Working Note A – Part 3[238]

11 Imagining, feeling and deciding

11.1 Imaginary recognition states

An essential aspect of how we perceive and experience ourselves in the world is that we routinely construct and 'perceive' *imaginary* recognition states. Denote any such imaginary recognition state Ξ^{τ^i}, where i denotes that the state is imaginary and τ is some imaginary moment assigned by the *imaginer* to be either in their past or in their future. If the imaginer does not assign the imaginary recognition state to either a past or future position in their A-series,[239] such a state can simply be denoted Ξ^i.

Most readers will readily be able to construct imaginary recognition states. For example, imagine yourself (1) biting into a crisp cold apple, (2) looking up at a grey sky feeling rain against your face, (3) jumping from a plane holding a rabbit while wearing red pyjamas, or (4) watching your best friend being hit by a car.

These phrases are intended to prompt construction and perception of evocative imaginary recognition states, Ξ^i. They demonstrate that although it is clear these states can be – and almost always are[240] – experienced as an *imaginary environment image*, $(W[i]\backslash B[i])^i$, made of imaginary Specific Objects distributed in a three dimensional space surrounding an *imaginary body image*, $B[i]^i$ – it is also clear that any accompanying need image, N[i], is *not* experienced as imaginary, and that we seem only to experience desires/emotions as real and present.[241]

For instance, in example (4), although we may fully appreciate that we are merely imagining our friend being hit by a car, the emotion momentarily evoked by this imaginary recognition state feels just as real as any emotion we might perceive, although it will almost certainly be far less intense than the emotion we would perceive if we were actually to witness – rather than imagine – such an event. Essentially then, if at time t = a, a person constructs and perceives an imaginary recognition state, then the desires/emotions evoked and perceived at that time will be substates of $N[i]^a$, and will *not* be experienced as some separable 'imaginary' need image, $N[i]^i$.

Along with a lower relative intensity of evoked emotion, any imagined spatial world that a person constructs and 'perceives' as the $B[i]^i$ and $(W[i]\backslash B[i])^i$ substates of an imaginary recognition state will almost always be experienced as 'less real' than, and quite separable from, the spatial world that they meanwhile perceive to be their real situation.[242] It will be experienced as somehow 'fainter', will almost always be less populated by Specific Objects, and will exhibit less rich Specific Characteristics than the reality that confronts them should they 'open their eyes' and attend to their actual environment. For example, a person will almost always know that in reality they are by a swimming pool, on a deck chair, with their eyes closed, even as they imagine themselves to be huddled in a cave, on an unknown mountainside, with a blizzard howling outside the cave.

In the same way that an imaginary recognition state may be constructed such that the imaginer does not assign it to any position in their A-series, it may be constructed – as in the example above of an imagined mountainside – such that the three dimensional space within which the substates of $(W[i]\backslash B[i])^i$ and $B[i]^i$ are 'perceived' to be distributed are not assigned to any position within the single eternal spatial arena that the imaginer experiences as that which contains all things physically real; where this latter spatial arena will from now on be called the imaginer's *real phenomenal space*.

This means that an imaginary recognition state can be constructed such that it is experienced by the imaginer as being at an imaginary time in an *imaginary* three dimensional space – i.e. an *imaginary phenomenal space* – that is entirely spatiotemporally *unconnected* to what they are experiencing in parallel as the actual spatiotemporal reality – past, present and future – in which they are situating themselves.

Call any imaginary recognition state that is constructed and experienced as entirely spatially and temporally unconnected to what the imaginer perceives to be the actual *reality* that they (the imaginer) are, have been, or will be situated in, a *pure imaginary recognition state*. Note that even for pure imaginary recognition states the emotions these evoke are perceived/experienced by the imaginer to be real, even if relatively mild.[243]

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[238] The ideas presented here are founded on those developed in Working Note A – Part 1 (from here on referred to as Part 1) and Working Note A – Part 2 (from here on referred to as Part 2). The numbering of sections, figures and footnotes continues sequentially from those in Part 2.

[239] A-series time is described in McTaggart, J.M.E. (1908) The Unreality of Time. *Mind 17*: 457–73. For further detail see Section 9.4.1 of Working Note A – Part 1 (Part 1) as well as *The Construction of Phenomenal Time* at https://teleodyne.com/time.pdf.

[240] A small minority of people seem unable to visualise imaginary substates $(W[i]\backslash B[i])^i$. This condition is called *aphantasia*, as coined by Zeman, A.Z. et al. (2015) Lives Without Imagery – Congenital Aphantasia. *Cortex 73*, 378-380. Moreover, there is evidence – where the prompt is to read examples such as (1) to (4) – that an absence of ability to visualise imaginary substates $(W[i]\backslash B[i])^i$ under stimulation of such prompts is accompanied by an absence of feeling imaginary substates $N[i]^i$ in emotional response to those prompts – see Wicken, M. et al. (2021) The Critical Role of Mental Imagery in Human Emotion: Insights from Fear-based Imagery and Aphantasia. *Proc. R. Soc. B. 288*: 20210267.

[241] Strictly, the way we experience emotions seems to allow us to make *no distinction* between whether they are 'real' or 'imagined'. We simply experience an emotion, or we do not. It is in this sense that we can say that all of the emotions we experience are real.

[242] If this were not the case the person would be experiencing some form of hallucination, or be asleep and dreaming.

[243] Pure imaginary recognition states constitute what we call fantasies, and in a more interesting and highly constructed way they constitute the 'moments' that make up – in imagined realms that are spatiotemporally unconnected to what we hold to be our actual reality – the contents of what we experience, including emotionally, as we read novels, hear stories or witness plays set in fictitious environments and landscapes.

11.2 Recalled recognition states

If a person imagines a recognition state but assigns it to a time in the past of their A-series and to a place within their real phenomenal space, that imaginary recognition state will be a memory – or more precisely, a *memory state* – and the act of imagination will be an act of *recall*.[244] This formulation captures memories recalled accurately as well as those poorly or falsely recalled. As with all imaginary recognition states, the emotion evoked when a person constructs and experiences a memory state will be experienced as happening in their 'now' as a real, not as an 'imagined', emotion.

A memory state can be further characterised as an imaginary recognition state recalled – i.e. constructed and perceived – through some process whereby D[r] draws upon information held in the system shown in Fig. 14 of Part 2 as *memory*.

The way we recall recognition states that we consider to have been real – i.e. those that we consider to be genuine memories of past situations – suggests that our ability to construct and experience other forms of imaginary recognition state may be a modified version of our facility for such recollection.

More specifically, although a person can experience a pure imaginary recognition state as taking place in an imaginary phenomenal space, the contents of such imaginary states seem almost always to be made up of Specific Objects that the person has previously experienced in reality,[245] even though these may be distributed and be moving in novel ways. Examples (1) and (2) in Section 11.1 illustrate this. To most readers what is imagined in each of these examples probably seems quite like a memory, but not one they have assigned to a position in their A-series or to anywhere in their real phenomenal space.

In this respect a pure imaginary recognition state can be considered a memory state that has been stripped of its temporal and spatial context but which – though it may have been modified through transformations made to types, distributions and motions of Specific Objects – is still made up of largely unmodified versions of Specific Objects the imaginer has previously encountered in reality. Example (3) illustrates this point. Compared to an actual memory it has a great deal of novelty in the distribution and motion of its Specific Objects, but little novelty in its Specific Objects per se.[246]

These observations suggest that the system referred to above as *memory* may be considered to hold at least two separable sets of records that may be described as follows:

Set 1 The first will be a set of records that does not encode temporal information but will form a library of previously encountered and – as D[r]'s recognition and generative models become better refined – progressively more optimally parsed, i.e. 'focused', substates of W[i]\B[i], B[i] and N[i].

As such it will be a library of encoded information available for invocation and perception of:

(a) Specific Objects, including the Self-as-Body – i.e. recognition state elements for chairs[i], houses[i], railway lines[i], apples[i] etc. – corresponding to what D[r]'s hierarchical processor 'expects', based on its 'experience', can be found as[247] substates of W[i]\B[i].

(b) Sensations internal to, or of, the Self-as-Body – i.e. recognition state elements for general or local body pain, cold, wetness, warmth etc. – corresponding to what D[r]'s hierarchical processor 'expects', based on its 'experience', can be found as substates of B[i].

(c) Desires/emotions – i.e. recognition state elements for appetites, fears, tiredness etc. – corresponding to what D[r]'s hierarchical processor 'expects', based on its 'experience', can be found as substates in N[i]

where for recognition state elements that might be found in W[i]\B[i] or B[i] only the *internal* spatial relations of a Specific Object, including the Self-as-Body, will be encoded in its Set 1 record.[248]

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[244] Hence a memory state can be designated $\Xi^{\tau i}$, where τ has been assigned by the imaginer to a position somewhere – no matter how well or poorly defined – in the past of their A-series.

[245] People rarely imagine novel Specific Objects in the normal course of day-to-day life and, if they do, these are usually simple modifications of familiar Specific Objects, say changed in colour or size. Although the actual practice of the design of novel Specific Objects – for example, of new tools and other implements – certainly requires imagination, it is also a concerted, high-level and specialised process that goes far beyond the natural, less disciplined, everyday processes of imagination under discussion here.

[246] Note that all previously encountered Specific Objects, and memory of them, will have resulted from the optimal parsing of recognition states generated through the hierarchical processing of actual exteroceptive input into D[r].

[247] Where the phrase, "…can be found as…", could be replaced with, "…have previously been resolved out under optimal parsing as discrete…".

[248] Noting that although they are perceived to have a location at the Self-as-Centre, states of N[i] are not perceived to have internal spatial relations.

Set 2 The second set of records will be a distribution over four dimensions of *pointers* to the records held in Set 1, where those pointers will be indexed to positions on one temporal and three spatial axes.

In this scheme, if a person's A-series is considered to extend from a subjectively experienced 'now', at t = a, into their past along a time axis of serially ordered moments t = (a - n), (where n = 1, 2, 3, … , n beats of the recognition cycle), then the person's *memory* as described above – assuming that it is ideal and complete[249] – will be a system that holds, indexed to any unique value for t on that axis, a subset of pointers configured such that they encode a map of the distribution in three spatial dimensions of all of those Specific Objects – and of all of those other optimally parsed substates of Ξ (e.g. substates of N[i]) – that made up the recognition state, $\Xi^{(a-n)}$, as it was experienced by that person at time t = (a - n).

11.3 Forecast recognition states: willingness and decision-making

11.3.1 Emulation, proto-goal states, and world maps

Although there is currently insufficient information available from neurological studies to determine how the processes associated with the construction and 'perception' of imaginary recognition states might work, it is empirically clear that such processes do take place and that they feed regularly into our subjective experience.[250]

One of the features of the imaginary recognition states described by example above is that in some senses they can be considered well formed. Although it is impossible to be sure, it seems most unlikely that other animals can reflect upon such well defined memories of past experiences, or imagine purely hypothetical situations with accompanying feelings, in the high degree of definition that people can.[251]

This is in support of the possibility that human capacity to construct and 'perceive' imaginary recognition states in high definition may sit at the subjectively explicit, and most evolutionarily advanced, tip of an iceberg of less advanced but similar activity constantly taking place *just at – or below – the threshold* of conscious awareness and that involves the construction and 'perception' of less well defined imaginary recognition states. This is to say that on those occasions when we take the time to draw forth a memory, or construct a daydream, it may be that we are drawing upon, and perhaps shaping, a pool of natural activity that is in any case almost always underway as a part of the normal operations of D[r].

Consider the following possibility. Say that when a person is conscious, their D[r] runs what can be called an *emulator*, which by some means spontaneously – and in a way that barely impinges on their perceptual awareness – generates multiple imaginary recognition states. Call each such state a *proto-goal state* and a set of such states an *array*. Say that these states are being very largely *subliminally* envisaged – and *assessed* – by the person as *potential future recognition states*, $\Xi^{\tau i}$, where τ is assigned to a position somewhere – no matter how well or poorly defined – in the *future* of the person's A-series.

The idea that some imaginary recognition states may be envisaged largely subliminally is empirically supported by the observation that, as invoked, imaginary recognition states can vary along a spectrum in their degree of perceptual definition. At the high-definition end of this spectrum people can invoke and perceive such states *vividly, clearly and at length* – with attendant strength and nuance of evoked emotion[252] – or, towards the lower end of the spectrum, a person can invoke and perceive such states *faintly and briefly*.

Consider then that, still further down such a spectrum, an invocation and perception of imaginary recognition states may occur that approaches being subliminal and is rapid. Consider further that in this way members of an array of proto-goal states, generated as described above, may be rapidly serially invoked and perceived by a person such that this allows them to decide on a *course of action*[253] where – following such decision – this will be a course of action predicted to reach a *prevailing proto-goal state*, where this will be the proto-goal state that the person *feels* the most willing actually to seek – i.e. seek to achieve in reality – out of all of the array of proto-goal states that have been assessed.

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[249] This assumption is made simply to allow the main idea presented in this paragraph to be presented as clearly as possible. The idea will hold regardless of whether there are high levels of incompleteness or inaccuracy in the Set 2 records. Indeed, ideal and complete autobiographical memory is never the case, with only the partial exception of people with an extremely rare condition known as hyperthymesia or highly superior autobiographical memory (HSAM). See Parker, E.S. et. al (2006) A Case of Unusual Autobiographical Remembering *Neurocase 12*, 35–49 and, for example, LePort, A.K.R. (2016) Highly Superior Autobiographical Memory: Quality and Quantity of Retention Over Time *Frontiers in Psychology 6* Art. 2017. For consciously invoked recall, a person's autobiographical memory can often be very poor and normally declines exponentially as a function of n (as defined in the text) as per Wixted, J.T. (2007) The Wickelgren Power Law and the Ebbinghaus Savings Function *Psychological Science 18*, 133-134.

[250] As broadly discussed under 'simulation' at pp 26-28 in Feldman Barrett, L. *How Emotions Are Made* Horton Mifflin Harcourt, New York 2017.

[251] A similar observation is made at pp 66 of ibid.

[252] Sexual and romantic fantasies – or daydreams of other forms of gratification and 'moments of success' – are common examples. A less common but striking example is the construction and perception of 'memory palaces' by mnemonists using the method of loci, as described for example in Bower, G.H. (1970) Analysis of a Mnemonic Device *American Scientist 58* 496-510.

[253] Or to decide, as discussed, to invoke a memory or construct a fantasy, which - although not in themselves imagined courses of action or proto-goal states – may serve as a form of 'thought experiment' to inform decisions on potential courses of action and goal states.

To flesh this proposal out, say that over some given period when a person is conscious the emulator within their D[r] rapidly and spontaneously generates an array of proto-goal states.[254] Denote these:

$${}^{0}\Xi^{\tau i},\ {}^{1}\Xi^{\tau i},\ {}^{2}\Xi^{\tau i},\ {}^{3}\Xi^{\tau i},\ \ldots\ ,\ {}^{n}\Xi^{\tau i} \qquad \text{A1}$$

where the left superscript identifies a unique member of such an array. Denote as ${}^{1}\Xi^{\tau i}$ the prevailing proto-goal state for that given period. This will be the goal state which, within that period, the person is actually physically moving to achieve. Further denote as ${}^{0}\Xi^{\tau i}$ a proto-goal state that can be called the *null goal state*, or *resting state*. This is defined below.

To be envisaged as candidate *real* future recognition states, proto-goal states will have to be assigned by the person not only as being at some time in the future of their A-series but also as being at some location in the single three dimensional space that they envisage houses reality, i.e. proto-goal states will have to be assigned to some location in the person's real phenomenal space.

The requirement that a proto-goal state be envisaged by a person as being in their real phenomenal space means that all proto-goal states must be generated – at least in part – by a person's recall from memory of a recognition state in conjunction with reassignment of that state's τ from the past in their A-series to the future in their A-series – with relatively minor, if any, modification to the Specific Objects and Specific Characteristics of the recalled recognition state.[255] If this were not the case, the proto-goal state could not be connected to what the person holds to be their spatiotemporal reality. This is because the only way for a person to envisage a spatial location as real will be if the imagined spatial configuration of certain Specific Objects in the proto-goal state matches a known configuration of such Specific Objects held in an overall map of the recallable contents of real phenomenal space that is held in the person's memory.

The proposal that a person progressively builds, retains and updates such a recallable overall map – call this their *world map* – encoding the spatial configuration of 'landmark' Specific Objects that they have observed to persist in a more-or-less enduring 'landscape' distributed across their real phenomenal space is empirically well supported. People almost always have a highly effective grasp of 'where things are' – from small and close to large and distant – in what they hold to be the overall layout of their physical environment, with this grasp held independently – but almost always in clear relation[256] – to the specific location in that environment that they perceive themselves to be occupying at any given moment, i.e. at their 'now'. Notably, the system described above as memory has the attributes required to provide for what is being described here as a world map. In particular, the records in an arrangement of records such as Set 2 will contain all of the information needed to constitute such a map.[257]

Taking all of this on board, say that at its deepest, fastest and most basic level the generation of an array of proto-goal states, A1, will amount to generation by the emulator in a person's D[r] – drawing on memory, as described above – of an array of imaginary recognition states ${}^{n}\Xi^{\tau i}$, such that any of these, if invoked and perceived, will be experienced by that person – no matter how fleetingly – as an imagined environment image, ${}^{n}(W[i]\backslash B[i])^{\tau i}$ containing an imagined body image, ${}^{n}B[i]^{\tau i}$, as perceived from an imagined position in their real phenomenal space from their perspective of being D[a] at their Self-as-Centre, where they will also locate and experience an evoked but *real* emotional state that can be denoted ${}^{n}N[i]$.[258]

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[254] A basis for the spontaneous generation of arrays of proto-goal states, and the determination of their contents, is proposed in Section 11.3.4.

[255] Although there may be considerable loss of definition (as opposed to modification) – i.e. a 'haziness' in the Specific Objects and Specific Characteristics of the recalled recognition state versus the actual recognition state as it *was* experienced.

[256] The exception being when a person is physically lost.

[257] In Section 11.2, on recalled recognition states, it was proposed that a person may draw on Set 2 records to construct and 'perceive' a memory state by *recalling* the subset of the spatial contents of Set 2 as indexed to some *moment of time* assigned by that person to be one of the past moments in their A-series. In the current context, by a different mechanism, and perhaps more importantly, it seems possible that a person may also draw on Set 2 records to construct and utilise a map whose contents are those pointers and their relative spatial positions that have remained constant over *a relatively long interval of time* from some moment in the past of the person's A-series to some moment as close to the present in their A-series as they can recall. Some of the contents of such a map will be pointers to what have been called 'landmark' Specific Objects in the text above, with the relative spatial positions of those Specific Objects forming an overall configuration corresponding to what has been called an 'enduring landscape'.

[258] Use of ${}^{n}N[i]$ to denote the emotional state evoked when a person invokes and experiences a proto-goal state ${}^{n}\Xi^{\tau i}$ is intended, through use of the left superscript, to signify that this evoked emotion is specific to the overall imaginary recognition state ${}^{n}\Xi^{\tau i}$. So for example, for a proto-goal state ${}^{2}\Xi^{\tau i}$ the emotional state evoked will be ${}^{2}N[i]$, where ${}^{2}\Xi^{\tau i}$ can be expressed as a sum of parsed terms: ${}^{2}\Xi^{\tau i} = {}^{2}(W[i]\backslash B[i])^{\tau i} + {}^{2}B[i]^{\tau i} + {}^{2}N[i]$. The term ${}^{n}N[i]$ does not carry the right superscript τi used with the other terms in this sum because, as defined earlier, i signifies that a state is *imaginary* while τ more specifically signifies that this state is imagined to be at some time in the past or future of the imaginer's A-series. As pointed out in Section 11.1, the emotional state evoked when an imaginary recognition state is invoked and perceived is experienced by the imaginer as *real* for the period over which that imaginary recognition state is invoked.

11.3.2 Potential paths, the emulative recognition cycle, the desire state and the fitness state

Further to this, have that the predictive processing apparatus within D[r] can be used to estimate *paths* to envisaged proto-goal states out of the differences, $\Xi^a \Delta {}^n\Xi^{\tau i}$ – by harnessing its generative and recognition models to implement within its emulator an 'off-line' application of active inference – as an array of *potential paths*:

$\Xi^a, {}^0\Xi^{(a+1)i}, {}^0\Xi^{(a+2)i}, {}^0\Xi^{(a+3)i}, \dots, {}^0\Xi^{\tau i}$	denote this potential path:	${}^0Þ^{\tau i}$	
$\Xi^a, {}^1\Xi^{(a+1)i}, {}^1\Xi^{(a+2)i}, {}^1\Xi^{(a+3)i}, \dots, {}^1\Xi^{\tau i}$	"	${}^1Þ^{\tau i}$	
$\Xi^a, {}^2\Xi^{(a+1)i}, {}^2\Xi^{(a+2)i}, {}^2\Xi^{(a+3)i}, \dots, {}^2\Xi^{\tau i}$	"	${}^2Þ^{\tau i}$	A2
⋮ ⋮ ⋮ ⋮ ⋮		⋮	
$\Xi^a, {}^n\Xi^{(a+1)i}, {}^n\Xi^{(a+2)i}, {}^n\Xi^{(a+3)i}, \dots, {}^n\Xi^{\tau i}$	"	${}^nÞ^{\tau i}$	

where each such potential path is an estimated path through Ξ space from Ξ^a – the actual recognition state at the time, t = a, of implementation of the emulator – to one of the proto-goal states in the array A1. A potential path can also be viewed as a potential *course of action*, as a *potential task*, or as a *potential movement* from the position Ξ^a through Ξ space to the potential position ${}^n\Xi^{\tau i}$.[259]

The proposal that D[r] can estimate potential paths through Ξ space out of differences $\Xi^a \Delta {}^n\Xi^{\tau i}$ is less challenging if it is again noted that:

- proto-goal states will almost always be generated by recall from memory of a recognition state in conjunction with reassignment of that state's τ from a position in the past to some position in the future of a person's A-series, with minor, if any, modification to the Specific Objects and Specific Characteristics of the recalled recognition state;
- in defining their real phenomenal space, people build, retain and update a world map where, in the current context, this can be understood to be an accumulated relational index across that inferred single and eternal space, of records of all previously actually experienced recognition states, including all states that can be recalled from memory; and if it is further noted that
- such an index will by definition – if it is like Set 2 – hold an indexed set of records that contains just the kind of information needed to estimate potential paths through real phenomenal space.

At a phenomenological level this is supported by the observation that people almost always know how to (can estimate a path to) get from where they currently are to any other place they can picture as being in their real phenomenal space (from where they are now, Ξ^a, to any ${}^n\Xi^{\tau i}$) by drawing on memory of the landscape of their physical environment (their world map). Moreover, it is apparent that as part of 'knowing where something is', a person also knows how – and if – they can get from their current position to that something,[260] and broadly how much time, and 'effort', that journey is likely to take.

Now say, along lines described above, that any given proto-goal state in an array can be generated and envisaged by a person within a *minimum* of one pass – but perhaps will be envisaged over many consecutive passes – of an emulative mode (see below) of the recognition cycle. In the general case, such an envisaged state will be ${}^n\Xi^{\tau i}$ which, as constructed and 'perceived' by that person, will take the parsed out form ${}^n(W[i]\backslash B[i])^{\tau i} + {}^nB[i]^{\tau i} + {}^nN[i]$ which can also be written ${}^n\{B[i] + W[i]\backslash B[i]\}^{\tau i} + {}^nN[i]$.

Say also, as proposed above, that any potential path, ${}^nÞ^{\tau i}$, through Ξ space to any given proto-goal state ${}^n\Xi^{\tau i}$ can be estimated through operation of D[r]'s emulator, drawing on D[r]'s world map, from the difference, $\Xi^a \Delta {}^n\Xi^{\tau i}$, where this can be considered a path through perceived physical space[261] in terms of an imagined movement of the states $\{B[i] + W[i]\backslash B[i]\}^a$ to some ${}^n\{B[i] + W[i]\backslash B[i]\}^{\tau i}$ in combination with a path through the desire/emotion component of perceived 'emotional space'[262] in terms of an imagined movement of the state $N[i]^a$ to ${}^nN[i]$. Figure 15 illustrates this proposed arrangement.

