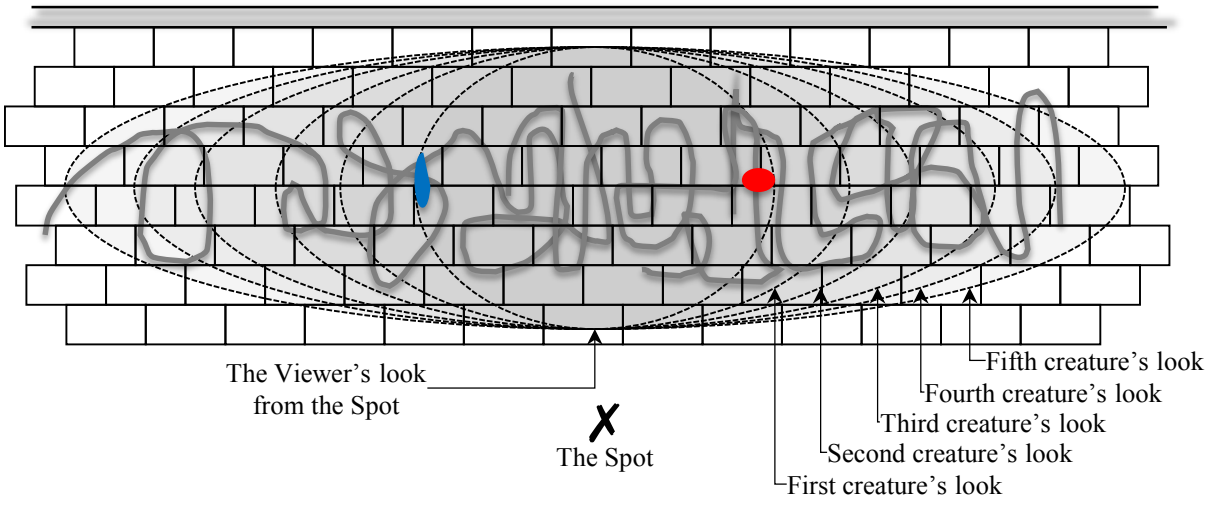

Figure 2. *The wall's different looks, as seen by different creatures*

Let us further stipulate that if any of these creatures were to walk along the wall and take in all of its visible qualities, they would all take in the very same qualities of the

wall.[26] Despite this, for each creature in this series, her experience of taking in all the visible qualities of the surface of the wall will be different from the way it goes with the other creatures. The relevant difference shows up in *the number of glances and corresponding looks* that it takes each of them to see all of the wall's qualities.

Consider, for instance, the last creature of our series. The viewer, by walking along the wall and glancing over it various times, and this creature, by exercising his super-powered vision and taking in at one glance all the visual qualities on the surface of the wall, both see exactly the same qualities of the wall. However, they see them differently. They take in different looks of the wall. While for the creature the qualities of the wall are all seen as being there side by side, in one coherent, interrelated unity, for the viewer they are seen as forming many different such wholes. In one glance from the spot, for instance, the creature can, while the viewer cannot, see the colors at the far extremes of the wall. This is why if the viewer wants to compare the tones of red at the two extremes, she has to *remember* how the red at one extreme looked while she stares at the red on the other extreme. The creature need not use his memory for this: the look he takes in already has both tones of red in it.

Thus, the number of glances in which the qualities of an object are taken in has effects on the overall experience of these qualities. The features in the same look, those seen in the same glance, will typically be experienced as tightly united, as forming an experiential whole.[27] Let the feeling of unity characteristic of experiencing the features of a look be its *phenomenal tightness*.[28] The features of a look are not just experienced as forming a unity but also as forming a *spatially bounded* whole. Let the feeling of spatial boundedness associated with experiencing the features of a look be called *spatial phenomenal boundedness*.

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[26] This stipulation is needed because which qualities are parts of which wholes might affect how they are seen. The redness of a spot on the wall, for instance, might not be seen in the same way if it is seen in a look that has blue in it. For the purposes of this paper, I will abstract away from these effects.

[27] Most of the time the qualities that constitute the look are seen as tightly unified. In pathological cases, however, the degree of tightness with which these qualities are seen can be disrupted.

[28] This felt unity and boundedness is also exhibited when the viewer has an afterimage as of bright yellow spots: even if there is no yellow spot in the wall, the yellow spot that the viewer sees as an afterimage is seen, say, as to the side of the red patch of the wall and as being part of the interrelated unity of which all the seen qualities seem to partake.

I will also say that the qualities or features of a look that are seen as occupying the outermost spatial positions of what is experienced in that look are the look's *spatial phenomenal limits.* Relative to the plane of the wall, the blue spot and the red speck in the look depicted in figure 1 would be the spatial phenomenal limits of that look.[29]

A Series of Objects

Just as we can order possible creatures by the number of glances it takes them to see the entire length of a given object at a given distance, we can likewise order large objects by the number of glances it takes a given type of creature, at a given distance from the object, to see the full extent of those objects. Consider such a series for creatures like us from a vantage point of a few steps away. From that distance, we could see a small car or a large elephant in one glance and hence as within the space delimited by the spatial phenomenal limits of the corresponding look. These objects will thus occupy the first position in the series. Seeing the full width of a soccer field when standing a few steps away from its sideline takes perhaps a minimum of fifteen glances. Hence, soccer fields will occupy the 15th position in the series. If seeing the entire Berlin Wall requires roughly the same number of glances as seeing the longest coast of Puerto Rico from a few steps away then both will take the same position in the series, further away from cars, elephants, and soccer fields.

The relevance of this series for our purposes is this. It delivers a rough ordering of large objects in terms of their relative lengths. Crucially, the ordering is arrived at *merely by considering the ways in which the objects are experienced*. That is, in forming the series, we exploited the experiential differences, illustrated through the Berlin Wall example, that arise from seeing the full extent of an object in different number of glances. Since, roughly, the larger the object is, the more glances it takes to see its full length from a fixed distance, the experiential features associated with seeing an object in a particular

[29] Spatial phenomenal limits are relative to looks. In our example, it is not enough to say that the viewer sees the blue spot and the red speck as spatially delimiting what the she sees. For if she were to walk to the right or to the left, she would see other qualities as being spatially positioned further to the right or to the left of the red speck and the blue spot, respectively. In other words, she doesn't take the object seen, the wall, as being delimited by the blue spot and the red speckle. Rather, it is the look, the collection of features of the wall experienced as forming one same whole, what is experienced as being spatially delimited by these. To capture the way in which these qualities are experienced, thus, we need to make reference to the look of which they are part.

number of glances—its phenomenal tightness and spatial phenomenal boundedness—can serve to give us a comparative sense of how big the object is. Put differently, the unit in terms of which the objects in this series are measured and ordered is subjectively defined: it is the longest section of an object that can be seen in the glance in which a subject typically experiences this object from a fixed distance away. We could, in effect, experience the spatial size of an object by experiencing how many glances from a given vantage point are required to take the whole object in. As will become clear, a similar idea will play a central role in the account of felt duration for long-lived events that I will offer.

Experiencing Temporal Features

In addition to colors, sizes, shapes and other such qualities, in a glance we also take in temporal features like brief changes, durations, and successions. Consider Peter's experience of a slice of the dance.

THE DANCE SHOW

> Take one of the pirouettes towards the end of the performance. From his seat, Peter can see the whole pirouette in one glance: he can see the dancer turning as she speeds up and presses her arms towards her body and then opens them up again as she slows a bit to settle in a beautiful position that makes the audience freeze in awe.

Apart from features like the orange of the dancer's suit or the shape of her figure, in the look taken in, Peter also sees some changes: the change in position along the dancer's own axis; the speeding up and down as she turns, and the stillness of her body as she takes the ending position. He also experiences their ordering: he sees the slowing of the turn as coming *after* its speeding up; the reaching out of her arms as *preceding* the movement in which she presses them against her chest; the ending posture as *the last in a succession* of rapid movements. All these temporal features are part of the same look of the dance Peter takes in.

Unlike the pirouette, however, Peter cannot see the whole dance in one glance. His experience of the dance does not exhibit the tightness of his seeing the pirouette. In this respect, his experience is like the viewer's experience of the whole Berlin Wall. Just

as in one glance the viewer can experience some of the qualities of the wall—the colors and shapes of a part of it—Peter can experience some of the turns, jumps, and stretches of the dancers in one glance. However, taking in all of the visual features of the dance, just as seeing all the qualities of the wall, requires many glances from him.

