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INDISCRIMINABILITY AND EXPERIENCE OF CHANGE

By Ian Phillips

It is obvious both that some changes are too small for us to perceive and that we can perceive constant motion. Yet according to Fara, these two facts are in conflict, and one must be rejected. I show that conflict arises only from accepting a 'zoëtrope conception' of change experience, according to which change experience is analysed in terms of a series of very short-lived sensory atoms, each lacking in dynamic content. On pain of denying the phenomenologically obvious, we must reject the zoëtrope conception. I offer an alternative account, according to which the dynamic content of our experience at short timescales is metaphysically dependent on the content of experience over longer timescales. Moreover, at short timescales such content is purely determinable.

I. INTRODUCTION

Here are two obvious facts about visual experience:

1. Some changes are too small for you to perceive. You cannot, for example, perceive the motion of slow moving objects such as the hour hands of ordinary clocks, or the moon climbing the night sky.

What counts as 'slow moving' is of course partly a matter of how close an object is: the moon is hurtling around its orbit at about a kilometre per second, but being so far away, it alters position by just over a ten-thousandth of a degree of visual angle in that time (contrast a very thin hour hand, viewed under a powerful microscope). Many other factors bear on our ability to detect changes, for example, luminance, retinal region stimulated, and the other elements in the visual scene.[1]

2. You can perceive constant motion. Often second hands tick, but many sweep. Typically, you perceive these sweeping second hands as moving constantly around the clock face. That is, you can be aware of a second

[1] For relevant reviews, see T.M. Tayama, 'The Minimum Temporal Thresholds for Motion Detection of Grating Patterns', *Perception*, 29 (2000), pp. 761–9; J.S. Lappin *et al.*, 'Spatial and Temporal Limits of Motion Perception across Variations in Speed, Eccentricity, and Low Vision', *Journal of Vision*, 9 (2009), pp. 1–14.

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> hand for an extended period of time, and yet there may be no interval (no matter how brief) during that period when the hand does not look to you to be changing its position. Similarly for watching a plane gliding through the air, or a puck sliding across the ice.

Obvious as these facts are, they generate a puzzle. For, according to Fara, the first precludes the second: if some changes are too small for you to perceive, then you cannot perceive constant motion.[2]

In this paper, I show how to reconcile these two obvious experiential facts. Experience of constant motion and the existence of imperceptibly small changes conflict only if we assume, as Fara and many others implicitly do, what I call a *zoëtrope conception* of perceptual experience. My central contention is that on pain of denying the phenomenologically obvious, we must reject the zoëtrope conception, and provide an alternative account of experience of change.

What is the zoëtrope conception? In a zoëtrope, a strip of ordinary pictures or photographs is wrapped inside a spinning drum and viewed through a slit in the drum's side; this creates the impression of a moving figure. Both in perceiving the spin of the drum, and misperceiving the several images as a single image in motion, we experience change. Reflecting on the temporal structure of change experience (as opposed to its contents), there is a widespread, if largely tacit, tendency to picture experience as *itself* like a zoëtrope. Just as a zoëtrope consists of a strip of static figures individually lacking in dynamic depictive content, we are tempted to think that change experience itself can be analysed in terms of a series of very short-lived sensory atoms, each enduring for an instant or brief moment, and each individually lacking dynamic content. This is the zoëtrope conception of experience.[3]

[2] D.G. Fara (originally D. Graff), 'Phenomenal Continua and the Sorites', *Mind*, 110 (2001), pp. 905–35.

[3] Such models go by various names, for example, 'snapshot', 'cinematic', or 'atomistic' (though these labels are sometimes used differently). The zoëtrope analogy comes from William James' classic discussion, *The Principles of Psychology* (New York: Holt, 1890), p. 200. For relevant philosophical discussion see, e.g., H. Bergson, *Creative Evolution*, tr. A. Mitchell (London: Macmillan, 1914); C. Hoerl, 'Time and Tense in Perceptual Experience', *Philosophers' Imprint*, 9 (2009), pp. 1–18; G.S. Lee, 'Consciousness and the Passing of Time', New York Univ. PhD Thesis (2009); B. Dainton, 'Temporal Consciousness', in E.N. Zalta (ed.), *The Stanford Encyclopedia of Philosophy* (2010), http://plato.stanford.edu/entries/consciousness-perceptual, §4. For relevant empirical discussion see J.M. Stroud, 'The Fine Structure of Psychological Time', in H. Quastler (ed.), *Information Theory in Psychology* (Glencoe: Free Press, 1955), pp. 174–207; D.A. Allport, 'Phenomenal Simultaneity and the Perceptual Moment Hypothesis', *British Journal of Psychology*, 59 (1968), pp. 395–406; F. Crick and C. Koch, 'A Framework for Consciousness', *Nature Neuroscience*, 6 (2003), pp. 119–26, at §7; R. VanRullen and C. Koch, 'Is Perception Discrete or Continuous?', *Trends in Cognitive Sciences*, 7 (2003), pp. 207–13; C. Koch, *The Quest for Consciousness* (Denver: Roberts, 2004), pp. 264–8.

My alternative account has two related commitments at its core. Both contrast with the zoëtrope conception. The first commitment is that the content of our experience at very short timescales is metaphysically dependent on the content of experience over longer timescales (contrast the independence of each sensory atom on the zoëtrope picture). The second is that at short timescales the dynamic content of experience is purely determinable. Thus, for example, we may experience an object's motion between two points without experiencing the determinate character of the motion (contrast the determinate static contents of individual atoms on the zoëtrope picture).

II. FARA'S PUZZLE

Locke (*Essay* II xiv 11) describes watching a slow moving object such as a clock's hour hand.

> The body, though it really moves, yet, not changing perceivable distance ... seems to stand still; as is evident in the hands of clocks, and shadows of sun-dials, and other constant but slow motions, where, though, after certain intervals, we perceive ... that it hath moved, yet the motion itself we perceive not.