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[259] This is because for D[r] – in predicting itself to be the force generator D[a] – will predict the *movement* of the state Ξ^a to any future state ${}^n\Xi^{\tau i}$ to be a *task* that D[a] might undertake.

[260] In this context 'something' could be a place, a Specific Object, a full stomach, a warm bed, an emotion or any defining substate of an ${}^n\Xi^{\tau i}$, with 'where' being the position in Ξ space of that ${}^n\Xi^{\tau i}$.

[261] Also called κ space (see Section 10.5.4)

[262] Also called ρ space (see Section 10.5.4).

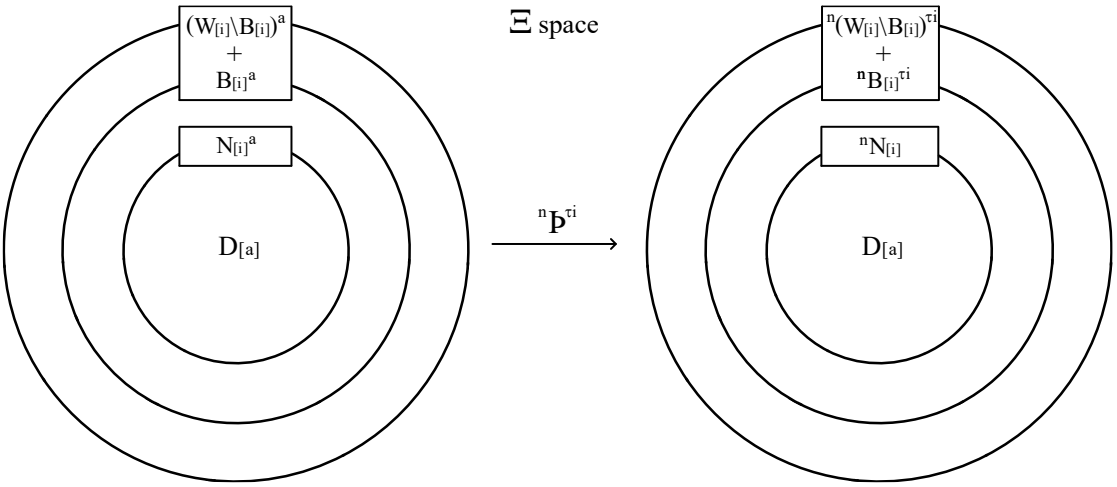

Figure 15

Figure 15 illustrates a *potential path*, ${}^{n}Þ^{\tau i}$, through Ξ space from an initial recognition state Ξ^{a} at time t = a to some proto-goal state ${}^{n}\Xi^{\tau i}$ at some t = τ imagined by a person as some future moment in their A-series. The contents of Ξ^{a} and of ${}^{n}\Xi^{\tau i}$ are shown as sphere world diagrams at either end of a potential path through the landscape of the imaginer's real phenomenal space – their world map – from $\{B[i] + W[i]\backslash B[i]\}^{a}$ to some ${}^{n}\{B[i] + W[i]\backslash B[i]\}^{\tau i}$, where the optimally parsed substates of $\{B[i] + W[i]\backslash B[i]\}^{a}$ make up the physical world, including their physical body, as the person perceives it[263] at t = a, and the imagined substates of ${}^{n}\{B[i] + W[i]\backslash B[i]\}^{\tau i}$ make up the physical world, including their physical body, as they imagine perceiving it at some ${}^{n}\Xi^{\tau i}$, at t = τ, through the operation of their emulator. The desire/emotion a person perceives when they imagine some ${}^{n}\Xi^{\tau i}$ will be composed of the substates of ${}^{n}N[i]$. It is proposed that these substates will at a minimum include a desire state ${}^{n}\underline{ds}$ and a fitness state ${}^{n}\underline{fs}$ which, when they are perceived together as ${}^{n}\{\underline{ds} + \underline{fs}\}$, will be felt by the person as *willingness* – i.e. how willing they are – to traverse the potential path ${}^{n}Þ^{\tau i}$ to attain the proto-goal state ${}^{n}\Xi^{\tau i}$. Out of any array of proto-goal states, a person will adopt as their *prevailing proto-goal state* that proto-goal state that they feel the most willingness to get to (see text).

The proposal to be described here on how a *prevailing proto-goal state*[264] can be selected through an assessment process in D[r] requires that the ${}^{n}\Xi^{\tau i}$ substate ${}^{n}N[i]$ be considered to contain *at least two substates* – call these substates *chords*, which will be perceived by D[r] – from the perspective of its inference of itself as D[a] – as a combination, where this combination of chords will be called a *chord harmony*.[265] These two substates, or 'chords', can be further each be called the *desire state*, ds, and the *fitness state*, fs.[266]

Say that ds and fs can be generated in the following way (see 1 and 2 next page) through operation of D[r]'s emulator, drawing for this purpose upon D[r]'s hierarchical processing system and the generative and recognition models inherent in that system. Say also for this purpose that, for any specific proto-goal state, this takes place through a process that *emulates* one beat of the recognition cycle, such that this emulation takes place 'offline', where 'offline' means specifically that – unlike in operation of the *actual* recognition cycle – such emulation generates *no* voluntary motor output from D[r].[267] Assume also that the *actual recognition cycle* (ARC) – which *is* expressing motor output from D[r] – runs such that its execution is *interleaved in time* with D[r]'s running of the *emulative recognition cycle* (ERC).[268]

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[263] Strictly this can be more accurately expressed as $\{\{B[i] + W[i]\backslash B[i]\}^{a} + \{B[i] + W[i]\backslash B[i]\}^{(a+1)*}\}$ but in the current context this is more of a complicating nuance, where the abbreviated form used above will be sufficient for all current explanatory purposes.

[264] The prevailing proto-goal state is defined in Section 11.3.1.

[265] The reasons for using musical terms to name states and substates of N[i] were first introduced at footnote 206 in Part 2. This becomes extremely useful here because the metaphor of music – as sequences of notes, chords (simultaneous notes) and harmonies (simultaneous chords) – uniquely allows for conceptually accessible descriptions of (1) a basic element of a substate (*note*), (2) a substate (*chord*) or (3) a combination of substates (*chord harmony*) of N[i], including how these might change over time (forming a *harmonic melody*) in such a way that a crucial characteristic of these substates is preserved. This crucial characteristic is that, under the 3-space inference and optimal parsing, substates of N[i] are default indexed and, as such, are perceived as a *spatially undifferentiated* combination *co-located* at the position of the Self-as-Centre. Moments and sequences of music in acoustic environments where the sound source is evenly distributed about the listener also have a *spatially undifferentiated* structure. Component sounds in music nevertheless *can* be differentiated from each other perceptually, *but such differentiation is non-spatial*. We can often discern individual notes – or chords from different instruments, or of different timbres etc. – as components in an evolving orchestral soundscape. The proposal here is that we can, and do, apply an analogous form of non-spatial differentiation in the way that we perceive emotions. For example, we may be able to discern strains of tiredness, delight and excitement all in the one, overall emotion that we are currently 'hearing'/perceiving.

[266] For any given ${}^{n}\Xi^{\tau i}$ there will be a substate ${}^{n}N[i]$ that may contain several substates, ${}^{n}N[i] = {}^{n}\{\underline{a}^{(p+1)}, \underline{a}^{(p+2)}, \ldots, \underline{ds}, \underline{fs}, \ldots, \underline{a}^{(p+q)}\}$, consistent with definitions given in Sections 9.3.2 and 9.3.3 of Part 1. Here however, our interest extends only to the proposed substates ds and fs as they apply to various proto-goal states.

[267] But, as discussed below, such offline emulation *will* – most clearly when one or more emotionally evocative proto-goal states are envisaged – result in D[r] output that drives involuntary changes in B[r]\D[r], for example, changes in heart rate[r], hormone levels[r], breathing rate[r] and so forth, and only involuntary – if any – motor output from B[r] into W[r]\B[r].

[268] Another way of describing this proposal is to say that at any given time the recognition cycle can run in either one of two modes: an 'actual' mode or an 'emulative' mode.

1. The Desire State; ds

   (a) This will be a prediction of how *desirable* – i.e. beneficial – *achievement* of the envisaged proto-goal state will be for purposes of sustaining B[r] homeostasis.

   (b) At any t = a, the ds for any given potential path will be determined by input to D[r] from t = (a – 1) onward coming from various interoceptors[269] in wider B[r] carrying cueing signals that can be used as a measure of B[r]'s physiological state in relation to its homeostatic set points.

   (c) This input will have propagated upward through D[r]'s hierarchical processor to balance in the course of S_α of the *emulative* recognition cycle (ERC) a set of downward propagating *predictions* based on what application of D[r]'s generative and recognition models *infer* that physiological state will have become *once the proto-goal state has been achieved.* At the moment of this balance, at S_β of the ERC, this process will deliver the ds substate of the Ξ^a substate $N[i]^a$.

   (d) Hence ds can be seen as an *estimate/prediction* of the extent to which movement from $\Xi^{(a-1)}$ along ${}^n\text{Þ}^{\tau i}$ to some specific ${}^n\Xi^{\tau i}$ will – once that ${}^n\Xi^{\tau i}$ has been achieved – take B[r] closer to (or further from) its homeostatic set points – i.e. closer to, or further from, Position 1.[270]

   (e) Put roughly, and in phenomenological terms, the emotional component – or 'chord'[271] – contributed by ds to ${}^nN[i]$ will be perceived as a 'gut-level answer' to a generalised form of question encompassing questions of the type: "How much do I want this?", "How much will I benefit if I get this?", "How much better will I feel if I get this?", where 'this' is ${}^n\Xi^{\tau i}$ and 'I' is D[a].

2. The Fitness State; fs

   (a) This will be a prediction of B[r]'s *fitness* to meet the requirements across all levels of capability – including in motor capability, energy supply, physical strength, visual acuity and all other relevant capabilities – to *traverse the path* (i.e. to undertake the task) of moving Ξ^a *to* the proto-goal state under assessment.[272]

   (b) At any t = a, the fs for any given potential path will be determined by input to D[r] from t = (a – 1) onward coming from various interoceptors, including nociceptors, and perhaps some proprioceptors,[269] within B[r] that carry cueing signals that can be used as a measure of B[r]'s overall fitness – including its overall readiness – to undertake physical tasks.

   (c) This input will propagate upward through D[r]'s hierarchical processor to balance in the course of S_α of the ERC a set of downward propagating predictions based on what application of D[r]'s generative and recognition models infer B[r]'s state of fitness will have become if the potential path under assessment is traversed *just up to the point of achievement* of the proto-target state. At the moment of this balance, at S_β of the ERC, this process will deliver the fs substate of the Ξ^a substate $N[i]^a$.

   (d) Hence fs can be seen as an *estimate/prediction* of the extent to which movement from $\Xi^{(a-1)}$ along ${}^n\text{Þ}^{\tau i}$ to some specific ${}^n\Xi^{\tau i}$ will require/consume certain motor, energy and other B[r] resources, where this predicted level of 'effort' and resource consumption may range along a spectrum from trivial to higher levels of difficulty, including up into levels where the estimates will be that B[r] is increasingly unlikely to be able to traverse the potential path required to reach the proto-goal state being envisaged.

   (e) Put roughly, and in phenomenological terms, the emotional component – or 'chord' – contributed by fs to ${}^nN[i]$ will be a 'gut-level answer' to a generalised form of question that encompasses questions of the type: "How hard will it be for me to get this?", "How much will it 'cost' me to get this?", "How tiring will it be for me to get this?", where 'this' is ${}^n\Xi^{\tau i}$ and 'me' is D[a].

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[269] Interoceptors of the relevant types are further described in Section 12.1 below.
[270] Consistent with the definition of Position 1 provided in Section 10.5.1 (and see also Section 10.5.4) of Part 2.
[271] To extend the musical metaphor, for ds the chord here might be thought of as composed of a set of notes, where one or more of these notes might correspond to an estimate of the distance between the current physiological state of B[r] and one of its homeostatic set points. A similar, but more considered approach to such 'chord composition' is given in Section 12.1 below.
[272] So, in analogy to thermodynamics, fs can be considered akin to a *path function* whereas ds can be considered akin to a *state function*.

Say that by this means a ds and fs can be generated for any proto-goal state, ${}^{n}\Xi^{\tau i}$, through operation of *at least* one beat of the ERC. So at t = a for any given ${}^{n}Þ^{\tau i}$ from $\Xi^{(a-1)}$ to ${}^{n}\Xi^{\tau i}$, substates of $N[i]^{a}$ that can be designated ${}^{n}ds$ and ${}^{n}fs$ will be generated. Together these will make up a compound substate of $N[i]^{a}$ that can be designated ${}^{n}\{ds + fs\}$. Applying the analogy of music, ${}^{n}ds$ and ${}^{n}fs$ can each be likened to a chord, and ${}^{n}\{ds + fs\}$ can be likened to the chord harmony that these will form as part of an overall chord harmony made up of all the substates that, at t = a, are members of $N[i]^{a}$.[273]

Turning to an example, for ${}^{1}Þ^{\tau i}$ – which is designated *the prevailing path*, or *prevailing task* – these substates will be ${}^{1}ds$ and ${}^{1}fs$; corresponding to the desire and fitness states determined at some time, t = a, by operation of the emulator for the path ${}^{1}Þ^{\tau i}$ from the recognition state $\Xi^{(a-1)}$ to *the prevailing proto-goal state*, ${}^{1}\Xi^{\tau i}$. Recall that the prevailing proto-goal state[264] is that proto-goal state which a person has decided/selected – through a process of assessment – to be the proto-goal state which, following such decision, they will actually be moving their current Ξ through Ξ space to achieve.[274]

For ${}^{0}Þ^{\tau i}$ – which can be called *the null path*, *null task* or *resting task* – these substates will be ${}^{0}ds$ and ${}^{0}fs$; corresponding to the desire and fitness states determined at some other time, t = b, by operation of the emulator for the path ${}^{0}Þ^{\tau i}$ from the recognition state $\Xi^{(b-1)}$ to *the null goal state* or *resting state*, ${}^{0}\Xi^{\tau i}$. Define the null goal state as that proto-goal state generated by taking $\Xi^{(b-1)}$ and envisaging a proto-goal state where there has been no movement – i.e. there is no change – in the substates of B[i] in going from $\Xi^{(b-1)}$ to that proto-goal state. This is the case where a person *imagines* staying still and physically doing nothing.

For example, when a person is in bed seeking to sleep – or sits back resting – this will follow an assessment process whereby the null goal state has been selected/decided from among an array of proto-goal states to be made the prevailing proto-goal state.

To describe such an overall selection/decision process, consider a situation where, over a series of emulative recognition cycles, beginning at some t = a+2, an array of proto-goal states is processed sequentially – with periodic suspension due to interleaving of the ARC with the ERC – to provide respective ds and fs substates of N[i] at, for example, the times shown in Table 1.[275]

Row[276]	Time	Proto-goal state	Potential path	Desire state	Fitness state	${}^{n}N[i]$	$N[i]^{n}$
0	a	suspended	suspended	not generated	not generated	none	$N[i]^{a}$
1	a+1	suspended	suspended	not generated	not generated	none	$N[i]^{(a+1)}$
2	a+2	${}^{0}\Xi^{\tau i}$	${}^{0}Þ^{\tau i}$	${}^{0}ds$	${}^{0}fs$	${}^{0}N[i]$	$N[i]^{(a+2)}$
3	a+3	suspended	suspended	not generated	not generated	none	$N[i]^{(a+3)}$
4	a+4	${}^{1}\Xi^{\tau i}$	${}^{1}Þ^{\tau i}$	${}^{1}ds$	${}^{1}fs$	${}^{1}N[i]$	$N[i]^{(a+4)}$
5	a+5	suspended	suspended	not generated	not generated	none	$N[i]^{(a+5)}$
6	a+6	${}^{2}\Xi^{\tau i}$	${}^{2}Þ^{\tau i}$	${}^{2}ds$	${}^{2}fs$	${}^{2}N[i]$	$N[i]^{(a+6)}$
7	a+7	suspended	suspended	not generated	not generated	none	$N[i]^{(a+7)}$
8	a+8	${}^{3}\Xi^{\tau i}$	${}^{3}Þ^{\tau i}$	${}^{3}ds$	${}^{3}fs$	${}^{3}N[i]$	$N[i]^{(a+8)}$
9	a+9	suspended	suspended	not generated	not generated	none	$N[i]^{(a+9)}$
10	a+10	${}^{4}\Xi^{\tau i}$	${}^{4}Þ^{\tau i}$	${}^{4}ds$	${}^{4}fs$	${}^{4}N[i]$	$N[i]^{(a+10)}$
11	a+11	suspended	suspended	not generated	not generated	none	$N[i]^{(a+11)}$
12	a+12	${}^{5}\Xi^{\tau i}$	${}^{5}Þ^{\tau i}$	${}^{5}ds$	${}^{5}fs$	${}^{5}N[i]$	$N[i]^{(a+12)}$
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
n	a+n	${}^{n}\Xi^{\tau i}$	${}^{n}Þ^{\tau i}$	${}^{n}ds$	${}^{n}fs$	${}^{n}N[i]$	$N[i]^{(a+n)}$

Table 1

[273] Consistent with notation used earlier, we can say that the emotional substate evoked when the proto-target state ${}^{n}\Xi^{\tau i}$ is under invocation at t = a will be ${}^{n}N[i]^{a}$ where, in terms of further substates, ${}^{n}N[i]^{a} = {}^{n}\{a^{(p+1)}, a^{(p+2)}, \{ds + fs\}, \ldots, a^{(p+q)}\}^{a}$ and where $N[i]^{a} = \{a^{(j+1)}, a^{(j+2)}, \ldots {}^{n}N[i], \ldots a^{(j+k)}\}^{a}$. (Note well, however, that possible additional substates of ${}^{n}N[i]^{a}$ and of $N[i]^{a}$ other than ${}^{n}\{ds + fs\}^{a}$ are included here for formal completeness and are not under consideration in this discussion.)

[274] As such, the series ${}^{1}\Xi^{(a+2)i}$, ${}^{1}\Xi^{(a+3)i}$, ${}^{1}\Xi^{(a+4)i}$, … , ${}^{1}\Xi^{ti}$ will, at any given time t = a+1, be under implementation as an affordance series $\Xi^{(a+2)*}$, $\Xi^{(a+3)**}$, $\Xi^{(a+4)***}$, … as shown in Figure 14 of Part 2 (provided that at t = a+1 the ARC is in operation with the ERC suspended).

[275] In the simplified, idealised example of Table 1, the ERC is envisaged as operating to give ds and fs substates of N[i] only for t = (a+2), (a+4) and so on, while the ARC is envisaged as operating for t = a, (a+1), (a+3) and so on. This idea is described in less idealised terms below.

[276] A row number is included in the table simply to allow reference in the text to the contents of one row or another.

Now say that the time sequence of proto-goal states and potential paths shown in Table 1 has been arbitrarily ordered to illustrate in the simplest way possible the *layout* of the proposed process, and instead say that there may be no specific order for such a sequence, that certain specific proto-goal states might repeatedly be envisaged, and that for some specific times or time intervals there may be a sustained suspension of operation of the ERC, including at times when a person's attention is fully absorbed in real time with challenges arising as they physically enact the prevailing task via concerted application of the ARC.[277]

In other words, say that the series being generated over successive ERCs from t = a to t = (a+n) might more reasonably be illustrated by using the time sequence of proto-goal states and potential paths shown in Table 2, where there is repetition, extended suspension[278] – and no particular order – in the sequence of specific proto-target states being generated and envisaged.

Row	Time	Proto-goal state	Potential path	Desire state	Fitness state	$^{n}N[i]$	$N[i]^{n}$
0	a	$^{2}\Xi^{\tau i}$	$^{2}\mathfrak{p}^{\tau i}$	$^{2}\underline{ds}$	$^{2}\underline{fs}$	$^{2}N[i]$	$N[i]^{a}$
1	a+1	$^{0}\Xi^{\tau i}$	$^{0}\mathfrak{p}^{\tau i}$	$^{0}\underline{ds}$	$^{0}\underline{fs}$	$^{0}N[i]$	$N[i]^{(a+1)}$
2	a+2	suspended	suspended	not generated	not generated	none	$N[i]^{(a+2)}$
3	a+3	$^{2}\Xi^{\tau i}$	$^{2}\mathfrak{p}^{\tau i}$	$^{2}\underline{ds}$	$^{2}\underline{fs}$	$^{2}N[i]$	$N[i]^{(a+3)}$
4	a+4	$^{1}\Xi^{\tau i}$	$^{1}\mathfrak{p}^{\tau i}$	$^{1}\underline{ds}$	$^{1}\underline{fs}$	$^{1}N[i]$	$N[i]^{(a+4)}$
5	a+5	$^{1}\Xi^{\tau i}$	$^{1}\mathfrak{p}^{\tau i}$	$^{1}\underline{ds}$	$^{1}\underline{fs}$	$^{1}N[i]$	$N[i]^{(a+5)}$
6	a+6	suspended	suspended	not generated	not generated	none	$N[i]^{(a+6)}$
7	a+7	suspended	suspended	not generated	not generated	none	$N[i]^{(a+7)}$
8	a+8	suspended	suspended	not generated	not generated	none	$N[i]^{(a+8)}$
9	a+9	suspended	suspended	not generated	not generated	none	$N[i]^{(a+9)}$
10	a+10	suspended	suspended	not generated	not generated	none	$N[i]^{(a+10)}$
11	a+11	suspended	suspended	not generated	not generated	none	$N[i]^{(a+11)}$
12	a+12	suspended	suspended	not generated	not generated	none	$N[i]^{(a+12)}$
13	a+13	$^{3}\Xi^{\tau i}$	$^{3}\mathfrak{p}^{\tau i}$	$^{3}\underline{ds}$	$^{3}\underline{fs}$	$^{3}N[i]$	$N[i]^{(a+13)}$
14	a+14	$^{3}\Xi^{\tau i}$	$^{3}\mathfrak{p}^{\tau i}$	$^{3}\underline{ds}$	$^{3}\underline{fs}$	$^{3}N[i]$	$N[i]^{(a+14)}$
15	a+15	$^{3}\Xi^{\tau i}$	$^{3}\mathfrak{p}^{\tau i}$	$^{3}\underline{ds}$	$^{3}\underline{fs}$	$^{3}N[i]$	$N[i]^{(a+15)}$
16	a+16	$^{1}\Xi^{\tau i}$	$^{1}\mathfrak{p}^{\tau i}$	$^{1}\underline{ds}$	$^{1}\underline{fs}$	$^{1}N[i]$	$N[i]^{(a+16)}$
17	a+17	$^{1}\Xi^{\tau i}$	$^{1}\mathfrak{p}^{\tau i}$	$^{1}\underline{ds}$	$^{1}\underline{fs}$	$^{1}N[i]$	$N[i]^{(a+17)}$
18	a+18	suspended	suspended	not generated	not generated	none	$N[i]^{(a+18)}$
19	a+19	suspended	suspended	not generated	not generated	none	$N[i]^{(a+19)}$
20	a+20	suspended	suspended	not generated	not generated	none	$N[i]^{(a+20)}$
21	a+21	suspended	suspended	not generated	not generated	none	$N[i]^{(a+21)}$
22	a+22	$^{5}\Xi^{\tau i}$	$^{5}\mathfrak{p}^{\tau i}$	$^{5}\underline{ds}$	$^{5}\underline{fs}$	$^{5}N[i]$	$N[i]^{(a+22)}$
23	a+23	$^{5}\Xi^{\tau i}$	$^{5}\mathfrak{p}^{\tau i}$	$^{5}\underline{ds}$	$^{5}\underline{fs}$	$^{5}N[i]$	$N[i]^{(a+23)}$
24	a+24	$^{4}\Xi^{\tau i}$	$^{4}\mathfrak{p}^{\tau i}$	$^{4}\underline{ds}$	$^{4}\underline{fs}$	$^{4}N[i]$	$N[i]^{(a+24)}$
25	a+25	suspended	suspended	not generated	not generated	none	$N[i]^{(a+25)}$
26	a+26	$^{5}\Xi^{\tau i}$	$^{5}\mathfrak{p}^{\tau i}$	$^{5}\underline{ds}$	$^{5}\underline{fs}$	$^{5}N[i]$	$N[i]^{(a+26)}$
27	a+27	$^{5}\Xi^{\tau i}$	$^{5}\mathfrak{p}^{\tau i}$	$^{5}\underline{ds}$	$^{5}\underline{fs}$	$^{5}N[i]$	$N[i]^{(a+27)}$
28	a+28	$^{0}\Xi^{\tau i}$	$^{0}\mathfrak{p}^{\tau i}$	$^{0}\underline{ds}$	$^{0}\underline{fs}$	$^{0}N[i]$	$N[i]^{(a+28)}$
29	a+29	$^{1}\Xi^{\tau i}$	$^{1}\mathfrak{p}^{\tau i}$	$^{1}\underline{ds}$	$^{1}\underline{fs}$	$^{1}N[i]$	$N[i]^{(a+29)}$
30	a+30	$^{1}\Xi^{\tau i}$	$^{1}\mathfrak{p}^{\tau i}$	$^{1}\underline{ds}$	$^{1}\underline{fs}$	$^{1}N[i]$	$N[i]^{(a+30)}$
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
n	a+n	$^{n}\Xi^{\tau i}$	$^{n}\mathfrak{p}^{\tau i}$	$^{n}\underline{ds}$	$^{n}\underline{fs}$	$^{n}N[i]$	$N[i]^{(a+n)}$

Table 2

[277] Noting that people do not seem genuinely to be able to *attend* to a real physical task while at the same time imagining doing something else.
[278] A period of extended suspension of the ERC during which the ARC is operating can be called a *suspension pattern*.