As before, we can contrast Peter's experience with that of a creature who could see the whole dance in the way in which Peter sees a pirouette. For this creature, all the movements of the performance would be experienced as tightly united, as exhibiting phenomenal tightness. Unlike Peter, by sticking her head in and glancing once over the scenario, the creature could see the whole dance. She would not need to appeal to her memory to decide whether the opening or the closing pirouette looks more impressive: she could decide this simply by looking at the scene before her eyes. Figure 3 depicts some features of the situation.

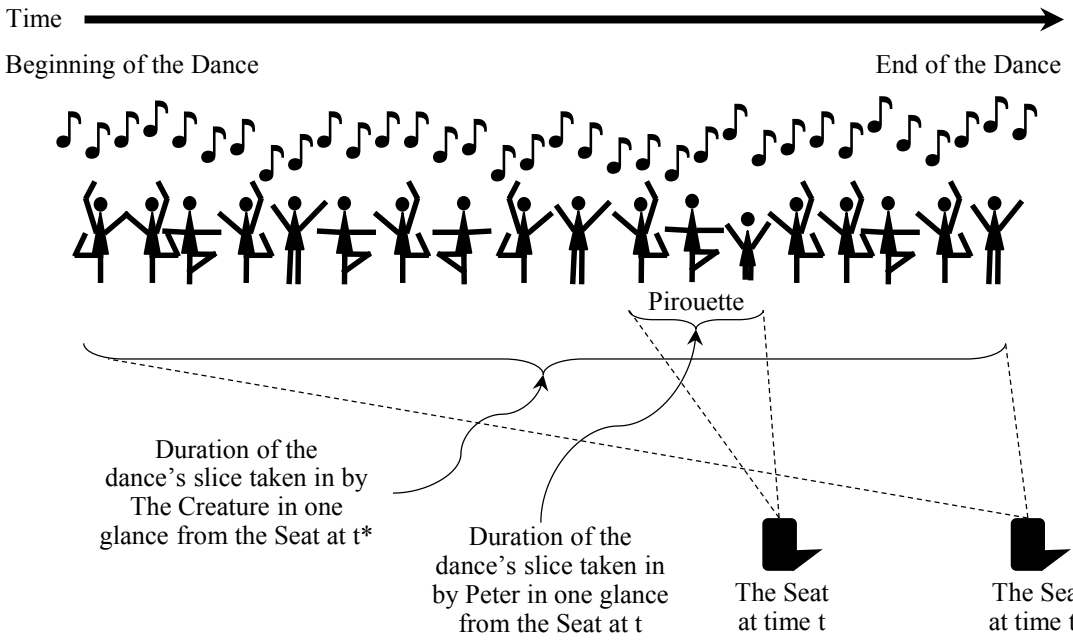

Figure 3. *The Dance Show*

Looks, we said, exhibit spatial phenomenal limits: qualities seen as spatially bounding what is being seen in one glance. Looks also exhibit temporal phenomenal limits: features that are seen as temporally bounding what is being taken in through one glance. To illustrate, consider again Peter's experience of the pirouette. Some parts of it

are seen as happening earlier than others. Relative to one glance, some are seen as the earliest while others are seen as the latest. These are the *temporal phenomenal limits* of the look taken in by Peter's glance. The raising of the dancer's arms with which she begins the pirouette and the gracious kneeling with which she ends it could be the temporal phenomenal limits of this look. The rest of the features are seen as occurring in between these.[30] The features taken in through a glance, hence, are usually experienced not just as forming a spatially bounded unity, but also as forming a temporally bounded whole. I will use *temporal phenomenal boundedness* to refer to this experiential feature.

The look Peter takes in of this section of the dance, thus, includes temporal and non-temporal qualities alike. The dancer's turning and the orange of her suit, for instance, are experienced as exhibiting phenomenal tightness and as being part of the same spatially and temporally bounded unity. This should not be surprising at all; what would be strange would be for him to experience all the colors and shapes as forming one whole and the movements, changes, and durations as in a different one.

A Quantum

Similar considerations apply to the rest of our sensory modalities. Think of the difference between tasting a chocolate chip vanilla ice cream and tasting, separately, plain vanilla ice cream and chocolate chips; smelling a room scented with roses and cinnamon and smelling, separately, a room scented with roses and another room scented with cinnamon; having someone step on both of your feet at the same time and having someone step on one of your feet and then, after a bit, stepping on the other. These differences reflect whether the features are experienced in one or in various experiential acts: in one or in various tastings, smellings, hearings, or touchings.

Just as with the case of seeing, through hearing, touching, tasting, or smelling, we also take in various temporal features. Think of feeling a finger slide across your arm, hearing the "dong" of your door bell as following the short "ding", tasting the changing

[30] Temporal phenomenal limits, like spatial phenomenal limits, are relative to looks. We cannot just think of them as the features experienced as being the earliest and latest seen. For before seeing this pirouette, Peter saw other slices of the dance and will see more afterwards as well. The dancer's raising of her hands and her kneeling on the floor are thus not the earliest and latest features seen by Peter. Rather, they are the earliest and latest features of the slice of the dance seen in *that glance*: they are the earliest and latest features of the particular look taken in by Peter at that time.

flavor of a strawberry-mint gum or smelling the increasing smoke in the room that prompts you to call the fire department. Contrast the felt unity of these experiences with the lack of it in hearing a whole symphony, experiencing a five-course meal, a two–hour massage or a twenty minute long perfume demonstration.

Further, our experiences exhibit phenomenal unity across different modalities. Think of having a sip of wine while seeing the Sun setting and hearing the waves of the beach from afar. Or think of lying in the sand and seeing the clouds moving in the sky while feeling little drops of water running over your body as you dry out. Experiencing these together is distinct from experiencing each of them separately.

In the case of visual experience, we said that a look is the collection of features, including some temporal ones that can be taken in by a glance. Looks, we also said, are characterized by being experienced as tightly united, temporally, and spatially bounded wholes. A quantum is akin to a look but includes all the features taken in through *any sensory modality*. That is, *a quantum* is the collection of all the features of the situation encountered that can be taken in by any sensory modality in performing the more general analog of a glance, namely a single act of directed awareness. The quantum is experienced as tightly united, as *one* temporally and usually also spatially[31] bounded whole. A look is thus a visual quantum, something that can be taken in by a single glance by beings with our kind of visual awareness.

The considerations offered so far can be used to give a minimum sense to a slightly odd term often employed in the time-consciousness literature. Think of the *specious present*[32] as the duration delimited by the earliest and latest temporal phenomenal limits of an experienced quantum. Just as the blue spot and the red speck in the look from the Berlin Wall example are seen as delimiting a spatial section of the surface of the wall taken in by the viewer from the spot, the temporal phenomenal limits of a quantum are experienced as delimiting the slice of the event that is taken in. *The*

[31] Sounds and thoughts, for instance, are experienced as being temporally but not spatially bounded.
[32] James (1890), taking the term from Clay, understood the specious present as "the short duration of which we are immediately and incessantly sensible" (1890, p. 631). The specious present was also discussed by Brentano (1988), Broad (1923), and Husserl (1991), amongst others. My characterization of a quantum has been much influenced from reading the discussions of these authors. From these, Husserl is perhaps who influenced me the most. I also found Chisholm's (1981) discussion on Brentano's account of time consciousness very helpful. See also Dainton (2006).

specious present can be understood as the characteristic duration of the slice thus delimited.

Consider again the slice of the dance taken in by Peter when he sees the pirouette. This slice includes the orange of the dancer's suit, the sounds from the orchestra, the smells of the theater and the mint flavor from the gum Peter chews as he sees the pirouette. Add 250 milliseconds to this slice and imagine a creature that can take in this longer-lived slice from the seat as one experiential whole. For this creature, as we are imagining it, more features would be experienced as exhibiting phenomenal unity, as being part of the same experienced quantum. In addition to the above, in this quantum this creature would see some of the previous movements of the dance, feel the neighbor's elbow as he touches it just after the pirouette ends, hear a few more sounds from the orchestra. By adding 250 milliseconds more to this slice and repeating this procedure over and again, we can form a series of creatures that begins with Peter and ends with the creature for whom the entire dance is experienced as one experiential whole.

Once more, even if we stipulate that each of these creatures experiences the same features of the dance, there is still a difference in how these are experienced. The difference lies in *how many quanta* it takes each creature to take all the dance's features in: only those features experienced in a single quantum will be experienced as bound tightly together. Contrast, for example, Peter's experience of the dance with the experience of the last creature in the series. For Peter, the features of the dance are taken in many pirouette-size bits; for this creature, they are experienced as in just one very rich whole.