Here Locke offers the standard story concerning the perception of slow moving objects. On typical clocks the hour hand moves too slowly for us to perceive its movement and the hand appears still. But as its imperceptible progress continues, we eventually perceive the hand as being in a distinct position and so infer that it has moved. In contrast, on typical clocks we can straightforwardly *see* the second hand moving around the clock face.[4] Moreover, if the hand 'sweeps' as opposed to 'ticks', you can experience it as *constantly* moving around the clock face: there is no period during one's experience of the hand over which it does not look to you to be moving. Constant motion, so understood, does not imply constant velocity. Constant motion must also be distinguished from strictly continuous motion which would require us (implausibly) to experience motion through every proper part of an interval through which we saw an object moving.[5]

Goodman cites 'phenomenal motion too slow to be momentarily perceived' as a paradigm example of the non-transitivity of indiscriminability.[6] As Dummett explains:

[4] See, e.g., C.D. Broad, *Scientific Thought* (London: Routledge & Kegan Paul, 1923), p. 351.

[5] Though this distinction needs to be secured in order to provide a plausible account of change experience, it is not immediately obvious how it can be. In §III, I claim that Fara's account of change experience has no way of doing so. To see how it can be that we experience constant motion without experiencing continuous motion requires the positive account to be developed below. I explicitly revisit this issue with the account in place in §VIII.

[6] N. Goodman, *The Structure of Appearance*, 3rd edn (Boston: Reidel, 1977), p. 203.

> I look at something which is moving, but moving too slowly for me to be able to see that it is moving. After one second, it still looks to me as though it is in the same position; similarly after three seconds. After four seconds, however, I can recognize that it has moved from where it was at the start, i.e., four seconds ago. At this time, however, it does not look to me as though it is in a different position from that it was in one, or even three, seconds before. Do I not contradict myself in the very attempt to express how it looks to me?[7]

In general, the non-transitivity of indiscriminability supposedly arises because it is thought possible to have three scenes s_1–s_3 such that s_1 looks the same as s_2 and s_2 the same as s_3, but s_1 does not look the same as s_3. (In each case what is relevant is how things look to the same subject.) Goodman and Dummett take our experience of the hour hand to provide a case with exactly this structure. In doing so, they endorse the standard Lockean story on which objects lying close enough in position look to be in the same position. This is why the hour hand 'seems to stand still' as Locke puts it, and why, in Dummett's words, 'after one second, [the clock hand] still looks to me as though it is in the same position'.

Now for Fara's challenge. According to the standard story, the changes of position made over a few seconds by hour hands and the like are too slight to be perceived. For example, in his first analysis of such a case (p. 317), Dummett has us assume that 'the smallest discriminable rotation is 24 min. of arc', and in his second (p. 322), 'that whether or not the minute hand occupies discriminably different positions at different moments depends uniformly upon whether or not the angle made by the two positions of the minute hand is greater than a certain minimum'. Fara (p. 926) challenges this explanation. It is 'very suspect ... since it should leave us wondering why not *every* experience of motion is an experience of slow motion':

> If the reason that the hour hand strikes us as still-looking for any twenty-second interval is that we cannot visually represent a change in position as small as, say, 1/6° (on a normal-size clock), then the *second* hand should look still for any 1/36 second interval, for *it* changes its position only that amount during such an interval. But, when we watch the second hand moving, it never looks still – it appears to be *constantly* moving.... Although the [proposed explanation] would explain why we experience slow motion [i.e., explain why hour hands do not look to change position over twenty-second intervals], the explanation seems too strong, since it seems to preclude the possibility of experiences of constant motion.

More generally, to perceive something as constantly moving requires there to be no period over which it does not look to be changing its position. Yet according to the standard Lockean account of the slow change case, objects close enough in position look to be in the same position. But then during a

[7] M. Dummett, 'Wang's Paradox', *Synthese*, 30 (1975), pp. 301–24, at p. 316.

small enough *time* period a moving object looks to be in the same position. So there is always some period over which the hand does not look to be changing position, precluding experience of constant motion.

Experience of constant motion is actual – just look at a sweeping second hand. Thus Fara concludes that the standard explanation of slow change cases in terms of imperceptibly small changes must be mistaken. In the next section, I briefly raise two concerns about her alternative account of experience in slow change cases. I then demonstrate how Fara's argument tacitly assumes the zoëtrope picture of change experience. Finally, by providing an alternative account to the zoëtrope picture, I show how we can reject her argument, and vouchsafe the two obvious facts with which I began.

III. FARA'S ALTERNATIVE

Fara's own reply to the puzzle that she raises is to suggest (pp. 927–8) that the tiniest of slow changes are in fact perceived but just not *noticed*. According to her, '*Noticing* the change in apparent position requires not only that there be an apparent change, but also that we believe there to be one'. It is not clear whether Fara thinks adding belief is sufficient or merely necessary for noticing. It is unclear that it is either. Belief does not seem to be a sufficient condition, since I might believe that there was an apparent change for a congeries of better or worse reasons (or none at all): perhaps someone I trust unreservedly tells me that there has been an apparent change. Clearly this does not mean that I notice it. Similarly, belief does not seem to be a necessary condition, since we can make sense of someone genuinely noticing a change and yet believing that there was no apparent change: perhaps again I am convinced by someone that there could not have been an apparent change, any appearance to the contrary being explained by failure to attend to my experience properly. Certainly Fara (p. 927) is more than happy to allow that individual judgements about the character of our experience can be mistaken.