11.3.3 Willingness: deciding on a course of action

Bearing this in mind, suppose then that the process operating in D[r] that assesses/selects/decides on a prevailing proto-goal state/prevailing path:

- takes place over *several-to-many iterations* of the ERC as D[r]'s emulator – when it is not suspended – serially generates proto-goal states and potential paths, to either fleetingly, at times repetitively – or sometimes repetitively and consecutively over many iterations – derive ds and fs substates specific to each of those envisaged proto-goal states; and

- that a relative assessment of proto-goal states is made by D[r] – from the perspective of its inference of itself as D[a] – through its perception of a sequence – or *flow* – of emotions *arising as the pattern and contents* of the series of N[i] substates {ds + fs} as these are serially generated over those several-to-many iterations of the emulative recognition cycle.

To draw again upon the analogy of music, say that perception of a such a sequence or flow of emotions is analogous to perception of a musical phrase, or series of musical phrases, where these are sequences of what have been defined above as chord harmonies. Here each chord harmony in the sequence will include inter alia[273] the two chords ds and fs as they arise together as {ds + fs} at each iteration of the ERC.

The result of the proposed assessment process – where this result will be selection of a prevailing proto-goal state/prevailing path – will relate to how each of these chord harmonies 'sound' to a person *as perceived emotions* where, to describe the simplest possible case:

- the desire state ds will 'sound to a person like' – be perceived by a person as – how much, and in what senses, they desire a given proto-goal state: call this 'chord' the proto-goal state's *desirability*; and

- the fitness state fs will 'sound to a person like' – be perceived by a person as – how much, and in what senses, they predict they may be physically challenged, fatigued – perhaps even hurt – by traversing the potential path to reach that proto-goal state – call this 'chord' the proto-goal state's *achievability*.

Say then that, for any given proto-goal state envisaged, these two chords 'heard together' as {ds + fs} will 'sound to a person like' – be perceived *emotionally* by that person as – how much, and in what senses, they are *willing* to seek that proto-goal state: call this 'chord harmony' a person's *willingness* to seek an envisaged proto-goal state by traversing the associated potential path.

So for any specific proto-goal state/potential path envisaged, the ERC will give a substate of N[i] that is ^{n}N[i], itself containing a substate ^{n}{ds + fs}, that will be perceived/*felt* by a person, as they envisage that proto-goal state/potential path – either fleetingly, repetitively, or consecutively and repetitively over many iterations of the ERC – as their willingness to seek that proto-goal state.

Then say further that, as a person 'listens to'/perceives/feels – the flow of emotions that arise as their emulator generates, and the ERC runs serially through, an array of proto-goal states – i.e. as they envisage that series of proto-goal states – they will:

- perceive – i.e. 'hear'/feel – a flow of *relative strengths* of willingness to seek one or another of the proto-goal states that are serially being invoked; and

- adopt as their prevailing proto-goal state/prevailing path that proto-goal state/potential path that evokes the strongest feeling of willingness – i.e. that they *feel* the most willing to pursue.

Now assume that when a person is conscious at some time, t = a, and their ARC is engaged and harnessing D[r]'s generative and recognition models in active inference in operation of its hierarchical processor, this will be driving motor outputs that the processor predicts will move the recognition state Ξ^a along that potential path, which at t = a is the prevailing path, ${}^{1}Þ^{\tau i}$, to that proto-goal state which at t = a is the prevailing proto-goal state, ${}^{1}\Xi^{\tau i}$.

Also assume that – *interleaved with* (i.e. in between) times when the ARC is operating in this way – D[r] will be implementing beats of the ERC to serially process proto-goal states drawn from an array of such states, and that in virtually all circumstances the prevailing proto-goal state ${}^{1}\Xi^{\tau i}$ will be among the proto-goal states in that array.

Table 3 provides an example of what is meant. Periods of suspension correspond to periods when the ARC is engaged, and the ERC is suspended. Call such periods of ERC suspension, *suspension patterns*.

Row	Time	Proto-goal state	Potential path	Desire state	Fitness state	${}^{n}N[i]$	$N[i]^{n}$
0	a	${}^{1}\Xi^{\tau i}$	${}^{1}\text{Þ}^{\tau i}$	${}^{1}\underline{ds}$	${}^{1}\underline{fs}$	${}^{1}N[i]$	$N[i]^{a}$
1	a+1	${}^{1}\Xi^{\tau i}$	${}^{1}\text{Þ}^{\tau i}$	${}^{1}\underline{ds}$	${}^{1}\underline{fs}$	${}^{1}N[i]$	$N[i]^{(a+1)}$
2	a+2	suspended	suspended	not generated	not generated	none	$N[i]^{(a+2)}$
3	a+3	suspended	suspended	not generated	not generated	none	$N[i]^{(a+3)}$
4	a+4	suspended	suspended	not generated	not generated	none	$N[i]^{(a+4)}$
5	a+5	suspended	suspended	not generated	not generated	none	$N[i]^{(a+5)}$
6	a+6	${}^{3}\Xi^{\tau i}$	${}^{3}\text{Þ}^{\tau i}$	${}^{3}\underline{ds}$	${}^{3}\underline{fs}$	${}^{3}N[i]$	$N[i]^{(a+6)}$
7	a+7	${}^{3}\Xi^{\tau i}$	${}^{3}\text{Þ}^{\tau i}$	${}^{3}\underline{ds}$	${}^{3}\underline{fs}$	${}^{3}N[i]$	$N[i]^{(a+7)}$
8	a+8	${}^{1}\Xi^{\tau i}$	${}^{1}\text{Þ}^{\tau i}$	${}^{1}\underline{ds}$	${}^{1}\underline{fs}$	${}^{1}N[i]$	$N[i]^{(a+8)}$
9	a+9	${}^{1}\Xi^{\tau i}$	${}^{1}\text{Þ}^{\tau i}$	${}^{1}\underline{ds}$	${}^{1}\underline{fs}$	${}^{1}N[i]$	$N[i]^{(a+9)}$
10	a+10	${}^{3}\Xi^{\tau i}$	${}^{3}\text{Þ}^{\tau i}$	${}^{3}\underline{ds}$	${}^{3}\underline{fs}$	${}^{3}N[i]$	$N[i]^{(a+10)}$
11	a+11	${}^{3}\Xi^{\tau i}$	${}^{3}\text{Þ}^{\tau i}$	${}^{3}\underline{ds}$	${}^{3}\underline{fs}$	${}^{3}N[i]$	$N[i]^{(a+11)}$
12	a+12	${}^{3}\Xi^{\tau i}$	${}^{3}\text{Þ}^{\tau i}$	${}^{3}\underline{ds}$	${}^{3}\underline{fs}$	${}^{3}N[i]$	$N[i]^{(a+12)}$
13	a+13	${}^{3}\Xi^{\tau i}$	${}^{3}\text{Þ}^{\tau i}$	${}^{3}\underline{ds}$	${}^{3}\underline{fs}$	${}^{3}N[i]$	$N[i]^{(a+13)}$
14	a+14	${}^{1}\Xi^{\tau i}$	${}^{1}\text{Þ}^{\tau i}$	${}^{1}\underline{ds}$	${}^{1}\underline{fs}$	${}^{1}N[i]$	$N[i]^{(a+14)}$
15	a+15	${}^{1}\Xi^{\tau i}$	${}^{1}\text{Þ}^{\tau i}$	${}^{1}\underline{ds}$	${}^{1}\underline{fs}$	${}^{1}N[i]$	$N[i]^{(a+15)}$
16	a+16	suspended	suspended	not generated	not generated	none	$N[i]^{(a+16)}$
17	a+17	suspended	suspended	not generated	not generated	none	$N[i]^{(a+17)}$
18	a+18	suspended	suspended	not generated	not generated	none	$N[i]^{(a+18)}$
19	a+19	suspended	suspended	not generated	not generated	none	$N[i]^{(a+19)}$
20	a+20	${}^{4}\Xi^{\tau i}$	${}^{4}\text{Þ}^{\tau i}$	${}^{4}\underline{ds}$	${}^{4}\underline{fs}$	${}^{4}N[i]$	$N[i]^{(a+20)}$
21	a+21	${}^{4}\Xi^{\tau i}$	${}^{4}\text{Þ}^{\tau i}$	${}^{4}\underline{ds}$	${}^{4}\underline{fs}$	${}^{4}N[i]$	$N[i]^{(a+21)}$
22	a+22	${}^{1}\Xi^{\tau i}$	${}^{1}\text{Þ}^{\tau i}$	${}^{1}\underline{ds}$	${}^{1}\underline{fs}$	${}^{1}N[i]$	$N[i]^{(a+22)}$
23	a+23	${}^{1}\Xi^{\tau i}$	${}^{1}\text{Þ}^{\tau i}$	${}^{1}\underline{ds}$	${}^{1}\underline{fs}$	${}^{1}N[i]$	$N[i]^{(a+23)}$
24	a+24	${}^{4}\Xi^{\tau i}$	${}^{4}\text{Þ}^{\tau i}$	${}^{4}\underline{ds}$	${}^{4}\underline{fs}$	${}^{4}N[i]$	$N[i]^{(a+24)}$
25	a+25	${}^{4}\Xi^{\tau i}$	${}^{4}\text{Þ}^{\tau i}$	${}^{4}\underline{ds}$	${}^{4}\underline{fs}$	${}^{4}N[i]$	$N[i]^{(a+25)}$
26	a+26	${}^{1}\Xi^{\tau i}$	${}^{1}\text{Þ}^{\tau i}$	${}^{1}\underline{ds}$	${}^{1}\underline{fs}$	${}^{1}N[i]$	$N[i]^{(a+26)}$
27	a+27	${}^{1}\Xi^{\tau i}$	${}^{1}\text{Þ}^{\tau i}$	${}^{1}\underline{ds}$	${}^{1}\underline{fs}$	${}^{1}N[i]$	$N[i]^{(a+27)}$
28	a+28	suspended	suspended	not generated	not generated	none	$N[i]^{(a+28)}$
29	a+29	suspended	suspended	not generated	not generated	none	$N[i]^{(a+29)}$
30	a+30	suspended	suspended	not generated	not generated	none	$N[i]^{(a+30)}$
31	a+31	suspended	suspended	not generated	not generated	none	$N[i]^{(a+31)}$
32	a+32	${}^{0}\Xi^{\tau i}$	${}^{0}\text{Þ}^{\tau i}$	${}^{0}\underline{ds}$	${}^{0}\underline{fs}$	${}^{0}N[i]$	$N[i]^{(a+32)}$
33	a+33	${}^{0}\Xi^{\tau i}$	${}^{0}\text{Þ}^{\tau i}$	${}^{0}\underline{ds}$	${}^{0}\underline{fs}$	${}^{0}N[i]$	$N[i]^{(a+33)}$
34	a+34	${}^{1}\Xi^{\tau i}$	${}^{1}\text{Þ}^{\tau i}$	${}^{1}\underline{ds}$	${}^{1}\underline{fs}$	${}^{1}N[i]$	$N[i]^{(a+34)}$
35	a+35	${}^{1}\Xi^{\tau i}$	${}^{1}\text{Þ}^{\tau i}$	${}^{1}\underline{ds}$	${}^{1}\underline{fs}$	${}^{1}N[i]$	$N[i]^{(a+35)}$
36	a+36	suspended	suspended	not generated	not generated	none	$N[i]^{(a+36)}$
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
n	a+n	${}^{n}\Xi^{\tau i}$	${}^{n}\text{Þ}^{\tau i}$	${}^{n}\underline{ds}$	${}^{n}\underline{fs}$	${}^{n}N[i]$	$N[i]^{(a+n)}$

Table 3

This is simply to illustrate that, by 'listening' to/perceiving/feeling the relative strengths of willingness that arise as the series of states of N[i] shown in Table 3 are invoked and perceived, D[r] will be able to 'hear', i.e. feel – from the perspective of its inference of itself as D[a] – when its willingness to pursue one or another of the proto-goal states/potential paths in an array is greater than or less than its willingness to pursue the prevailing proto-goal state/prevailing path, ${}^{1}\Xi^{\tau i}/{}^{1}\text{Þ}^{\tau i}$.

In Table 3 the proto-goal states/potential paths ${}^{3}\Xi^{\tau i}/{}^{3}\text{Þ}^{\tau i}$, ${}^{4}\Xi^{\tau i}/{}^{4}\text{Þ}^{\tau i}$ and ${}^{0}\Xi^{\tau i}/{}^{0}\text{Þ}^{\tau i}$ are shown as being assessed against ${}^{1}\Xi^{\tau i}/{}^{1}\text{Þ}^{\tau i}$. If, after running through the series shown in Table 3, D[r] – from the perspective of its inference of itself as D[a] – has felt *less* willingness in invoking and perceiving the chord harmonies of each respective {ds + fs} for ${}^{3}\Xi^{\tau i}/{}^{3}\text{Þ}^{\tau i}$, ${}^{4}\Xi^{\tau i}/{}^{4}\text{Þ}^{\tau i}$ or ${}^{0}\Xi^{\tau i}/{}^{0}\text{Þ}^{\tau i}$ than it has felt for ${}^{1}\Xi^{\tau i}/{}^{1}\text{Þ}^{\tau i}$, it will have *decided* with respect to each of those alternatives to keep seeking ${}^{1}\Xi^{\tau i}$ through enacting ${}^{1}\text{Þ}^{\tau i}$.

To better illustrate this, the following example steps through how a *different* decision could have been made in relation to ${}^{0}\Xi^{\tau i}/{}^{0}\text{Þ}^{\tau i}$ versus ${}^{1}\Xi^{\tau i}/{}^{1}\text{Þ}^{\tau i}$; specifically, a decision to adopt ${}^{0}\Xi^{\tau i}/{}^{0}\text{Þ}^{\tau i}$ as the new prevailing proto-goal state/prevailing path.

Example 1
With reference to Table 3, at the phenomenal level the series of states N[i] shown in Rows 32-35 will correspond to a series of perceptions of emotion allowing D[r] – from the perspective of its inference of itself as D[a] – to feel whether to continue with ${}^{1}\Xi^{\tau i}/{}^{1}\text{Þ}^{\tau i}$ as invoked and perceived at t = a+34, a+35, or to *decide* at Row 35 to adopt ${}^{0}\Xi^{\tau i}/{}^{0}\text{Þ}^{\tau i}$ – as invoked and perceived at t = a+32, a+33 – as the new prevailing proto-goal state/prevailing path. (Note that adopting ${}^{0}\Xi^{\tau i}/{}^{0}\text{Þ}^{\tau i}$ amounts to a decision to rest.[279])

A *decision* to make the resting state/resting path the prevailing proto-goal state/prevailing path will result when:

- 'listening' to the ${}^{1}\underline{\text{fs}}$ chord in the chord harmony ${}^{1}\{\underline{\text{ds}} + \underline{\text{fs}}\}^{\tau i}$ gives a feeling (prediction) of the *effort and fatigue* likely to accrue in pursuing ${}^{1}\text{Þ}^{\tau i}$, and
- 'listening' to the ${}^{1}\underline{\text{ds}}$ chord in the chord harmony ${}^{1}\{\underline{\text{ds}} + \underline{\text{fs}}\}^{\tau i}$ gives a feeling (prediction) of the *benefit* likely to accrue in attaining ${}^{1}\Xi^{\tau i}$, such that
- 'listening' to the ${}^{1}\{\underline{\text{ds}} + \underline{\text{fs}}\}^{\tau i}$ chord harmony gives a net feeling of willingness to seek ${}^{1}\Xi^{\tau i}/{}^{1}\text{Þ}^{\tau i}$ that is *weaker* – i.e. less – than the consecutively experienced feeling of willingness to seek ${}^{0}\Xi^{\tau i}/{}^{0}\text{Þ}^{\tau i}$.

Where it is also the case that:

- 'listening' to the ${}^{0}\underline{\text{fs}}$ chord in the chord harmony ${}^{0}\{\underline{\text{ds}} + \underline{\text{fs}}\}^{\tau i}$ gives a feeling (prediction) of the *recovery and revitalisation* likely to accrue in pursuing ${}^{0}\text{Þ}^{\tau i}$, and
- 'listening' to the ${}^{0}\underline{\text{ds}}$ chord in the chord harmony ${}^{0}\{\underline{\text{ds}} + \underline{\text{fs}}\}^{\tau i}$ gives a feeling (prediction) of the *benefit* likely to accrue through attaining ${}^{0}\Xi^{\tau i}$, such that
- 'listening' to the ${}^{0}\{\underline{\text{da}} + \underline{\text{fs}}\}^{\tau i}$ chord harmony gives a net feeling of willingness to seek ${}^{0}\Xi^{\tau i}/{}^{0}\text{Þ}^{\tau i}$ that is *stronger* – i.e. greater – than the consecutively experienced feeling of willingness to pursue ${}^{1}\Xi^{\tau i}/{}^{1}\text{Þ}^{\tau i}$.

This example of how such a perception of emotions might decide whether the prevailing proto-goal state/prevailing path is sustained or is changed to seeking the resting state/resting path can be more broadly applied to deciding between any current prevailing proto-goal state/prevailing path and any other proto-goal state/potential path that might be envisaged. Essentially, the same comparison of feelings of willingness can be made through applying the same process described above.

Beyond this, it seems plausible that as D[r] – from the perspective of its inference of itself as D[a] – perceives an *extended flow over time* of emotions arising as its emulator generates arrays and serially runs their proto-goal states through the emulative recognition cycle – it will serially be able to identify and adopt, as new prevailing proto-goal-states/prevailing paths, those proto-goal states/potential paths that the ERC predicts will best serve the physical needs of B[r].

[279] Given that, as defined in Section 11.3.2, ${}^{0}\Xi^{\tau i}$ is the resting state and ${}^{0}\text{Þ}^{\tau i}$ is the resting path.

In the analogy of listening to a series of musical phrases D[r] will – from the perspective of its inference of itself as D[a] – serially 'hear'/feel each chord harmony/emotion {ds + fs} in the context of an unfolding 'song' – a '*harmonic melody*' – of relative willingnesses to adopt one or another of the proto-goal states in those arrays. By this means, as it 'listens' to this 'harmonic melody' unfold over time, it will serially adopt as new prevailing proto-goal-states/prevailing paths those proto-goal states/potential paths that, *as they arise*, evoke its strongest feelings of willingness: i.e. it will adopt those which it feels most willing to pursue.

11.3.4 When and how arrays of proto-goal states are generated – the role of affordances

The arrangement described above allows for situations where a change of circumstance – such as an unpredicted change in W[r], as reflected in an unpredicted change in the environment image, W[i]\B[i] or the body image B[i] – can lead to a decision to adopt a new prevailing proto-goal state/prevailing path.

Example 2

An example of this would be where, say, a person with a strong appetite for food is serially experiencing proto-goal states/potential paths from arrays where the ${}^{n}\Xi^{\tau i}/{}^{n}\text{Þ}^{\tau i}$ that they feel most willing to pursue – and so retain as their prevailing proto-goal state/prevailing path, ${}^{1}\Xi^{\tau i}/{}^{1}\text{Þ}^{\tau i}$ – is to drive five kilometres to a café they recall, buy pizza, and eat it sitting at a table at the café, where they recall seats are always available.

In enacting this ${}^{1}\Xi^{\tau i}/{}^{1}\text{Þ}^{\tau i}$ they set out and drive two kilometres past various recalled landmarks on their way to the cafe but then, as they turn a corner they see a new hot dog stand they've never seen before. The stand is just off the road with some empty tables and chairs beside it. Quickly – within say eight seconds, or ~32 beats of interleaved ERC + ARC – the emulator within the person's D[r] *spontaneously generates* a new array of proto-goal states and, through the steps described above, their D[a] adopts one of these as their *new* prevailing proto-goal state/prevailing path, i.e. their new ${}^{1}\Xi^{\tau i}/{}^{1}\text{Þ}^{\tau i}$, where this is to pull off the road, buy a hot dog, and eat it sitting at one of the tables by the stand.[280]

Beyond describing a decision – here a 'change of mind' – Example 2 also enables insight into when and how arrays of proto-goal states/potential paths may be generated.

Example 2 describes a new array of proto goal states as being spontaneously generated by D[r]'s emulator straight after the moment that a new, unpredicted, distribution of optimally parsed substates and motions arises in W[i]\B[i] in the form of perception by D[r] – from the perspective of its inference of itself as D[a] – of an unpredicted hot dog stand.

Through consideration of examples of this type, which empirically are born out by experience – even down to the double-take a person may experience as their ARC iteratively corrects their hierarchical processor's downward predictions of 'no hot dog stand' through repeated upward cueing signals/errors of 'yes, hot dog stand' – it can be proposed that new arrays of proto-goal states will arise in response to such 'surprises' due to presentation to D[r] of new – i.e. unpredicted – affordances.[281]

Specifically, the relevant occurrence in Example 2 is when the person suddenly perceives an ensemble of Specific Objects that go to make up an unpredicted hot dog stand and, with this, suddenly perceives a new ensemble of affordances. This observation points to a general proposal that when a person serially perceives one proto-goal state or another drawn from an array of proto-goal states this amounts to their serially perceiving one permutation or another drawn from the array of affordances they perceive in the Specific Characteristics that make up their current, overall physical environment.[282]

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[280] Mention of available tables and chairs is made in Example 2 to allow the role of the fitness state fs component in {ds + fs} to be highlighted. Modify the example such that the person still sees the new hot dog stand, but sees no tables and chairs next to it. Say that they then make a different decision, and drive on towards the café. This plausible difference in decision would have been due to the *absence* of perceived affordances (see subsequent text) around 'tables and chairs to rest at while eating' at the hot dog stand. It can be assumed that the relative values of the desire states ds would have been almost entirely due to 'pizza versus hot dog' and have remained unchanged going from Example 2 to the modified example. But the relative values of fs would be different going from one example to the other because in the modified example the fs would not contribute as much of a feeling (prediction) of recovery and revitalisation to the overall feeling of willingness {ds + fs} to make a hot dog stand stop. So the different decision described would be due to there not being enough of such a contribution to make the person's willingness to stop for a hot dog stronger than their willingness to proceed to the café. A different modification to Example 2, where it is pouring raining on the tables and chairs seen at the new hot dog stand, can be used to make a similar point in relation to the contribution of fs to the {ds + fs} for a hot dog stand proto-goal state/potential path versus the {ds + fs} for a pizza café prevailing proto-goal state/prevailing path.