A Series of Events

For every long-lived event there will be a number of experienced quanta it normally takes one of us to experience the event from beginning to end. As with spatial size, we can arrive at a rough ordering of the duration of events in terms of this number. The falling of a coin out of my pocket or a dancer's pirouette can be experienced in just one quantum. These will thus take the first position in the series. Seeing most of the runners of the New York City Marathon crossing the finishing line takes many more. In

between these, there will be others. Hearing the full ring of my phone before it goes off, for instance, takes me just a couple.

As with length, the series so construed delivers a rough ordering of long-lived events in terms of their relative durations. Crucially, the ordering was arrived at *merely by considering the way in which these events are experienced*. That is, the unit in terms of which the events are measured and ordered in the series is subjectively defined: it is the longest-lived slice of an event that can fit into a quantum—that is, a tightly unified arrangement of qualities that can be taken in at a single glance or, more generally, in a single act of directed sensory awareness. Since, all else equal, the longer-lived the event is the more quanta it takes to experience the event's entire duration, the feelings of unity and temporal boundedness associated with experiencing a quantum can serve to give us a sense of the durations of different events. In this way, the quantum could serve as the unit in terms of which we experience events as having different but comparable durations.

Let us now turn these thoughts into an actual model of felt duration.

IV.

A Two-Fold Model for Felt Duration

Felt Duration for Long-Lived Events: A Subjective Pacemaker

A good way of modeling felt duration of long-lived events is by means of what I call *a subjective pacemaker.* Unlike sub-personal pacemakers, which work with features of our brain processes that may or may not underlie particular experiences, this pacemaker works only with features of our experiences.[33] Like other pacemakers, a subjective pacemaker works by 'counting' 'ticks'. The differences lie in what a 'tick' is and in what sense they are 'counted'.

[33] If you think that the features of our brain processes are *just* the features of our experiences, then you can see the difference between a subjective and a sub-personal pacemaker as a difference on the level of description of the features involved. The features with which a subjective pacemaker works are given in experiential terms, that is, in terms of features that we get to experience and recognize as such.

'Ticks'

Could we, for example, say that the 'ticks' of this pacemaker are minutes and that, thus, Peter counts ninety of these when he experiences the dance show as lasting for an hour and a half? No, for this would simply push back the question of how the duration of the dance show is experienced to how the duration of a minute is experienced. Had we a red dot blinking at a fixed rate in a corner of our visual fields, we could have used *this* as the subjective unit of duration. But of course there is no such thing.

Unlike minutes, experienced quanta are the 'ticks' of our subjective pacemaker. Each quantum directed experience presents us with a short but temporally extended slice of an event. Each time such a slice is presented, it exhibits the particular experiential features we called phenomenal unity and temporal phenomenal boundedness. That is, with each quantum directed experience we are presented with a temporally extended unit that we recognize as such. After all, to take in a quantum is just to experience certain features of the events we experience as forming a tight, temporally bounded unity. We could thus exploit these features as delimiting the unit of felt duration we are looking for. What this means is that whatever features are presented in a quantum will be experienced as taking one subjective unit of duration.

Besides being the objects of our awareness and being experienced as forming a temporally extended unity, quanta have another feature that makes them suitable to be the subjective unit of measure for duration. They usually present us with short-lived slices *of roughly the same duration*. That is, it is not the case that we sometimes take in a dance show in pirouette-size slices and other times in hour-long bits. If this were so, taking a quantum as the unit of felt duration would be disastrous. It would be like having a car that 'measured' the distance travelled with an odometer that randomly switched from meters to miles. Because the duration of our quanta do not exhibit abrupt changes like this, they can serve to get a pretty good estimate of the duration of the events being experienced.

In order to have a subjective unit of duration, hence, there is no need for a constant red blinking dot on the corner of our visual fields or a constant beeping at the back of our auditory fields: experience itself is structured so as to do this work.

'Counting'

The number of quanta 'counted' while experiencing a long-lived event determines the amount of duration that the long-lived event is experienced as having. To 'count', however, is not to go 'one, two, three, …,' in our minds as quanta keep passing. It is instead to experience their number, to form an impression of their count.

Consider seeing a room with some people in it. Simply by glancing over the room you can form an impression of the count of people in it. You can tell, roughly, whether there are ten, twenty, a hundred, or fewer than six people in it. Note that in forming this impression you did not have to point to each person while thinking of the natural numbers in order. All you had to do was look into the room.

We form an impression of the number of quanta involved in experiencing an event in a similar way. As will be discussed in the section on duration illusions, there are various factors that can interfere with how this impression is formed and which can thus give rise to particular kinds of illusions. What is important to see at the moment is that forming this impression of *how many* and of *more and less* need not be the product of a conscious cognitive process of going through the natural numbers while thinking of a series of experienced quanta. We form the relevant impressions simply by experiencing the event in question. To 'count' quanta, thus, is to form an impression of their number, of their count.

Consider the number of quanta 'counted' in experiencing an event from beginning to end when our attention, emotions, stress, and other such factors are affecting our experiences as little as possible. Let this number be a measure of *the characteristic felt duration of a long-lived event*.[34]

We are now in a position to explain what goes on when Peter comes out of the dance show and claims that he experienced it as lasting for roughly an hour and a half. What happened is that Peter formed an impression of the count of quanta involved in experiencing the dance show. This impression is roughly the same as the one he normally forms in experiencing an hour and a half-long event. In other words, the number of

[34] If experienced quanta overlap, the felt duration and the characteristic felt duration of an event would rather be given in terms of the number of *non-overlapping* quanta that it takes to experience the event from beginning to end.

quanta he 'counted' during the dance show is like the number he would 'count', under normal circumstances, during an hour and a half-long event. This is how the felt duration of the dance is like the characteristic felt duration of an hour and a half-long event.

The felt duration of a long-lived event, thus, is the impression we form of the number of quanta involved in experiencing an event from beginning to end.

Felt Duration for Short-Lived Events

In the case of short-lived events, those that fit completely within sub-parts of a quantum like half of a pirouette or the passing of a fly across your computer's screen, their felt duration is not the 'count' of quanta in which they are taken in: their duration is too short for this. Instead, it is how much duration of their surrounding quantum they strike us as taking up.

To illustrate, consider again the section of the Berlin Wall seen by the viewer from the spot. Suppose there are two clearly visible squared figures on it: one is orange and four times larger than the other, which is yellow. By looking at this section of the wall the viewer does not just see the figures as having some extension or other: they also strike her as having a particular extension. Further, she sees the orange square as being, roughly, four times larger than the yellow one. This suggests that there is a common unit by means of which their experienced sizes are measured and compared. The following considerations support this idea.

Suppose the case is as before but that I had previously disassembled the section of the wall the viewer is looking at and reassembled it on top of a movable device. With this device I can move the section of the wall towards the viewer while she blinks so that when she opens her eyes again the section of the wall is positioned just a few inches away from her. If I were to do this, the viewer's first impression after the blink would be as if the figures had expanded: while the figures will still be seen as maintaining their relative sizes with respect to each other, they will be seen as being much larger.[35] This suggests that the experienced sizes of the figures are a measure of how much of their

[35] I am imagining that depth cues are neutralized. Since time is one-dimensional, in the case of duration there is nothing corresponding to spatial depth.

look's spatial extension they appear as occupying. Figure 4 depicts the looks before and after the wall is moved.

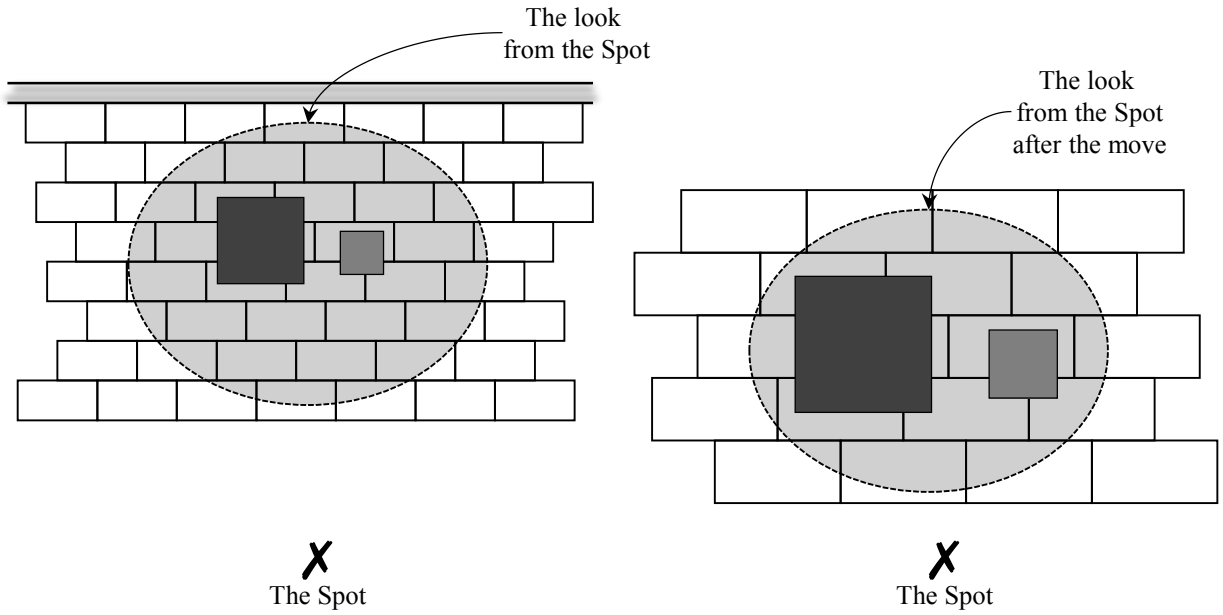

Figure 4. *Seeing two squares on The Berlin Wall*

Before the move, the big square takes about one tenth of the section of the wall taken in in that look. After the move, the larger square takes about a third of the size of its look. This sudden change in how much space of their corresponding looks these figures are seen as occupying explains why they are seen as having suddenly grown.[36] (Because walls don't just grow like this, the viewer will very soon realize that the squares have their same old sizes but are being seen from a closer distance.)