Whatever the correct account of noticing, there are two serious concerns about Fara's suggestion. First, she argues (p. 927) that her 'distinction is naturally invoked in other cases', offering the example of a friend's lightened hair colour, only noticed when pointed out. However, here the change in colour is perfectly *noticeable* before it is noticed; its being pointed out merely helps one to notice it. In contrast, normally, we think that we simply *cannot* see hour hand changes over a period of just a few seconds. In other words, we think that normal (unaided) vision is incapable of consciously presenting the changes made by a standard hour hand – pointing them out is no help!

As a result, Fara's noticing-based account must insist that an object or event can be perceived even though it is unnoticeable. This is not something we naturally admit in other cases, and it is far from clear that it is coherent.[8]

The second concern is that on Fara's account there is no limit to the visible discriminations that we can make. The argument above assumed that 'we cannot visually represent a change in position as small as, say, 1/6° (on a normal-size clock)'. But the form of argument is quite general: nothing in it depends upon the particular figure of 1/6°. Thus if this argument convinces us that a change of position as small as 1/6° is visible but unnoticeable, we must also allow that changes of position as small as 1/6,000,000° are visible but unnoticeable. This is utterly outlandish. Microscopes do not simply help us to *notice* things that we could already see! Thus even if we allow for cases in which something is perceived despite being unnoticeable, Fara's account cannot constitute a general alternative approach to change experience. Yet we are offered no further materials out of which to fashion such an account. In what follows, I show how to resolve Fara's puzzle and thereby avoid the problems with her alternative account.

IV. VARIATION AND CHANGE

In thinking about clock hands or colour swatches, a crucial distinction needs drawing between, as I shall put it, mere variation and genuine change. Body temperature varies between the body's parts: my feet may be colder than my hands. This involves no change. Change, on my understanding, is, minimally, the variation in the properties of some object *over time*.[9] If I move my feet closer to the fire, their temperature changes as they get gradually warmer. Looking at a static array of colour swatches, I perceive variation in colour but do not perceive change; there is no change to see, only variation across space. Looking at the hour hand, I do not perceive change either; the changes of the hour hand are too slight to see. Only in the second hand case is change genuinely an object of experience.

In discussions of non-transitivity the distinction between variation and change, if drawn at all, is treated as inconsequential. In particular, if the fast, second hand case is explicitly considered, it is held to present no special problems. For instance, although Wright does discuss the case of 'seemingly

[8] Cf., e.g., Tye's view that 'you cannot see a thing, if you cannot attend to it': M.M. Tye, 'A New Look at the Speckled Hen', *Analysis*, 69 (2009), pp. 258–63, at p. 260.

[9] Goodman (pp. 271–2) gives a similar example to illustrate the contrast between mere variation and change, which he defines as 'concomitant variation in time and some other respect'. He holds that 'ordinary usage marks an important distinction' here. However, he does not apply it to his discussion of non-transitivity.

continuous processes in time', acknowledging, quite rightly, that they do not come 'ready made out of finitely many stages', he nevertheless treats the case as merely a less 'artificial', more 'dignified' version of the colour patch case.[10] He achieves this by analysing it in terms of the discriminability or otherwise of *stages* of the process, where a stage is 'an instantaneous exposure, as it were, of the process at [a] point [in time]'. Likewise, although Burgess distinguishes between fast, dynamic cases on the one hand and static cases on the other, he claims that 'we can know *a priori* that [a continuous change] must be ... divisible' into 'observed [temporal] stages of the process of change'. On this basis, he concludes that there is no essential difference between the cases.[11]

In decomposing change experience into 'instantaneous exposures' or 'stages', and analysing it in terms of the presentation of successive static clock hand positions, these authors effectively adopt the zoëtrope picture with which I began. The central element of the zoëtrope picture is that change experience can be analysed in terms of a series of non-dynamic experiences of varying static scenes. This is exactly the model that Wright's and Burgess' analyses presume.

For her part too, Fara is happy to generalize across 'processes of change over a space [i.e., mere variation] as well as over time [i.e., genuine change]' (p. 929, fn. 20; likewise p. 931, fn. 21). In her treatment of powers of discrimination (p. 916, fn. 14), she notes her intention 'that remarks in this discussion be taken to hold *mutatis mutandis* for perceived differences between two things at a single time, as well as for perceived changes in a single thing over time'. Again the zoëtrope model is insidiously at work in warranting this generalization across cases of variation and change. Without the zoëtrope picture, one cannot simply assume that what holds for perceived variation holds for perceived change. In fact, rejecting this assumption permits a response to Fara's challenge.

V. CLOSENESS

The essential explanatory claim made in Locke and Dummett's standard story, and called into question by Fara's challenge, is the claim that objects (such as clock hands) *close* enough in position look to be in the *same* position:

[10] C.J.G. Wright, 'On the Coherence of Vague Predicates', *Synthese*, 30 (1975), pp. 325–65, at p. 345.

[11] J.A. Burgess, 'Phenomenal Qualities and the Nontransitivity of Matching', *Australasian Journal of Philosophy*, 68 (1990), pp. 206–20, at pp. 212, 208. See also R. De Clercq and L. Horsten, 'Perceptual Indiscriminability: in Defence of Wright's Proof', *The Philosophical Quarterly*, 54 (2004), pp. 439–44, at p. 440.