[281] N.B. the term affordances is used here in the extended sense defined in Section 10.7 of Part 2, noting that this approach to affordances – including in relation to decision-making processes – has strong resonance with proposals to do with decision-making made in Pezzulo, G. & Cisek, P. (2016) Navigating the Affordance Landscape: Feedback Control as a Process Model of Behaviour and Cognition *Trends in Cognitive Sciences 20* 414-424 and made at a more general level in Ch. 6 in Clark, A. *Surfing Uncertainty: Prediction, Action and the Embodied Mind* Oxford University Press, New York, USA 2016. And for a related approach see Thill, S. et al. (2013) Theories and Computational Models of Affordance and the Mirror Systems: An Integrative Review. *Neuroscience & Biobehavioural Reviews 37*, 491-521.

[282] Such an array of affordances is defined in Section 10.7 of Part 2 as *block affordance* or simply as the *affordance* a person perceives in their environment.

To generalize further, consider that despite all the predictive processing power and memory that, at any time t = a, D[r] has available to it to estimate the prevailing path, these can never be sufficient to deliver a perfect, fully detailed prediction of $\Xi^{(a+1)*}$. In other words, there will always be *some* amount of error – either small or large – as the ARC steps D[r] one beat forward in time.

The kind of 'error' described in Example 2 – failure to predict a hot dog stand – is by everyday standards a fairly large, but not unusually large. 'Hot dog stand' kinds of prediction errors will arise where changes in W[r] have happened in circumstances where D[r] has not received input enabling corresponding updates to its memory, including to its world map.

A second, more frequent kind of error will arise simply where D[r]'s memory/world map lacks *capacity* to maintain *all* of the detail needed to generate a prediction, $\Xi^{(a+1)*}$, that contains *all* of the detail that will actually show up in $\Xi^{(a+1)}$ through completion of a t = a to t = (a + 1) beat of the ARC. This type of error will occur even where no change of the 'hot dog stand' kind has happened in W[r]. Examples of this second kind of error are empirically obvious from experience, most clearly in cases where a person is surprised to find where they have left something, and in other forms of rediscovery.

Broadly, the likelihood and degree of such prediction errors will be greater the further forward in time the predicted Ξ is from the t = a at which the prediction is being made. This will amount to increasing uncertainty in predictions along the prevailing path:

Ξ^{a}, ${}^{1}\Xi^{(a+1)i}$, ${}^{1}\Xi^{(a+2)i}$, ${}^{1}\Xi^{(a+3)i}$, … , ${}^{1}\Xi^{\tau i}$ " ${}^{1}Þ^{\tau i}$

which at that t = a is the path *actually being enacted* by D[r] through operation of the ARC, and where this uncertainty in predictions can, as illustrated in Fig. 14 of Part 2, be expressed using the notation:

Ξ^{a}, $\Xi^{(a+1)*}$, $\Xi^{(a+2)**}$, $\Xi^{(a+3)***}$, $\Xi^{(a+4)****}$ …

where a larger number of asterisks denotes a greater uncertainty in prediction of the annotated Ξ.

For the purposes of current discussion the implication is that, to a smaller or greater extent – depending on a range of factors, including the incidence of errors of the first and second kind described above – a person will always be 'finding' or 'uncovering' new affordances as they proceed in enacting a prevailing path.

This will correlate with D[r] – to a commensurately smaller or greater extent – generating and assessing new arrays of proto-goal states/potential paths in *spontaneous response* to the 'surprise appearance' of substates and motions in Ξ that have not been predicted in preceding beats of the ARC as D[r] enacts the prevailing path.

11.3.5 Unwillingness and dilemmas

To round out the ideas proposed above on how decisions are made it is appropriate to consider cases where a person experiences *unwillingness*, which will be a 'chord harmony'/emotion 'heard'/perceived when a proto-goal state/potential path is envisaged that evokes what can be called a *negative* {ds + fs}.

The two examples of proto-goal states/potential paths used so far can be considered to have involved comparisons between two or more *positive* {ds + fs}, where the *most positive* {ds + fs} evokes the greatest willingness. Call those proto-goal states that contribute to a proto-goal state/potential path that evokes a positive {ds + fs} *positive proto-goal states*. In the following proposal, whether a proto-goal state/potential path will, when envisaged, evoke a positive or negative {ds + fs} will depend on the sign and magnitude of its constituent ds and fs, as follows.

Again consider Example 1. In this example respective use of the phrases 'effort and fatigue' and 'rest and recovery' to describe the feeling D[r] gets – from the perspective of its inference of itself as D[a] – as it 'listens to' ^{1}fs versus ^{0}fs, is a reflection that fs is a substate that can make either a negative or positive contribution to the degree of willingness felt when it forms part of some {ds + fs}. The two phrases lie on either side of zero on a spectrum of degrees of predicted impact on the 'fitness' of B[r].

Similarly, ds can be considered a substate able to make either a positive or negative contribution to the degree of willingness felt when it forms part of some {ds + fs}. A negative contribution by ds would arise where the proto-goal state envisaged would define a position that would place B[r] *further from* (not closer to) Position 1, the position in ρ space where the set points for B[r] homeostasis are satisfied.[283]

If both ds and fs make a negative contribution to the degree of willingness felt when they form {ds + fs}, or if the net feeling is still a 'bad sounding chord harmony' because the negative contribution of one outweighs the positive contribution of the other, the feeling evoked will be *unwillingness* which might, for example, be described as a reluctance or even an aversion towards the envisaged proto-goal state/potential path.

Call a proto-goal state that evokes a feeling of unwillingness when envisaged a *negative proto-goal state*. Negative proto-goal states will generally only arise in an array of proto-goal states/potential paths spontaneously generated in response to an unpredicted, or at least unwanted, development in W[r], as described in Section 11.3.4 immediately above. The most serious cases of negative proto-goal states will arise when a person becomes physically trapped, including in cases where they face a dilemma, as in Example 3.

Example 3
An extreme example of a dilemma will arise if a person is caught in a burning high rise building and must decide whether to jump or burn. Here the array of proto-goal states/potential paths is highly limited and there are no good options. But say the fire-brigade is on one side of the building with a net to catch jumpers while on the other side of the building there is a large swimming pool that the person recalls is deep.

The person can see the swimming pool immediately below their open window. It looks awfully small from the tenth floor. But to jump into the net would require running across the wide, smoke-filled interior of the building risking suffocation or being caught by the fire.

Based on ideas described in the previous section a reasonable assumption can be made that for this person D[r] has responded to their situation by generating an array of at least three proto-goal states/potential paths and is – from the perspective of its inference of itself as D[a] – poised to make a decision as it rapidly and repeatedly runs each of these through its ERC.

One of these proto goal states/potential paths is the current prevailing proto-goal state/preferred path ${}^{1}\Xi^{\tau i}/{}^{1}\text{Þ}^{\tau i}$ which remains ${}^{0}\Xi^{\tau i}/{}^{0}\text{Þ}^{\tau i}$ for at least as long as the person pauses to consider their options. The other two are ${}^{2}\Xi^{\tau i}/{}^{2}\text{Þ}^{\tau i}$, which is to run to jump into the net, and ${}^{3}\Xi^{\tau i}/{}^{3}\text{Þ}^{\tau i}$, which is to jump into the pool.

As the person 'listens' intently to 'chord harmonies' for ${}^{1}\{\underline{ds} + \underline{fs}\}^{\tau i} = {}^{0}\{\underline{ds} + \underline{fs}\}^{\tau i}$ interleaved with ${}^{2}\{\underline{ds} + \underline{fs}\}^{\tau i}$ and ${}^{3}\{\underline{ds} + \underline{fs}\}^{\tau i}$ they don't 'hear'/feel anything they like. In each case the ds prediction is either mildly negative/neutral – for being in the net at ${}^{3}\Xi^{\tau i}$ or in the pool at ${}^{2}\Xi^{\tau i}$ – or maximally negative for staying put and burning if ${}^{0}\Xi^{\tau i}$ is retained as the prevailing proto-goal state.

All fs predictions are negative. Enacting ${}^{2}\text{Þ}^{\tau i}$ by running through the smoke, maybe fire, and hopefully hitting the net from the tenth floor is dangerous and risks doing some, a lot or even maximal damage (death) to B[r] fitness. Enacting ${}^{3}\text{Þ}^{\tau i}$ by jumping and hopefully entering the pool from the tenth floor is dangerous and again risks some, a lot and even maximal damage to B[r] fitness. But retaining ${}^{0}\text{Þ}^{\tau i}$ and staying on the window ledge *ensures* maximal damage to B[r] fitness.

In this situation D[r] – from the perspective of its inference of itself as D[a] – will 'listen'/feel as intently and in as focused a way as it can the 'music'/emotions made as these three primary chord harmonies are repeated over and over, and to any nuances that may arise in this due to any minor envisaged path variations. All ${}^{n}\Xi^{\tau i}/{}^{n}\text{Þ}^{\tau i}$ in this array will evoke feelings of unwillingness, but that which evokes a 'sound'/feeling of *least* unwillingness will be adopted and enacted as the prevailing proto-goal state/prevailing path.

In this respect then, it will be the case for negative proto-goal states/potential paths as for positive proto-goal states/potential paths – and thus for all proto-goal states/potential paths – that D[r] will decide, from any array of ${}^{n}\Xi^{\tau i}/{}^{n}\text{Þ}^{\tau i}$ arising, to adopt as the prevailing proto-goal state/preferred path that ${}^{n}\Xi^{\tau i}/{}^{n}\text{Þ}^{\tau i}$ that evokes the greatest willingness where, when viewed in terms of relative magnitude, greatest willingness and least unwillingness can be considered equivalent ideas.

[283] As per point 1(d) in Section 11.3.2 and see Section 10.5.1 of Part 2.

12 Emotion and mood

12.1 Discerning the 'notes' that make up feelings – the examples of 'air appetite' and 'fear'

In the approach described above it has been proposed that D[r] – from the perspective of its inference of itself as D[a] – 'listens to'/feels the 'music'/emotional states generated as a 'harmonic melody'/series of {ds + fs} substates/series of 'chord harmonies' in N[i] as these are serially generated and run through the emulative recognition cycle (ERC). Through 'listening to'/feeling this 'harmonic melody'/time-series-of-emotions it will compare these and decide on/enact that course of action towards which it feels most willingness.

In Sections 11.3.2 and 11.3.3 the analogy of music was used to liken the N[i] substates the desire state ds and the fitness state fs to 'chords', and to liken those substates, when combined to make an N[i] substate {ds + fs}, to a 'chord harmony'.

Each of ds and fs have been likened to chords because, each can be considered to be made up of a set of 'notes', where each note may vary going from one ds chord to another and from one fs chord to another. It will be the variations in these notes, going then from one {ds + fs} to another, that will modulate the overall chord harmonies {ds + fs}, which in turn will evoke greater and lesser degrees of willingness.

A. 'Notes' that make up ds – Set S

Although the neurology[r] is a work in progress, it can be conjectured – consistent with Points 1b and 2b of Section 11.3.2 – that the individual 'notes' that make up any ds correlate with individual modes of input – cueing signals/errors – into D[r] that originate from a member of the set of interoceptors 'reporting' information about B[r]'s physiological state in relation to its homeostatic set points.[284] Call this *Set S*. For example:

1. Osmoreceptors will be a member of Set S, where these report blood solute concentration, which is associated with water hunger.[285]

2. Chemoreceptors of a certain kind are members of Set S, where these report blood pH level, which is associated with air hunger.[286]

Beyond such examples, there exist deeply complex systems – including the endocrine system[r] – that manage B[r] homeostasis inter alia through the excretion and regulation of various hormones.[287] The respective levels of at least a number of these hormones are detected by one kind of interoceptor or another and input to D[r]. It is proposed that a number of these interoceptors will be members of Set S. For example:

3. Chemoreceptors of a certain kind that report levels of the hormone orexin, which is one of several hormones associated with food hunger.[288]

In the model being developed, each of the 'notes' respectively contributing to ds will correlate with one or another of the interoceptor members of Set S – which may have many members – and will be a 'sound' of how, for example, the reported level of blood solute, blood pH or orexin is *predicted* under the ERC to change going from Ξ^{a} to ${}^{n}\Xi^{\tau i}$ for any given proto-goal state, including negative proto-goal states.

But say that a person will only very rarely, if ever, be able to discern any *individual* 'note'/feeling of this simple kind, no matter how intently and discriminatively they 'listen to'/feel the overall 'sounds'/emotions they 'hear' in the ongoing 'harmonic melody' of chord harmonies being generated through operation of the ERC.

Example 4

An exception may be an increasingly 'loud, simple note' generated as a prediction of blood pH level in a pearl diver who has gone too and deep too long, and who begins to experience an ever more intense desire/appetite for air. This ever louder note is not only likely to come to dominate the sound of the chord ds, but also to dominate the sound of a chord harmony, say ${}^{5}\{ds + fs\}^{\tau i}$, to a degree that the diver will feel an increasingly strong willingness to adopt ${}^{5}\Xi^{\tau i}/{}^{5}Þ^{\tau i}$ as her ${}^{1}\Xi^{\tau i}/{}^{1}Þ^{\tau i}$, where ${}^{5}\Xi^{\tau i}$ will be an imaginary recognition state of 'taking a massive deep breath at the surface' and ${}^{5}Þ^{\tau i}$ will be an optimal (almost certainly the fastest) potential path to get to the surface of the sea.

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[284] Consistent, for example, with Quadt, L. et al. (2018) The Neurobiology of Interoception in Health and Disease *Ann N Y Acad Sci* Vol. 1428 pp112-128.
[285] Bourque, C.W. (2008) Central Mechanisms of Osmosensation and Systemic Osmoregulation *Nat. Rev. Neurosci. 9* 519-531.
[286] See references and material at https://en.wikipedia.org/wiki/Control_of_ventilation.
[287] See Chapter 23 in Patestas, M.A. and Gartner, L.P. *A Textbook of Neuroanatomy Ed.2* Wiley & Sons, Hoboken New Jersey USA 2016.
[288] See pp454 ibid.

B. 'Notes' that make up fs – Set F

Similarly, the individual 'notes' that make up any fs can be considered to correlate with individual modes of input – cueing signals/errors – to D[r] that originate from a member of the set of interoceptors 'reporting' information about B[r]'s physiological state in relation to its fitness, including its readiness to implement and maintain certain kinds of physical exertion. Call this *Set F*. For example:

1. Nociceptors of many kinds will each be members of Set F, and are associated with *pain*, including:
   (a) Mechanonociceptors, which report the intense mechanical stimulation that accompanies force damage to B[r] tissues.
   (b) Thermonociceptors, which report the intense heat or cold that accompanies burn damage to B[r] tissues.
   (c) Chemonociceptors, which report the intense chemical stimulation accompanies toxin damage to B[r] tissues.
2. Each of certain kinds of mechanoreceptors and thermoreceptors that report mechanical and thermal information at levels not high enough to constitute pain, and which are not accompanied by significant B[r] tissue damage.[289]

Beyond such examples, here again there exist deeply complex systems – including the endocrine system[r] – that manage B[r] fitness inter alia through the excretion and regulation of various hormones.[287] The respective levels of a number of these hormones may be detected by one kind of interoceptor or another and reported to D[r]. It is proposed that a number of these interoceptors will be members of Set F. [290] For example:

3. Chemoreceptors of a certain kind that report levels of the hormone leptin, which correlates with the amount of chemical energy stored in B[r] and available for expenditure of effort.[291]

Again, in the model being developed, each of the 'notes' respectively contributing to fs will correlate with one or another of the interoceptor members of Set F – which may have many members – and will be a 'sound' of how, for example, the reported level of chemical energy availability, muscle resilience and other forms of feelings of readiness for physical exertion are predicted under the ERC to change going from Ξ^{a} to ${}^{n}\Xi^{\tau i}$ for any given proto-goal state/potential path.

And again, it is proposed that a person will almost always be unable to discern any *individual* 'note'/feeling of this simple kind, no matter how intently and discriminatively they 'listen to'/feel the overall 'sounds'/emotions they 'hear' in the ongoing 'harmonic melody' of chord harmonies being generated through operation of the emulative recognition cycle.

Example 5

An exception may be increasingly, 'loud, simple notes or sub-chords' generated as predictions of tissue damage in a climber who – nearing the top of a cliff – suddenly sees a snake known for its excruciating, potentially deadly bite slither from a crack above to come closer and closer. Each of these ever louder notes will arise in the fs chord of the chord harmonies {ds + fs} present in members of a new array of proto-goal states spontaneously generated in response to the surprise of the snake.[292] These members will include at least one negative proto-goal state/potential path where the climber imagines a snake bite – label this ${}^{3}\Xi^{\tau i}$ /${}^{3}\text{Þ}^{\tau i}$ – or imagines striking the rocks below having lost her grip trying to avoid the snake – label this ${}^{6}\Xi^{\tau i}$ /${}^{6}\text{Þ}^{\tau i}$.

Envisaging these negative proto-goal states will entail envisaging their respectively parsed substates, including the imaginary body images, ${}^{3}\text{B[i]}^{\tau i}$ and ${}^{6}\text{B[i]}^{\tau i}$, where imagining these will in turn entail imagining types of *strong to extreme pain*. As the climber's D[r] – from the perspective of its inference of itself as D[a] – 'listens to'/feels the 'music'/emotional states generated as a 'harmonic melody'/series of {ds + fs} substates/'chord harmonies' in N[i], as these are serially generated and repetitively run through its ERC – it/she will 'hear'/feel ever more 'loudly', as the snake approaches, the 'simple notes or sub-chords' of *strong to extreme fear*. This distinctive sound/feeling will be present in each of the chords ^{3}fs and ^{6}fs that will form part of the repeating chord harmonies ^{3}{ds + fs} and ^{6}{ds + fs} being generated by the ERC running in the climber's D[r].

[289] For a description of nociceptors, mechanoreceptors and thermoreceptors cited in 1 and 2 above see Chapter 12 ibid.
[290] The levels of complexity in these Set F affiliated systems, and those affiliated with Set S, suggests these sets of interoceptors may have an intersection (overlap). Even so, there is no reason why having some interoceptors common to both sets should change the thrust of conjecture being made here around the ideas of ds and fs, which in any case it is proposed will always be 'heard together'/felt as the 'chord harmony'/emotion {ds + fs}.
[291] Klok, M.D. et al. (2007) The Role of Leptin and Ghrelin in the Regulation of Food Intake and Body Weight in Humans *Obesity Reviews 8* 21-34.
[292] Where such spontaneous generation of an array of proto-goal states will arise through the process proposed in Section 11.3.4.

12.2 Disambiguating appetite and hunger

Words used on an everyday basis to identify and describe emotions are imprecise and vary from culture to culture.[293] This creates room for ambiguity. If the ideas described above are correct, then one important area of ambiguity applies to a distinction which can be drawn between what will now strictly be called *appetite* and what will strictly be called *hunger*.

Example 5 rests on the entirely reasonable presumption that when a B[r] accrues tissue damage, this will be perceived directly as pain. This is to say that, if the climber in the example is actually bitten by the snake, or does actually fall onto the rocks, her B[r] will be damaged and that once such damage has been sustained her D[r] hierarchical processor will receive interoceptive inputs from nociceptors which, when those come to balance with downward predictions, will give one or more substates in B[i] which will be perceived by her D[r] – from the perspective of its inference of itself as D[a] – as strong pain.

Such substates are often moderately to highly spatially indexed, and so can be perceived by D[a] to be at some more-or-less well defined position in B[i], say as a break in the left leg[i] or a bite on the left wrist[i]. Such perceptions of real – as opposed to imagined – pain will be experienced through operation of the *actual recognition cycle* (ARC) in D[r]. So, at some time t = a, pain will reflect one or more substates of Ξ^a that are parsed into $B[i]^a$, where this will be perceived from the perspective of D[a] as a physical sensation located at some more-or-less well defined place inside, or at the surface, of its body image, $B[i]^a$, and at the 'now' of that t = a.

By this account a pain will *not* be a perception of a substate in $N[i]^a$ – but of a substate in $B[i]^a$ – and will *not* under the definitions being developed here be a perception of an *emotion*. In this respect, what Example 5 shows about how emotion relates to pain is that:

- when an imaginary recognition state – for instance $^3\Xi^{\tau i}$ in Example 5 – is constructed and then 'perceived'
    - from say t = (a – 100) onwards, through operation of D[r]'s emulator and the *emulative recognition cycle* (ERC), in response to the appearance of the snake
- and where $^3\Xi^{\tau i}$ is a negative proto-goal state entailing an *imagined* 'perception' of pain – a snake bite – as reflected in one or more substates in its $^3B[i]^{\tau i}$ substate,
- this *prediction* of pain will – from t = (a – 101) – have propagated down through D[r]'s hierarchical processor to be balanced, through S_α of the *ERC*, against upward propagating interoceptive input from B[r] nociceptors
    - which at t = (a – 101) will *not*, for the climber, be signaling any pain
- to give, at t = (a – 100), a substate in $N[i]^{(a-100)}$ that will be perceived by D[r] – from the perspective of its inference of itself, D[a] – as the emotion *fear*.

All of this is simply to spell out in detail that at the level of the processes being proposed here, at any moment when a normal person *imagines* perceiving serious bodily pain as a *genuine upcoming possibility*, they will perceive/feel the emotion fear. In this example the proposed process aligns with the climber feeling fear for a total period of 100 beats of interleaved actual and emulative recognition cycles where, at a rate for both of ~4Hz, this has arbitrarily been set for this example at about 40 seconds of fear before a bite, striking the rocks, or getting to safety.[294]

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[293] See in particular Feldman Barrett, L. *How Emotions Are Made* Horton Mifflin Harcourt, New York 2017.

[294] As will be discussed below, the process being described in Example 5 calls for the fear to be generated only through the *ERC* as part of the N[i] substates $^3\underline{fs}$ or $^6\underline{fs}$. If this is so, it will mean that for periods *when the ARC is engaged, and the ERC is suspended* – in suspension patterns such as those shown in Tables 2 and 3 – *the fear should momentarily abate*. This would be expected to happen if the climber were fully (constantly) applying her ARC to make difficult moves across the cliff face to get away from the snake. It would also be expected to happen if the climber were imagining some $^x\Xi^{\tau i}$ which is *not* either $^3\Xi^{\tau i}$ or $^6\Xi^{\tau i}$ – i.e. where x is not 3 or 6 – and where $^xB[i]^{\tau i}$ is *not* imagined to be experiencing pain. Such an $^x\Xi^{\tau i}$ could well be her prevailing proto-goal state, $^1\Xi^{\tau i}$, which might be to attain a place on the cliff that evades both the snake and falling. Overall, this scenario would align with a subjective experience for the climber of fear 'coming in waves' in step with each re-engagement of ERC beats processing $^3\Xi^{\tau i}$ or $^6\Xi^{\tau i}$, and receding with sustained engagement of the ARC – i.e. engagement in concerted and focussed physical action to get to safety – where this would all seem broadly to align with the actual experiences of 'waves of fear' a person can experience when facing a dangerous situation and striving to get to a situation of safety.

