

The Construction of Phenomenal Time

Time is a striking example of where human subjective experience is at odds with our growing objective understanding of the physical world. If the approach developed here¹ to explain how consciousness – and specifically, the moment-by-moment subjective, phenomenal experience of being a physical self in a physical world – has merit, then it should provide means to reconcile these different ways we view time.

Two kinds of time

At the everyday level of individual subjective experience, we seem only to be able to understand time as an A-series² – that is, always from the perspective of ourselves at a time we call ‘now’. We experience our ‘now’ as inexorably moving ‘forward’ into an open, undetermined future that we can partly shape through voluntary, consciously planned actions. We cannot remember the future though we can envisage it. As our ‘now’ moves forward along the timeline, we feel we are leaving ‘behind’ a fixed past – that no agency can change – and that for most practical purposes we can remember. We feel our memories are reliable since things in the world, if left alone, stay where we leave them and to within acceptable error other people remember the same past as we do. In terms of the concepts developed on this website, experiencing an A-series is the way we consciously experience time in the course of experiencing ourselves as the self-model, B[i] in W[i].³ Call A-series time *phenomenal time*.

At the more abstract level of collective human knowledge and analysis of the physical world through science, we seem only to be able to understand time as a B-series, which exhibits no privileged ‘now’. In this understanding, all points along the timeline are equal, with no absolute past or future, just a past and future relative to any arbitrarily selected point on the timeline. Moreover, under the laws of physics as currently understood, the future⁴ looks to be as fixed as the past. This leads physicists and philosophers to speak of a Block Universe where, in one temporal and three spatial dimensions, the entire universe exists as a static ‘block’.

In terms of the concepts developed on this website, the B-series is time as we understand it at the most developed and objectified level of the collectively acknowledged physical world, W[z]. It is important to recognize that W[z] is not the same as the noumenal world, W[r].⁵ Even so, at least in the first instance, assume that what we collectively understand and agree through the physical sciences to be the physical world, W[z], is under collective refinement as science progresses such that it corresponds ever more closely to the underlying noumenal world, W[r]. So, for simplicity, call B-series time *noumenal time*.

¹ This note forms part of a wider discussion accessible at <http://teleodyne.com>, and should be read in conjunction with its predecessor note *How is Free Will Possible?* at https://teleodyne.com/free_will.pdf.

² The designations A-series and B-series follow McTaggart, J.M.E. (1908) *The Unreality of Time*. *Mind* 17: 457–73.

³ For definitions see https://teleodyne.com/intro_summary.html and other material attached to <https://teleodyne.com>, and in particular https://teleodyne.com/free_will.pdf.

⁴ Some approaches envisage multiple futures, following Everett, H. (1957). *Relative State Formulation of Quantum Mechanics*. *Review of Modern Physics* 29, 454–462 and De Witt, B and Graham, N. (eds.). *The Many-Worlds Interpretation of Quantum Mechanics*. Princeton University Press, Princeton New Jersey 1973. These potential approaches will be not be considered within this note for simplicity, and because they seem unlikely to bear on the main thrust of ideas presented.

⁵ The distinction between W[z] and W[r] has been explained as follows: “The third, and most abstracted level of understanding of the physical world can be called W[z]: When people, including scientists, refer to the “physical world”, what is being referred to is that which we collectively agree to be the contents of our respective W[i]s (the phenomenal worlds we each experience in the course of experiencing ourselves as B[i] in W[i]). We reach agreement on the contents of our respective W[i]s by use of language and, for quantitative purposes, by use of agreed measuring procedures. Thus, through collective agreement by these means, we form a view of ourselves as inhabiting a single, shared physical environment. In other words, whomever you are, you believe that the physical world you experience – your W[i] – is one and the same, by agreed measuring procedures and by all perceived contents, as the physical world which all others experience (i.e. their respective W[i]s). Thus, W[z] is the “physical world” as it is collectively acknowledged. In its highest, most sophisticated, and integrated form, W[z] is the physical world as it is articulated in the literature of the physical and biological sciences.” Ref: Introductory Summary – see https://teleodyne.com/intro_summary.html – at the entry for 24 Jan 1998. For a detailed description of the proposed relationship between W[z] and W[r], and why a distinction must be drawn between W[z] and W[r] in certain circumstances, see https://teleodyne.com/deconstructing_the_physical_world.pdf.

Relating the A-series to the B-series

Within the conceptual framework described in the note *How is Free Will Possible?*⁶, it has been proposed that a series of subjective moments will arise at around four times a second each time a particular step in a cyclic neurological[r] process called the *action cycle* is executed.

There is no need here to go into the detail of the overall cycle since for current purposes it is well described in that note⁶, which *inter alia* proposes that subjective self-awareness is delivered as a sequence of moments, each of which arises when a particular step in the action cycle denoted S5 is executed in the time course of the cycle.

Figure 1 illustrates the time course of the action cycle.

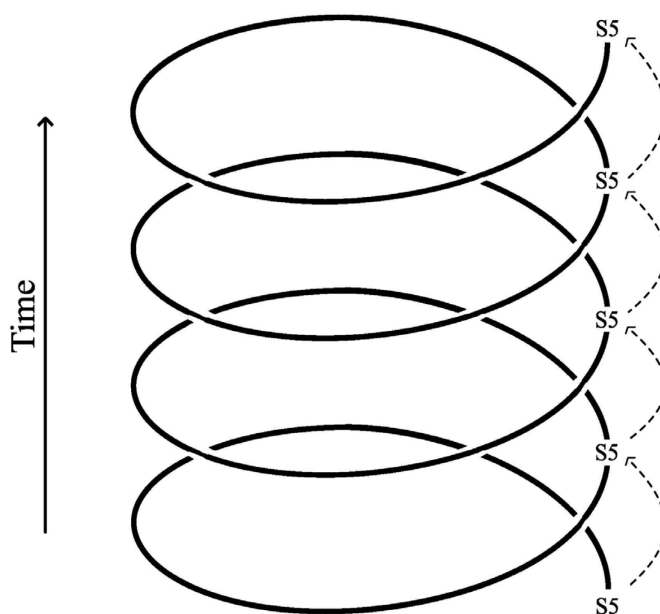


Figure 1

Figure 1 illustrates the action cycle in noumenal time. As fully described elsewhere⁶, it is proposed that each iteration, or *beat*, of the action cycle has a minimum of six steps (S1 to S6) and takes ~220 msec to complete. To avoid clutter only S5 is labelled here. It has also been proposed that at each S5 a person experiences a ‘moment’ of subjective self-awareness of themselves as a physical being surrounded by – and acting upon – a physical world, coinciding with information processing systems within their brain[r] that, via successive S5s, ground and sustain an inductive presumption that their noumenal body, B[r], is in identity with their phenomenal body B[i]. (It is this subliminal presumption of identity between B[r] and B[i] that delivers subjective awareness of the self in the form of the phenomenal self-model, B[i] in W[i]). Thus, the diagram illustrates each successive instance of subjective self-awareness – as it arises at each successive S5 – along the action cycle as it sits in noumenal time. The arrows linking each successive S5 illustrate the ‘step-forward’ of a person’s subjective self-awareness as they experience themselves moving forward in phenomenal time.