C. Variation within small enough intervals appears as no variation at all.[12]

(C) has struck most philosophers as obvious. Dummett (p. 316) uses (C) to explain our failure to see the movement of a single slow moving clock hand, when he claims that if the hand has only changed orientation by some minimal threshold angle $\delta\theta$ or less, it 'still looks to [you] as though it is in the same position'.[13]

(C) is equivalent to what Fara (p. 924) somewhat misleadingly terms 'the homogeneity thesis', the thesis that variation within small enough intervals appears homogeneous (i.e., as no variation at all). Yet Fara's puzzle about constant motion challenges the support provided for (C) on the standard story. As Fara puts it (p. 933), 'if the [(C)] thesis were required to explain experiences of slow change [such as in the hour hand case above], then the possibility of experiences of *constant* change would be precluded, which it had better not be'. To repeat the challenge, if I experience an object as *constantly* moving over some period, then there is *no* interval during that period during which I see the object and yet it does not look to me to be changing its position. Suppose I see the second hand moving constantly around a clock face from one to two o'clock, sweeping out an angle of 30°. According to (C), all hand positions lying within a small enough sector $\delta\theta$ appear the same. It follows that hand positions occupied during small enough *temporal* intervals (specifically, intervals of δt or less, where $\delta t = \delta\theta/\omega$, and ω is angular velocity) appear the same. Hence there is a period δt during which the hand does not look to be changing position, for it appears to be in the same position during that period.

In short, (C) appears to preclude constant motion experience. This leaves us embroiled in paradox. For on the one hand, you only need to move your hand across your visual field to see that we do experience constant motion: the phenomenological data leave no room for doubt. Yet on the other hand, Wright (p. 346) plausibly insists that to reject (C) would be 'to suppose that we have infinite powers of discrimination'. No one wants to suppose this.

[12] Hellie rightly insists that we should distinguish between (i) hand positions within $\delta\theta$ look the same, and (ii) hand positions within $\delta\theta$ merely do not look distinct: see B. Hellie, 'Noise and Perceptual Indiscriminability', *Mind*, 114 (2005), pp. 481–508, at p. 489, fn. 9. However, simply insisting on the weaker second reading of (C) is not enough to avoid Fara's challenge, since the distinction is otiose on the zoëtrope picture. If I experience a hand as moving constantly, there is no period during which I perceive it as unchanging in position. What we need to know is how this could be true, if over sufficiently small sectors the hand does not look to occupy *distinct* positions. To this question the zoëtrope picture has no answer. For an answer we must turn to the alternative account developed below, on which Hellie's distinction has a natural home.

[13] (C) is also implicit in Dummett's 'dot' argument (pp. 314–15). See also Wright (p. 343), and (in relation to both Wright and Fara) De Clercq and Horsten, 'Perceptual Discriminability'.

VI. CLOSENESS AND FINITE POWERS OF DISCRIMINATION

Intuitive support for the idea that our powers of discrimination are finite rests with the claim with which I began, namely, that there are changes too small to be perceptually detected. In order to respond to the paradox the relation of this idea to (C) needs to be examined. As Fara points out, the claim that some changes are too small to be perceptually detected must be understood as a negative claim about our representational limits.[14]

Fara (p. 917) offers just such an elucidation.[15]

> For some sufficiently slight amount of change (in colour, sound, position, etc.), we cannot perceive an object as having changed by less than that amount unless we perceive it as not having changed at all (as having changed by a zero amount).

According to this claim, there can be no representation of change below a certain limit. Does this entail (C), as Wright suggests when he avers that to reject (C) would be 'to suppose that we have infinite powers of discrimination'? A very natural line of thought suggests that it does.

An experience of a large change *typically* involves the representation of sub-changes. For example, my experience of a second hand turning around a clock face typically involves experiencing various parts of the motion, parts corresponding to the hand's movement through proper segments of the whole arc traced. However, if there can be no representation of change below a certain limit, then when we perceive large changes, we cannot perceive *all* the sub-changes that occur. Some are simply beyond our powers of discrimination. As a result, it may seem that during the periods when such sub-changes are occurring, the hand must look still.

Suppose a second hand constantly sweeps out a 30° sector over a period of 5s. If there can be no representation of changes below a certain limit,

[14] I talk for convenience in terms of perceptual representation. Nothing of significance turns on this. My account is not intended to presuppose a representationalist approach to perceptual experience.

[15] In fact Fara wavers between two distinct claims, of which this is the stronger. Her weaker gloss (p. 918) is that 'for every experience I could have as of a change, there is an experience I could have as of a lesser change (but for [an experience of "zero change"])'. The stronger claim in the text insists that can be *no* representation of sub-changes below a certain limit. This weaker gloss does not insist on any limit to representable sub-changes. What it apparently rules out is that small changes below a certain limit might be the *sole* objects of a change experience, i.e., that they might be experienced on their own and not as part of a larger change. It is just not plausible to think of the visual system as affording discriminations down to 10^{-25}m (cf. Dainton, p. 170). Thus it is clear that Fara's weaker reading will not do. That said, the weaker gloss unintentionally highlights the important idea discussed below that some changes might only be representable as part of larger changes but not on their own.

there are sub-changes during the 5s period which are beyond our powers of perceptual discrimination. In particular there is an imperceptible sub-change during the 5s period when the clock hand moves through a small angle $\delta\theta$ over a brief period δt. Given this – and here is the nub of Fara's challenge – it may seem that the hand *cannot* look to be in constant motion. If we perceive the hand's motion as constant, then we *never* perceive the hand as stationary or unchanging, not during *any* period, no matter how small. But what about this period δt? δt seems to be just such a period. After all, we might further reason, the clock hand must look to be in some position at the start of the period δt; and we have just acknowledged that changes over angles as small as the angle $\delta\theta$ swept out during δt are imperceptible; so the clock hand must look to be in the same position at the end of the period δt, and hence must look stationary over the period.

In short, the fact that our discriminatory powers are finite appears to entail (C). To see what is wrong with this reasoning, we need to recognize that there are special conditions on the representation of change as opposed to the representation of mere variation. We can approach this idea by first considering the traditional suggestion that experience has a temporal field within which motion and change can be directly perceived.