Fortunately most of us can avoid fear of physical pain, and actual serious physical pain, for long periods, and do not expect to experience such sensations in the normal course of our daily lives. But there are other unpleasant sensations that, in a certain sense, we *do* expect to experience. These are forms of *hunger* – air hunger, water hunger and food hunger – where these are the physical sensations we expect respectively to perceive should our B[r] actually start to run out of air, water or food.

But we expect to experience these unpleasant degrees of hunger only if we do not breathe, drink or eat 'in time'. Because of this we almost always – in the course of our daily lives – breathe, drink or eat at times well before any of these expectations actually materialise.

Short of pain, what a person perceives when experiencing genuine air, water or food hunger are specific sensations which – like pain – are bodily sensations, not emotions. These include specific sensations of 'emptiness' in the lungs, a 'dry' mouth, or 'emptiness', even 'gnawing', in the stomach. These are perceived as physical sensations at locations in B[i] which – when perceived at some time t = a – will have as their basis substates of Ξ^{a} optimally parsed to $B[i]^{a}$ through operation of the *ARC*, as it balances through S_{α} predictions made at $\Xi^{(a-1)}$ for Ξ^{a*} against incoming cueing signals/errors from relevant interoceptors in Set S.

If hungers are like pains, in that they are bodily sensations – i.e. substates in B[i] – it is reasonable to expect that like pains – where the *prediction* of pain manifests as the emotion fear – there will be emotions that manifest as *predictions* of hunger. Call such emotions *appetites*, where these will include air appetite, water appetite and food appetite.

Because many of us rarely experience genuine hungers the language we use to describe hungers and appetites is ambiguous, especially in the case of food hunger and food appetite. A person may go without perceiving food hunger for months, or even longer, because by convention they eat regular meals at times well ahead of its potential onset. Where this is the case, such people will only ever perceive variations in the strength of their *appetite* for food, and will not experience genuine hunger for food.

Whether such a person has an appetite for – i.e. 'feels like' – food in general, or has an appetite for some specific type of food, might be controlled by a number of factors, but as a generality this appetite will be due to a *prediction* of food hunger, not due to food hunger itself. Example 6 is designed to illustrate this point.

Example 6
Say that the climber from Example 5 wakes up envisaging the goal she has decided on for the day, which is to climb a set of cliffs to get to a mountain summit. At t = a, when she imagines herself standing at the summit, she is envisaging a prevailing proto-goal state, ${}^{1}\Xi^{\tau i}$, and 'hearing'/feeling the 'chord harmony'/emotion of willingness generated as ${}^{1}\Xi^{\tau i}/{}^{1}Þ^{\tau i}$ is processed through her ERC. A sub-chord in what she hears in the ${}^{1}\underline{fs}$ chord contributing to this chord harmony will be the result of a *balancing of predictions of inputs* for ${}^{1}\Xi^{\tau i}$ from certain Set F interoceptors – such as the chemoreceptor described at B.3. of Section 12.1 that reports B[r] energy availability – *against the actual inputs* from those interoceptors at t = (a – 1). The sub-chord of ${}^{1}\underline{fs}$ – i.e. the substate of $N[i]^{a}$ – that results from this balancing will be perceived – perhaps subliminally, or perhaps consciously if the climber 'listens for it' – as a degree and kind of food appetite. This perceived appetite will correlate with a prediction of the nutrition and energy intake needed by B[r] to have D[r], at the time of reaching the summit, receive the same inputs from those Set F interoceptors as it is receiving at t = (a – 1).[295, 296]

In the case of a practised climber intending to spend the day making a big climb, their appetite could be expected to be larger than if, instead, they were intending to spend the day watching movies or doing some other equally physically easy activities.

[295] The accuracy of this prediction would depend on a range of factors. Two of the most important would be how much overall experience, and recent practice, the climber has had with this or similar climbs. Such experience and practice would better inform the recognition and generative models being applied through the emulative recognition cycle to make the prediction.
[296] The complexity of the endocrine system and other systems engaged in managing B[r] homeostasis and fitness, along with factors described in the next section, mean this is an idealised example, including because an assumption is being made here that the climber is not experiencing any genuine hunger, as opposed to appetite, at t = (a – 1) allowing an assumption that Set F interoceptor inputs are reporting an energy availability within a normal/acceptable range at that time. The example is nevertheless sufficient for the purpose of describing in principle how a specific type of PPP-consistent distinction can be drawn between appetites and hungers. A less idealised proposal as to how food appetite arises is provided in Section 12.5.

12.3 Mood and task environment; 'relief', 'delight', 'disappointment' and 'dismay'

Example 6 describes a situation where a person has settled on a relatively straight forward goal that will take considerable time and energy to reach. But in some cases a person may wake to a day of activity without having decided on any single straight forward objective. Here they may be 'listening for'/feeling relative degrees of willingness across a wide ranging 'harmonic melody'/emotional sequence generated by their ERC as it serially runs through a wide array of proto-goal states/potential paths.

In a situation where a person really has no ${}^{1}\Xi^{\tau i}/{}^{1}\text{Þ}^{\tau i}$ 'in mind' – say they are waking to nothing more considered than 'a lazy Sunday' – then their current array of proto-goal states/potential paths will, if the ideas proposed above[297] apply, be generated in a 'free wheeling' kind of way out of the full sweep of affordance they perceive in their current environment.[298] If this environment is familiar – i.e. it is a well defined position in a well defined *region* of the person's world map – this affordance may be broad and temporally long-range in its stimulus of proto-goal states/potential paths. As the person contemplates what to do, they will hear a commensurately broad, varied, familiar and relatively lengthy harmonic melody of emotion as they listen for a proto-goal state/potential path that evokes their greatest willingness.

Moreover, a person waking to a lazy Sunday in their inner-city apartment to hear rain will perceive a different affordance to that which they would perceive if they awoke to a lazy Sunday in their beach house to see sunshine. The respectively generated arrays of proto-goal states/potential paths would give rise to different arrays of {ds + fs}, with each of those arrays perceived as a different ongoing harmonic melody of emotion.

So far the focus of discussion has been on a person – i.e. a D[r], from the perspective of its inference of itself as D[a] – 'listening for' the *specific* 'sound'/feeling of one {ds + ds} compared to others in the flow from an array of ${}^{n}\Xi^{\tau i}/{}^{n}\text{Þ}^{\tau i}$ in order to 'hear'/feel which 'chord harmony' – i.e. which proto-goal state/potential path – is evoking the most willingness to be made/kept as its ${}^{1}\Xi^{\tau i}/{}^{1}\text{Þ}^{\tau i}$.

But say that as a person listens to the harmonic melody being generated from some given array of proto-goal states/potential paths they will – beyond simply listening for such a specific sound/feeling – also be able to hear/feel – i.e. perceive – an *overall melody*, not just its separate or momentary chord harmonies, chords, sub-chords or notes. Again the analogy of music can be applied, the point being that although it is possible in listening to a piece of music for a person to listen for, and discern, specific chords, chord harmonies and notes as they arise, it is *also* quite natural for them to gather a sense of the overall melody they are hearing, especially if it is a familiar or repetitious melody.

Say then that when a person 'listens to'/feels *over time* the harmonic melody/emotional sequence of the overall suite of proto-goal states/potential paths in their current array – as these are generated and processed over time through their ERC – the overall sense of 'melody'/emotion that they perceive can be defined as a *mood segment*. So, whereas willingness will be an emotion perceived in relation to one specific proto-goal state/potential path or another within a given array, a mood segment will be an overall perception/feeling of the averaged degree of willingness a person is feeling across *all* of the proto-goal states/potential paths being generated within that array.

The idea of a mood segment can then be extended to encompass more than one array of proto-goal states/potential paths. On this basis define the *mood* that a person is actually experiencing/perceiving/feeling at any given moment to be a form of *rolling average* over some preceding period of time up until that moment, of the feelings of willingness that they have been perceiving over *all* of the arrays of proto-goal states/potential paths that have sequentially arisen, in response to the series of affordances that have arisen, as their recognition state has moved through recognition space over that preceding period of time.

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[297] Section 11.3.4 describes when and how arrays of proto-goal states are generated.

[298] In this situation to say that 'the person has no ${}^{1}\Xi^{\tau i}/{}^{1}\text{Þ}^{\tau i}$ in mind' as they lie in bed imagining what they might get up and do, can be understood as meaning that the ${}^{1}\Xi^{\tau i}/{}^{1}\text{Þ}^{\tau i}$ they have adopted at that time is the resting state/resting path, ${}^{0}\Xi^{\tau i}/{}^{0}\text{Þ}^{\tau i}$, as described in Section 11.3.2.

In this formulation then, a person's mood will be a rolling average of the mood segments they perceive as feelings of willingness – from new arrays of proto-goal states/potential paths – feed into the harmonic melody they are hearing, and feelings of willingness from older arrays fade out. Again, this is in analogy to how a person listens to and appreciates/understands an ongoing piece of music as it unfolds over time.

Put broadly then, to say that a person is experiencing a *positive mood* will be to say they are perceiving a positive rolling average of willingness across all the arrays of proto-goal states/potential paths that they are currently, and have recently been, generating and running through their ERC. The idea of positive and negative willingness (unwillingness) was introduced earlier[299] and underpins the idea proposed here that at any given time a person's mood will be at some position on a spectrum – call this a *mood spectrum* – that runs from positive through neutral into negative mood. Empirically, this idea of mood, with its potential to be positive or negative, aligns fairly well with meanings given in common usage to the word 'mood'.

Because, in the scheme proposed, mood will be determined by a rolling average over time of perceived {ds + fs}, and because adopting and enacting a specific ${}^{1}\Xi^{\tau i}/{}^{1}\text{Þ}^{\tau i}$ can be considered to be moving to – or persisting with – one specific *task* from out of an ongoing series of arising arrays of potential tasks – mood can be considered a function of what can be called a person's *task environment*.

In a positive task environment the balance of {ds + fs} that a person perceives as a rolling average of willingness over time will be positive. Here the arrays of $\Xi^{\tau i}/\text{Þ}^{\tau i}$ being spontaneously generated based on the person's current and recent recognition states will, on balance, be things a person 'feels like' doing. Generally, if a person's task environment is positive their mood will be positive. Similarly, in a negative task environment a person will, on balance, be facing things they do not feel like doing and their mood will be negative.[300]

Essentially then, the proposal here is that a person's mood will be how they feel about their task environment, whereas their willingness will be how they feel about one specific potential task or another.

To use concrete examples, in the scheme proposed above the person faced with the burning building dilemma in Example 3 should feel a negative mood if they were to pause to 'listen to'/feel the 'harmonic melody' of their task environment. Meanwhile, the person in Example 2 could be expected to feel an improvement in mood as a new 'harmonic melody' of {ds + fs} chord harmonies – i.e. those arising from the new array of proto-goal states/potential paths generated by the sight of a new hot dog stand – begins to add into their rolling average of willingness.

Similarly, the mood of the climber in Example 5 would be expected to plunge into the negative when she sees the snake. Equally, if she then manages to scramble around the snake to get over the cliff top to a place of safety, a whole new array of $\Xi^{\tau i}/\text{Þ}^{\tau i}$ will arise. Here she will not only likely feel an improvement in mood, but might also describe the *change of mood* she is feeling, as 'relief'. More generally, *relief* can be defined as the emotion a person perceives as they feel a negative task environment move a long way in a positive direction along the mood spectrum.

If a person feels an already positive task environment move even further in a positive direction they may feel *delight*. A similar degree of movement in the opposite direction may be felt as *disappointment* where, after the negative shift, the person still feels an overall positive task environment. But if such a movement were to take a person from feeling a positive task environment down the mood spectrum into feeling a negative task environment they may feel *dismay*. The rock climber in Example 5 probably would have felt dismay as well as fear when she saw a dangerous snake emerge and come towards her.

[299] See Section 11.3.5.

[300] Consistent with this proposal, a person's sense of their task environment – and the extent to which they perceive it to be positive, neutral or negative – will be a function of the arrays of proto-goal states/potential paths being generated and run through their ERC to cumulatively over time produce a rolling average of perceived willingness. Given the reliance of that process on the contents and operation of the memory system, world map and the generative and recognition models held within any given D[r], any given person – even if they have highly similar skill sets and life experience to a second person – can be expected to experience a sense of task environment that is quite different to that which a second person experiences even if both people are placed from identical circumstances, by identical means, into objectively identical physical environments. One person could sense a negative task environment, while the other might sense a positive task environment. This expected difference will inter alia translate into one person's versus another's '*confidence*', and overall '*attitude*', in seeing and acting upon opportunities in their environment.

12.4 Mood modulators

In the general case then, it is proposed that when a person perceives their task environment to be either positive, neutral or negative, this position on the mood spectrum will have been determined by the contents of the arrays of $\Xi^{\tau i}/Þ^{\tau i}$ that have been spontaneously generated as their recognition state moves through recognition space. In other words, when change in their recognition state, Ξ, generates a significant change in their task environment, a person will feel this as a mood change.

Given that perception of Ξ is parsed into perception of states and substates of N[i], B[i] and W[i]\B[i], it can then be proposed for the general case, that:

1. A change in N[i] – which will amount to a change in perceived emotion, including in mood itself – will not *in itself* cause any significant change in the perceived task environment or in mood because, if it did, this would allow potentially destabilizing emotional feedback loops. In other words, and as empirically observed, change in mood does not of itself seem to drive further change in mood.[301]

2. A change in body image, B[i] – which is a perceived map of the state and state change of B[r] – will cause a change in the perceived task environment – i.e. a change in mood – if such a change in B[i]:

   (a) is due to an altered input to D[r] of a type that alters ds, recalling[302] that ds derives from a measure of B[r]'s physiological state in relation to its homeostatic set points, or

   (b) is due to an altered input to D[r] of a type that alters fs, recalling[302] that fs derives from a measure of B[r]'s physiological state in relation to its overall fitness – including its overall readiness – to undertake physical tasks, and

   (c) where such a change in B[i] will to some extent be unpredicted by the ARC in its prediction – right up until that change occurs, at say t = a – of the future states $\Xi^{(a+1)*}$, $\Xi^{(a+2)**}$, $\Xi^{(a+3)***}$, … as operation of that cycle inferentially enacts the prevailing path ${}^{1}Þ^{\tau i}$.[303]

3. A change in the environment image, W[i]\B[i] – which is a perceived map of the state and state changes of W[r]\B[r] – will cause a change in the perceived task environment – i.e. a change in mood – where such a change in W[i]\B[i]:

   (a) stimulates spontaneous generation by the emulator in D[r] of an array of $\Xi^{\tau i}/Þ^{\tau i}$, where individual $\Xi^{\tau i}/Þ^{\tau i}$ in that array are processed – as has been described – through the ERC, and

   (b) where such a change in W[i]\B[i] will to some extent be unpredicted by the ARC in its prediction – right up until that change occurs, at say t = a – of the future states $\Xi^{(a+1)*}$, $\Xi^{(a+2)**}$, $\Xi^{(a+3)***}$, … as operation of that cycle inferentially enacts the prevailing path ${}^{1}Þ^{ti}$.[303]

Changes of the type described at 3 above, and their effects on mood, have been discussed in Examples 2 and 5, where a new hot dog stand and the appearance of a dangerous snake constitute unpredicted changes in W[i]\B[i] that it is proposed respectively will lead to positive and negative changes in mood.[304, 305]

Changes of the type described at 2 have not been covered in preceding examples, but can be straightforward to describe. A simple case would be where the climber in Example 5 suddenly, unexpectedly tears a leg muscle as she tries to escape the snake. Such a change in B[i] would shift the fs component – and through this {ds + fs} – sharply in a negative direction across all subsequently generated arrays of $\Xi^{\tau i}/Þ^{\tau i}$ relative to where it would have been without the tear. (The mood shift in this example might be felt as dismay.)

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[301] This is not to rule out the possibility of serious but *abnormal* conditions where a person's mood may be unstable due to such feedback.
[302] See Section 11.3.2 points 1(a) and 2(a).
[303] This formulation in relation to the predicted series $\Xi^{(a+1)*}$, $\Xi^{(a+2)**}$, $\Xi^{(a+3)***}$, … which can also be expressed as, Ξ^{a}, ${}^{1}\Xi^{(a+1)i}$, ${}^{1}\Xi^{(a+2)i}$, ${}^{1}\Xi^{(a+3)i}$, … , ${}^{1}\Xi^{\tau i}$, was introduced and described in detail in Section 11.3.4.
[304] As described in Section 12.3, immediately above.
[305] In some situations changes in W[i]\B[i] can arise that give 'one-on-top-of-the-next' spontaneous generation of arrays of $\Xi^{\tau i}/Þ^{\tau i}$ where predominantly these new $\Xi^{\tau i}/Þ^{\tau i}$ evoke positive willingness. Here serial new positive task environments will be perceived as serial positive shifts in mood. For some people walking into a hardware store can have this effect as they perceive the 'possibilities' on offer. More generally, people may go window shopping to garner this mood-lifting effect. In the same vein going out to find and buy items is sometimes referred to as "retail therapy". In other examples, changes to W[i]\B[i] may arise that do not much stimulate generation of new proto-goal states, $\Xi^{\tau i}$, but which do stimulate generation of new potential paths, $Þ^{\tau i}$. Where these new $Þ^{\tau i}$ make a net positive fs contribution to overall willingness, the positive shift in task environment will again be perceived as a positive shift in mood. An example would be where a farmer, who has been away several months, comes around a corner to discover that a new bridge has been built cutting many kilometres off her usual journey to town.

A milder example would be where a person develops a headache in the course of undertaking some $^{1}\Xi^{\tau i}/^{1}Þ^{\tau i}$. Here again the mood change would be negative. Similarly, a positive mood change could occur if a person eats sugar, or perhaps chocolate, since this should – at least for a while – boost energy availability, increasing 'readiness' in B[r], moving the fs component – and through this {ds + fs} – in a positive direction across subsequently generated arrays of $\Xi^{\tau i}/Þ^{\tau i}$.[306]

Consideration of longer-term changes in mood allows identification of certain longer-term patterns of change that arise across substates of the environment image, W[i]\B[i] or the body image, B[i], where such patterns can be called *mood modulators*. Mood modulators will be evolving patterns of change that arise across substates of W[i]\B[i] or B[i] where these evolving patterns of change have an evolving general effect on the task environment, and therefore an evolving effect on mood.

Weather is the most obvious example of a longer-term pattern of change arising across substates of W[i]\B[i] that is a mood modulator. If the weather pattern moves from fine to poor a person's mood may well follow, at least to some extent and in a way that depends on their exposure to weather.[307] So for example, a farmer's mood could be expected to be more affected than a person working in an air conditioned office. This is consistent with bad weather leading to serially lower contributions from fs to the willingness felt for any $\Xi^{\tau i}/Þ^{\tau i}$, where this will be due to predictions that many potential paths $Þ^{\tau i}$ exposed to weather will be more physically demanding, depleting and perhaps even damaging – as with facing extreme cold or heat – relative to similar potential paths taken in good weather.

If the term *weather* can be considered to mean an evolving overall pattern of change that prevails across swathes of the substates that make up a person's environment image W[i]\B[i], where this pattern is a mood modulator, then its counterpart term with respect to an evolving overall pattern of change that prevails across swathes of the substates that make up a person's body image B[i], will be *health*.

Just as 'weather' can be a catchall for many kinds of evolving patterns in the environment image, W[i]\B[i] – from smoke haze to thunderstorm to heat wave – so 'health' can be a catchall for many kinds of evolving patterns in the body image, B[i]. If the pattern of a person's health moves from good to bad their mood is likely to follow. This would be consistent with bad health leading to serially lower contributions from fs to the willingness felt for any $\Xi^{\tau i}/Þ^{\tau i}$, where this will be due to predictions that many potential paths $Þ^{\tau i}$ will be more physically demanding, depleting and perhaps even damaging – as with carrying an injury or some other biological or physical disability – relative to similar potential paths taken in good health.

A great many factors might affect a person's health, and – if the proposed model applies – all of these should to some degree and in some way have a short, medium or long-term affect on a person's mood. Examples of health factors that can affect mood are body weight,[308] quality and quantity of sleep and rest,[309] discomfort and pain,[310] and diet and nutrition,[311] including levels of hydration.[312] The short term effects on mood of a sustained period of aerobic exercise, and the long term effects of maintaining a high level of physical fitness also fall into this category.[313]

Examples of other factors predicted to affect mood, if the general ideas proposed here about mood modulators apply, will include ambient air quality, changes due to impacts of disease, and changes in a person's quality of vision or hearing, or in their physical strength, coordination and other capabilities.

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[306] Intake of sugar could reduce willingness to seek some proto-goal states. Specifically, it ought to reduce the ds contribution to willingness to adopt proto-goal state/potential paths where the proto-goal state is to consume further calories, as might arise in an array generated by coming across a confectionary store. Otherwise, willingness to adopt a wide range of proto-goal state/potential paths should increase after sugar intake, where those proto-goal states do not replenish energy and their associated potential paths require energy consumption. Notably, empirically these expectations are a good match to most people's experience.

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[308] Wootton, R.E. et al. (2018) Evaluation of the causal effects between subjective well-being and cardiometabolic health *BMJ* 2018;362:k3788.

[309] Finan, P.H. et al. The Effects of Sleep Continuity Disruption on Positive Mood and Sleep Architecture in Healthy Adults *SLEEP 38* 1735-1742 and references therein, Bower, B. et al. (2010) Poor Reported Sleep Quality Predicts Low Positive Affect in Daily Life Among Healthy and Mood-disordered Persons *Journal of Sleep Research 19* 323-332.

[310] Gorczyca, R. et al. (2013) Psychological Aspects of Pain *Ann Agric Environ Med* 20 23-27 and Castelnuovo, G. et al. (2016) Psychological Considerations in the Assessment and Treatment of Pain *Frontiers in Psychology 7* 468.

[311] Firth, J. et al. (2020) Food and Mood: How do Diet and Nutrition Affect Mental Well-Being *BMJ* 2020;369:m2440 and references therein, Lassale, C. et al. (2018) Healthy Dietary Indices and Risk of Depressive Outcomes: A Systematic Review *Molecular Psychiatry* https://doi.org/10.1038/s41380-018-0237-8, and Lesani, A. et al. (2016) Eating Breakfast, Fruit and Vegetable Intake and their Relation with Happiness in College Students *Eating & Weight Disorders 21* 645–651.

[312] Armstrong, L.E. (2012) Mild Dehydration Affects Mood in Healthy Young Women *Journal of Nutrition 142* 382-388 and Ganio, M.S. et al. (2011) Mild Dehydration Impairs Cognitive Performance and Mood of Men *British Journal of Nutrition 106* 1535-1543.

[313] For example see Olutende, M.O. et.al (2017) Effects of Aerobic Exercise on Mood State of University Students International *Journal of Current Research 9* 61107-61112 and references therein.

12.5 Parts of mood – better describing appetite

Say that a person is not only able to 'listen for'/feel as a 'harmonic melody'/mood an overall pattern/rolling average of the 'chord harmonies'/willingness/{ds + fs} they 'hear'/feel as these are serially generated over time, but can also 'listen for', and can sometimes discern and feel, 'sub-melodies' – or *parts* – that individually are being contributed to this overall 'harmonic melody' by the chords ds or fs, or by evolving patterns of ds or fs sub-chords.

This idea enables improvement of the earlier explanation of food appetite given in Example 6, where it was proposed, as paraphrased below, that the climber's food appetite at t = a could be 'derived' as follows:

1. At t = a, as the climber imagines herself standing at the summit, having decided on this as her prevailing proto-goal state, $^{1}\Xi^{\tau i}$, she can 'hear'/feel her willingness as the 'chord harmony'/emotion $^{1}\{ds + fs\}$ as $^{1}\Xi^{\tau i}/^{1}Þ^{\tau i}$ is processed through her ERC.