⁶ See https://teleodyne.com/free_will.pdf

Figure 2 shows another time dependent illustration of the action cycle with some additional annotation.

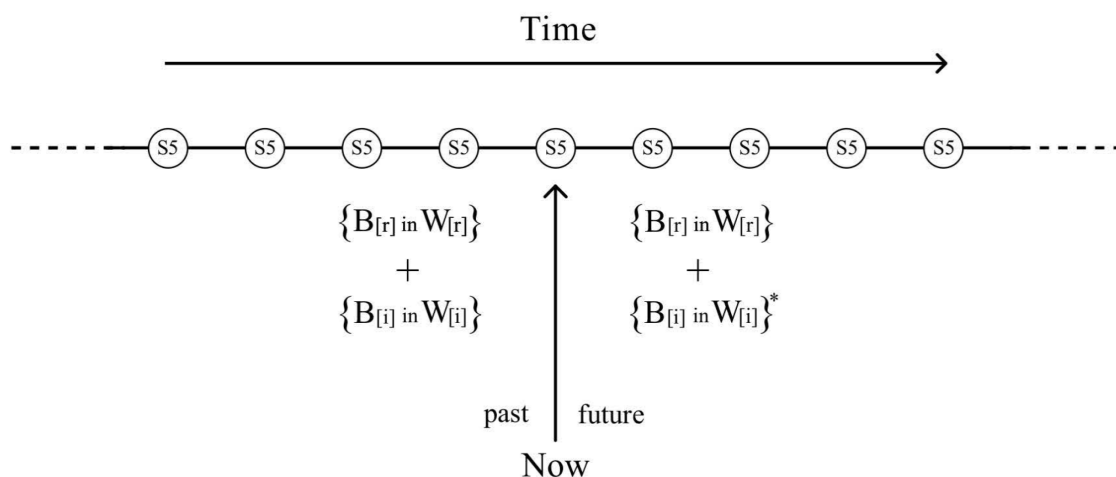


Figure 2

Figure 2 illustrates the action cycle in noumenal time, but unlike Figure 1 the cycle is presented here simply as a line punctuated by successive instances of S5. For the purposes of the figure, a subjective ‘now’ associated with an arbitrarily chosen S5, as subjectively experienced in phenomenal time, is indicated by the vertical arrow. To the left of the arrow is the phenomenal past, where $\{B[i] \text{ in } W[i]\}$ is used to denote memory that we can consciously draw upon of having been a phenomenal self in a phenomenal world. To both the left and right of the arrow $\{B[r] \text{ in } W[r]\}$ is used to denote the noumenal self in the noumenal world, which is present regardless of where the ‘now’ is positioned. To the right of the arrow is the ‘phenomenal future’, denoted here as $\{B[i] \text{ in } W[i]\}^*$, which we cannot remember but which we can *envisage* in forming purposive voluntary actions including, for example, in an immediate and indispensable way, when we consciously direct our efforts in sensory-motor coordination to tasks such as catching an incoming ball, crossing a busy road or playing tennis.⁷

Further to the caption to Figure 2, it is proposed here that a person will subjectively experience a ‘now’ – as indicated by the vertical arrow – at any given S5, but that no specific S5 will have inherent to it any property whatsoever to mark it as a ‘privileged’ now.

In this respect, it is proposed that a person will have a momentary subjective experience of being physically present as a physical body acting upon, and anticipating acting upon, a physical world – i.e. of being a $\{B[i] \text{ in } W[i]\} + \{B[i] \text{ in } W[i]\}^*$ – at all S5s, with the difference between any one S5 and any other being only the difference in what the person subjectively experiences as their $\{B[i] \text{ in } W[i]\}$ in relation to their $\{B[i] \text{ in } W[i]\}^*$. This will simply be the difference – at the noumenal time of any given ‘now’ – between what a person momentarily subjectively perceives to be their past in relation to what they momentarily subjectively perceive to be their future.

This formulation keeps the B-series perspective intact in relation to what is being subjectively experienced in a person’s A-series. In particular, it can preclude the existence of any noumenal marker as to which S5 is – across the total series that makes up a subjective life – the only S5 that the person will be experiencing as ‘now’. Logically then, it will follow that all S5s in the total series are equally viable as a subjective ‘now’, and this is the position adopted in this note. Essentially, the position here is that all of a person’s S5s are ‘always’ subjectively ‘nowing’ along the complete length of their world line in the B-series block.

⁷ The existence of subjective perception of anticipated action and its potential outcomes is widely described in the literature on *affordances*, for example see McClelland, T. (2019) Representing Our Options: The Perception of Affordances for Bodily and Mental Action. *Journal of Consciousness Studies* 26, 155-180 and the references therein. See also Grush, R. (2009) Space, Time and Objects in *The Oxford Handbook of Philosophy and Neuroscience* Ed. Bickle, J. Oxford University Press.

Consistent with keeping the B-series perspective intact this formulation also allows that, for all conscious observers, any moment in B-series time can be ‘now’ provided it occurs within their life’s S5 series.⁸ This removes any need to invoke the existence of some universal, noumenal ‘now’, that would move forward through the B-series block, somehow turning a ‘noumenal future’ into a ‘noumenal past’. Instead, it simply expects that all possible collectively acknowledged, subjectively experienced ‘nows’ coexist side-by-side and coequally in the block.⁹

If this formulation is sound there remains an important challenge, which is to explain how it can be that as individuals we experience only one subjective ‘now’, moving steadily and inexorably ‘forward’ in time, if all S5s are equally present in noumenal time and are therefore all equally available to be subjectively experienced as ‘now’.

The answer proposed here is that there is a mechanism operating in brain[r] that passes a person’s subjective frame of reference, the ‘eye of their mind’, forward from one S5 to the next. If such a mechanism exists, then the picture of a human life as lived would be of an eternal subjective progression along a world line of successive S5s, with one subjective ‘you’ following exactly one S5 behind the ‘you’ that you are experiencing as you read this line, and with another ‘you’ moving forward exactly one S5 ahead of the ‘you’ that you are experiencing as you read this line – and so on and so forth behind and ahead of your ‘now’ for all of the S5s you ever have.

In other words, from a B-series perspective such an A-series phenomenal experience is possible if the noumenal level information processing system in your B[r] that generates your B[i] in W[i] at each of your subjective ‘nows’ contains a *frame shifting mechanism* that passes the subjective frame of reference generated as ‘now’ for your B[i] in W[i] at any given S5 forward along the noumenal timeline to the next S5 to where your next ‘now’ is subjectively experienced.

Figure 3 outlines a frame shifting mechanism able to deliver a subjective experience of phenomenal time as an A-series while remaining consistent with a general understanding of noumenal time as a B-series. The figure shows two stages relevant to subjective self-awareness, labelled α and β .