VII. THE TEMPORAL FIELD

If you stare at an hour hand for a whole hour, the change in hour hand position over the course of the hour is not too small to be perceived – it would not be much use as a clock hand if it was – yet despite this, you do not see the hour hand moving over that longer period of time. What this reveals is that there is an upper bound to the stretches of time over which we can directly apprehend complete events and processes. As a simple model, we can think of our experience as having a 'temporal field', and of there being limits to the extent of the field, say 300ms.[16] Given the upper bound imposed by the extent of the temporal field, one is only able to perceive movement if the clock hand moves a sufficient distance within its 300ms

[16] See, e.g., Broad, p. 354. For discussion of the true length of the field or 'specious present' in the wake of James' pioneering (and perplexing) discussion (in ch. 15), see, e.g., Dainton, p. 171; M. Lockwood, *The Labyrinth of Time: Introducing the Universe* (Oxford UP, 2005), p. 381; S. Kelly, 'The Puzzle of Temporal Experience', in A.F. Brook and K. Akins (eds), *Cognition and the Brain* (Cambridge UP, 2005), pp. 208–40; R. Grush, 'Time and Experience', in T.F. Müller (ed.), *Philosophie der Zeit* (Frankfurt: Klosterman, 2007), pp. 27–44. We should not of course assume that the specious present has the same length across different subjects, times, modalities, or perhaps even features. See also the empirical work cited in fn. 3 above, particularly discussion of the 'perceptual moment hypothesis'.

limits. In hour hand cases, the hand does not do this. We are well outside such a field before sufficient movement takes place.[17]

There are different accounts of temporal experience, and so of the temporal field. Dainton distinguishes three different models, which he terms 'cinematic models', 'retentional models' and 'extensional models'. Cinematic models endorse the zoëtrope conception of experience detailed above on which experience is composed of independent sensory atoms, each individually lacking in dynamic content. Retentional and extensional models reject such a conception. According to retentional models (e.g., in Husserl, Tye[18]), experience itself is confined to the instant but is none the less capable of embracing extended temporal structure (perhaps in conjunction with some form of memory). In other words, the retentionalist makes sense of the temporal field by insisting that the *contents* of sensory atoms are extended in time: what is represented as occurring at some instant has temporal extension. Here the zoëtrope picture is rejected because the contents of individual atoms are not held to be static but (at least potentially) dynamic.

According to extensional models, not only are the contents of experience essentially extended in time, experience itself is: we are aware of temporally extended goings on over the course of extended stretches of experience.[19] Here the zoëtrope conception is rejected root and branch: not only are the contents of experience fundamentally dynamic, so too is experience itself. In my view we should endorse the extensional model,[20] and I shall assume that this picture is correct in what follows. However, the core components of the account below can be endorsed from a retentional perspective. From such a perspective the ideas below should be understood as focused on the *contents* of experience, as opposed to experience itself. The core of the account is that the dynamic *content* of our experience at short timescales is metaphysically dependent on the *content* of experience over longer timescales.

To illustrate the role of temporal fields in our experience, consider what would happen to us if our temporal field were suddenly to be altered. Suppose that instead of a 300ms field, we suddenly started experiencing with a much shorter 30ms field (if you like, a 'specious present' of 30ms). Assuming that our powers of discrimination remained fixed, a consequence would be that we could only perceive movement if a clock hand moved a sufficient

[17] Cf. Russell, *The Analysis of Matter* (London: Paul, Trench, Trübner, 1927), p. 281, and *Human Knowledge: its Scope and Limits* (London: Allen & Unwin, 1948), p. 226; Broad, pp. 351–2.

[18] See E. Husserl, *The Phenomenology of Internal Time-Consciousness* (Indiana UP, 1964); Tye, 'Representationalism and the Transparency of Experience', *Noûs*, 36 (2002), pp. 137–51.

[19] See J. Foster, 'In Self-Defence', in G.F. Macdonald (ed.), *Perception and Identity* (London: Macmillan, 1979), pp. 175–82; Dainton, *Stream of Consciousness*.

[20] See my 'The Temporal Structure of Experience', in D.F. Lloyd and V. Arstila (eds), *Subjective Time: the Philosophy, Psychology, and Neuroscience of Temporality* (MIT Press, forthcoming).

distance within that 30ms field. On many clocks, it is plausible that a second hand does not move far enough within 30ms for any change to be detected. Thus the effect of the reduction in field-width would be that second hand experience became like hour hand experience. We would see *that* the second hand had moved, but cease to see its movement. Conversely, if our field were suddenly expanded to 30s, we would begin to see the minute hand's movement in just the same way as we normally see the second hand's.

What the idea of a temporal field highlights is the existence of conditions which need to be in play in representing change but which need not be in play in representing mere variation. If we are to perceive change at all, a certain amount of change must take place within the temporal field. As a result, whether one is perceiving change over some very brief period may depend on whether the change presented over that very brief period forms part of a change across the whole temporal field which is large enough to be perceived. More generally, the idea of a temporal field highlights that whether our experience represents something as occurring over a brief period can depend on what it represents as occurring over a longer encompassing period.[21]

These ideas are entirely lost on the zoëtrope picture. On the zoëtrope picture, change experience is analysed in terms of series of very short-lived, and wholly independent, representations of static scenes. There is no room on this conception for the idea that whether our experience has a content at some moment might depend on what is presented in experience over some encompassing period. Indeed, there can be no room for the idea that there is something special about the case of change which contrasts the case of simple variation: change is analysed in terms of variation. However, the zoëtrope picture is not mandatory, and to do justice to our experience of change we must reject it.