2. A sub-chord of what she hears in the chord ^{1}fs contribution to this chord harmony will be the result of a balancing of *predictions* of inputs for $^{1}\Xi^{\tau i}$ from certain Set F interoceptors – such as the chemoreceptor described at B3 of Section 12.1 that reports B[r] energy availability – against the actual inputs from those interoceptors at t = (a – 1).

3. She will then 'hear'/feel the sub-chord of ^{1}fs – i.e. the substate of $N[i]^{a}$ – that results from this balancing subliminally – or perhaps consciously if she listens for it – as a degree and kind of food appetite. This perceived appetite would correlate with a prediction of the nutrition and energy intake needed by B[r] to have D[r], at the time of reaching the summit, receive the same inputs from those Set F interoceptors as it is receiving at t = (a – 1).

Say then that:

- the sub-chord referred to above as the result of balancing predictions of inputs for $^{1}\Xi^{\tau i}$ from certain Set F interoceptors against actual inputs from those interoceptors through operation of the emulative recognition cycle from t = (a – 1) to t = a,
- can be viewed as one in a series of sub-chords created through a balancing of those predicted versus actual Set F inputs for each of the series of $\Xi^{\tau i}/Þ^{\tau i}$ in one array, and in subsequent arrays, of proto-goal states/potential paths as they serially arise and are processed through D[r]'s emulative recognition cycle
- such that, over time, this series of sub-chords constitutes a 'part' in the overall 'harmonic melody' that a person 'hears' as their mood, and where this part – if they 'listen for it' and can discern it as a specific sub-melody – will be 'heard'/felt as a degree and kind of food appetite.

This revised concept of food appetite allows for situations such as the 'lazy Sunday' scenario described in Section 12.3 because here D[r] processes take into account in their prediction of B[r] food requirements *the full range* of proto-goal states/potential paths that a person might choose, or have available to them, to adopt given their current situation. So if the proposals here apply, food appetite will be a feeling that is generated for a person through a best estimate of the nutritional and energy requirements that *might* arise for them across the full range of possible goals and courses of action that their environment is presenting to them.[314]

Since this account proposes that appetite is a part of mood, it implies that if a person 'listens for' the 'sub-melody' of their appetite, what they 'hear'/feel should be affected by the *context* being set by the overall 'harmonic melody'/mood that they are 'hearing'/feeling. In other words, it implies that food appetite should to some extent be affected by overall mood and changed by mood shifts. Here use of the terms mood and food appetite as defined above seem to align well with the meanings these terms take on in common usage. People certainly do observe that their appetite for food 'can be affected by' or 'can change with' their overall mood. Sudden changes in mood can also be accompanied by changes in water appetite and even, in some cases, in air appetite.[315]

[314] This proposed process for, and definition of, appetite differs and would have wider real-world applicability than the simplified case described in Example 6, where the person/climber was required to have already decided on one clear goal that they planned single-mindedly to pursue for several hours.

[315] On encountering some new and emotionally affecting thing a person might find they have lost their appetite, that they want a glass of water, or they may begin to breathe with a different depth or rhythm. Certainly all of these things can happen in response to a sudden encounter with a new risk or threat, in which case they can be seen as part of a change in overall mood due to the sudden generation of a new array of proto-goal states/potential paths and the accompanying new feelings arising as these are envisaged and run through the ERC.

13 Relative dynamics of the Emulative Recognition Cycle and the Actual Recognition Cycle

The ideas presented in Section 11.3, and on which those in Section 12 rest, rely on the proposal that there is an actual recognition cycle (ARC) and an emulative recognition cycle (ERC), and that these operate such that their cycles – called beats – are interleaved with each other.[316]

Table 3 from Section 11.3.3 illustrated such interleaving and is reproduced below. Periods of suspension – called suspension patterns – correspond to periods when the ARC is engaged, and the ERC is suspended.

Row	Time	Proto-goal state	Potential path	Desire state	Fitness state	$^{n}N[i]$	$N[i]^{n}$
0	a	$^{1}\Xi^{\tau i}$	$^{1}\mathfrak{p}^{\tau i}$	$^{1}\underline{ds}$	$^{1}\underline{fs}$	$^{1}N[i]$	$N[i]^{a}$
1	a+1	$^{1}\Xi^{\tau i}$	$^{1}\mathfrak{p}^{\tau i}$	$^{1}\underline{ds}$	$^{1}\underline{fs}$	$^{1}N[i]$	$N[i]^{(a+1)}$
2	a+2	suspended	suspended	not generated	not generated	none	$N[i]^{(a+2)}$
3	a+3	suspended	suspended	not generated	not generated	none	$N[i]^{(a+3)}$
4	a+4	suspended	suspended	not generated	not generated	none	$N[i]^{(a+4)}$
5	a+5	suspended	suspended	not generated	not generated	none	$N[i]^{(a+5)}$
6	a+6	$^{3}\Xi^{\tau i}$	$^{3}\mathfrak{p}^{\tau i}$	$^{3}\underline{ds}$	$^{3}\underline{fs}$	$^{3}N[i]$	$N[i]^{(a+6)}$
7	a+7	$^{3}\Xi^{\tau i}$	$^{3}\mathfrak{p}^{\tau i}$	$^{3}\underline{ds}$	$^{3}\underline{fs}$	$^{3}N[i]$	$N[i]^{(a+7)}$
8	a+8	$^{1}\Xi^{\tau i}$	$^{1}\mathfrak{p}^{\tau i}$	$^{1}\underline{ds}$	$^{1}\underline{fs}$	$^{1}N[i]$	$N[i]^{(a+8)}$
9	a+9	$^{1}\Xi^{\tau i}$	$^{1}\mathfrak{p}^{\tau i}$	$^{1}\underline{ds}$	$^{1}\underline{fs}$	$^{1}N[i]$	$N[i]^{(a+9)}$
10	a+10	$^{3}\Xi^{\tau i}$	$^{3}\mathfrak{p}^{\tau i}$	$^{3}\underline{ds}$	$^{3}\underline{fs}$	$^{3}N[i]$	$N[i]^{(a+10)}$
11	a+11	$^{3}\Xi^{\tau i}$	$^{3}\mathfrak{p}^{\tau i}$	$^{3}\underline{ds}$	$^{3}\underline{fs}$	$^{3}N[i]$	$N[i]^{(a+11)}$
12	a+12	$^{3}\Xi^{\tau i}$	$^{3}\mathfrak{p}^{\tau i}$	$^{3}\underline{ds}$	$^{3}\underline{fs}$	$^{3}N[i]$	$N[i]^{(a+12)}$
13	a+13	$^{3}\Xi^{\tau i}$	$^{3}\mathfrak{p}^{\tau i}$	$^{3}\underline{ds}$	$^{3}\underline{fs}$	$^{3}N[i]$	$N[i]^{(a+13)}$
14	a+14	$^{1}\Xi^{\tau i}$	$^{1}\mathfrak{p}^{\tau i}$	$^{1}\underline{ds}$	$^{1}\underline{fs}$	$^{1}N[i]$	$N[i]^{(a+14)}$
15	a+15	$^{1}\Xi^{\tau i}$	$^{1}\mathfrak{p}^{\tau i}$	$^{1}\underline{ds}$	$^{1}\underline{fs}$	$^{1}N[i]$	$N[i]^{(a+15)}$
16	a+16	suspended	suspended	not generated	not generated	none	$N[i]^{(a+16)}$
17	a+17	suspended	suspended	not generated	not generated	none	$N[i]^{(a+17)}$
18	a+18	suspended	suspended	not generated	not generated	none	$N[i]^{(a+18)}$
19	a+19	suspended	suspended	not generated	not generated	none	$N[i]^{(a+19)}$
20	a+20	$^{4}\Xi^{\tau i}$	$^{4}\mathfrak{p}^{\tau i}$	$^{4}\underline{ds}$	$^{4}\underline{fs}$	$^{4}N[i]$	$N[i]^{(a+20)}$
21	a+21	$^{4}\Xi^{\tau i}$	$^{4}\mathfrak{p}^{\tau i}$	$^{4}\underline{ds}$	$^{4}\underline{fs}$	$^{4}N[i]$	$N[i]^{(a+21)}$
22	a+22	$^{1}\Xi^{\tau i}$	$^{1}\mathfrak{p}^{\tau i}$	$^{1}\underline{ds}$	$^{1}\underline{fs}$	$^{1}N[i]$	$N[i]^{(a+22)}$
23	a+23	$^{1}\Xi^{\tau i}$	$^{1}\mathfrak{p}^{\tau i}$	$^{1}\underline{ds}$	$^{1}\underline{fs}$	$^{1}N[i]$	$N[i]^{(a+23)}$
24	a+24	$^{4}\Xi^{\tau i}$	$^{4}\mathfrak{p}^{\tau i}$	$^{4}\underline{ds}$	$^{4}\underline{fs}$	$^{4}N[i]$	$N[i]^{(a+24)}$
25	a+25	$^{4}\Xi^{\tau i}$	$^{4}\mathfrak{p}^{\tau i}$	$^{4}\underline{ds}$	$^{4}\underline{fs}$	$^{4}N[i]$	$N[i]^{(a+25)}$
26	a+26	$^{1}\Xi^{\tau i}$	$^{1}\mathfrak{p}^{\tau i}$	$^{1}\underline{ds}$	$^{1}\underline{fs}$	$^{1}N[i]$	$N[i]^{(a+26)}$
27	a+27	$^{1}\Xi^{\tau i}$	$^{1}\mathfrak{p}^{\tau i}$	$^{1}\underline{ds}$	$^{1}\underline{fs}$	$^{1}N[i]$	$N[i]^{(a+27)}$
28	a+28	suspended	suspended	not generated	not generated	none	$N[i]^{(a+28)}$
29	a+29	suspended	suspended	not generated	not generated	none	$N[i]^{(a+29)}$
30	a+30	suspended	suspended	not generated	not generated	none	$N[i]^{(a+30)}$
31	a+31	suspended	suspended	not generated	not generated	none	$N[i]^{(a+31)}$
32	a+32	$^{0}\Xi^{\tau i}$	$^{0}\mathfrak{p}^{\tau i}$	$^{0}\underline{ds}$	$^{0}\underline{fs}$	$^{0}N[i]$	$N[i]^{(a+32)}$
33	a+33	$^{0}\Xi^{\tau i}$	$^{0}\mathfrak{p}^{\tau i}$	$^{0}\underline{ds}$	$^{0}\underline{fs}$	$^{0}N[i]$	$N[i]^{(a+33)}$
34	a+34	$^{1}\Xi^{\tau i}$	$^{1}\mathfrak{p}^{\tau i}$	$^{1}\underline{ds}$	$^{1}\underline{fs}$	$^{1}N[i]$	$N[i]^{(a+34)}$
35	a+35	$^{1}\Xi^{\tau i}$	$^{1}\mathfrak{p}^{\tau i}$	$^{1}\underline{ds}$	$^{1}\underline{fs}$	$^{1}N[i]$	$N[i]^{(a+35)}$
36	a+36	suspended	suspended	not generated	not generated	none	$N[i]^{(a+36)}$
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
n	a+n	$^{n}\Xi^{\tau i}$	$^{n}\mathfrak{p}^{\tau i}$	$^{n}\underline{ds}$	$^{n}\underline{fs}$	$^{n}N[i]$	$N[i]^{(a+n)}$

Table 3

[316] The idea of an actual recognition cycle (ARC), including how it is proposed to operate, is introduced and described in detail in Section 9.4 of Part 1, where it is simply called the recognition cycle. The ideas of an emulator and an emulative recognition cycle (ERC), and how these are proposed to operate, along with the idea that beats of the ARC and ERC are interleaved with each other over time are introduced and described in Section 11.3, where Section 11.3.2 most closely describes how the ERC is proposed to operate.

Apart from the ideas about willingness and decision-making Table 3 was designed to illustrate[317] the table can also be used to better propose how the timing of ARC-ERC interleaving might be patterned.

To assist with developing such a proposal, recall that units of time shown in Table 3 are beats of the ARC, where each of these is estimated to take ~ 250 msec.[318] If then, for working purposes, it is assumed that the EMC also operates around ~ 4 Hz, this would mean that going from Row 0 to Row 36 in the Table 3 would take around nine seconds.

Essentially then, it is implicit in Section 11.3.4 that D[r] – from the perspective of its inference of itself as D[a] – would be able within nine seconds to feel its willingness to persist with its current prevailing proto-goal state/prevailing path, ${}^{1}\Xi^{\tau i}/{}^{1}\text{Þ}^{\tau i}$, relative to its willingness to adopt one of three other proto goal states/potential paths being run through its ERC – i.e. feel its relative willingness to stay with ${}^{1}\Xi^{\tau i}/{}^{1}\text{Þ}^{\tau i}$ or 'changing its mind' to adopt either, ${}^{3}\Xi^{\tau i}/{}^{3}\text{Þ}^{\tau i}$, ${}^{4}\Xi^{\tau i}/{}^{4}\text{Þ}^{\tau i}$ or ${}^{0}\Xi^{\tau i}/{}^{0}\text{Þ}^{\tau i}$.

This raises the question of whether it is possible to make such an estimate of timing with respect to making a decision about which of four possible courses of physical action to take.[319]

In this connection it seems possible that insight into what may be a realistic estimate in such cases might reasonably be drawn from personal introspection as to how much time a person, say you, expect it might take for you to envisage a basic near-term proto-goal state/potential path – say going to have a cup of coffee – and through this to feel if your willingness to get such a coffee outweighs your willingness to stick with pursuit of your current prevailing proto-goal state/prevailing path.[320]

It should be possible for readers to imagine many examples of this kind and to apply introspection to these to get a better sense of the sequencing and timing of your own everyday decision-making than that implicit in Table 3.[321] It may also be helpful to examine introspectively what it seems to you is actually happening as you make decisions about physical objectives and tasks as you go about your day.

This reader exercise is simply designed to lend intuitive support to the conjecture that by and large, in normal and unpressured circumstances, (and with certain other caveats covered below):

1. Only proto-goal states/potential paths that generate sufficiently high willingness to be genuine 'contenders' for adoption will be imagined in any more than a fleeting and virtually subliminal way.[322]

2. Usually only one – rather than say three – such *high-willingness* proto-goal state/potential paths will be imagined 'at a time'[323] and that

    (a) when this happens up to several seconds – or possibly a much longer period of time – may be taken up with imagining such a high-willingness proto-goal state/potential path in conjunction with imagining the current prevailing proto-goal state/prevailing path, and that

    (b) this length of time will equal the amount of time required to allow attainment of a clear sense of which one of these two options evokes the greater willingness.

3. In very familiar environments and circumstances, the length of time between generation of one high-willingness proto-goal state/potential path and the next may extend for minutes.

4. In very familiar environments and circumstances, situations may often arise where – despite the sporadic generation and imagination of high-willingness proto-goal states/potential paths – the current prevailing proto-goal state/prevailing path may end up being sustained for up to hours.

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[317] See Section 11.3.3.
[318] See Section 9.4.4 of Part 1 for the basis of this timing estimate.
[319] To get a sense of this timing, note that the table shows (1.5+1) sec being given to imagining ${}^{3}\Xi^{\tau i}/{}^{3}\text{Þ}^{ti}$ versus ${}^{1}\Xi^{\tau i}/{}^{1}\text{Þ}^{ti}$, (1+1) sec being given to imagining ${}^{4}\Xi^{\tau i}/{}^{4}\text{Þ}^{ti}$ versus ${}^{1}\Xi^{\tau i}/{}^{1}\text{Þ}^{ti}$, and (0.5+0.5) sec being given to imagining ${}^{0}\Xi^{\tau i}/{}^{0}\text{Þ}^{ti}$ versus ${}^{1}\Xi^{\tau i}/{}^{1}\text{Þ}^{ti}$.
[320] Which may be to keep reading this note until you have finished it.
[321] Noting that Table 3 was designed to illustrate a range of other features of the proposed decision-making process, as discussed in Section 11.3.3. Moreover, as will be shown, a table serving the same purpose but also illustrating a more realistic estimate of sequencing and timing for decision-making would likely need to be pages long, making it impractical to put into this text.
[322] This idea has already essentially been proposed along with some supporting observations in Section 11.3.1.
[323] Here, '(one) at a time' is just a familiar way to say that each such high-willingness proto-goal state/potential path that arises will usually be assessed, and either rejected or adopted, through a sequence of beats of the ERC that is not interleaved with the imagining of any other high-willingness proto-goal state/potential path except for the prevailing proto-goal state/prevailing path and beats of the ARC. In other words, the claim here on empirical grounds, from personal introspection, is that people almost always imagine/envisage and decide upon potential alternative future objectives *one at a time*.

Row	Time	Proto-goal state	Potential path	Desire state	Fitness state	$^{n}N[i]$	$N[i]^{n}$
0	a	suspended	suspended	not generated	not generated	none	$N[i]^{a}$
1	a+1	$^{2}\Xi^{\tau i}$	$^{2}\text{Þ}^{\tau i}$	$^{2}\underline{ds}$	$^{2}\underline{fs}$	$^{2}N[i]$	$N[i]^{(a+1)}$
2	a+2	$^{1}\Xi^{\tau i}$	$^{1}\text{Þ}^{\tau i}$	$^{1}\underline{ds}$	$^{1}\underline{fs}$	$^{1}N[i]$	$N[i]^{(a+2)}$
3	a+3	suspended	suspended	not generated	not generated	none	$N[i]^{(a+3)}$
4	a+4	$^{3}\Xi^{\tau i}$	$^{3}\text{Þ}^{\tau i}$	$^{3}\underline{ds}$	$^{3}\underline{fs}$	$^{3}N[i]$	$N[i]^{(a+4)}$
5	a+5	$^{1}\Xi^{\tau i}$	$^{1}\text{Þ}^{\tau i}$	$^{1}\underline{ds}$	$^{1}\underline{fs}$	$^{1}N[i]$	$N[i]^{(a+5)}$
6	a+6	suspended	suspended	not generated	not generated	none	$N[i]^{(a+6)}$
7	a+7	$^{4}\Xi^{\tau i}$	$^{4}\text{Þ}^{\tau i}$	$^{4}\underline{ds}$	$^{4}\underline{fs}$	$^{4}N[i]$	$N[i]^{(a+7)}$
8	a+8	$^{1}\Xi^{\tau i}$	$^{1}\text{Þ}^{\tau i}$	$^{1}\underline{ds}$	$^{1}\underline{fs}$	$^{1}N[i]$	$N[i]^{(a+8)}$
9	a+9	suspended	suspended	not generated	not generated	none	$N[i]^{(a+9)}$
10	a+10	$^{5}\Xi^{\tau i}$	$^{5}\text{Þ}^{\tau i}$	$^{5}\underline{ds}$	$^{5}\underline{fs}$	$^{5}N[i]$	$N[i]^{(a+10)}$
11	a+11	$^{1}\Xi^{\tau i}$	$^{1}\text{Þ}^{\tau i}$	$^{1}\underline{ds}$	$^{1}\underline{fs}$	$^{1}N[i]$	$N[i]^{(a+11)}$
12	a+12	suspended	suspended	not generated	not generated	none	$N[i]^{(a+12)}$
13	a+13	$^{6}\Xi^{\tau i}$	$^{6}\text{Þ}^{\tau i}$	$^{6}\underline{ds}$	$^{6}\underline{fs}$	$^{6}N[i]$	$N[i]^{(a+13)}$
14	a+14	$^{1}\Xi^{\tau i}$	$^{1}\text{Þ}^{\tau i}$	$^{1}\underline{ds}$	$^{1}\underline{fs}$	$^{1}N[i]$	$N[i]^{(a+14)}$
15	a+15	suspended	suspended	not generated	not generated	none	$N[i]^{(a+15)}$
16	a+16	$^{6}\Xi^{\tau i}$	$^{6}\text{Þ}^{\tau i}$	$^{6}\underline{ds}$	$^{6}\underline{fs}$	$^{6}N[i]$	$N[i]^{(a+16)}$
17	a+17	$^{6}\Xi^{\tau i}$	$^{6}\text{Þ}^{\tau i}$	$^{6}\underline{ds}$	$^{6}\underline{fs}$	$^{6}N[i]$	$N[i]^{(a+17)}$
18	a+18	$^{6}\Xi^{\tau i}$	$^{6}\text{Þ}^{\tau i}$	$^{6}\underline{ds}$	$^{6}\underline{fs}$	$^{6}N[i]$	$N[i]^{(a+18)}$
19	a+19	$^{6}\Xi^{\tau i}$	$^{6}\text{Þ}^{\tau i}$	$^{6}\underline{ds}$	$^{6}\underline{fs}$	$^{6}N[i]$	$N[i]^{(a+19)}$
20	a+20	$^{1}\Xi^{\tau i}$	$^{1}\text{Þ}^{\tau i}$	$^{1}\underline{ds}$	$^{1}\underline{fs}$	$^{1}N[i]$	$N[i]^{(a+20)}$
21	a+21	suspended	suspended	not generated	not generated	none	$N[i]^{(a+21)}$
22	a+22	$^{6}\Xi^{\tau i}$	$^{6}\text{Þ}^{\tau i}$	$^{6}\underline{ds}$	$^{6}\underline{fs}$	$^{6}N[i]$	$N[i]^{(a+22)}$
23	a+23	$^{6}\Xi^{\tau i}$	$^{6}\text{Þ}^{\tau i}$	$^{6}\underline{ds}$	$^{6}\underline{fs}$	$^{6}N[i]$	$N[i]^{(a+23)}$
24	a+24	$^{6}\Xi^{\tau i}$	$^{6}\text{Þ}^{\tau i}$	$^{6}\underline{ds}$	$^{6}\underline{fs}$	$^{6}N[i]$	$N[i]^{(a+24)}$
25	a+25	$^{6}\Xi^{\tau i}$	$^{6}\text{Þ}^{\tau i}$	$^{6}\underline{ds}$	$^{6}\underline{fs}$	$^{6}N[i]$	$N[i]^{(a+25)}$
26	a+26	$^{1}\Xi^{\tau i}$	$^{1}\text{Þ}^{\tau i}$	$^{1}\underline{ds}$	$^{1}\underline{fs}$	$^{1}N[i]$	$N[i]^{(a+26)}$
27	a+27	suspended	suspended	not generated	not generated	none	$N[i]^{(a+27)}$
28	a+28	$^{6}\Xi^{\tau i}$	$^{6}\text{Þ}^{\tau i}$	$^{6}\underline{ds}$	$^{6}\underline{fs}$	$^{6}N[i]$	$N[i]^{(a+28)}$
29	a+29	$^{6}\Xi^{\tau i}$	$^{6}\text{Þ}^{\tau i}$	$^{6}\underline{ds}$	$^{6}\underline{fs}$	$^{6}N[i]$	$N[i]^{(a+29)}$
30	a+30	$^{6}\Xi^{\tau i} \rightarrow {}^{1}\Xi^{\tau i}$	$^{6}\text{Þ}^{\tau i} \rightarrow {}^{1}\text{Þ}^{\tau i}$	$^{6}\underline{ds} \rightarrow {}^{1}\underline{ds}$	$^{6}\underline{fs} \rightarrow {}^{1}\underline{fs}$	none	$N[i]^{(a+30)}$
31	a+31	$^{1}\Xi^{\tau i}$	$^{1}\text{Þ}^{\tau i}$	$^{1}\underline{ds}$	$^{1}\underline{fs}$	$^{1}N[i]$	$N[i]^{(a+31)}$
32	a+32	$^{1}\Xi^{\tau i}$	$^{1}\text{Þ}^{\tau i}$	$^{1}\underline{ds}$	$^{1}\underline{fs}$	$^{1}N[i]$	$N[i]^{(a+32)}$
33	a+33	suspended	suspended	not generated	not generated	none	$N[i]^{(a+33)}$
34	a+34	suspended	suspended	not generated	not generated	none	$N[i]^{(a+34)}$
35	a+35	suspended	suspended	not generated	not generated	none	$N[i]^{(a+35)}$
36	a+36	suspended	suspended	not generated	not generated	none	$N[i]^{(a+36)}$
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
x	a+x	suspended	suspended	not generated	not generated	none	$N[i]^{(a+x)}$
x+1	a+x+1	$^{2}\Xi^{\tau i}$	$^{2}\text{Þ}^{\tau i}$	$^{2}\underline{ds}$	$^{2}\underline{fs}$	$^{2}N[i]$	$N[i]^{(a+x+1)}$
x+2	a+x+2	$^{1}\Xi^{\tau i}$	$^{1}\text{Þ}^{\tau i}$	$^{1}\underline{ds}$	$^{1}\underline{fs}$	$^{1}N[i]$	$N[i]^{(a+x+2)}$
x+3	a+x+3	suspended	suspended	not generated	not generated	none	$N[i]^{(a+x+3)}$
x+4	a+x+4	$^{3}\Xi^{\tau i}$	$^{3}\text{Þ}^{\tau i}$	$^{3}\underline{ds}$	$^{3}\underline{fs}$	$^{3}N[i]$	$N[i]^{(a+x+4)}$
x+5	a+x+5	$^{1}\Xi^{\tau i}$	$^{1}\text{Þ}^{\tau i}$	$^{1}\underline{ds}$	$^{1}\underline{fs}$	$^{1}N[i]$	$N[i]^{(a+x+5)}$
x+6	a+x+6	suspended	suspended	not generated	not generated	none	$N[i]^{(a+x+6)}$
x+7	a+x+7	$^{4}\Xi^{\tau i}$	$^{4}\text{Þ}^{\tau i}$	$^{4}\underline{ds}$	$^{4}\underline{fs}$	$^{4}N[i]$	$N[i]^{(a+x+7)}$
x+8	a+x+8	$^{1}\Xi^{\tau i}$	$^{1}\text{Þ}^{\tau i}$	$^{1}\underline{ds}$	$^{1}\underline{fs}$	$^{1}N[i]$	$N[i]^{(a+x+8)}$
x+9	a+x+9	suspended	suspended	not generated	not generated	none	$N[i]^{(a+x+9)}$
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
n	a+n	$^{n}\Xi^{\tau i}$	$^{n}\text{Þ}^{\tau i}$	$^{n}\underline{ds}$	$^{n}\underline{fs}$	$^{n}N[i]$	$N[i]^{(a+n)}$

Table 4

Table 4 is designed to illustrate some of the proposals made in Points 1 to 4 above as well as some further ideas, where unless otherwise stated it is expected that these proposals and ideas will apply in relatively familiar, normal and unpressured circumstances.[324]

Row 0 to Row 15 of Table 4 illustrates an idealisation of a normal progression of interleaving between the ARC and the ERC. Here it is proposed that an array of proto-goal states/potential paths has been spontaneously produced by the emulator in D[r] and that members of this array are being serially processed through the ERC at one beat per proto-goal state/potential path. Each beat that processes a given proto-goal state/potential path will be followed by a second beat processing the current prevailing proto-goal state/prevailing path. This will generate a first, fleeting, virtually subliminal preliminary perception – i.e. feeling – of either greater or lesser willingness to adopt that proto-goal state/potential path than retaining the prevailing proto-goal state/prevailing path.