The duration of a short-lived event is experienced in an analogous way. Consider Peter's experience of the pirouette. Suppose that, aside from the pirouette, there is another dancer bouncing a big yellow ball on the other side of the stage and that Peter can see them both. In taking in this scene, Peter experiences the pirouette as taking longer than a bounce of the ball. He further sees the complete pirouette as taking four bounces of it. He also experiences it as lasting for about the same as two chews of his gum or five

[36] You might think that the reason why the figures look bigger is because we are increasing the resolution with which we see them. The temporal resolution hypothesis for the case of duration will be discussed in the next section.

drumbeats. The reason for this is that while the pirouette is seen as taking up the entire duration of the quantum in which it is seen, each bounce of the ball, gum chew, and drumbeat is experienced as taking up, respectively, a fourth, about a half, and a fifth of the duration of the experienced quantum in which they lie. That is, just as the experienced size of a plane figure relative to a location is how much of the total spatial size of the corresponding look the figure is seen as occupying, *the felt duration of a short-lived event* is how much of the duration of its corresponding quantum the event is experienced as taking up.

As illustrated by the case of the squares on the wall, it is a consequence of what felt duration is that if the duration of the quantum were to decrease suddenly, the felt duration of its short-lived events would proportionally increase. Conversely, if for some reason the duration of the quantum were to increase, the felt duration of its short-lived sub-events would proportionally decrease. The reason for this is that these events would now be experienced as taking up, respectively, more or less of the quantum's total duration. We will come back to this in the following section, as it will play an important role in explaining some types of duration illusions.

In the previous section, we said that a quantum is also the unit in terms of which we experience the duration of long-lived events. In that case, the duration experienced is the impression formed of how many quanta are taken in while experiencing the event from beginning to end. In the case of short-lived events, their felt duration is how much of the duration of its corresponding quantum the event appears to take up.[37] Because in both cases the duration of a quantum is the common unit in terms of which the experienced duration is subjectively measured, the felt duration of short- and long-lived events can be compared with each other, allowing for a unified measuring system of felt duration.

Let us turn to put these ideas into work by considering different duration illusions and explaining how this theory can account for them.

[37] It follows from this that while the felt duration of long-lived events are given in natural numbers, the felt durations of short-lived events will be given as fractions that range between 0 and 1. For instance, the felt durations of a ball bounce, a gum chew, and a drumbeat in the example are, respectively, 1/4, 1/2 and 1/5.

V.

Duration Illusions

Consider first the two duration illusions with which we began the discussion, THE SURPRISE PARTY and THE BORING MOVIE. They exhibit an interesting feature: even if in both cases, the felt duration of the long-lived event is considerably longer or shorter than that of other events of the same objective duration, the illusion does not affect the felt durations of their short-lived events.

Take THE SURPRISE PARTY. You experience the party by experiencing several of its short-lived events. Examples of these are two friends shaking hands, everybody shouting "Surprise!" as you come in or the falling of a glass of wine on the floor. Despite the fact that you experience the party as lasting a lot less than it did, none of its short-lived events were experienced as having abnormally short durations: you do not, for instance, hear everybody's voice as they yell "Surprise!" going so fast that you can hardly understand what they are saying. Nor do you see the glass crashing to the floor at a super-high speed. The short-lived events of the party are neither experienced nor remembered as being experienced in the way in which a TV program would be seen if you were to press the fast-forward button.

The same occurs in the case of THE BORING MOVIE. Even if the movie seems to be taking a really long time, you do not experience it as a slow motion film: the characters, for instance, does not seem to be speaking ex—tre—me—ly slow—ly nor are the other events of the movie experienced as slowed down episodes.

Upon reflection, there is something puzzling about this. Since it is through experiencing short-lived events that one gets to experience a long-lived event and the short-lived events in these cases are experienced as exhibiting their usual durations, one would expect the long-lived event to be also experienced as with its usual duration. Despite this, the felt durations of these long-lived events are, respectively, much shorter or longer than those of events with the same objective duration. Our experience of the durations of the short- and long-lived events in each of these cases, thus, seems to be incongruent.

To further illustrate, contrast these cases with the following.

THE SCARY ACCIDENT

> Right after merging onto the highway, you see the line of cars in front of yours suddenly coming to a full stop. You press hard on the brake pedal, thinking that you won't be able to avoid a crash. Your car then seems to you to start slowly swerving to the right, which saves you from crashing into the car ahead. Unfortunately, a van from behind fails to see you in time and smashes into the back of your car, making it enter what feels like a slow spin that ends with the front of your car crashing into the concrete barrier. Luckily, apart from being terrified, everyone manages to get out of the accident without major injuries.

In extremely frightening situations like this, subjects report experiencing the events around them as occurring in slow motion.[38] After such experiences, they find themselves disoriented, making claims like "time seemed to have slowed down during the accident".[39] The phenomenon has recently been experimentally studied by subjecting individuals to 31-meter long free falls. The study showed that while all of the falls lasted for the same amount of time, each subject overestimated the duration of her own fall by an average of 36%. The quantitative study was accompanied by verbal reports "that their fall had 'seemed to take a very long time'".[40]

Some studies suggest that drugs such as haloperidol produce the opposite effect.[41] If this is so, while under the drug's effect, not only would the whole episode seem to last less time than it does, but its short-lived events would also be experienced as 'speeding

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[38] See, for instance, (Eagleman and Pariyadath, 2009).
[39] Stetson *et al.*, 2007.
[40] Stetson *et al.*, 2007, 3.
[41] As explained in Lee et al., (2009) "pharmacological studies indicate that time perception performance is highly sensitive to dopaminergic modulation. For example, dopamine agonists such as methamphetamine and cocaine produce lengthening of perceived time, whereas the dopamine antagonist *haloperidol causes subjective shortening of time* (Meck, 1996)", Lee et al. (2009, p. 180), my emphasis. Ogden et al. (2011) explain that the effects of haloperidol are found in time ranges below and above 1 second:

> Rammsayer (1999) also suggests the processing of very brief intervals e.g. < 100 ms is thought to be based on a sensory timing mechanism which is largely beyond cognitive control (Rammsayer & Lima, 1991) whereas the timing of longer durations (1s and over) is thought to be mediated by cognitive processes (Rammsayer, 1999). Such suggestions were supported by Rammsayer (1999) who demonstrated that midazolam affected timing of longer durations (around 1000ms) but had no effect on timing of short durations (50 ms), *whereas haloperidol was found to affect the timing of both duration ranges.*"

Ogden et al. (2011, p. 260). See also Maricq et al. (1981), Maricq and Church (1983), and Meck (1996).

up': lamp posts would be seen as flying by really fast as the subject walks towards them at a normal pace. It has also been suggested that similar effects occur in patients with schizophrenia.[42] Alcohol has also been thought to produce these effects.[43] I will simply refer to these cases as DRUG-INDUCED EFFECTS.

Like THE SURPRISE PARTY and THE BORING MOVIE, in THE SCARY ACCIDENT and DRUG-INDUCED EFFECTS the duration of the long-lived event is experienced as lasting for significantly more or less time than it actually did.[44] In the case of the durations of short-lived events, however, the latter cases are unlike the former. In the latter cases the short-lived events *are* also experienced as lasting, correspondingly, more or less than they usually do, delivering in this way experiences of the short-lived events that cohere with that of the long-lived event. The following chart summarizes these four types of illusions.