VIII. PERCEIVING CONSTANT CHANGE

As I have just pointed out, whether you perceive the motion of a clock hand depends on whether its motion constitutes a large enough change within your temporal field. However, to make sense of *constant* motion perception, something has to be said about our experience over sub-intervals of the

[21] A closely related idea is exploited in M. Soteriou, 'Content and the Stream of Consciousness', *Philosophical Perspectives*, 21 (2007), pp. 543–68, esp. pp. 552–4. For further development of this idea see Soteriou, 'Perceiving Events', *Philosophical Explorations*, 13 (2010), pp. 223–4; I.B. Phillips, 'Perceiving Temporal Properties', *European Journal of Philosophy*, 18 (2010), pp. 176–202, and 'The Temporal Structure of Experience'; Hoerl, 'Time and Tense in Perceptual Experience'.

temporal field. For there are always brief enough sub-intervals during which a visibly moving clock hand sweeps out an angle too small to detect, given our limited powers of visual discrimination. As Fara's challenge brings out, it is natural to reason that over such brief intervals the clock hand must look stationary, precluding experience of constant motion.

To resist this reasoning I rely on two ideas: first, the idea encountered in my discussion of the temporal field, that whether we perceive change over a brief period of time may be dependent on whether we experience change over a longer encompassing period; secondly, the idea that the content of experience can be determinable in respect of fine-grained motion, and in particular, that some sub-changes are simply seen *as such* (i.e., purely determinably).

The idea of determinable *spatial* content is familiar from representationalist accounts of experience alive to the limited discriminative power of vision. For example, in his treatment of blurry vision, Tye proposes that if you stare at a serrated stamp with 20/20 vision, your experience represents the stamp's relatively precise shape. However, if you take off your glasses, you merely represent the squarishness of the stamp without representing the relatively determinate serrated shape that is the stamp's particular way of being squarish.[22]

The idea needed in the current context is that fine-grained motion can also be represented purely determinably. For example, we might visually represent an object as moving constantly and fairly rapidly between two points but fail to represent any more determinate characteristics of the movement, such as whether the object speeded up or slowed down as it moved between the points, or when exactly it reached the midway point, or if the motion was strictly continuous, or instead discontinuous and 'jumpy'. In fact, empirical work on motion perception suggests that our visual systems can respond to motion *per se*, as opposed simply to detecting the change of position of features over time.[23] As a result, it may be that the

[22] Here I follow the interpretation of Tye, 'Representationalism and the Transparency of Experience', p. 149, given in M. Pace, 'Blurred Vision and the Transparency of Experience', *Pacific Philosophical Quarterly*, 88 (2007), pp. 328–54, at p. 334. The same basic idea is available on other accounts of perceptual experience. As Pace comments (p. 351), 'a naïve realist could adapt Tye's solution to the problem of blurred vision in terms of determinable spatial properties. For example, a naïve realist might claim that when one's vision is out of focus one is directly aware of the stamp and its squarishness (though not aware of its more determinate shape).' The only catch is that the naïve realist cannot then endorse the claim made, for example, in C. Gillett and B. Rives, 'The Non-Existence of Determinables: or, a World of Absolute Determinates as Default Hypothesis', *Noûs*, 39 (2005), pp. 483–504, and D.M. Armstrong, *A Theory of Universals* (Cambridge UP, 1978), ch. 22, that worldly properties are all absolutely determinate.

[23] See, e.g., K. Nakayama and C.W. Tyler, 'Psychophysical Isolation of Movement Sensitivity by Removal of Familiar Position Cues', *Vision Research*, 21 (1981), pp. 427–33.

content of our experience in some circumstances is *highly* determinable: we may see motion without any awareness of position. For present purposes (namely, resolving Fara's paradox), I abstract from these empirical issues here, and provide the broad structural outlines of an account of constant motion perception.

A constantly moving clock hand does not look still during any sub-periods of its movement. Consequently, it must be that during all sub-periods of its movement we experience it as moving. Since our powers of discrimination are finite, there are some periods over which we see the hand sweeping out an angle only just large enough for our powers of visual discrimination to discern. (This may be smaller than the smallest movement detectable on its own. But some movements must be too small to detect even as part of larger movements.) In such a case we cannot perceive this motion in any more determinate a way, since that would require us to perceive finer-grained facts about the motion, even though the motion is supposed to be at the limit of our powers of discrimination. For example, we cannot experience the hand as speeding up during its motion, for then we would be able to distinguish phases of the motion. But then each phase would itself be a perceptible movement, contradicting the assumption that the movement in question was the smallest discernible. In these circumstances, we see the hand moving constantly, *without* perceiving its determinate time-course. In short, if you perceive constant motion, then over brief periods the content of your experience is purely determinable.

What exactly is the content of experience over intervals even shorter than those over which the hand makes the smallest detectable movement? According to the characterization of constant motion offered above, over these intervals too we must see a constantly moving hand as moving. Since we cannot perceive the specific movement accomplished during such a brief period, during such intervals we must be experiencing the hand's movement over some larger interval. How can this be? Here again we need the idea that whether we enjoy change experience over a brief period of time may be dependent on our change experience (or lack thereof) over a longer encompassing period. In particular, in virtue of perceiving visually discriminable motion over the whole (or some significant part) of the temporal field we can thereby be aware of that very motion *continuing to unfold* during brief sub-periods of the field. Over brief intervals when we are perceiving constant motion we do not have an experience of some complete movement. This is only achieved over longer periods. Rather, the content of our experience at these timescales is of some movement *continuing to unfold*.

As noted at the outset, it is not plausible to claim that we perceive strictly *continuous* motion, i.e., motion through every proper part of an interval

through which we see an object as moving. Yet it is not initially obvious how we can perceive constant motion without perceiving continuous motion. It is not obvious, for instance, how can there be no period during your awareness of a second hand during which the hand does not look to you to be changing its position, while it is also not the case that you experience the second hand's motion through every proper sub-interval of the interval in question. With the crucial idea that what we experience over brief intervals is dependent on what we experience over longer periods in play, I am now in a position to address this concern.