To apply the analogy of music, D[r] – from the perspective of its inference of itself as D[a] – will feel/'hear' two willingnesses/'chord harmonies' in rapid succession. The first will be new – the novel 'sound' of the {ds + fs} of the proto-goal state/potential path under assessment – and the second will be familiar – the 'sound', or 'drone' of the ^{1}{ds + fs} 'chord harmony' of the prevailing proto-goal state/prevailing path.[325] In this idealisation each of these chord harmony pairs will be interleaved with one beat of the ARC, the process by which D[r] will in the meantime be moving the recognition state through recognition space.

In this idealised progression, one cycle of this initial vetting process will take ~0.75 sec and will, as stated, be virtually subliminal. A proto-goal state/potential path evoking clearly lower willingness than the prevailing proto-goal state/prevailing path will be discarded and another from the array run in the next ~0.75 sec cycle. This is the type of progression illustrated from Row 0 to Row 12 in Table 4.

But if, on such initial vetting, a proto-goal state/potential path is felt to evoke a comparable or higher willingness than the prevailing proto-goal state/prevailing path – i.e. it is a *high-willingness* proto-goal state/potential path – say that it is not discarded but is then envisaged/imagined for a longer period – as described at Point 2 above – with an accompanying extension and refinement of the feeling of willingness that doing so evokes.

This type of progression is illustrated from Row 15 to Row 29 in Table 4, where the proto-goal state/potential path $^{6}\Xi^{\tau i}/^{6}\text{Þ}^{\tau i}$ is envisaged in relation to the prevailing proto-goal state/prevailing path $^{1}\Xi^{\tau i}/^{1}\text{Þ}^{\tau i}$ over a series of cycles lasting around five seconds. This is well into the time period over which $^{6}\Xi^{\tau i}/^{6}\text{Þ}^{\tau i}$ would be consciously imagined. There is no reason this period should not be longer and, as proposed in Point 2 above, just as long as is needed for D[r] – from the perspective of its inference of itself as D[a] – to clearly determine whether it feels more willingness to adopt $^{6}\Xi^{\tau i}/^{6}\text{Þ}^{\tau i}$ than to persist with its current $^{1}\Xi^{\tau i}/^{1}\text{Þ}^{\tau i}$.

If a greater feeling of willingness is evoked by $^{6}\Xi^{\tau i}/^{6}\text{Þ}^{\tau i}$ then it will be adopted and implemented as the new $^{1}\Xi^{\tau i}/^{1}\text{Þ}^{\tau i}$. This is illustrated as taking place at Row 30 in Table 4. At this time the new prevailing proto-goal state/prevailing path will be loaded as a prediction into the ARC and will begin to be implemented through active inference of motor output from D[r]. This will be experienced as a decision, and with it there will be a shift in mood – somewhere from imperceptibly small to large – that in normal, unpressured circumstances will always be positive since the 'drone' of the new $^{1}\Xi^{\tau i}/^{1}\text{Þ}^{\tau i}$ will be at a higher willingness than its predecessor.

[324] Other kinds of circumstances – for example where pressure exists to make action-related decisions at very short notice – for example in playing a football game – or where rapidly changing environmental restraints arises that force decisions – the processes involved may be quite different.
[325] The 'chord harmony' for ^{1}{ds + fs} can be described as a 'drone' in the situation prevailing from Rows 0 to 15 because it will be 'heard' as a constant contributor to each of the pairs of willingnesses successively 'heard' as the ERC steps serially through those rows.

Previously ${}^{1}\Xi^{\tau i}/{}^{1}\text{Þ}^{\tau i}$ has been expressed as one of the members of an array of proto-goal states/potential paths generated at time, t = a:

$\Xi^{a}, {}^{0}\Xi^{(a+1)i}, {}^{0}\Xi^{(a+2)i}, {}^{0}\Xi^{(a+3)i}, \dots, {}^{0}\Xi^{\tau i}$	denote this potential path:	${}^{0}\text{Þ}^{\tau i}$	
$\Xi^{a}, {}^{1}\Xi^{(a+1)i}, {}^{1}\Xi^{(a+2)i}, {}^{1}\Xi^{(a+3)i}, \dots, {}^{1}\Xi^{\tau i}$	"	${}^{1}\text{Þ}^{\tau i}$	
$\Xi^{a}, {}^{2}\Xi^{(a+1)i}, {}^{2}\Xi^{(a+2)i}, {}^{2}\Xi^{(a+3)i}, \dots, {}^{2}\Xi^{\tau i}$	"	${}^{2}\text{Þ}^{\tau i}$	A2
. . . . .		.	
. . . . .		.	
. . . . .		.	
$\Xi^{a}, {}^{n}\Xi^{(a+1)i}, {}^{n}\Xi^{(a+2)i}, {}^{n}\Xi^{(a+3)i}, \dots, {}^{n}\Xi^{\tau i}$	"	${}^{n}\text{Þ}^{\tau i}$	

But since it is the prevailing proto-goal state/prevailing path it can also be expressed in the form in which it is being implemented through operation of the ARC, which at any time, t = a, can be written:

$\Xi^{a}, \Xi^{(a+1)*}, \Xi^{(a+2)**}, \Xi^{(a+3)***}, \Xi^{(a+4)****}, \dots, \Xi^{(a+\tau)****\cdots*}$	${}^{1}\text{Þ}^{\tau i}$	B1

where the growing number of asterisks denotes a growing degree of uncertainty in prediction moving to the right along the subjective timeline from a 'now' of t = a into the predicted future.[326]

Row 31 to Row x in Table 4 describes a long period – perhaps minutes – where the ERC remains suspended. This is intended to illustrate periods during which a person is so closely focussed on execution of the prevailing path that this excludes capacity to run – or at least to attend to – the ERC.

Examples of this will be where a particularly high level of hand-eye coordination is needed to execute some fine work of one kind or another, such as threading a needle, or where other forms of demanding physical coordination or exertion are needed, such as in skiing a difficult slope, scaling a difficult cliff, playing a game of tennis or doing some exacting physical repair work or building work. Here D[r] – from the perspective of its inference of itself as D[a] – will be attending very closely to incoming error signals as a means of correcting its predictions and by this means minimizing error in the inferential process driving its motor output.

If, as proposed, it is through operation of the ERC that the various 'chord harmonies', {ds + fs}, of arising proto-goal states/potential paths are serially generated, and then 'heard'/felt serially as a 'harmonic melody'/mood, then suspension of the ERC over some period should be accompanied by suspension of perception of mood. This seems to be the case. Engaging in activities such as those described in the preceding paragraph does seem to suspend perception of mood consistent with people in a low mood sometimes using this method to, 'take their mind off things'.

'Boredom'

Another situation that may arise is where a person has adopted a prevailing proto-goal state ${}^{1}\Xi^{\tau i}$ and is traversing ${}^{1}\text{Þ}^{\tau i}$ in circumstances where they do not, for a lengthy period of time, encounter any states in B[i] or W[i]\B[i] that have the properties needed to stimulate their emulator to generate any array that, when its members are run through their ERC, turns out to contain any high-willingness proto-goal state/potential path.

With reference to Section 11.3.4, which describes when and how arrays of proto-goal states/potential paths are generated, these will be circumstances where – as the ARC operates on B1 to move the recognition state through recognition space towards a ${}^{1}\Xi^{\tau i}$ – it simply turns out to be the case that nothing arises in B[i] or W[i]\B[i] that is sufficiently unpredicted or surprising that it stimulates the emulator to generate such an array.

This situation could be illustrated with a table similar to Table 4, but where it would be as long as a phone book made of rows that simply cycle through the same pattern shown in Table 4 from Row 0 to Row 12.

[326] This use of asterisks was introduced in Section 10.7 – in particular see Figure 14 – and is further utilised in Section 11.3.5 in discussing when and how arrays of proto-goal states are generated.

Example 7
An example of such a situation would be where a person is driving along 50km of a straight, highly familiar road – say between wheat fields in Australia – to achieve a destination/situation which is their current $^{1}\Xi^{\tau i}$. They might easily travel the full 50 km without encountering anything unexpected. The same can be said for any situation where a highly familiar $^{1}Þ^{\tau i}$ is being traversed to a $^{1}\Xi^{\tau i}$ over a considerable period of time during which nothing at all surprising happens.

In this circumstance a person's mood would be expected to remain steady with few, if any, fluctuations arising, since their emulator will not generate any new arrays that contain a high-willingness proto-goal state/potential path. In such a circumstance, and where implementation of the ARC does not require any form of demanding physical coordination – such as in the examples provided above of threading a needle or skiing a difficult slope – the 'sound'/feeling of the monotonous 'harmonic melody'/mood, containing the steady 'drone' of $^{1}\{\underline{ds} + \underline{fs}\}$, may grow to become what is known as *boredom*.[327]

14 Path arrays, path refinement and optimising paths to a prevailing proto-goal state

It remains to describe one further important situation. To do this the ideas provided in Section 11.3.4 about when and how arrays of proto-goal states are generated requires some nuancing.

Recall from Section 11.3.4 the proposal that:

- to a smaller or greater extent, a person will always be 'finding' or 'uncovering' new affordances as they proceed with enacting a prevailing path, and
- this will correlate with D[r] – to a commensurately smaller or greater extent – generating and assessing new arrays of proto-goal states/potential paths in a spontaneous response to the 'surprise appearance' of substates and motions in Ξ that have not been predicted through preceding beats of the recognition cycle as D[r] enacts the prevailing path.

The needed nuancing is simply to propose that in certain situations such 'finding' and 'uncovering' of new affordances can, over extended periods of time, lead the emulator in D[r] spontaneously to generate arrays of proto-goal states/potential paths where – across of all those arrays and within each of those arrays – it will transpire that the only *high-willingness* proto-goal states/potential paths that are spontaneously generated have proto-goal states equivalent to the prevailing proto-goal state, but *where variation arises in the potential paths*. This situation is most easily described through use of an example.

Example 8
Say a farmer who has just flown back to her farm after being away for some months feels a strong appetite for food and is pursuing a $^{1}\Xi^{\tau i}/^{1}Þ^{\tau i}$ which is to drive 30 kilometres into town to her favourite café to have their famous steak dinner.

As she drives the familiar road to town she begins to find herself in a situation akin to that of the person in Example 7. But then, as she rounds a familiar bend, she suddenly sees that a new bridge over the river that was under construction when she left is now finished. She had not anticipated this, but in seeing the new bridge she recalls that using it should cut 15 kilometres off her trip to town.

[327] Although beyond the scope of this Working Note it is interesting to observe that people seek to avoid feeling bored and that only four alternative non-social methods to avoid boredom seem available to those constrained to a boring environment. To illustrate this the example of lone long distance travellers can be used, and specifically the driver in Example 7. One method available to avoid boredom would be to speed up to a point where the physical coordination demanded of the ARC 'takes their mind off' the feeling of boredom by putting their ERC into suspension. A second method would be for them to otherwise engage their ERC through *daydreaming* – i.e. constructing and experiencing pure imaginary recognition states – or *reminiscing* – i.e. constructing and experiencing recalled recognition states – consistent with the definitions of these provided in Sections 11.1 and 11.2. These activities should, for as long as the daydream or reminiscence lasts, displace boredom with moods evoked by such imaginary recognition states. A third method is for the driver to direct their imagination towards what can broadly be called *planning*. Each of daydreaming, reminiscing and planning seem to be uniquely human capabilities. So does the fourth method, which can be labelled with the catch all *problem solving*, by which is meant directed abstract reasoning. (Another way to alleviate boredom might – if it is available – be to listen to music. Some proposals as to how music can act as a mood modulator will be provided in a separate note (in preparation).

Consistent with the ideas referred to in the bullet points above, the farmer's response to this new, unpredicted distribution of substates in her W[i]\B[i], will begin with her emulator spontaneously generating a new array of proto-goal states/potential paths.

But, given the circumstances, say it turns out that across all of the members of that new array her prevailing proto-goal state of eating steak at her favourite café remains a constant; in other words, all of the high-willingness proto-goal states/potential paths generated by her emulator retain the same proto-goal state, where that proto-goal state is equivalent to the ${}^{1}\Xi^{\tau i}$ she had already adopted prior to seeing the new bridge.

In this simple example the only high-willingness proto-goal state/potential path likely to evoke greater willingness than the farmer's current ${}^{1}\Xi^{\tau i}/{}^{1}\text{Þ}^{\tau i}$ will be, call it ${}^{2}\Xi^{\tau i}/{}^{2}\text{Þ}^{\tau i}$, where ${}^{1}\Xi^{\tau i}$ and ${}^{2}\Xi^{\tau i}$ are equivalent, but where ${}^{1}\text{Þ}^{\tau i}$ envisages keeping to the old route to town while ${}^{2}\text{Þ}^{\tau i}$ envisages using the new bridge. In going from ${}^{2}\Xi^{\tau i}$ to ${}^{1}\Xi^{\tau i}$ the ds chord will remain the same, but in going from ${}^{2}\text{Þ}^{\tau i}$ to ${}^{1}\text{Þ}^{\tau i}$ the fs chord will change. In this case, it is likely that ^{2}fs as against ^{1}fs will lead to a ^{2}{ds + fs}/'chord harmony' that will be felt/'heard' as a greater willingness than will be felt/'heard' for ^{1}{ds + fs}. This is because driving a much shorter distance to the café will entail less effort and consumption of energy by the farmer's B[r].

Having made up her mind to take the new bridge the farmer drives on towards her goal. The ideas proposed Sections 12.2 and 12.3 above suggest that regardless of its starting point, her mood will have shifted in a positive direction. If her appetite had become very strong by the time she saw the new bridge, she may even have felt delighted to see the bridge. If her appetite had remained steady she may have just felt pleased to see it. If she had actually become truly hungry by the time she saw the new bridge she may also have felt some relief to see it.

None of this should seem particularly surprising or unfamiliar because situations of this type arise reasonably often in everyday life. That is, situations where for extended periods of time the only decisions a person is making are about finding the best path to the goal they are seeking and are not about whether the goal they are seeking is the best goal they can seek.[328]

If an array of proto-goal states/potential paths is of the type described above – i.e. where all of the proto-goal states generated by the emulator for that array are equivalent to the current ${}^{1}\Xi^{\tau i}$ – such an array can be called a *path array*. A path array for any ${}^{1}\Xi^{\tau i}/{}^{1}\text{Þ}^{\tau i}$ can be written:

${}^{1}\text{Þ}^{\tau i},\ {}^{1}_{2}\text{Þ}^{\tau i},\ {}^{1}_{3}\text{Þ}^{\tau i},\ {}^{1}_{4}\text{Þ}^{\tau i},\ \ldots\ ,\ {}^{1}_{n}\text{Þ}^{\tau i}$ A3

where those paths that are distinguished from each other by use of a left subscript are all different potential paths to the current prevailing proto-goal state, ${}^{1}\Xi^{\tau i}$. The current prevailing path is distinguished from those other potential paths by being given no left subscript.

Table 5 is designed to illustrate the distinction between deciding between proto-goal states and deciding between potential paths to one such goal.

The upper area of the table provides a more condensed example of the process shown for deciding between proto-goal states, as was previously illustrated in Table 4. In Table 5 the decision between proto-goal states is shown at Row 15. The proposed process for deciding between potential paths alone is similar, with this type of decision being shown at Row 36. Note that with the latter type of decision only the prevailing path and the fs substate of N[i] shift with the decision.

[328] The former being the case with the farmer in Example 8, and the latter being the case with the hot dogs versus the pizza in Example 2.