In stage α , where t is noumenal time measured in beats of the action cycle, and where at an initial S5 we can set $t = a$, information processing systems in $\{B[r] \text{ in } W[r]\}^a$ will be able subjectively to experience $\{B[r] \text{ in } W[r]\}^a$ as $\{B[i] \text{ in } W[i]\}^a$, since they will have just shown $\{B[i] \text{ in } W[i]\}^{a*} \equiv \{B[i] \text{ in } W[i]\}^a$.¹⁰

So in human terms, at a given ‘now’, at $t = a$, $\{B[i] \text{ in } W[i]\}^a$ is what we experience of ourselves *in that moment* as that which we *have just become* as a physical body in the physical world, as derived from the latest sensory information s received by our brain[r]. What we will literally see, hear and more widely sense as we experience ourselves as $\{B[i] \text{ in } W[i]\}^a$, is the ‘face’ of a block that, beneath its 3-dimensional surface, recedes backwards into our subjective past and is made up of all of our subjectively available memory of ourselves as goal-oriented physical beings acting in, and on, a physical world.¹¹ Moreover, as we experience it from within our frame of reference in A-series, phenomenal time, this presently experienced surface will actually be in the immediate noumenal past due to the short, but real, noumenal time interval taken for brain[r] in B[r] to generate $\{B[i] \text{ in } W[i]\}$ by using sensory input, s .

⁸ A life series of S5s will be made up of intervals of consciousness punctuated by intervals of unconsciousness, wherein the S5 series is temporarily suspended, e.g. during non-dreaming sleep or anaesthesia. First onset of consciousness post-conception and last loss of consciousness ahead of death are the only true termini.

⁹ Hence, the idea of a unique, privileged *collectively experienced* ‘now’ is an incorrect W[z]-level assumption that does not reflect W[r] (see footnote 5 for context).

¹⁰ This equivalence, and how it delivers a moment of subjective self awareness for B[r], is discussed in detail on pages 7-8 in the note *How is Free Will Possible?* at https://teleodyne.com/free_will.pdf. Specifically, the equivalences available at S5 are that when $\{B[i] \text{ in } W[i]\}^{aE}$ has been found to be $\sim nil$ then B[r] information processing systems can put that $\{B[i] \text{ in } W[i]\}^a \equiv \{B[r] \text{ in } W[r]\}^a$ since $\{B[i] \text{ in } W[i]\}^a \equiv \{B[i] \text{ in } W[i]\}^{a*}$ where $\{B[i] \text{ in } W[i]\}^{a*}$ can only represent B[r] in W[r] because $\{B[i] \text{ in } W[i]\}^{a*}$ can only have been *realised* by the actioning of its correlate motor output, m , into the noumenal world through the *agency* of $\{B[r] \text{ in } W[r]\}^{(a-1)}$ acting to become $\{B[r] \text{ in } W[r]\}^a$, as then verified when processing of next s gives $\{B[i] \text{ in } W[i]\}^a$.

¹¹ It is proposed that this block of memory is embodied in what has been described elsewhere on this website as the *association matrix*, where it has been proposed that our momentary subjective experience of ourselves in the physical world is literally ‘seen’ from the perspective of a specific locus in that matrix, which is a locus that *inter alia* positions us both in space and time, but also with respect to our goals and our options for physical action. For a partial outline see https://teleodyne.com/summary_notes.pdf page 2 (‘Section 7.1 to Section 7.8’) – to page 9. For depth see https://teleodyne.com/main_essay.pdf.

