# Definitions[1]

## 1. Terms for noumena and phenomena

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| U | The universe, everything there is. |
| W[r] | The *noumenal world* – or *absolute world* – is that component of U that underlies appearances but does not include appearances. It is the source of information capable of sensory perception, regardless of whether an observer is present to perceive that information. This includes any 'hidden states' that can constitute the 'hidden causes' of sensory input, as referred to in the *Predictive Processing Paradigm* (PPP).[2] Denoted $W_r$ in the Main Essay (the Essay).[3, 4] |
| B[r] | The *noumenal body* – or *absolute body* – is that component of a person that exists as a subset of W[r]. Denoted $B_r$ in the Essay.[3] |
| W[r]\B[r] | The *noumenal environment* – or *absolute environment* – is that component of W[r] which is the set of all subsets of W[r] other than the subset B[r].[5] |
| Entity[r] | The noumenal – or absolute – component of any object, thing or process; for example it is expected that W[r] will contain subsets that are rocks[r], brains[r], wind[r], gravitation[r] etc. (Denoted $rocks_r$, $brains_r$ etc. in the Essay.[3]) Strictly, within the PPP any specific entity[r] will be made up of those hidden states that give rise to the hidden causes of the specific sensory input that evokes a person's perception of a specific correlate entity[i]. |
| W[i] | The *phenomenal world* – or *world image* – is the physical world as a person subjectively, consciously experiences it. |
| B[i] | The *phenomenal body* – or *body image* – is a person's physical body as they subjectively, consciously experience it. B[i] is a subset of W[i]. |
| W[i]\B[i] | The *phenomenal environment* – or *environment image* – is that component of W[i] that a person subjectively, consciously experiences as their physical environment. It is the set of all subsets of W[i] other than the subset B[i]. |
| Entity[i] | The phenomenal – consciously experienced – component of any object or thing, including any process; for example, your W[i] will contain rocks[i], brains[i], wind[i], gravitation[i] etc. (Designated $rocks_i$, $brains_i$ etc. in the Essay.[3]) Note that entities[i] will be subjectively, phenomenally experienced as elements within each person's individual W[i] or as patterns of transformation over time of those elements. |
| B[r] in W[r] | Denotes a person's noumenal body *in situ* in the noumenal world. Also denoted {B[r] in W[r]}, B[r] in W[r]\B[r] and {B[r] + W[r]\B[r]}. |

[1] These definitions, although serving as Appendix 1 to Working Note A, apply equally to all material at https://teleodyne.com/. Note also that an extensive account of what is meant by W[r], B[r], W[i], B[i] and W[z], and of the utility of the concepts underlying these terms, is provided at https://teleodyne.com/deconstructing_the_physical_world.pdf.
[2] For example, references to 'hidden states' and 'hidden causes' made in Ramstead, M.J.D. et al. (2020) A Tale of Two Densities: Active Inference is Enactive Inference *Adaptive Behaviour 28* pp225-239 and Friston, K. (2010) The Free Energy Principle: A Unified Brain Theory? *Nature Reviews, Neuroscience 11* pp127-138. The meaning of the phrase Predictive Processing Paradigm (PPP) is provided in Section 1 of Working Note A – Part 1, and see Section 2 of this appendix.
[3] The Essay is at https://teleodyne.com/main_essay.pdf.
[4] N.B. The notation W[r], B[r], W[i], B[i] etc. is entirely equivalent to the notation $W_r$ $B_r$, $W_i$, $B_i$, $W_r$ etc. used in the Essay.
[5] Where the notation '\' has the same meaning as in set theory.

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| B[i] in W[i] | Denotes a person's phenomenally experienced body *in situ* in its phenomenally experienced world. Thus a person's B[i] in W[i] is their phenomenal self-model of their B[r] in W[r]. Also denoted {B[i] in W[i]} and {B[i] + W[i]\B[i]}.[6] |
| W[z] | The physical world as collectively agreed. When people, including scientists, refer to "the physical world", what is being referred to is that which we collectively agree to be the contents of our respective W[i]s. We reach this agreement by use of language, successfully coordinated collective physical actions and, for quantitative purposes, by use of agreed measuring procedures.[7] |
| $\{B[r] \text{ in } W[r]\}^{a}$ | The momentary state of a person's B[r] in W[r] at a time, t, where t = a and a is in units of one beat of the action cycle or of the recognition cycle.[8] |
| $\{B[i] \text{ in } W[i]\}^{a}$ | The momentary state of a person's – i.e. a {B[r] in W[r]}'s – phenomenal self-model, {B[i] in W[i]}, as they subjectively experience it at a time, t, where t = a and a is in units of one beat of the action cycle or of the recognition cycle.[8] |
| $\{B[i] \text{ in } W[i]\}^{a*}$ | The state of {B[i] in W[i]} *predicted* for t = a by information processing systems operating within D[r] which is within brain[r] which is within X[r] which is within $B[r]^{(a-1)}$, where $B[r]^{(a-1)}$ is the state of B[r] at t = (a – 1). |
| $\{B[i] \text{ in } W[i]\}^{aE}$ | The prediction error, or difference, between $\{B[i] \text{ in } W[i]\}^{a*}$ and $\{B[i] \text{ in } W[i]\}^{a}$, also denoted $\{B[i] \text{ in } W[i]\}^{a*} \Delta \{B[i] \text{ in } W[i]\}^{a}$. |
| $\{B[i] \text{ in } W[i]\}^{G}$ | A phenomenally experienced goal state – designated a *g state* – at which a person satisfies a physical need, such as a need for water. Such needs arise because B[r] operates to maintain internal homeostasis. In the PPP, maintenance of B[r] internal homeostasis is expressed in terms of the physical body as a system operating to minimise its free energy around a configuration of set points. |
| N[i] | The *need image*. A person's desires and other emotions as they subjectively, consciously experience them. |
| X[r] | Denotes persons nervous system[r], which houses their brain[r]. (In the Essay it is denoted X, and is given a less precise meaning.) |
| D[r] | Denotes an information processing system within X[r] that lies within a Markov blanket and that inter alia hierarchically processes exteroceptive, proprioceptive and interoceptive inputs to make and, through active inference, drive motor and other outputs into X[r], wider B[r] and W[r]\B[r]. (In the Essay it is denoted D, and is given a less precise meaning.) |