[42] In a study where subjects were asked to differentiate between short (≈400 ms) and long (≈800ms) sound signals, patients with schizophrenia took a significantly larger proportion of the long signals for the short ones when compared to control subjects, suggesting that the patients experienced the same events as lasting less time. As reported by Lee et al. (2009, p. 174), "[i]n the 400/800 ms condition, patients judged durations significantly shorter than did control subjects." As they also pointed out, similar results have been found in a study using 200/800 ms as the reference stimuli (Elvevåg et al. 2003) and the results in Franck et al. (2005) also support these findings. See also Rammsayer et al. (1990) for a similar study performed for shorter time intervals.

[43] In the studies reported by Ogden et al. (2011), a significantly larger proportion of the subjects who were given a high dose of alcohol reported that time seemed to pass faster than those subjects whose drinks had no alcohol. The intervals of time studied were all less than 1.5 seconds long. Thanks to Fiona Macpherson and Ian Phillips for pointing out to me that some studies have suggested that alcohol produce these effects.

[44] In the case of schizophrenia, how the duration of long-lived events is experienced is a matter of controversy. While some studies report that these are experienced as having *longer* durations than those they indeed have others report that the subject experiences long-lived events as having *shorter* durations. Since there are several other factors relevant for experiencing the duration of long-lived events that are affected in these patients (emotional states, memory formation, attention, decision making, *etc.*) it is hard to draw inferences of what is going on in these cases.

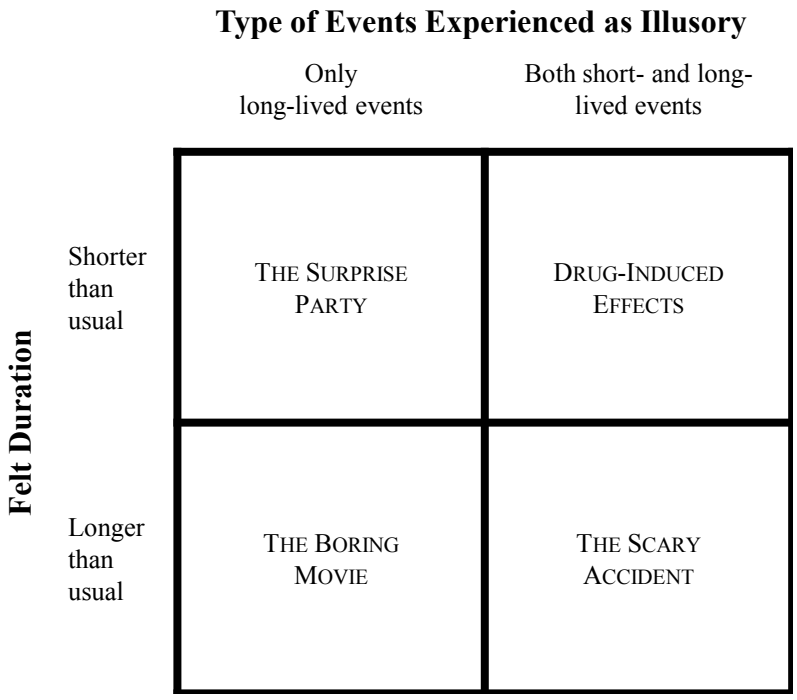

Chart 1. *Classification of Duration Illusions*

In all four cases the illusions consist in the felt duration of the long-lived event being a misestimate of its actual duration. In the cases on the first row—THE SURPRISE PARTY and DRUG-INDUCED EFFECTS—the duration of the long-lived event is experienced as being *shorter* than the way events with the same objective duration are usually experienced. That is, their felt duration is shorter than the characteristic felt duration of events with the same objective duration. The opposite occurs in the cases on the second row, THE BORING MOVIE and THE SCARY ACCIDENT. In these cases, the felt durations of the long-lived events are *longer* than the way events with the same objective duration are usually experienced.

The same does not hold for short-lived events. Take the first column: THE SURPRISE PARTY and THE BORING MOVIE. The felt duration of their short-lived events is not affected. The falling of a wine glass or the utterance of some words in the movie appears as having their characteristic felt durations. This is not so for the short-lived events of the cases on the second column. In THE SCARY ACCIDENT cars appear to be moving unusually slowly, while in cases like DRUG-INDUCED EFFECTS, lamp posts seem to be rushing towards the subject as they are approached at a normal walking pace.

Before offering an account of each of these illusions, let us briefly consider a proposal that might have seemed attractive as an account of felt duration when considering some of these cases in isolation. Unlike the models discussed in section II, the explanation in this case is not given in terms of a sub-personal mechanism.

Temporal Resolution

According to the temporal resolution hypothesis, when we experience an event as lasting for more or less time than it does, what happens is that we experience, accordingly, more or less temporal features: the temporal resolution of our senses increases or decreases. To get a feel for this idea think of it as analogous to what happens when, by using a microscope, we sharpen our spatial resolution: spatial features that are too small to be seen with the naked eye become visible. In the case of duration, the effect of having an increase in temporal resolution is that we become able to experience changes that would otherwise be too fine-grained to be perceived, such as small shifts in frequency that usually go unheard. The contrary occurs, according to this theory, when we experience an event as lasting less time than it does. In these cases, our temporal resolution would decrease: we would experience fewer temporal features. A rapidly flickering light that would normally be seen as flickering, for instance, would be seen as being constantly on.[45]

The temporal resolution hypothesis, however, faces two problems. First, if what explains duration illusions were an increase in temporal resolution we would have to give up the intuition that in cases like THE SURPRISE PARTY or THE BORING MOVIE we experience their durations as shorter or longer than they really are. For if what explains these illusions is that we become aware of more or less fine-grained temporal phenomena, this would have to have effects on how we experience the short-lived events as well. But in these cases the felt duration of the short-lived events remains unaffected. To the extent that these two familiar cases are left unexplained, the hypothesis is defective.

[45] See Stetson et al. (2007). Thanks to Geoffrey Lee for drawing my attention to this paper.

The best the hypothesis could offer, then, is an account of cases in which the short-lived events are also affected by the illusion (those on the second column of the chart). However, even restricting the hypothesis to cases like THE SCARY ACCIDENT and DRUG-INDUCED EFFECTS, it faces serious empirical difficulties. The results on the free fall experiment mentioned earlier show that subjects under a duration illusion like THE SCARY ACCIDENT failed to exhibit the expected increase in temporal resolution.[46] These results, for instance, were partly what drove Stetson, Fiesta, and Eagleman to suggest that it is features of how we encode our experiences in *memory*, and not how the event is experienced, that explains inflated duration judgments. They wrote:

> [W]e speculate that the involvement of the amygdala in emotional memory may lead to dilated duration judgments *retrospectively*, due to a richer, and perhaps secondary encoding of the *memories*. Upon later readout, such highly salient events may be erroneously interpreted to have spanned a greater period of time.[47]

There are two ways of making sense of this idea, none of which can help us explain the datum. According to the first, features about how events are encoded *in memory*, not features about how they are *experienced*, are what ground the duration judgments. According to the second, features of our memories would explain *only* the illusory cases. In veridical cases, our duration judgments would indeed be grounded on features of our experiences.

It should be clear by now why the first way of understanding the proposal, which may be called *the memory hypothesis*, cannot be the account of felt duration we are looking for. The reason is that it amounts to a denial of the datum. That is, it involves denying that the actual, cotemporaneous experience of the event is what grounds the corresponding judgment about its duration. We should try to hold on to the datum.

The problem with the second way of understanding the proposal is that it is incomplete in a crucial respect: it is in need of an account of how, in the good cases, our experiences ground our duration judgments (it also requires an explanation of why this same account does not work for illusory cases). This, however, is precisely what we would need if the datum were to be vindicated. Short of this, there is not much to say about this view.

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[46] For more on this, see (Stetson *et al.*, 2007).
[47] Stetson *et al.*, 2007, 3, my emphasis.

As I now turn to explain, the theory we have developed offers an explanation that respects the datum and explains all four cases.

Illusions by 'Miscount'

Just as with other objects of our experience, experienced quanta can fail to be noticed. To illustrate this phenomenon, consider the following two cases.

WALK BY A FENCE WITH A FRIEND

> You and your friend decide to take a walk in the countryside. To avoid getting lost, you walk along a fence, on the other side of which you can see a prairie. The fence is uniformly made: it has a post every four and a half feet. Throughout the hour-long walk, you and your friend engage in an old philosophical dispute. Still, the prairie is pretty enough to have you both always be staring, through the fence, towards the large surface of land.