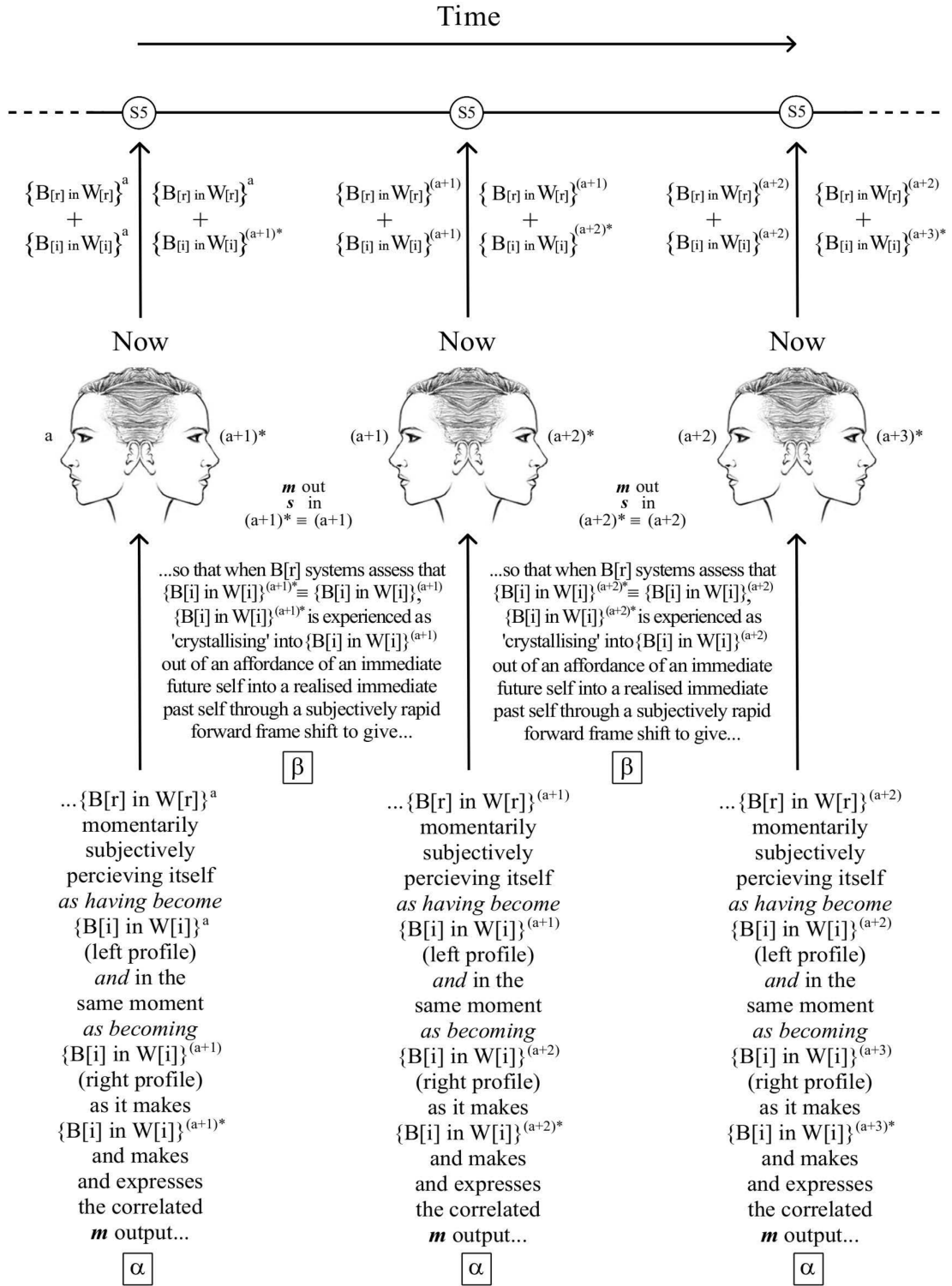


Figure 3

Figure 3 extends Figure 2 by illustrating the action cycle in noumenal time, t , abbreviated to a timeline punctuated by successive instances of S5, running in B-series sequence from $t = a$ to $t = (a+2)$, where the units of t are in beats of the action cycle (~ 4 Hz). For any specific t , $\{B[i] \text{ in } W[i]\}^t$ denotes the noumenal level B[r]'s most up-to-date s -derived rendition – as subjectively experienced in that ‘now’ – of its *immediate past* phenomenal body in its phenomenal world. Similarly, for any specific t , $\{B[i] \text{ in } W[i]\}^{(t+1)*}$ denotes B[r]'s most up-to-date affordance – as subjectively experienced in that ‘now’ – of its *immediate future* phenomenal body in its phenomenal world. The long columns of text – at α – describe the contents of a momentary subjective ‘now’, with the correlate phenomenal self illustrated above each in Janus profile as perceiving both its sensorially affirmed immediate past as well as its affordance of its immediate future (illustrated at Janus only by the relevant $\{B[i] \text{ in } W[i]\}$ superscripts). The short columns of text – at β – describe a frame shifting mechanism that will drive an imperceptibly rapid subjective perspective shift when it transposes the subjective ‘now’ one S5 forward precisely in the stroke within which B[r] information processing systems operating in noumenal time show $\{B[i] \text{ in } W[i]\}^{t*} \equiv \{B[i] \text{ in } W[i]\}^t$.

But *also* in stage α , and subjectively indistinguishable from its experience of *having become* $\{B[i] \text{ in } W[i]\}^a$, $B[r]^a$ will also subjectively experience itself *as becoming* $\{B[i] \text{ in } W[i]\}^{(a+1)*}$. For each of us this perception will take the form of a second ‘face’ – seamlessly and indistinguishably ‘overlaid with’¹² that of $\{B[i] \text{ in } W[i]\}^a$ – which beneath its surface recedes forwards into our future and is made up of all of our subjectively available affordances of ourselves as goal-oriented physical beings acting in, and on, a physical world.¹³

On this account the symmetry between our subjective perception of past and future may look high for any given ‘now’, but this symmetry will be skewed so that at any given ‘now’ our subjective past will be better defined to us in memory, and will be perceived as being fixed however far back we ‘look’, whereas we will perceive our subjective future of affordances as increasingly open and diffuse the further forward we ‘look’, regardless of how fixed that future may actually be at the noumenal level.¹⁴

What most matters here however, for the purposes of this note, is that the face of the *immediate* future – what $\{B[r] \text{ in } W[r]\}^a$ information processing systems predict will constitute the very next ‘now’, i.e. $\{B[i] \text{ in } W[i]\}^{(a+1)*}$ – will be subjectively perceived in the current ‘now’ as vanishingly close to being fixed. And just as $B[r]^a$ ’s subjective perception of the $\{B[i] \text{ in } W[i]\}^{(a+1)*}$ ‘overlay’ arises, $\{B[r] \text{ in } W[r]\}^a$ will be expressing motor output, *m*, into the noumenal world, receiving *s*, deriving $\{B[i] \text{ in } W[i]\}^{(a+1)}$ and then – in stage β – assessing that $\{B[i] \text{ in } W[i]\}^{(a+1)*} \equiv \{B[i] \text{ in } W[i]\}^{(a+1)}$ and putting that it has thereby *become* $\{B[i] \text{ in } W[i]\}^{(a+1)}$, in the stroke that shifts its subjective frame of reference one S5 forward along the noumenal timeline.¹⁵

At the subjective level, for any $t = a$, the stage β shift from perceiving oneself to be that which is becoming $\{B[i] \text{ in } W[i]\}^{(a+1)*}$ into that which has become $\{B[i] \text{ in } W[i]\}^{(a+1)}$ will – in circumstances of normal adult sensory-motor coordination – be virtually seamless, given $B[r]^a$ ’s ability in those circumstances very accurately to make and express an *m* output, in association with making $\{B[i] \text{ in } W[i]\}^{(a+1)*}$, able to deliver $\{B[i] \text{ in } W[i]\}^{(a+1)}$. The stage β shift can also be expected perceptually to be of fleeting duration compared to the perceived duration of stage α . This is because stage β will not entail $B[r] \text{ in } W[r]$ defining its state in terms of $B[i] \text{ in } W[i]$, but will constitute only a shift from one such state to the next, precisely at the noumenal time at which $B[r]^{(a+1)}$ information processing systems deliver that $\{B[i] \text{ in } W[i]\}^{(a+1)*} \equiv \{B[i] \text{ in } W[i]\}^{(a+1)}$.

A useful time dependent metaphor to help describe the relative durations of stages α and β is that of walking, where if the interval that either foot is on the ground is assigned the perceived length of the α stage then the moment of weight shift from one foot to the next – where both feet are on the ground – could be assigned the perceived length of the β stage. Obviously though, the rate of completion of any cycle of α stage plus β stage will be far faster than walking, taking in total only as long as one beat of the action cycle, which is estimated elsewhere on this website to be ~ 220 msec.¹⁶

One way of measuring the perceived duration of the β stage might be through examining how we subjectively experience certain kinds of optical effects, as demonstrated in Figure 4.

¹² The phrase ‘overlaid with’ is not really accurate but is a useful descriptive approximation in the first instance. More accurately, it is proposed there will be a coincidence of perception of the two layers that may be likened to the synthesis of perception of the two very slightly different images we use when our visual systems generate a single, unified stereoscopic perception.

¹³ These affordances will also be embodied in the proposed association matrix – potentially as synthetic regions – as referenced at footnote 11.

¹⁴ This will be because predictive information processing systems in $B[r]$ will have capacity limits, including not always having all the data needed to predict $W[r]$, and because of a wider and widening range of future possibilities in $W[r]$ under the second law of thermodynamics.

¹⁵ Appendix 1, *Dynamics*, provides a more precise description of this process.

¹⁶ See https://teleodyne.com/action_cycleF.pdf.



Figure 4

Figure 4 shows two images that elicit bistable perception, where a person's perception of an image oscillates between two mutually exclusive interpretations. If there is an action cycle exhibiting α and β stages, then it might reasonably be expected that the subjectively experienced time intervals over which the perception of one form or the other of such an image remains stable would correspond to a person being in the α stage whereas the subjectively experienced time interval over which the image is in transition from one form to the other would correspond to the duration of the β stage. Under laboratory conditions subjects almost always report such transitions to be instantaneous, whereas they report that periods of stability have a tangible duration.¹⁷ For periods where the image remains stable for more than one consecutive beat of the action cycle it would be expected that the β stages occurring within that period would be subjectively silent.

Figure 5 elaborates further on the subjective 'now'.