As the discussion of the temporal field brought out, what we experience over brief intervals is dependent on what we experience over longer periods. Thus in virtue of having an experience of the second hand moving from one discriminably different location to another within the temporal field, it can be true that over even the briefest of sub-periods during our awareness of the moving second hand, we are *experiencing* its motion between those two discriminably different locations. This is what secures our experience of constant motion, for over no period (no matter how small) during our awareness of the hand does it appear to be stationary. It always appears (minimally) to be moving between those two discriminably different locations. On the other hand, we do not experience *continuous* motion because what we are aware of in experiencing the hand's motion between those two discriminably different locations over very short timescales is simply the hand's *continuing on* its motion through the larger interval. We are not aware of its motion over any particular smaller interval, and certainly not its motion through every proper sub-interval of every interval traversed. This is why the idea of determinable content is crucial. We experience motion over the larger interval without experiencing its determinate nature, and so without experiencing the hand's motion through every proper part of its path.

This can be put precisely as follows. During the perception of a constantly moving second hand there are periods with the properties of a threshold interval $\delta\tau$. Throughout the course of $\delta\tau$, one is experiencing the second hand sweeping out an angle $\delta\theta = \delta\tau \times \omega$. (This is what secures our experience of constant motion.) Nevertheless it is not true over any proper sub-period of $\delta\tau$ that one has *an experience* of the hand sweeping out an angle $\delta\theta$. That is, one does not undergo an episode which, in and of itself, counts as a perceptual experience of the hand sweeping out an angle $\delta\theta$. It is only over the whole period $\delta\tau$ that one has *an experience* of the hand sweeping out the angle $\delta\theta$. Moreover, it is not true that over any proper sub-period of $\delta\tau$ that one experiences, or is experiencing, the hand sweeping out some *sub-interval* of $\delta\theta$: such tiny changes are beyond our powers of discrimination. (This is what vouchsafes our failure to perceive continuous motion.) Rather,

over sub-periods of $\delta\tau$, and indeed, throughout $\delta\tau$, one is simply *experiencing* the second hand sweeping out an angle $\delta\theta$. The most basic characterization of our experience during a sub-period of $\delta\tau$ is that we are experiencing the second hand sweeping out an angle $\delta\theta$. We do not experience this sweeping motion in any more determinate way on pain of committing ourselves to perceiving strictly continuous motion. (This is why the content of our experience at such timescales must be determinable, for there is no more determinate truth about our experience at such timescales.)

It may sound absurd to suggest that experience has any content over nanosecond intervals. However, on the account here proposed, such contents are attributable only in a derivative sense. Experiential contents are fundamentally temporally extended: they are the contents of temporal fields. There can be truths about the contents of very brief periods within such fields. But these hold only in virtue of the whole content attribution, and there is no reason to assume that they could be experienced in independence of experiencing the content of the whole field. Compare the *prima facie* absurdity of suggesting that a person was dancing for a nanosecond. Certainly, no one could dance just for a nanosecond, nor, realistically, could there even be a dance-move accomplished just within a nanosecond. Nevertheless, it can be true to say of people that what they are doing over a nanosecond is dancing, if it is a nanosecond during a longer period during which they are constantly dancing.[24]

For the same reason we can talk of *experiencing* an object's movement *at an instant*, if one is experiencing motion over some surrounding period. This may sound puzzling, since motion essentially unfolds over time. But it should be no more puzzling than the fact that an object can truly be said to be moving at an instant as long as that instant is located within a period when the object is travelling along a path. Of course, during an instant it does not make any progress along that path. Nevertheless it can truly be said to be in the midst of its journey, and so moving along the path at that instant, in virtue of what is true over the relevant period of time. Similarly, it can also be true that one is experiencing an object as moving at an instant in virtue of one's experience of that object's motion over some period of time.

IX. AUDITORY APPLICATIONS

In this section I further illustrate the account just articulated by discussing its potential application to three auditory cases familiar from the literature

[24] Again cf. Soteriou, 'Content and the Stream of Consciousness', esp. pp. 552–4. See also Phillips, *Experience and Time*, University College London PhD Thesis (2009), esp. ch. 4.

on temporal experience. In the next section I conclude the discussion by showing how the present account solves the puzzle with which I began.

When it comes to audition, the zoëtrope model struggles even to get started. Plausibly all auditory experience is experience of sound (or silence), and sounds (and silences) are essentially extended in time.[25] Thus there is no static auditory content for a sensory atom to have, and no way of constructing auditory experience along zoëtrope lines.[26] So much the worse for the zoëtrope conception. My question here is how the current account can be applied to auditory experience.

First, suppose a sustained high C steadily rises in volume over a few seconds. What sort of content does one's auditory experience have, over brief durations of this experience? In a case where we can discriminate the note's pitch throughout the interval and are aware of it as constantly rising in volume, then the content of our experience is of the form 'high-C-tone constantly increasing in volume'. Since our auditory powers of discrimination are finite, over very brief intervals during this experience our experience has at most determinable content of the form 'tone continuing constantly to increase in volume from one discriminably different level to another'. (If one thinks that the nature of sounds cannot outstrip these capacities, then one must think that sounds themselves fill time in a purely determinable way.) But throughout all brief periods during this experience there is no reason to deny that we can then be experiencing the C-tone rising in volume in virtue of our enjoying experience of it rising throughout some larger interval.

This discussion bears on the case of the sustained operatic high-C recently adduced by Kelly, and discussed by Clark and Noë.[27]

> There you are at the opera house. The soprano has just hit her high note – a glass-shattering high C that fills the hall – and she holds it. She holds it. She holds it. She holds it. She holds it. She holds the note for such a long time that after a while a funny thing happens: you no longer seem only to hear it, the note as it is currently sounding ... in addition, you also seem to hear something more ... the note now sounds like it has been going on for a very long time ... what you hear no longer seems to be limited to the pitch, timbre, loudness and other strictly audible qualities of the note. You seem in addition to experience, even to hear, something about its temporal extent.