WALK BY A FENCE ON YOUR OWN

> Days later, you come back to the same place and, remembering the prairie, decide to take the same path on your own. Just as before, throughout the hour-long walk, you keep staring through the fence towards the landscape. This time no deep thought catches your mind. So even if you manage to entertain yourself with the mild beauty of the scenery, the walk is much duller than it was before. Halfway through the walk, you become slightly annoyed by the many posts of the fence. This makes you wonder whether you are in the same path from some days ago: you don't recall having seen *that* many posts.

Two things are relevant about these cases. First, they suggest that in both walks you formed an impression of the number of posts seen on the fence. For even if during the first walk you never wondered how many posts there were, and in neither of them did you count them one by one, comparing your experiences of the number of posts in both walks made perfect sense.

Second, the cases also suggest that it is the number of posts that you *noticed*, and not simply the number of posts you *saw*, what affects the impression you formed of their count. This explains why when you were engaged in the conversation you 'counted' fewer. For in both cases your eyes were always open and looking in the right direction

and, thus, presumably in both occasions you saw roughly the same number of posts. What differs is the number of posts you noticed. By being engaged in the conversation in the first walk, you directed less attention to the surroundings and, as a result, noticed fewer posts. Having less exciting things to focus on during the second walk the fence captured more of your attention. You thus noticed a larger number of posts.

Similarly, the number of quanta 'counted' in experiencing a long-lived event depends on the number of quanta *noticed* and not just in the number of quanta experienced throughout the event. Since the impression formed of the count of the experienced quanta during a long-lived event just is the felt duration of the long-lived event, noticing more or fewer quanta than usual, and hence, 'counting' more or fewer of them than usual, explains why events like THE BORING MOVIE or THE SURPRISE PARTY feel as if they last, respectively, more or less time than events with the same objective durations.

Consider THE SURPRISE PARTY. Because the party is so much fun, you pay less attention to the features of your own experience and much more to the things going on around you. Thus, even if the party is experienced in roughly the same number of quanta as any other event with that same objective duration, during the party you noticed *fewer* of them. Because it is the number of experienced quanta noticed what affects the impression you form of their number, you also 'count' fewer of them. But then, since the felt duration of the party is the number of quanta 'counted' while experiencing it, you feel like the party lasted less time than it did.

Consider THE BORING MOVIE. Because you are not at all into the movie, your attention starts drifting away from it. Having nothing else around to capture your attention, you focus each time more on features of your experience. As a result, you notice more quanta than you otherwise would and, hence, form an impression of a larger count. This explains why the movie feels as if it lasts longer than an equally long but less boring one.

Failing to notice a quantum need not involve failing to notice the features of the slice being experienced through it. Failing to notice a quantum only involves failing to notice the type of unity that characterizes them. One can, for instance, notice each of the flowers in a vase without noticing the bouquet; or notice the bright colors on a cup

without noticing the cup; or notice the people in a room while failing to notice the room. Likewise, one can notice the colors of the landscape, your friend's words, and the sounds of a dry piece of wood as you step over it while failing to notice the unity that ties these all together as one of the experiential wholes by means of which you experience the walk. Because of this, noticing more or fewer quanta than usual during an event need not involve noticing more or fewer features of the event.

Let a '*miscount'* occur whenever we form an impression of a larger or smaller number of quanta than usual *due to an abnormally high or low level of attention directed towards our own experiences*. A 'miscount' of quanta is, thus, what explains the type of illusions involved in THE SURPRISE PARTY and THE BORING MOVIE.

Illusions by 'Compression' or 'Extension'

To say that an experienced quantum is 'compressed' or 'extended' is to say that its duration is shorter or longer than that of a typical quantum. Consider again the dance show. If in a typical quantum you take in just one pirouette, you can think of an 'extended' quantum as one in which you take in the pirouette and some other movements. In terms of the series of creatures ordered by experienced quanta considered earlier, having 'extended' quanta would be as if you suddenly became one of the creatures further along this series. Conversely, think of a 'compressed' quantum as one in which you cannot take in the whole pirouette: maybe you can see a third of it. Figure 5 depicts this situation. [48]

[48] Ian Phillips recently pointed out to me that in Lockwood (2005) a similar hypothesis is discussed. The two hypotheses, however, differ in at least the following crucial respect: unlike mine, Lockwood's hypothesis involves a commitment to a version of the temporal resolution hypothesis, discussed in the text. See Lockwood (2005). Thanks to Ian Phillips for the reference.

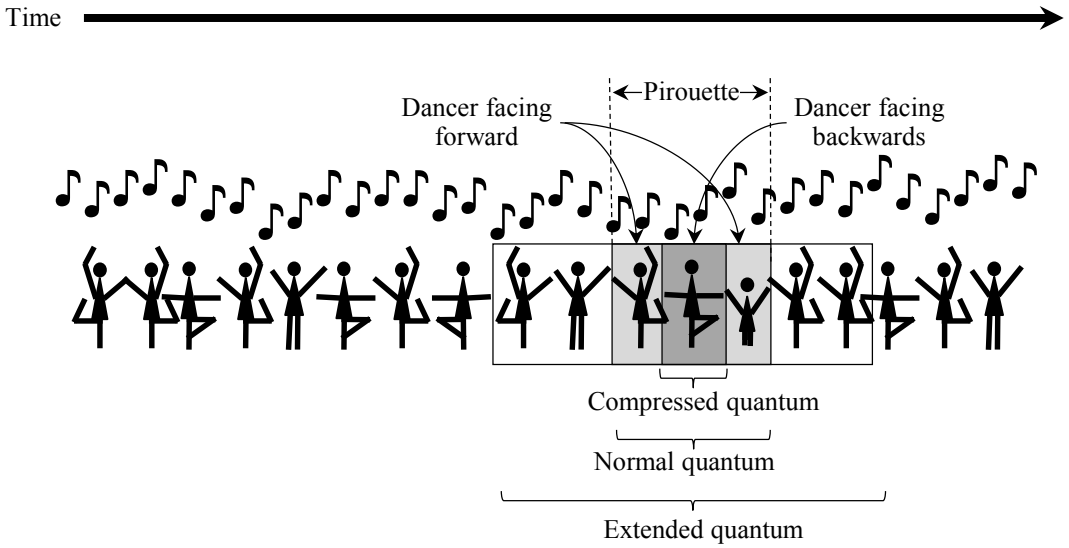

Figure 5. *'Compressed' and 'Extended' quanta*

There are two effects of having 'compressed' and 'extended' quanta, one over the felt duration of long-lived events and one over the felt duration of the short-lived events. Let us first consider the former.

When there is a decrease in the duration of each quantum, that is, when there is a 'compression', we will need to experience more quanta to experience the same temporal features of the event. As a result, at normal levels of attentiveness, more of them are noticed and hence we form an impression of a larger count: we 'count' more quanta. The effect of this is that the felt duration of the long-lived event is like the characteristic felt duration of an event with a much larger objective duration. This is what explains the "slowing down of time" illusion in cases like THE SCARY ACCIDENT.

Conversely, when the size of the quanta increases, that is, when there is an 'extension', fewer of them are involved in experiencing the same features of the perceived event. Because there are fewer, a smaller number of quanta are noticed and an impression of a smaller count is formed: we 'count' fewer. Because of this, the long-lived event feels as if it takes less time; its felt duration is like the characteristic felt duration of an event with a shorter objective duration. This is what explains the illusions over long-lived events in cases like DRUG-INDUCED EFFECTS. The hypothesis is then that drugs like haloperidol widen the temporal extent of the quanta we experience under the drug. More

fits into these experientially unified temporal wholes than into the quanta we normally experience.

Let us turn to explain what goes on in the case of short-lived events. According to our theory, the felt duration of a short-lived event is how much of the duration of its surrounding quantum it takes up. Taking in the same short-lived event in a quantum of a longer or shorter duration will thus have effects on how much of the quantum's total duration the short-lived event strikes us as taking up. As shown in figure 5, when the quantum has its normal size, the whole pirouette fits exactly in it. Its felt duration can thus be said to be a single quantum in length. If the duration of the quantum were shorter—if it were 'compressed'—only the section of the pirouette in which the dancer faces backwards would fit in one experienced quantum. This section would thus be experienced as lasting as much as the whole pirouette is experienced as lasting in a normal quantum. If the quantum were 'extended' as in the figure, the whole pirouette would take a bit less than a half of the 'extended' quantum. It would thus be experienced as lasting a bit less than half of its normal duration.

We said that in cases like THE SCARY ACCIDENT, experienced quanta 'compress'. Since the quanta have a smaller duration and hence fit fewer events, the duration of the short-lived events that it does fit are experienced as taking more of the quantum's total duration. This is why the cars around yours during the accident appear to be moving so slowly. Conversely, in cases like DRUG-INDUCED EFFECTS, the quanta are 'extended'. Because of this, the same short-lived events take less of the duration of their quantum. They are hence experienced as lasting less time than they would in a quantum of normal duration. Lamp posts, thus, would be seen as flying by as they are approached at a normal walking pace.