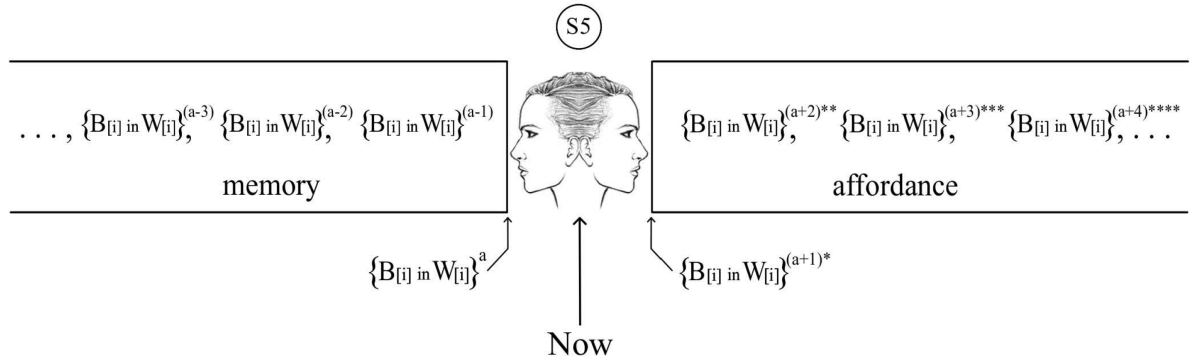


Figure 5

Figure 5 describes the structure of a subjective 'now'. The 'faces' of memory and affordance – as described in the text – are represented by the vertical edges to the left and right of the Janus profile, which represents the seat of $\{B[r] \text{ in } W[r]\}$'s subjective perception of itself as $\{B[i] \text{ in } W[i]\}$ for time $t = a$. The increasing number of asterisks going to the right are just to signify increasing levels of uncertainty in the predictions made by $\{B[r] \text{ in } W[r]\}$ information processing systems as they 'look' further into the phenomenal future of $\{B[i] \text{ in } W[i]\}$. But in the α stage of any given subjective 'now' $\{B[r] \text{ in } W[r]\}$ systems will normally so accurately be able to predict the next $\{B[i] \text{ in } W[i]\}^*$, that it will perceive itself to be within an immediate world made up of a subjectively seamless synthesis of $\{B[i] \text{ in } W[i]\}$ and $\{B[i] \text{ in } W[i]\}^*$.¹⁸

¹⁷ See Weinhhammer, V.A., Ludwig, K. Hesselman, G. and Sterzer, P. (2013). Frontoparietal Cortex Mediates Perceptual Transitions in Bistable Perception. *The Journal of Neuroscience* 33, 16009-16015.

¹⁸ Not as strongly perceived will be the memories and affordances under the surface of the two faces, receding from higher to lower definition in proportion to their distance from the 'now'.

Figure 5 is designed to convey with greater definition that for each α stage of the action cycle – where α will be the subjectively experienced moment in which a sense of being in a particular now will persist – $\{B[r] \text{ in } W[r]\}^a$ will momentarily subjectively perceive itself both as having become $\{B[i] \text{ in } W[i]\}^a$ and as becoming $\{B[i] \text{ in } W[i]\}^{(a+1)*}$. Thus, the momentary subjective physical self in physical world that $\{B[r] \text{ in } W[r]\}^a$ experiences in any given ‘now’ where $t = a$ will be the synthesis we can denote $\{\{B[i] \text{ in } W[i]\}^a + \{B[i] \text{ in } W[i]\}^{(a+1)*}\}$.

To more clearly show that what we are perceiving at any given ‘now’, where $t = a$, is a synthesis of $\{B[i] \text{ in } W[i]\}^a$ and $\{B[i] \text{ in } W[i]\}^{(a+1)*}$, it is helpful to consider what happens when there is an error in the prediction $\{B[i] \text{ in } W[i]\}^{(a+1)*}$. Say that a play of light and shadow, together with a particular pattern of stems and leaves suggests to the eye that a person is standing some distance away on the opposite bank of a lake. The person seems to us to be perfectly solid and real until a moment comes when – in a strong gust of wind – the vegetation moves wildly, the impression is shattered, and the person is revealed to have been an illusion.

What has happened? First, in the right circumstances, and for the duration of the illusion, the person will have seemed just as real and as concrete as any other element of the ongoing scene. But the prediction that a person is there then turns out to be wrong, with the error exposed at some specific β stage when it transpires – due to a new, revealing s input – that across a relatively small subsection of the two faces referred to above, $\{B[i] \text{ in } W[i]\}^* \neq \{B[i] \text{ in } W[i]\}$.¹⁹

Logically this means that *all* of the scene – indeed *all* of *any* scene we might currently subjectively experience as perfectly solid and real – could *conceivably* turn out in some future moment to have been a misinterpretation of then available s input. Such misinterpretations essentially constitute incorrect predictions, some of which could actually be sustained through multiple iterations of the action cycle provided a situation does not arise where the misinterpretation is exposed through some action or event at the level of $B[r] \text{ in } W[r]$ that tests its veracity by generating a new s input revealing of an interpretive error.

Taking this to its limit, we could correctly characterize *all* of what we perceive at any specific ‘now’ to be a set of *potentially* incorrect predictions. But as has been pointed out elsewhere on this website – and at length – the iterative, trial-and-error learning that has gone into the development of a mature association matrix means that, within the error tolerances needed for the practical purposes of sensory-motor coordination, such incorrect predictions – i.e. incorrect formulations in any part of $\{B[i] \text{ in } W[i]\}^{(a+1)*}$ – will be exceptionally rare in the *normal* course of adult experience.²⁰

In any case, what is of main importance here is to recognize that the kind of illusion discussed above shows that what we are subjectively perceiving and experiencing in the α stage of any given ‘now’ can indeed be in the form of a synthesis $\{\{B[i] \text{ in } W[i]\}^a + \{B[i] \text{ in } W[i]\}^{(a+1)*}\}$.

¹⁹ Note that for such a mild illusion the extent to which $\{B[i] \text{ in } W[i]\}^*$ fails to match $\{B[i] \text{ in } W[i]\}$ is insufficiently grave – both in extent and duration – seriously to disrupt a person’s stable ongoing subjective sense of self-awareness. But when exposed to us, such illusions *do* create a momentary existential ‘double take’ – a kind of reflexive momentary self questioning – just as in the moment when a prediction failure leads us to find ourselves to be slipping or tripping up.