Row	Time	Proto-goal state	Potential path	Desire state	Fitness state	ⁿN[i]	N[i]ⁿ
0	a	suspended	suspended	not generated	not generated	none	$N[i]^{a}$
1	a+1	${}^{5}\Xi^{\tau i}$	${}^{5}\text{Þ}^{\tau i}$	${}^{5}\underline{ds}$	${}^{5}\underline{fs}$	${}^{5}N[i]$	$N[i]^{(a+1)}$
2	a+2	${}^{1}\Xi^{\tau i}$	${}^{1}\text{Þ}^{\tau i}$	${}^{1}\underline{ds}$	${}^{1}\underline{fs}$	${}^{1}N[i]$	$N[i]^{(a+2)}$
3	a+3	suspended	suspended	not generated	not generated	none	$N[i]^{(a+3)}$
4	a+4	${}^{6}\Xi^{\tau i}$	${}^{6}\text{Þ}^{\tau i}$	${}^{6}\underline{ds}$	${}^{6}\underline{fs}$	${}^{6}N[i]$	$N[i]^{(a+4)}$
5	a+5	${}^{1}\Xi^{\tau i}$	${}^{1}\text{Þ}^{\tau i}$	${}^{1}\underline{ds}$	${}^{1}\underline{fs}$	${}^{1}N[i]$	$N[i]^{(a+5)}$
6	a+6	suspended	suspended	not generated	not generated	none	$N[i]^{(a+6)}$
7	a+7	${}^{6}\Xi^{\tau i}$	${}^{6}\text{Þ}^{\tau i}$	${}^{6}\underline{ds}$	${}^{6}\underline{fs}$	${}^{6}N[i]$	$N[i]^{(a+7)}$
8	a+8	${}^{6}\Xi^{\tau i}$	${}^{6}\text{Þ}^{\tau i}$	${}^{6}\underline{ds}$	${}^{6}\underline{fs}$	${}^{6}N[i]$	$N[i]^{(a+8)}$
9	a+9	${}^{6}\Xi^{\tau i}$	${}^{6}\text{Þ}^{\tau i}$	${}^{6}\underline{ds}$	${}^{6}\underline{fs}$	${}^{6}N[i]$	$N[i]^{(a+9)}$
10	a+10	${}^{6}\Xi^{\tau i}$	${}^{6}\text{Þ}^{\tau i}$	${}^{6}\underline{ds}$	${}^{6}\underline{fs}$	${}^{6}N[i]$	$N[i]^{(a+10)}$
11	a+11	${}^{1}\Xi^{\tau i}$	${}^{1}\text{Þ}^{\tau i}$	${}^{1}\underline{ds}$	${}^{1}\underline{fs}$	${}^{1}N[i]$	$N[i]^{(a+11)}$
12	a+12	suspended	suspended	not generated	not generated	none	$N[i]^{(a+12)}$
13	a+13	${}^{6}\Xi^{\tau i}$	${}^{6}\text{Þ}^{\tau i}$	${}^{6}\underline{ds}$	${}^{6}\underline{fs}$	${}^{6}N[i]$	$N[i]^{(a+13)}$
14	a+14	${}^{6}\Xi^{\tau i}$	${}^{6}\text{Þ}^{\tau i}$	${}^{6}\underline{ds}$	${}^{6}\underline{fs}$	${}^{6}N[i]$	$N[i]^{(a+14)}$
15	a+15	${}^{6}\Xi^{\tau i} \rightarrow {}^{1}\Xi^{\tau i}$	${}^{6}\text{Þ}^{\tau i} \rightarrow {}^{1}\text{Þ}^{\tau i}$	${}^{6}\underline{ds} \rightarrow {}^{1}\underline{ds}$	${}^{6}\underline{fs} \rightarrow {}^{1}\underline{fs}$	none	$N[i]^{(a+15)}$
16	a+16	${}^{1}\Xi^{\tau i}$	${}^{1}\text{Þ}^{\tau i}$	${}^{1}\underline{ds}$	${}^{1}\underline{fs}$	${}^{1}N[i]$	$N[i]^{(a+16)}$
17	a+17	${}^{1}\Xi^{\tau i}$	${}^{1}\text{Þ}^{\tau i}$	${}^{1}\underline{ds}$	${}^{1}\underline{fs}$	${}^{1}N[i]$	$N[i]^{(a+17)}$
18	a+18	suspended	suspended	not generated	not generated	none	$N[i]^{(a+18)}$
19	a+19	suspended	suspended	not generated	not generated	none	$N[i]^{(a+19)}$
20	a+20	suspended	suspended	not generated	not generated	none	$N[i]^{(a+20)}$
21	a+21	suspended	suspended	not generated	not generated	none	$N[i]^{(a+21)}$
22	a+22	${}^{1}\Xi^{\tau i}$	${}^{1}_{2}\text{Þ}^{\tau i}$	${}^{1}\underline{ds}$	${}^{1}_{2}\underline{fs}$	${}^{1}_{2}N[i]$	$N[i]^{(a+22)}$
23	a+23	${}^{1}\Xi^{\tau i}$	${}^{1}\text{Þ}^{\tau i}$	${}^{1}\underline{ds}$	${}^{1}\underline{fs}$	${}^{1}N[i]$	$N[i]^{(a+23)}$
24	a+24	suspended	suspended	not generated	not generated	none	$N[i]^{(a+24)}$
25	a+25	${}^{1}\Xi^{\tau i}$	${}^{1}_{3}\text{Þ}^{\tau i}$	${}^{1}\underline{ds}$	${}^{1}_{3}\underline{fs}$	${}^{1}_{3}N[i]$	$N[i]^{(a+25)}$
26	a+26	${}^{1}\Xi^{\tau i}$	${}^{1}\text{Þ}^{\tau i}$	${}^{1}\underline{ds}$	${}^{1}\underline{fs}$	${}^{1}N[i]$	$N[i]^{(a+26)}$
27	a+27	suspended	suspended	not generated	not generated	none	$N[i]^{(a+27)}$
28	a+28	${}^{1}\Xi^{\tau i}$	${}^{1}_{3}\text{Þ}^{\tau i}$	${}^{1}\underline{ds}$	${}^{1}_{3}\underline{fs}$	${}^{1}_{3}N[i]$	$N[i]^{(a+28)}$
29	a+29	${}^{1}\Xi^{\tau i}$	${}^{1}_{3}\text{Þ}^{\tau i}$	${}^{1}\underline{ds}$	${}^{1}_{3}\underline{fs}$	${}^{1}_{3}N[i]$	$N[i]^{(a+29)}$
30	a+30	${}^{1}\Xi^{\tau i}$	${}^{1}_{3}\text{Þ}^{\tau i}$	${}^{1}\underline{ds}$	${}^{1}_{3}\underline{fs}$	${}^{1}_{3}N[i]$	$N[i]^{(a+30)}$
31	a+31	${}^{1}\Xi^{\tau i}$	${}^{1}_{3}\text{Þ}^{\tau i}$	${}^{1}\underline{ds}$	${}^{1}_{3}\underline{fs}$	${}^{1}_{3}N[i]$	$N[i]^{(a+31)}$
32	a+32	${}^{1}\Xi^{\tau i}$	${}^{1}\text{Þ}^{\tau i}$	${}^{1}\underline{ds}$	${}^{1}\underline{fs}$	${}^{1}N[i]$	$N[i]^{(a+32)}$
33	a+33	suspended	suspended	not generated	not generated	none	$N[i]^{(a+33)}$
34	a+34	${}^{1}\Xi^{\tau i}$	${}^{1}_{3}\text{Þ}^{\tau i}$	${}^{1}\underline{ds}$	${}^{1}_{3}\underline{fs}$	${}^{1}_{3}N[i]$	$N[i]^{(a+34)}$
35	a+35	${}^{1}\Xi^{\tau i}$	${}^{1}_{3}\text{Þ}^{\tau i}$	${}^{1}\underline{ds}$	${}^{1}_{3}\underline{fs}$	${}^{1}_{3}N[i]$	$N[i]^{(a+35)}$
36	a+36	${}^{1}\Xi^{\tau i}$	${}^{1}_{3}\text{Þ}^{\tau i} \rightarrow {}^{1}\text{Þ}^{\tau i}$	${}^{1}\underline{ds}$	${}^{1}_{3}\underline{fs} \rightarrow {}^{1}\underline{fs}$	none	$N[i]^{(a+36)}$
37	a+37	${}^{1}\Xi^{\tau i}$	${}^{1}\text{Þ}^{\tau i}$	${}^{1}\underline{ds}$	${}^{1}\underline{fs}$	${}^{1}N[i]$	$N[i]^{(a+37)}$
38	a+38	${}^{1}\Xi^{\tau i}$	${}^{1}\text{Þ}^{\tau i}$	${}^{1}\underline{ds}$	${}^{1}\underline{fs}$	${}^{1}N[i]$	$N[i]^{(a+38)}$
39	a+39	suspended	suspended	not generated	not generated	none	$N[i]^{(a+39)}$
40	a+40	suspended	suspended	not generated	not generated	none	$N[i]^{(a+40)}$
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
x	a+x	suspended	suspended	not generated	not generated	none	$N[i]^{(a+x)}$
x+1	a+x+1	${}^{1}\Xi^{\tau i}$	${}^{1}_{2}\text{Þ}^{\tau i}$	${}^{1}\underline{ds}$	${}^{1}_{2}\underline{fs}$	${}^{1}_{2}N[i]$	$N[i]^{(a+x+1)}$
x+2	a+x+2	${}^{1}\Xi^{\tau i}$	${}^{1}\text{Þ}^{\tau i}$	${}^{1}\underline{ds}$	${}^{1}\underline{fs}$	${}^{1}N[i]$	$N[i]^{(a+x+2)}$
x+3	a+x+3	suspended	suspended	not generated	not generated	none	$N[i]^{(a+x+3)}$
x+4	a+x+4	${}^{1}\Xi^{\tau i}$	${}^{1}_{3}\text{Þ}^{\tau i}$	${}^{1}\underline{ds}$	${}^{1}_{3}\underline{fs}$	${}^{1}_{3}N[i]$	$N[i]^{(a+x+4)}$
x+5	a+x+5	${}^{1}\Xi^{\tau i}$	${}^{1}\text{Þ}^{\tau i}$	${}^{1}\underline{ds}$	${}^{1}\underline{fs}$	${}^{1}N[i]$	$N[i]^{(a+x+5)}$
x+6	a+x+6	suspended	suspended	not generated	not generated	none	$N[i]^{(a+x+6)}$
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
n	a+n	${}^{n}\Xi^{\tau i}$	${}^{n}\text{Þ}^{\tau i}$	${}^{n}\underline{ds}$	${}^{n}\underline{fs}$	${}^{n}N[i]$	$N[i]^{(a+n)}$

Table 5

Personal experience suggests that most decisions a person makes as they shape the movements and interactions of their physical body, B[r], in and with its physical environment, W[r]\B[r] – respectively perceived as substates of their B[i] and their W[i]\B[i] – are decisions between potential paths.

It also seems likely, in deciding to adopt a new prevailing proto-goal state/prevailing path – if this is through the decision process illustrated in Tables 4 and 5, which show ${}^{6}\Xi^{\tau i}/{}^{6}\text{Þ}^{\tau i}$ being adopted as a new ${}^{1}\Xi^{\tau i}/{}^{1}\text{Þ}^{\tau i}$ – that such decisions are based on a 'first cut' prediction of ${}^{6}\text{Þ}^{\tau i}$, and that such a decision between goals will then be followed by a *path refinement* process, illustrated from row 22 to row 36 of Table 5, entailing spontaneous generation of – and serial application of the ERC to – a path array for the new ${}^{1}\text{Þ}^{\tau i}$, that then leads to adoption of an optimised predicted path to the new ${}^{1}\Xi^{\tau i}$.

On this basis it is proposed that:

- for most of the time any new affordances uncovered as a person's recognition state moves through recognition space will not be of types that stimulate generation of arrays of proto-goal states/potential paths that contain new proto-goal states of high enough willingness to be run for more than one beat of the ERC, let alone adopted as a new prevailing proto-goal state,[329] and that
- new affordances uncovered will far more often be of types – including many arising due to prediction errors of the second kind described in Section 11.3.4[330] – that stimulate generation of path arrays.

Put simply, it is proposed that a person will most frequently find themselves refining and adjusting, mainly in minor ways – but sometimes in major ways, as in Example 8 – the path that they are taking to get to a goal that they have already adopted, and find that they are continuing to adopt.

15 Prediction error estimates; 'uncertainty' and 'doubt'

The *quality* – good, indifferent or poor – of all decisions made through the processes described in this note will rely on the proposed emulator in D[r] generating arrays of proto-goal states/potential paths such that the ERC can predict ds and fs for each of those proto-goal states/potential paths with sufficient *accuracy* and *precision* that the feeling of relative willingnesses evoked by their respective {ds + fs} will *soundly* predict their relative value for B[r] well-being.

To better define these terms: If the magnitude of willingness predicted is correct, the prediction will be accurate. More precisely, if the value at the centre of the error distribution of estimated willingness – the mode – is correct, the prediction will have high *accuracy*. This will reflect high accuracy in the predictions of both ds and fs. If the error distribution of estimated willingness about the mode is narrow the prediction will have high *precision*, but if the error distribution is spread broadly about the mode it will have low precision. Again, this will reflect the degree of precision in the predictions of both ds and fs.

The accuracy and definition – call this combination the *soundness* – of predictions of any given pair of ds and fs will depend on many factors. Among these will be the degree to which D[r]'s recognition and generative models are refined and capable. This in turn will depend on how much experience – including the breadth, quality and typicality of experience – a person's D[r] has had, through operation of its ARC, with the states and motions of its own B[r], including in its interactions with various physical environments in W[r]\B[r]. This accumulated experience will also affect how complete, accurate and well defined D[r]'s world map of its environment is.

[329] This situation will be more predominant the more familiar the person's physical environment is and so the more accurate their world map.
[330] The key text from Section 11.3.5 is that: "Another kind of [prediction] error will arise simply if D[r]'s memory/world map lacks *capacity* to maintain *all* of the detail needed to generate a prediction, $\Xi^{(a+1)*}$, that contains *all* of the detail that will actually show up in $\Xi^{(a+1)}$ through completion of a t = a to t = (a + 1) beat of the recognition cycle. This type of error will occur even where no [major] change … has happened in W[r]. Examples of this second kind of error are empirically obvious from experience, such as when a person is surprised to find where they have left something, and in other forms of rediscovery."

Other factors will include the extent of D[r]'s raw capacity and processing power in relation to: (1) establishing and operating a hierarchical processing system, and its inherent recognition and generative models, to enable active inference through an ARC and with this to, (2) establish and operate a memory system,[331] entailing a world map, enabling an emulator to produce of arrays of proto-goal states/potential paths, and to assess these through operation of an effective ERC.

With respect to the kinds of emotions and moods discussed so far, it has been proposed[332] that these can be described in terms of the ongoing contents, pattern, and changes in pattern, in the perceived[333] 'harmonic melody'/patterns-of-willingness serially generated and perceived/felt over time as D[r] moves through its environment W[r]\D[r], where this movement prompts it via perception of affordances to generate and process proto-goal states/potential paths – one array after another – through its ERC.

To keep the presentation of ideas as straight forward as possible, these kinds of emotions and moods have all been open to explanation without any need to consider the soundness of the predictions of ds and fs substates of N[i] – and thus of willingness – being generated through the ERC for any particular proto-goal state/potential path, array of these, or sequence of arrays of these. In other words, the preceding proposals to do with emotion and mood have all de facto assumed sufficient degrees of accuracy and precision in the predictions of ds and fs substates of N[i], to allow a de facto assumption that all of the willingnesses, relative willingnesses, and serial patterns of willingnesses that have been described have been sound.

Clearly though, a person's relative level of well-being – perhaps at times their survival – will depend on how well their D[r] is able to predict ds and fs across the members of the arrays of $\Xi^{\tau i}/Þ^{\tau i}$ it is generating in response to its environment. Moreover, due to the plethora of factors described in earlier paragraphs of this section, *some* degree of error – perhaps at times large – is likely to arise in those predictions.

Serial high levels of error in the accuracy of predictions of ds and/or fs could lead a person serially to experience high relative willingness to seek goals and take paths that fail to deliver predicted rewards (ds accuracy error) or are far harder to achieve than anticipated (fs accuracy error).[334] A person experiencing these types of error serially would be observed to have *poor judgement*.

A question then arises as to how most people seem to be able reliably to make reasonably good decisions about what courses of physical action to take – and goals to seek – despite variations in the soundness of the ds and fs 'chords'/substates they 'hear'/feel when envisaging one or another $\Xi^{\tau i}/Þ^{\tau i}$.

Introspection suggests the answer is likely to be that the 'chords' ds and fs, and the resultant 'chord harmony' {ds and fs}, for any given $\Xi^{\tau i}/Þ^{\tau i}$ will have a 'sound quality'/substate property that is 'heard'/sensed as *uncertainty* about the degree of willingness being felt. The intensity of this sense of uncertainty – or sense of *doubt* – will be a perception of the degree of precision in the substates ds and/or fs, and therefore of {ds + fs} as a whole, being predicted for any given $\Xi^{\tau i}/Þ^{\tau i}$. Here high (or low) precision in any ds or fs predicted through one or more beats of the ERC would be perceived by D[r] – from the perspective of its inference of itself as D[a] – as an attendant feeling of low (or high) uncertainty[335] in how much willingness it is feeling towards the proto-goal state/potential path being envisaged through the course of those beats of the ERC.

On this basis, if all of the relevant systems in D[r] are well tuned, the extent of the feeling of uncertainty – as defined above – attending any feeling of willingness should provide a person with a sound sense of the range and degree of possible error around how much willingness they are feeling in envisaging taking a particular path in pursuit of a particular goal. This sense of uncertainty will play into a sense of how much of a risk – of how much of a relative gamble – a person would feel they were taking if they were to adopt a high-uncertainty $\Xi^{\tau i}/Þ^{\tau i}$ as their ${}^{1}\Xi^{\tau i}/{}^{1}Þ^{\tau i}$. People who have *good judgement* – i.e. serially make sound decisions – will have a well-tuned ability to perceive uncertainty and perceive this in a way that appropriately tempers their perceptions of willingness.

[331] This is the system described as memory in Section 11.2.
[332] See in particular Section 12 for a full account of this.
[333] Perceived by D[r] – from the perspective of its inference of itself as D[a] – as serial substates {ds + fs} arising in its need image N[i].
[334] Or equally, a person could experience inappropriately low relative willingness to seek highly rewarding goals that would be easy to achieve.
[335] Where, to translate, this will be perceived by a person – i.e. by a D[r] from the perspective of its inference of itself as a D[a] – as uncertainty in relation to how strongly they want to adopt/avoid a certain course of action (potential path) or achieve/avoid a certain goal (proto-goal state).

One circumstance where a person might adopt a high-uncertainty $\Xi^{\tau i}/Þ^{\tau i}$ as their ${}^{1}\Xi^{\tau i}/{}^{1}Þ^{\tau i}$ would be where the mode of the willingness they feel towards that $\Xi^{\tau i}/Þ^{\tau i}$ is at a much higher magnitude on the unwillingness-willingness spectrum than the modes of willingnesses they feel for all other available $\Xi^{\tau i}/Þ^{\tau i}$, even where those other $\Xi^{\tau i}/Þ^{\tau i}$ are perceived to have a much lower sense of uncertainty in the willingnesses they are evoking, and where their modes fall within the lower end of the error distribution for the high-uncertainty $\Xi^{\tau i}/Þ^{\tau i}$. There would be a feeling that the chance of attaining a high value goal is 'worth the risk' of perhaps finding it harder to get than estimated, or perhaps finding it of less value than estimated.[336]

The essential observation to make concerning circumstances of this kind is that whether or not a person has good or poor judgement will not be revealed by one such higher uncertainty "roll of the dice" but by whether, over many such rolls of the dice, they achieve ongoing higher relative B[r] well-being than they would have had they accepted less risk.

16 Free will

The note *How is Free Will Possible?*[337] sought to show that a person's conscious formulation and implementation of actions in the physical world is not *causally driven* by the sensory input that they receive at any given moment although it will be *informed* by it.

Whether or not this is so, showing that a person's formulation and implementation of actions in the physical world are not deterministically driven by the momentary sensory input they receive does not squarely address the deeper question of how free will might exist in a universe that seems likely overall to be deterministic at the noumenal level of W[r], as evidenced by the successive development of ever more effective scientific theory as applied to W[z],[338] where so far such theory is consistent with determinism, eternalism and a Block Universe.[339]

In such a universe, even if momentary sensory input does not determine motor output, some configuration of information inputs and information processing arrangements must do so. If this is accepted, key questions then become:

(1) Are any choices being made, and if so about what and how?
(2) Does the way we experience making choices entail an illusion of free will?

The conceptual framework and ideas developed above in relation to willingness, including how it is generated, perceived and implemented by D[r] in making decisions, provide answers to these questions.

Recalling the discussion of 'what it is like' provided in the closing paragraphs of Part 2, it is useful to revisit a key paragraph from there, which states that:

> "If it is accepted that a D[r] … can inferentially experience itself as a D[a], and that the form and general contents of that experience will be phenomenal experience, including in the overall form illustrated through use of sphere world diagrams, then it can be proposed at the most general level that:
>
> - When a D[r] inferentially experiences itself to be a D[a], this is 'what it is like' to be an operating D[r]
>
> where experiencing itself to be a D[a] will be to experience being a 'self'[340], and will – from the perspective of such a self – encompass experiences of 'what it is like' to have all of the conscious, subjective, phenomenal experiences that a person has."

On this basis we can say that when a D[r] experiences itself as a D[a] it experiences its 'self' as being a person, in just the same sense that you or I experience ourselves as being a person.

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[336] Where 'finding it harder to get than estimated' means that the mode of the fs estimate is subsequently found to have helped invoke a higher willingness than it turns out should have been the case, and where 'finding it of less value than estimated' means that the mode of the ds estimate is subsequently found to have helped invoke a higher willingness it turns out should have been the case.

[337] For *How is Free Will Possible?* see https://teleodyne.com/free_will.pdf.

[338] For definitions and an explanation for this assertion see *The Construction of Phenomenal Time* – including footnote 5 – at https://teleodyne.com/time.pdf and Appendix 1 at https://teleodyne.com/working_note_A_appendix_1.pdf.

[339] See for example, Sean Carroll at https://www.youtube.com/watch?v=KYfFCApo-Rg&list=PLrxfgDEc2NxZJcWcrxH3jvjUUrJlnoyzX&index=11. For a penetrating and germane discussion see also 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 for a sense of related contemporary ideas and discussion see, for example, Vaccaro, J.A. (2018) The Quantum Theory of Time, the Block Universe, and Human Experience *Phil. Trans. R. Soc. A 376*: 20170316 and Slavov, M. (2020) Eternalism and Perspectival Realism About the 'Now' *Foundations of Physics 50* 1398-1410.

[340] Where, more precisely, being a D[a] can be viewed as being a 'self-model' of {D[r] in W[r]} run at the noumenal level by D[r] within D[r], by means described in the body of the text, and where D[r] – when making reports about itself – will, as proposed in Section 10.5.1, refer to itself (to its self-model) as "I".

With this in mind, we can ask of introspection 'what it is like' to experience exercising free will. On the face of it, the answer seems simply to be that we equate free will with our expectation – based on experience – that when we are presented with options for future action we are 'free to choose' from among those options.

This is surely as it seems. But consistent with the overall thesis developed in this note, it can be further proposed that in making such 'choices', we will *always* choose the option that we feel most willing to adopt,[341] and that we will decide how willing we are to take one option over others *not* by *choosing* – but by perceiving/feeling/discerning – our relative degree of willingness to adopt that option over others.

To expand and recapitulate at the objectified level of the thesis developed in this note, the overall process within which a person makes a choice will be that:

- The emulator in their D[r] will over time serially and spontaneously generate new arrays of proto-goal states/potential paths.[342]

- D[r] will then, for each of these, serially envisage from the perspective of its inference of itself as a D[a] – through operation of the emulative recognition cycle (ERC) – each of the proto-goal states/potential paths that make up those arrays.[343]

- In so doing D[r] will – from the perspective of its inference of itself as a D[a] – serially 'hear'/feel/perceive each 'chord harmony'/emotion/N[i] substate {ds + fs} evoked by each envisaged proto-goal state/potential path in the context of an unfolding 'harmonic melody'/series-of-feelings of relative willingnesses to adopt one or another proto-goal state/potential path from out of such arrays.[344]

- Once D[r] has – from the perspective of its inference of itself as D[a] – perceived/felt/discerned its relative willingness to adopt one proto-goal state/potential path over all others, that proto-goal state/potential path will be adopted by D[r] as its prevailing proto-goal state/preferred path.

- At the subjective, phenomenal level of D[r]'s inferential experience of itself as a D[a] – i.e. from its perspective of being a person – it will, at that moment of adoption, experience itself as having freely chosen to adopt, from all of the options presented to it, that option it has felt most willing to adopt.

To be entirely clear:

- It will seem to a person – i.e. to a D[r] from its inferred perspective of its 'self' as a D[a] – as they envisage proto-goal states/potential paths and seek to perceive varying degrees of willingness to adopt one or another of these – that they are exercising 'freedom of choice' when they 'choose' to adopt the proto-goal state/potential path that they feel the most willing to adopt,

- even though all of the proto-goal states/potential paths that present to a person – i.e. that present to a D[a] for envisagement at such time as the emulator in D[r] kicks in, and are then envisaged by the person – i.e. are envisaged from the perspective of a D[a] – through D[r]'s operation of the ERC

    - will be experienced by the person as arising more-or-less spontaneously – i.e. as 'coming to mind' – *not* as having been *chosen*, and

    - will evoke feelings of relative willingness that will be perceived/felt/discerned but, again, will *not* have been *chosen*.

[341] This may seem to be a tautology, but this is not the case if it is accepted that the term 'willing' as it is used here is equivalent to the term 'willingness' as it has been defined in Sections 11.3.2 and 11.3.3.
[342] Through the process proposed in Sections 11.3.1 and 11.3.4.
[343] Through the process proposed in Sections 11.3.1 to11.3.3.
[344] (1) Consistent with proposals made in Section 11.3.3 based on 11.3.2, and (2) in relation to the analogy of music (Section 11.3.2, incl. footnote 265).

Now consider question (1) above. In all of this, are any choices actually being made? Not really. Certainly decisions are being made, but while a person may *infer* that these are being 'made by choice', they are actually being made as a determined consequence of the person's perception/feeling/discernment of their relative willingness to adopt one presented option over all others. Once that act of perceptual discernment has reached a clear enough estimate of relative willingnesses to determine a winner, a decision is made. Indeed, there is no reason to draw a distinction. The act of perceptual discernment of a winner – i.e. of which option evokes greatest willingness – can be viewed as being what a decision actually is.[345]

This process can overall be considered to be compatible with determinism at the level of W[r], since all of the 'choices' – i.e. the proto-goal states/potential paths – presented to a person are generated 'unconsciously',[342] and all of the subjectively perceived willingnesses then invoked by each of these in the running of the ERC are also generated 'unconsciously',[344(1)] where there is no reason to assume that both of these unconscious generative processes cannot be deterministic.

By this reasoning we can then say in answer to question (2) that while it may seem to us that we exercise 'freedom to choose' the best option – we don't actually choose, we *discern* – where this process of discernment is an act of perception *not* an act of choice. A choice can be said to have been made, but not through an *act* of choice, but as a consequence that simply flows from the process of estimating/perceiving greatest relative willingness to take one option over any other at that moment when a winner is discerned.

So to answer question (2) more directly, we can say that our sense of 'freedom to choose' entails an illusion of free will if the definition of free we use requires that our decision making must evade determinism at the level of W[r]. Such determinism need not be evaded in the scheme proposed above.

Consequently a new question arises: Why does it seem unsatisfactory to us, even objectionable, to hold that we do not have free will? Perhaps it is because we feel that such an assertion places in jeopardy something we value most highly in ourselves. But what is this? By introspection, the thing that seems most to be placed in jeopardy is our sense of 'freedom' – in reality, our sense of the extent of our *ability*, our *canniness* – to accurately, perhaps brilliantly, perceive/feel/discern – just which of the options presented to us we should feel most willing to adopt.

In other words, when we place value on our ability to 'freely choose' – we seem actually to be placing value on our ability 'freely' *to discern* which option, from among an array of options, *evokes our greatest willingness*. That is to say that we place value on our 'freedom to discern' (even if we call this 'freedom to choose') what we feel is the *best* from among a range of options.

So perhaps when we say we have free will we don't really mean by 'free will' that our decision-making evades determinism, we mean by 'free will' that we have what we call 'freedom to choose' what goals we will pursue and what paths we will take where, in turn, what we really mean by 'freedom to choose' is freedom to discern from among a range of options which potential goal and path we most want to pursue.[346]

[345] This is fully consistent with, and implicit in, the proposals to do with decisions based on relative willingness described in Section 11.3.3.
[346] Where 'most want' is equivalent to 'feel the most willing' is equivalent to 'feel the most willingness'.