This dual effect explains why the experiences of the long- and short-lived events in these cases cohere. Because in cases like THE SURPRISE PARTY and THE BORING MOVIE the size of the quanta is the usual, there is no illusion at the level of short-lived events, explaining the otherwise surprising incongruence between the felt duration of the short- and long-lived events.

A Speculation about Aging and the Experience of Time

There is one more phenomenon about which I would like to say something in a more preliminary way. It has been widely held that during childhood, days, months, and years seem to last for much longer than the way we experience them later in life.[49] Because it is not just this particular party or that particular soccer match that seems to go slower or faster, I will say that the phenomenon is *non-transient*. Instead, this has been thought of being a progressive phenomenon that begins early on: as we become older, time seems to pass faster.[50] What this means is that on her 45th birthday, someone that will live for 90 years would already be well past the first half of her subjective life.

While this phenomenon would affect how the duration of long-lived events are experienced, it is less clear that it also affects our experiences of the durations of short-lived events. For a child, the bouncing of a ball or the falling of a coin from her pocket does not seem to happen in slow motion, nor do the words uttered by her parents seem to go really slowly. Rather, it is the whole day what seems to be so long, a school year an eternity. Likewise, it is not as if during adulthood the falling of the glass from the table to the floor appears to happen especially quickly. Rather, it is years, months, weeks, or days that seems to be flying by. Thus, if we were to include these cases in our earlier illusion chart, we would classify them as shown in Chart 2 below.

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[49] For instance, in a study involving almost 300 subjects between 62 and 94 years old (with a mean at 75 years), Baum et al. (1984) reported that "[f]or the majority of elderly in this study (60.1 percent) time passed quickly. Only 22.7 percent experienced time as moving about the same as it had always moved, and 13.3 percent felt as though time were moving slower than previously experienced." Baum et al. (1984, p. 56). As noted by Block et al. (1998) it was James (1890, p. 284)) who "claimed that "the same space of time seems shorter as we grow older," but he qualified this by saying "that is, *the days, the months and the years* do so; whether the hours do so is doubtful, and the minutes and seconds to all appearances remain the same"" (Block et al. (1998), p. 585, my emphasis).

[50] As pointed out in Friedman and Janssen (2010), there are a number of studies (Gallant et al. (1991); Joubert (1983); Joubert (1984); Joubert (1990); Lemlich (1975); Tuckman (1965); Walker (1977); Wittmann and Lhenhoff (2005)) in which subjects were asked to compare how fast time seems to be passing at their current age with how it seemed to pass at earlier ages, and from which one can conclude that older adults think that time passes faster during adulthood. Moreover, young adults *also* think that time seems to be passing more quickly now than when they were younger (Cf. Friedman and Janssen (2010, 132)). This suggests that the phenomenon begins at an early age and progresses as we become older. Note, however, that the results in these studies suggest that "[o]nly when reflecting on *very long intervals of time* [of the order of ten years] does the speed of time's passage seem to increase during adulthood" (Friedman and Janssen 2010, p. 139, my emphasis).

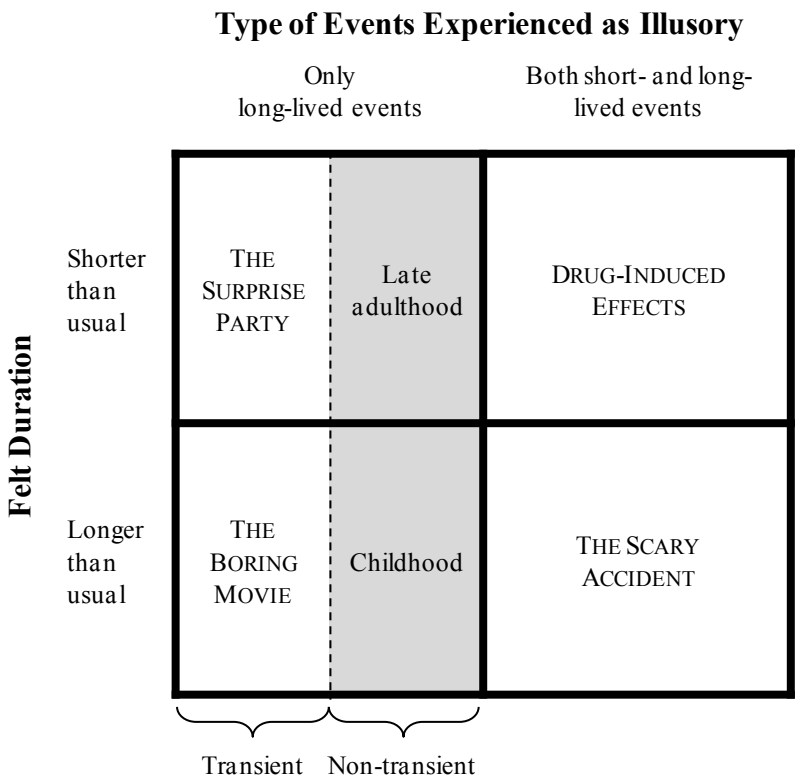

Chart 2. *Expanded Classification of Duration Illusions*

As can be seen from this chart, the duration experiences characteristic of childhood and late adulthood would be, respectively, the non-transient analogues of THE BORING MOVIE and THE SURPRISE PARTY. Because of this, it is appealing to try out the same explanation offered in these transient cases to capture what is going on in the non-transient ones. This would involve explaining the changes in the experiences of the duration of long-lived events between childhood and late adulthood as the result of a chronic change in attention that comes with the process of aging. This would, in turn, give rise to more 'miscounts' of the number of quanta involved in experiencing long-lived events as we age.

Changes in Attention

One way in which these 'miscounts' could be produced would be if our overall level of attention declined with age. This hypothesis has been supported by studies showing that young adults asked to perform different, simultaneous tasks and divide their attention between them showed a reduction of performance that matched that of older

people who perform only one of these tasks and, thus, were able to allocate all of their attention to it.[51] Let us assume that the number of quanta that it takes a younger and an older subject to experience an event is the same. It follows that because the older subject has fewer attentional resources, she will notice fewer quanta than the younger. But then the older subject would form an impression of a smaller number of quanta; that is, the older subject would 'count' fewer. The older subject would thus experience the event as lasting for less time than the time the younger subject would experience it as lasting.

Some studies, however, have challenged the idea that our level of attention declines as we age. Instead, it has been proposed that there is a change in how older people *allocate* the same attentional resources.[52] The idea is that the decline in the motor and perceptual abilities of older people requires them to dedicate more attention to the performance of ordinary activities that younger people do almost automatically.[53] Since for older people more attention would be devoted to performing these simple tasks, less attention would be devoted to keeping track of time. In terms of our model, this would mean that as we age, we would pay less attention to the passing quanta and their 'counts', which would then result in noticing less quanta and, therefore, in 'undercounting' them (as explained in the section on illusions by 'miscount' in chapter 1). It would be as if older people were permanently in a situation like THE SURPRISE PARTY. Their attention is not captured by the exciting events of the party that they are living through, but by what it

[51] See Lustig (2003, section 10.1.2). This paper offers as helpful summary and discussion of these issues. As mentioned in this paper, the studies from Craik and Hay (1999) and Anderson et al. (2000) lend some support to the idea that our level of attention decreases with age.

[52] See Lustig (2003). As Lustig explains, the meta-study in Block et al. (1998) and the study of Craik and Hay (1999), taken together, support the idea that what could explain the differences between older and younger duration estimates is a difference in how they allocate their attentional resources (see also Block et al. (1998)). As Lustig explains, the study in Block et al. (1998) analyzed experiments in which subjects of different ages were asked to hold a button until they thought that a few seconds had passed. Importantly, while the experiments were conducted nothing else was going on. The study showed that, contrary to what was expected, older people judged these 'empty intervals' as being longer than younger people. However, these effects have been found to be reversible when the interval is filled with attention-grabbing elements. In their study, Craik and Hay (1999) asked subjects to make judgments about the sizes and shapes of some visual stimuli. They were then interrupted and asked how long they thought the task had lasted for. It was found that the older underestimated the duration to a greater extent than the younger. (Cf. Lustig, 2003, section 10.2.1). See also the discussion at the beginning of Levy et al. (2001).

[53] This idea is supported by a study in which subjects of various ages were asked to walk while memorizing something. The study suggests that older adults allocated more attention to walking while younger adults allocated more attention to the memorization task. See Lustig (2003, section 10.2.1).

takes to get around. This would explain why their days, weeks, and years feel like they are flying by.