²⁰ For example, illusions of the type described are rare and almost never occur within the areas of $\{B[i] \text{ in } W[i]\}$ that are engaged in sensory-motor coordination. Predictive failures do however arise in situations where a person has to push their sensory-motor coordination to its limits or operates in an environment involving many complex or fast-moving external events. Playing a challenging game of football is a good example. Lots of predictive capability is required to play well, and failures to achieve the level of sensory-motor coordination needed to pull off difficult manoeuvres arise. Though these failures are insufficient both in number and nature to destabilise consciousness they nevertheless involve disruptions through delivering moments where quite palpably $\{B[i] \text{ in } W[i]\}^{a*} \Delta \{B[i] \text{ in } W[i]\}^a \neq \text{nil}$. Players practice because this helps the association matrix minimise these moments through the learning process that takes place at S5. All of this is in keeping with the proposal that the association matrix, which is used at S6 to generate $\{B[i] \text{ in } W[i]\}^{a*}$, is a form of *working hypothesis* held within brain[r] designed *inter alia* to predict the outcomes of $B[r]$ m output on $B[i]$ in $W[i]$ (pp 73 Main Essay, see <http://teleodyne.com>). N.B. this approach – including the concept of an association matrix and of how it is built and operates – is consistent with contemporary conceptual frameworks within the predictive processing paradigm – for example see Hohwy, J. (2020) *New Directions in Predictive Processing*. *Mind & Language* 35, 209-223; Fotopoulou, A. (2015) *The Virtual Bodily Self: Mentalisation of the Body as Revealed in Anosognosia for Hemiplegia*. *Consciousness and Cognition* 33, 500-510 and Clark, A. *Surfing Uncertainty: Prediction, Action and the Embodied Mind* Oxford University Press, New York, USA 2016 – where the association matrix can be considered a form of *generative model* and the action cycle an implementation of *active inference*.

Conclusion

The aim of this note has been to validate the self-model approach developed more widely on this website by showing it can solve the difficult problem of reconciling our subjective experience of time (A-series) with our growing collective understanding through physics of objective or noumenal time (B-series). I believe this validation has been successful, and that the note shows that a means to relate phenomenal time to noumenal time can flow naturally from the wider self-model related conceptual framework developed on the website.²¹

I also believe, consistent with the 24 January 1998 entry in the Introductory Summary, that this note demonstrates the strong working utility of explicitly acknowledging – and of using an appropriate notation to differentiate between – the noumenal level of B[r] in W[r], the phenomenal level of B[i] in W[i] and, where needed²², the more abstract level of W[z], which is the world we collectively agree to be the physical world and is the world we refer to in physics and the wider sciences, but which is not the noumenal world, W[r].

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²¹ Although the work provided here originates in an effort to validate a self-model approach, and uses unique diagrams, notation, and terminology, it has noteworthy concurrence at a holistic level with the insights and analysis of others. In particular, see Ismael, J. (2017) Passage, Flow and the Logic of Temporal Perspectives, pp 23-38 in *Time of Nature and the Nature of Time*, Eds Bouton, C. and Huneman, P., Boston Studies in the Philosophy and History of Science 326, Springer International Publishing AG. and Ismael, J. (2013) Decision and the Open Future, pp 149-168 in *The Future of the Philosophy of Time*. Ed. Adrian Bardon, Taylor and Francis, New York USA.

²² For example, see footnote 9, and for the Introductory Summary see: https://teleodyne.com/intro_summary.html.

²³ This revision is simply to flag through this footnote that new material in Section 9.4 of Working Note A – Part 1 proposes recasting the action cycle into what is called the *recognition cycle*. Importantly for the purposes of the current note, the recognition cycle plays virtually the same net role as the action cycle and can be substituted for it without undermining any of the key concepts presented here. This substitution is discussed in Section 9.4.5 of Working Note A – Part 1, and proposes the replacement of S5 with a more precisely described but operationally isomorphic step, S_β.

The idea of a recognition cycle updates the idea of an action cycle by recasting it in terms of predictive processing, as described in references provided in the final sentence of footnote 20. Additional relevant material, including to do with affordances, is provided in Section 10.7 of Working Note A – Part 2. Refs: https://teleodyne.com/working_note_A_1.pdf and https://teleodyne.com/working_note_A_2.pdf.

Appendix 1 – Further perspectives

Dynamics

This note – and its predecessor, *How is Free Will Possible?* – develop the conjecture that a $\{B[r] \text{ in } W[r]\}$ will experience a moment of subjective perception of itself as being a $\{B[i] \text{ in } W[i]\}$ at any time $t = a$ when brain[r] information processing systems within B[r] operating the action cycle are able to establish – to within the working tolerances of effective sensory-motor coordination – that $\{B[i] \text{ in } W[i]\}^{a*} \equiv \{B[i] \text{ in } W[i]\}^a$, which equivalence allows them to operate on the inductive presumption that B[i] is in fact B[r] and to place themselves – and refer to themselves – as being within B[i] and to phenomenally experience themselves as $\{B[i] \text{ in } W[i]\}$.

Moreover, through the means described in the body of this note it has been proposed that, in the α stage for $t = a$, $\{B[r] \text{ in } W[r]\}$ will subjectively perceive itself as $\{\{B[i] \text{ in } W[i]\}^a + \{B[i] \text{ in } W[i]\}^{(a+1)*}\}$ as per Figure 5 and accompanying discussion. If then, we consider each instance of $\{B[i] \text{ in } W[i]\}^t$ to be a set, this can be expressed as $\{\{B[i] \text{ in } W[i]\}^a \cup \{B[i] \text{ in } W[i]\}^{(a+1)*}\}$.

Now consider what is taking place over the time course of several iterations of the action cycle in terms of the transformation of affordance into memory, as has been described for the β stage.

At a specific noumenal time, $t = a$, the prevailing situation – as illustrated in Figure 5 – is that:

- (1) A procession of semantically generated, inductive suppositions – in the form of affordances – sits adjacent to the subjective ‘now’ and stretches off to the right (future). The elements of this procession are more and more sketchily defined the further away in time they are from the ‘now’ of $t = a$, and are ever better defined the closer they are to this ‘now’, such that only one, highly defined affordance, $\{B[i] \text{ in } W[i]\}^{(a+1)*}$, is under immediate perception in the α stage of the ‘now’. There can only be one because the *m* output designed to turn this affordance into a memory is already formulated and its expression by $\{B[r] \text{ in } W[r]\}$ is underway.²⁴
- (2) At the same ‘now’ of $t = a$, a procession of sensorially generated, deduced records – in the form of memories – sits adjacent to the subjective ‘now’ and stretches off to the left (past). Only the most recent of these, $\{B[i] \text{ in } W[i]\}^a$, is under immediate perception in the α stage of the ‘now’, in perceptual synthesis with $\{B[i] \text{ in } W[i]\}^{(a+1)*}$. But in the procession of remembered $\{B[i] \text{ in } W[i]\}$, each predecessor of $\{B[i] \text{ in } W[i]\}^a$ logically will sit nested within its more recent adjacent memory – Russian Doll like – such that if, again, we take the information contained in each $\{B[i] \text{ in } W[i]\}^t$ to be a set, these memories can be represented in the form:

$$\{B[i] \text{ in } W[i]\}^{(a-n)} \subset \{B[i] \text{ in } W[i]\}^{(a-n+1)} \subset \{B[i] \text{ in } W[i]\}^{(a-n+2)} \subset \dots \subset \{B[i] \text{ in } W[i]\}^a$$

- (3) Dynamically, as the $t = a$ α stage then evolves through the β stage transition into the $t = (a+1)$ α stage there will be a subjectively near instantaneous ‘condensation’ of $\{B[i] \text{ in } W[i]\}^{(a+1)*}$ into $\{B[i] \text{ in } W[i]\}^{(a+1)}$, which will thereby form the latest, outermost ‘Russian Doll’ accretion onto the corpus of memory. In the same β transition, the relevant information processing systems within brain[r] will update to identify $\{B[r] \text{ in } W[r]\}$ as having become $\{B[i] \text{ in } W[i]\}^{(a+1)}$ and as becoming $\{B[i] \text{ in } W[i]\}^{(a+2)*}$, and will subjectively experience themselves as such, from onset of the new, $t = (a+1)$ α stage.