[25] See, e.g., Foster, *The Case for Idealism* (London: Routledge & Kegan Paul, 1982), p. 256; Husserl, *The Phenomenology of Internal Time-Consciousness*, p. 43.

[26] Cf. H.A. Prichard, 'The Apprehension of Time', in his *Knowledge and Perception* (Oxford: Clarendon Press, 1950), pp. 47–51.

[27] Kelly, 'The Puzzle of Temporal Experience', p. 208; A. Clark, 'That Lonesome Whistle: a Puzzle for the Sensorimotor Model of Perceptual Experience', *Analysis*, 66 (2006), pp. 22–5, at p. 23; A. Noë, 'Experience of the World in Time', *Analysis*, 66 (2006), pp. 26–32, at p. 27.

Clark (p. 23, raising an objection to Noë's sensorimotor account of perceptual content) sees the crucial challenge here as how to explain how 'perceptual experience depicts the sound as, in some real sense, right now (this instant) sounding "as if it has been going on for a long time" '.

Put in this way, it is inessential to Clark's challenge that the note has been going on for a long time. As just mentioned, all auditory experience involves hearing sounds or noises which unfold over time. Thus at every instant of auditory awareness we are aware of something which is itself necessarily extended in time and heard as such. The account of change offered above allows us to account for this. Audition has a temporal field. Auditory experience is essentially experience of sounds and silences filling this field. In so far as we want to attribute content to auditory experience at some instant, the content is derivative on the content of the temporal field as a whole. If you hear a sustained high-C held throughout the auditory field, the content at an instant can thereby be high-C *continuing on* through that period. The same applies to very brief periods, for our auditory powers of discrimination are limited.

Over very brief periods of auditory awareness, the content of our experience is of the form 'tone continuing on over some longer period'. Thus Clark's initial challenge is met by pointing out that, quite generally, in virtue of hearing a sound over some extended period of time (up to the length of the temporal field), we can during sub-periods be hearing the note as continuing to be sustained throughout the longer period.

There is, of course, an additional aspect to Kelly's case, involving as it does a note sustained for an exceptionally long period. The temporal field is not long enough to accommodate direct perception of a note sustained for many seconds. To account for what it is like to hear a note sustained in this way we need plausibly to recognize the ways in which phases of experience overlap, together with our capacity to track our recent experience in short-term memory. These aspects of experience are beyond the scope of this paper.[28]

Finally, here is another case, that of hearing a C-major broken chord played *staccato* and *allegro* on a well damped piano. Assuming the notes are played rapidly enough, then on hearing the final note, we typically not only hear the final G-note, but hear it as continuing on from the C- and E-notes preceding it.[29] This aspect of experience may seem puzzling if we think of every phase of experience as having an independent content. On the account I have given above, this is not so. Rather, we should naturally

[28] For discussion of issues concerning experiential overlap in this relation see Dainton, 'Temporal Consciousness', and references therein.

[29] See Phillips, 'Perceiving Temporal Properties', pp. 178–9.

insist that in such cases the content of our experience of hearing the final G is not fixed in isolation from the fact that the G is part of a series of notes heard within the temporal field. Thus the fundamental content of our experience in this case is hearing the broken chord played over some brief period, *C-then-E-then-G*. The content of our experience in relation to the G-tone reflects this fact, and so differs from a case where we simply hear a G-tone in isolation.

X. CONCLUSION

Armed with this new account of change experience, I can return to Fara's challenge. Her challenge was this: 'If the reason that the hour hand strikes us as still-looking for any twenty-second interval is that we cannot visually represent a change in position as small as, say, 1/6° (on a normal-size clock), then the second hand should look still for any 1/36 second interval'. What can now be seen is that even if a 1/36 second experience of the second hand *on its own* would be an experience as of no change, this does not mean that the clock hand appears still throughout 1/36 second periods when such periods are sub-periods of, say, a second-long experience of the hand turning through 6°. In such circumstances, we experience 6°-change going on *throughout* the one-second period. In virtue of so doing, the hand never looks still, for we are constantly in the process of experiencing 6°-change, through all 1/36 second sub-periods.

(C) is thus false. Our experience of constant change is a counter-example, for the hand does not appear to be in the same position throughout 1/36 second sub-periods of such experience; it appears to be constantly moving during them. In this way, constant motion experience is safeguarded as well as the obvious truth cited in explanations of hour hand cases, namely, that our powers of discrimination are finite. (C) appeared to follow from the finitude of our discriminatory powers because it was presumed that the clock hand must look to be in some precise position at any given instant. On the account here proposed, the question 'Where does the hand look to be position-wise at any given instant?' should be answered by saying not something of the form 'It looks to be at orientation θ_i', but rather something of the form 'It looks to be continuing to move constantly between orientations θ_i and θ_j'. There need be no determinate answer to where *exactly* it looks to be. Constant change is not perceived as unfolding in a fully determinate way.

The account of change experience here offered reconciles the two obvious claims about our experience with which I began. In contrast, if we

tacitly adopt a zoëtrope conception of experience, we find ourselves forced to deny that we can perceive constant motion, on pain of pretending to infinite powers of discrimination.[30]

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[30] Ancestors of this paper were presented at graduate conferences at Columbia/NYU and UT Austin, as well to the Vicious Circle discussion group in Oxford. A more recent version was presented at UCL. I am grateful to the audiences on all those occasions, and especially to my commentators John Morrison and Tomas Bogardus. I am also grateful to Mark Kalderon, Christopher Peacocke, John Schwenkler, Paul Snowdon, David Sosa, Matt Soteriou, Scott Sturgeon and anonymous referees for helpful advice and discussion of this material. Special thanks to Hemdat Lerman, Mike Martin and Hanna Pickard for invaluable input at various stages. This paper is dedicated to the memory of my grandfather, Bert Phillips, who first introduced me to zoëtropes as a young boy.