One problem with this account, however, is that it presupposes that the challenges that older people face require more attention than those faced by younger adults and children. While it is true that what becomes challenging for people of different ages may very well vary, it still seems to be true that for most people and almost at every age there are daily activities that are challenging. Learning how to deal with the world and its complex social structure requires a lot of attention from children and adolescents. Taking care of children and providing for them are amongst the daily challenges faced by many young adults. For some of them, there are also the challenges that come with having a profession. Contrary to what seems to be the case, instead of younger ages being those at which time seems to pass the slowest, if this hypothesis were the case it would be perhaps only adults with no children and in a comfortable life position for whom time should be experienced as passing the slowest. The "golden years" should seem to drag on compared to the twenties, thirties, and forties.

As I turn to explain, the theory we have developed allows for a different and interesting way of accounting for this phenomenon that does not depend on attention. I offer it here only as a suggestion that, like the others, would have to be empirically tested.

Experiential Blackout

In experiencing an event we do not take in every single feature available to be experienced: every now and then we have short experiential blackouts. Consider again the dance show. Because of these blackouts, for instance, Peter could have failed to see some of the details of the dancer's movements or to hear some bits of the music played during the show.[54] Consider a creature for which these experiential blackouts are longer and more frequent than for Peter. Assume further that they both have the same level of attentiveness and that the quanta each takes in are roughly of the same duration. It follows that for the creature, fewer quanta would be involved in experiencing the same

[54] An experiential blackout need not be accompanied by a corresponding cognitive blackout. That is, while we might fail to experience certain features of an object, in some cases we might still have cognitive access to them.

long-lived event than for Peter. Figure 6 depicts the situation for this creature, Peter, and a super-creature with no experiential blackout at all.

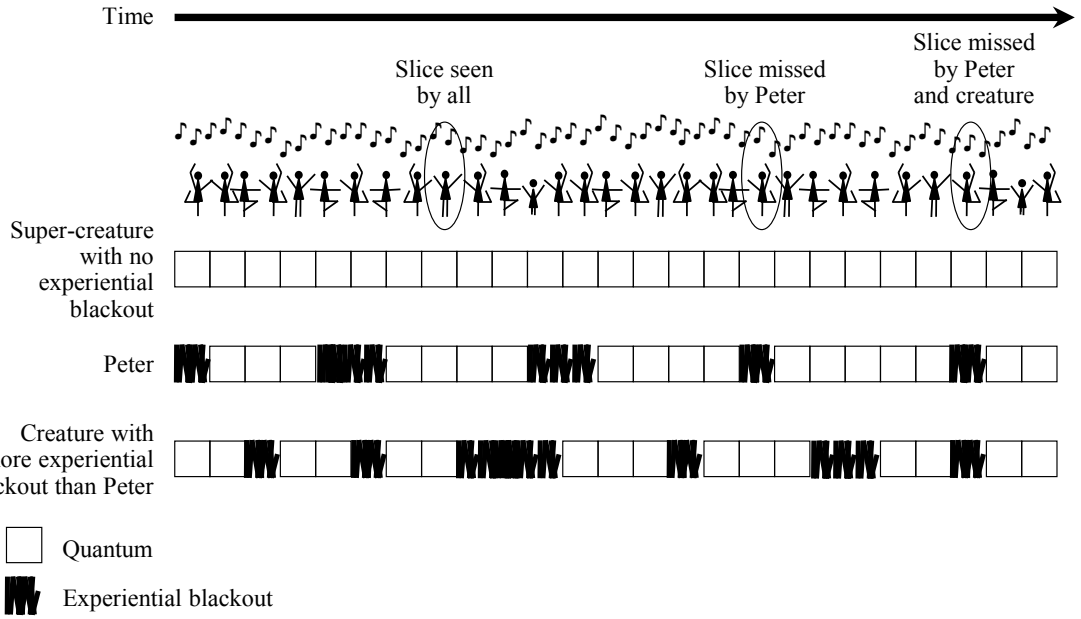

Figure 6. *Experiential Blackout*

As illustrated, there will be, for example, slices of the dance that Peter misses but that the creature with no experiential blackout experiences. There will also be features of the show that both Peter and the creature with more extended and frequent experiential blackouts both fail to experience. Assuming that the levels of attentiveness and how they are split between the dance show and the subject's experiential features is held fixed for the three subjects, it follows from the experiential profile of each of the subjects and the theory of felt duration developed here that the creature with no experiential blackout will experience the dance show as lasting the longest. Peter will be next and the creature with more experiential blackouts will experience the dance as having the shortest duration.

Consider, for instance, the creature with no experiential blackout. Her experience of the show involves the largest number of experienced quanta. Because of this, other things being equal, she will notice more quanta than Peter and the other creature. She will thus form an impression of a larger number of them during the show. Hence, she will experience the event as lasting longer than do the other two subjects.

More generally, keeping other things equal, the felt duration of a long-lived event increases or decreases with an increase or decrease in the density of the quanta involved in experiencing the event. Since the effect of the experiential blackout is to decrease this density, the more experiential blackout, the lower the density of quanta involved in experiencing the event, and therefore the shorter the duration that the event is experienced as having. Increasing or decreasing the density of the experienced quanta involved in taking in an event, moreover, has no effects on how short-lived events are experienced. The only consequence of having a higher or lower density of quanta is that more or fewer short-lived events get to be experienced.

The suggestion, thus, is that as we age the length and frequency of these experiential blackouts increases. As illustrated in the example above, the consequence of this is that, keeping all else equal, the density of quanta involved in experiencing a long-lived event is lower for older adults. But then, their felt duration for long-lived events should be shorter than for younger adults. Any given day, week, or year will thus have fewer experienced quanta than for those who are younger. Hence, older people would experience these as lasting for less time, and thus, as passing by more quickly. Since the days, weeks, and months of children would have, on average, more experienced quanta than those who are older, for them a school year would feel like an eternity compared to how their parents and grandparents experience it. The creature at the bottom of Figure 31 could serve to depict a subject considerably older than Peter.[55]

If this hypothesis were true, it would not only be true that younger adults experience the duration of a day as lasting longer than the way older adults experience it. It would *also* be the case that younger adults experience *more* in a day. You would thus be better off not waiting too long to cash in that free day in the spa. Putting that dreadful operation off further, on the contrary, might save you some of the pain!

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[55] As mentioned before, most experiments in the psychological literature involve very short periods of time. Since while in the testing environment the subject is paying attention to the experiment, it is less likely that experiential blackouts occur. It is only if an experiential blackout happens to coincide with the stimulus being presented that some effect would be found. To test this hypothesis, measuring the features experienced by subjects of different ages engaged in some long-term activity (perhaps lasting various hours) would be preferable. Lustig (2003) suggests something similar but for testing flickering rates of *attention* in older adults.

This hypothesis is independent of the previous one. Thus, it could be that both are true. The combined effects of having more experiential blackouts and allocating more attentional resources in ordinary tasks could be what explain why, compared to our younger years, as we age time seems to fly by.[56]

VI.

Conclusion

Most of us know what it is like to see orange. In case of doubt, just hold a big, bright, ripe tangerine in your hands and look at it for as long as you need to. Time is by nature more slippery than this. I cannot lay a well-paced ten-minute walk in front of myself for my perusal. Even if I myself take the walk, every new step will wash away the previous one: no matter how hard I try, I cannot have all of the steps in front of me as I can have the whole of the facing front of the tangerine. This, however, does not show that we do not really experience time, that there is no such thing as experiencing the duration of a ten-minute walk. It only makes its characterization more challenging.

What is it like to experience the duration of an event? According to the theory developed, the short answer is this. For a long-lived event, it is to form an impression of how many quanta are involved in experiencing it from beginning to end. For a short-lived event, it is how much of the duration of its surrounding quantum it strikes us as taking up. In both cases, experienced quanta provide the subjective unit of our experience of duration. Thus, experienced quanta are the analogues of qualia like seen color, seen shape, felt texture, and heard sound for the case of the perception of duration. The passing of time has a feel to it, but it is not a novel color or shape or texture or sound. It is the passing of experienced units, and our temporal experience provides us with an impression of the count of these units or quanta.[57]

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[56] An alternative way of accounting for 'the speeding up of time' phenomenon observed with aging would be if the approximate number system, as we age, produced more 'undercounts' of quanta. If quanta indeed overlap, another explanation compatible with the theory offered would be to argue that what the subjective pacemaker 'counts' are quanta (as opposed to non-ovelapping quanta) and that, as we age, quanta tend to overlap less. Thanks to Fiona Macpherson for a helpful discussion on this last point.

[57] [Acknowledgments]

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