In this way information processing systems operating the action cycle and association matrix in brain[r] within $\{B[r] \text{ in } W[r]\}$ are – from one S5 to the next – sequentially, recursively capturing self-models of $\{B[r] \text{ in } W[r]\}$, in the form of $\{B[i] \text{ in } W[i]\}$, consistent with the series of sets shown at (2) above.

²⁴ $\{B[r] \text{ in } W[r]\}$ has not been assigned a superscript because in the moment described it will be in transition from $\{B[r] \text{ in } W[r]\}^a$ to $\{B[r] \text{ in } W[r]\}^{(a+1)*}$ as it expresses the *m* correlate of $\{B[r] \text{ in } W[r]\}^{(a+1)*}$.

- (4) Applying the same reasoning used at (2) to consider the information in $\{B[i] \text{ in } W[i]\}^{(a+1)*}$ as it relates to the procession of affordances of $\{B[i] \text{ in } W[i]\}$ reaching to the right of the ‘now’ in Figure 5, it is apparent that this series will have the structure:

$$\{B[i] \text{ in } W[i]\}^{(a+1)*} \subset \{B[i] \text{ in } W[i]\}^{(a+2)*} \subset \{B[i] \text{ in } W[i]\}^{(a+3)*} \subset \dots \subset \{B[i] \text{ in } W[i]\}^{(a+n)*}$$

which is to say that the affordance of $\{B[i] \text{ in } W[i]\}$ closest to any given ‘now’ – which of all affordances will be that which brain[r] predictive systems will have most clearly defined – and which is under direct subjective perception within the α stage of that ‘now’ as part of $\{\{B[i] \text{ in } W[i]\}^a \cup \{B[i] \text{ in } W[i]\}^{(a+1)*}\}$ – can be represented as a subset of all of the less well-defined affordances to its right. So, just as for memories, we can postulate that any affordance of $\{B[i] \text{ in } W[i]\}$ that lies to the left of any other on the noumenal timeline can be represented as a subset of that other.

- (5) This can all now be looked at from the perspective of an ongoing sequence of subjective ‘nows’ being generated through systems within brain[r] that are operating on an iterative inductive presumption for $\{B[r] \text{ in } W[r]\}$ that take the general form: “that *was me* that did that” in synthesis with “this *will be me* that will do this” where, at $t = a$, the first ‘me’ is the self-model component $\{B[i] \text{ in } W[i]\}^a$ and the second ‘me’ is the self-model component $\{B[i] \text{ in } W[i]\}^{(a+1)*}$.²⁵

In differentiating at any one particular S5 between the past and the future, these brain[r] systems could then be said to be defining $\{B[i] \text{ in } W[i]\}^a$ – with all of its predecessor selves sitting like Russian Dolls within it – as being “the set of all sets of me that *are* me”, in concurrence with their defining $\{B[i] \text{ in } W[i]\}^{(a+1)*}$ as being “a *member* of the set of all sets of me that *are not* me” (at least *not yet*, and perhaps not ever).²⁶

- (6) So at any stage α where $t = a$, $\{B[r] \text{ in } W[r]\}^a$ will be experiencing itself as both *being* the set of all sets of itself that are members of *itself* – i.e. of being $\{B[i] \text{ in } W[i]\}^a$ – but also as being a member – i.e. of being $\{B[i] \text{ in } W[i]\}^{(a+1)*}$ – of the set of all sets of itself that are *not* (yet) members of itself.

This construction offers a sense of the logic by which the rhythm of ... α stage to β stage to α stage to β stage... passes our subjective self-awareness forward from one phenomenal ‘now’ to the next:

- a) In any α stage where $t = a$, as B[r] systems are momentarily experiencing $\{B[r] \text{ in } W[r]\}$ – i.e. experiencing *themselves* – as $\{\{B[i] \text{ in } W[i]\}^a \cup \{B[i] \text{ in } W[i]\}^{(a+1)*}\}$ an underlying existential gap will exist within the self-model which can objectively be expressed as the question: Is $\{\{B[i] \text{ in } W[i]\}^a \cup \{B[i] \text{ in } W[i]\}^{(a+1)*}\}$ a member of $\{B[r] \text{ in } W[r]\}^a$ or not? If the answer is ‘no’, the self-model is either invalid, or – as applies here – it has *incompleteness*.²⁷
- b) But within the same noumenal time interval that this question is being posed, just as $\{B[r] \text{ in } W[r]\}$ is experiencing itself as $\{\{B[i] \text{ in } W[i]\}^a \cup \{B[i] \text{ in } W[i]\}^{(a+1)*}\}$, it is also outputting the $\{B[i] \text{ in } W[i]\}^{(a+1)*}$ associated motor output *m*, receiving resultant sensory input *s*, and then sliding into the β stage to stop the implicit ‘no’ from becoming explicit by filling the incompleteness with the answer, ‘yes’, provided that *s* *does* show to within practical tolerances that $\{B[i] \text{ in } W[i]\}^{(a+1)} \equiv \{B[i] \text{ in } W[i]\}^{(a+1)*}$.

²⁵ N.B. this is just a shorthand version of what has already been described at length in the body of the note.

²⁶ The difference being that, at $t = a$, $\{B[i] \text{ in } W[i]\}^a$ will have been verified to *have been* $\{B[r] \text{ in } W[r]\}$ via error correction against the most recent *s* input (and, in the nested sense, all previous *s* input) whereas $\{B[i] \text{ in } W[i]\}^{(a+1)*}$ – despite the overwhelming and presumed likelihood it will come to be – will not have been so verified, or ‘crystallized’ to use the metaphor of Figure 3. Nor will any of the affordances containing $\{B[i] \text{ in } W[i]\}^{(a+1)*}$ that reach further out to the right of the current ‘now’, and which B[r]^a systems will be less and less able to reliably predict the further away from $t = a$ that they are.

²⁷ At the subjective level I suspect this question is experienced as a *sense of incompleteness* – or ‘*not yet-edness*’ – and that, since we are talking here about short timeframes to do with the creation of consciousness of the self as a physical agent, this sense of incompleteness can manifest as a sense of angst around possible sensory-motor coordination failure; a sensation that can become quite intense and drive great focus on task during very difficult coordination challenges. On the bigger picture of consciousness as a whole – whose architecture and process seem to operate as an elaboration of self-modelling built off the foundation of basic physical self-model creating processes described here – it seems possible this form of question runs up through the propagation of higher forms of self-model ultimately to manifest in forms of existential angst.

- c) This then will have shifted the self-model forward in noumenal time into the α stage for $t = (a+1)$, and so on, with the overall process taking the form of information processing systems with $\{B[r] \text{ in } W[r]\}$ experiencing themselves serially in the form of successive $\{B[i] \text{ in } W[i]\}$, "...becoming themselves, becoming themselves, becoming themselves, becoming themselves...", through each iteration of the action cycle, which at the level of the noumenal level person $\{B[r] \text{ in } W[r]\}$ amounts to their subjectively experiencing themselves as a phenomenal self-model moving forward in time.

‘Optics’

It is well understood that a person’s neurological systems are able to process the two, 2-dimensional, slightly spatially displaced images that fall upon their retinas to generate a single, unified perception of a world with spatial depth.

In the case of neurological processes through which we serially experience ourselves as a unified physical self in a physical world based at each ‘now’ on a synthesis of two very slightly temporally displaced self-models – $\{B[i] \text{ in } W[i]\}^a$ and $\{B[i] \text{ in } W[i]\}^{(a+1)*}$ – it seems plausible that this synthesis is experienced as a single, unified perception of a world with ‘temporal depth’.

By perception of temporal depth is meant the subjective experience of time as unfolding smoothly out of a future – through a ‘now’ we perceive to have duration and within which we can perceive motion – and on into a past; in other words, a subjective experience of being in a moving ‘now’ of finite breadth situated within an A-series.

Moreover, if the analogy of visual processing holds, this perceptual experience could be achieved even if the two temporally displaced self-models being generated for any given α stage – i.e. $\{B[i] \text{ in } W[i]\}^a$ and $\{B[i] \text{ in } W[i]\}^{(a+1)*}$ – are actually compiled in brain[r] into constructions that are ‘static’ in noumenal time ahead of their synthesis to form the perception of $\{\{B[i] \text{ in } W[i]\}^a \cup \{B[i] \text{ in } W[i]\}^{(a+1)*}\}$, which itself may be encoded in a ‘static’ neurological[r] state that could deliver an indivisible ‘atom’ of phenomenal time. This would solve a range of issues around the idea – consistent with the concept of an action cycle – that sensory inputs may be neurologically[r] compiled into, and processed, in discrete segments²⁸, even though our phenomenal experience of the world is smooth.²⁹

Scale considerations

The noumenal timescale of the cyclic processes examined in this note correspond to the interval required to get from one S5 of the action cycle to the next which is estimated to be ~ 220 msec. Within this period it has been proposed there is an α stage of tangible subjective duration and a subjectively \sim instantaneous β stage. Call the order of time interval of $\sim 220 - 2200$ msec, the *critical scale*.

Noumenal time can be sliced down to intervals that will exhibit virtually frozen moments of neuronal[r] activity. Call the order of time intervals from this degree of duration up to the time intervals of the critical scale the *subcritical scale*. The processes that create what goes into one iteration of the action cycle will lie within the upper areas of this subcritical scale.

To complete the picture, call the order of intervals longer than ~ 2500 msec the *supercritical scale*.

²⁸ This issue is discussed in the Appendix 1 to the note *How is Free Will Possible?*, at https://teleodyne.com/free_will.pdf, and see VanRullen, R. (2016). Perceptual Cycles. *Trends in Cognitive Sciences* 20, 723-735; Benedetto, A., Morrone, M. C. and Tomassini, A. (2019) The Common Rhythm of Action and Perception. *Journal of Cognitive Neuroscience* 32, 187-200.

²⁹ For more on this – including attribution of the idea of an ‘atom’ of phenomenal time – see below in reference to the ‘subcritical scale’.

This note, and associated material³⁰, has focused on the information processing that might be going on to generate a person's moment-by-moment phenomenal experience of themselves as a physical agent acting purposefully and successfully – through successful sensory-motor coordination – on a physical world. This is the most concrete, immediate, and ‘real’ type of subjective experience we have. The window of duration over which this fundamental sense of ourselves applies is at the critical scale and corresponds to our sense of being in a bounded ‘now’ that is moving forward in A-series time. The upper bound of this scale has been set liberally, by introspection, to ~ 2500 msec – roughly ten times the duration of a ‘now’ as defined in the main body of the note – simply to ensure that the range of the scale captures a subjectively palpable stretch of ‘nowing’. The lower bound is a hard boundary set by the estimated period of the action cycle.

Clearly there is much more to human consciousness than that which can be fully apprehended at the critical scale. But it seems likely that the processes that deliver consciousness of the physical self at this scale form the foundation for all ‘higher’ forms of consciousness which, although they may be partly apparent over a 2500 msec period, are far less immediate and do not meaningfully evolve within this timescale. The processes generating these forms of subjective self-awareness manifest in subjective experience that evolves at the supercritical scale, and in forms of self-awareness that are not experienced as having a concrete objective manifestation in the physical world.

We do not subjectively experience *durations* of time periods at the subcritical scale, wherein the noumenal time interval taken for neural[r] compilation of one α stage can be considered to be what goes into making one *indivisible* ‘atom’ of phenomenal time. This would be an ‘atom’ wherein the single synthesis, $\{\{B[i] \text{ in } W[i]\}^t \cup \{B[i] \text{ in } W[i]\}^{(t+1)*}\}$, is experienced *phenomenally* as covering the full period in noumenal time of one beat of the action cycle (i.e. ~ 220 msec). This could be so even though this ‘building block’ of our subjective perception of a smoothly unfolding ‘now’ as having duration – and containing motion – might be derived from neural[r] correlates of $\{\{B[i] \text{ in } W[i]\}^t \cup \{B[i] \text{ in } W[i]\}^{(t+1)*}\}$ that encode those properties in states that do not in themselves evolve in noumenal time, but are simply iteratively replaced.³¹ For the sensorially derived component, $\{B[i] \text{ in } W[i]\}^t$, this could be achieved through neural[r] processes along lines of what Geoffrey Lee has called ‘trace integration’³². The affordance component, $\{B[i] \text{ in } W[i]\}^{(t+1)*}$, would need to be compiled in a different way, but there is no reason to believe that an appropriate compilation mechanism for this component could not exist.

³⁰ At <http://teleodyne.com>.

³¹ In terms of the ideas described in the body of this note, this iterative ‘replacement’ would correspond at some time $t = (a+1)$ to replacement of $\{\{B[i] \text{ in } W[i]\}^a + \{B[i] \text{ in } W[i]\}^{(a+1)*}\}$ with $\{\{B[i] \text{ in } W[i]\}^{(a+1)} + \{B[i] \text{ in } W[i]\}^{(a+2)*}\}$.

³² Lee, G. (2014) Temporal Experience and the Temporal Structure of Experience. *Philosophers' Imprint* 14 (3), and for a related conceptual framework see also Grush, R., (2016) On the Temporal Character of Temporal Experience, its Scale Non-invariance, and its Small Scale Structure. *Manuscript*. doi: 10.21224/P4WC73, and Grush, R., (2005) Internal Models and the Construction of Time: Generalizing from State Estimation to Trajectory Estimation to Address Temporal Features of Perception, Including Temporal Illusions. *Journal of Neural Engineering* 2, 209-218.