[6] {B[i] in W[i]} is equivalent to {B[i] + W[i]\B[i]}. The distinction is purely contextual. The formulation {B[i] in W[i]} is useful where discussion places emphasis on a person's phenomenal experience of themselves as a physical body, B[i], that is *integrated with and embedded in* a physical world, W[i], whereas the formulation {B[i] + W[i]\B[i]} is useful where discussion places emphasis is on a person's phenomenal experience of themselves as a physical body that is *distinct and separable from* its physical environment, W[i]\B[i].

[7] Through such means of collective agreement we form a view of ourselves as inhabiting a single, shared physical environment. Whoever you are, you believe that the physical world you experience – your W[i] – to be one and the same, by agreed measuring procedures and by all perceived contents, as the physical world which all others experience (i.e. their respective W[i]s). Thus, W[z] is the 'physical world' *as it is collectively acknowledged*. In its highest, most sophisticated, and integrated form, W[z] is the physical world as articulated in the literature of the physical sciences. Obviously, for nearly all people agreement on, and reference to, W[z] is a transparent process that occurs from an early age. So for nearly all people W[z] is simply that which they consider to be the physical world. This takes place without any reflective understanding of the possibility that such things as W[r] and W[i] may exist. For an extensive discussion of this see https://teleodyne.com/deconstructing_the_physical_world.pdf.

[8] A description of the action cycle is provided in https://teleodyne.com/free_will.pdf. The idea of a recognition cycle is described in Section 9.4.1 of Working Note A – Part 1.

## 2. Terms used in relation to the Predictive Processing Paradigm

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| PPP | The *Predictive Processing Paradigm* (PPP), where this term is used to encompass the general conceptual domains of hierarchical processing, generative and recognition models, active inference and what have been broadly identified as candidate neurological and physiological structures underpinning implementation of such things in humans and animals.[9] |
| Nodes | Cortical areas that form networks and are situated within the layers of the hierarchical processor housed within D[r].[10] Nodes are functional units within this hierarchical processor that can carry activation states. Nodes can be either unimodal or heteromodal.[11] |
| Activation state | The *activation state* of a node is defined as the state carried by that node at some moment in time, t – say at t = a – where a is one of the moments at which the hierarchical processor attains maximal balance – a.k.a. balance to near zero – between outward propagating predictions and inward propagating errors.[12] |
| Σ | The *node set*. The set of all nodes in the hierarchical processor capable of carrying an activation state. |
| Ξ nodes | *Xi nodes*. All of the nodes that carry an activation state at some moment, t = a (as above, under 'activation state'). These will momentarily form a subset of Σ. |
| Θ | The *activated node set*. The subset of Σ whose members are Ξ nodes at t = a. This can be expressed as the set $\Theta = \{a^1, a^2, a^3, a^4, \ldots, a^n\}$, where $a^1, a^2, a^3, a^4, \ldots, a^n$ denotes a list of each of the nodes carrying an activation state at t = a. |
| Ξ network | The *Xi network*. The network of all nodes that carry an activation state at t = a. This is simply a way of making it clear that the activation of Ξ nodes forms a network state across the hierarchical processor.[13] |
| Ξ state | The *recognition state*. The permutation of activation states across the Ξ network at t = a. This is also denoted simply as Ξ. This permutation can be expressed as the set, $\Xi = \{\underline{a}^1, \underline{a}^2, \underline{a}^3, \underline{a}^4, \ldots, \underline{a}^n\}$, where $\underline{a}^1, \underline{a}^2, \underline{a}^3, \underline{a}^4, \ldots, \underline{a}^n$ respectively denote the activation states of each of the activated nodes $a^1, a^2, a^3, a^4, \ldots, a^n$ in Θ. Note that for any given activated node, say $a^2$, there potentially may be many possible activation states, $\underline{a}^2$, but that at some specified time t = a, $a^2$ will carry only one of those possible states. |
| Ξ space | *Recognition space*. The space defined by the number of degrees of freedom required to express any possible momentarily activated recognition state, Ξ, as a unique position in that space. |
| Ξ locus | *Xi locus*. The position in recognition space defined by a specific recognition state.[14] |

[9] Some key references that variously introduce, explore and apply the PPP include Mesulam, M. M. (1998) From Sensation to Cognition. *Brain 121* 1013-1052; Friston, K. (2003) Learning and Inference in the Brain. *Neural Networks 16* 1325-1352; Friston, K. (2010) The Free-Energy Principle: A Unified Brain Theory? *Nature Reviews Neuroscience 11* 127-138; Hohwy, J. (2020) New Directions in Predictive Processing. *Mind & Language 35,* 209-223; Ramstead, M.J.D. et al. (2020) A Tale of Two Densities: Active Inference is Enactive Inference *Adaptive Behaviour 28* pp225-239; and Clark, A. *Surfing Uncertainty: Prediction, Action and the Embodied Mind* Oxford University Press, New York, USA 2016.

[10] This is an encompassing, multimodal hierarchical processor as envisaged by Friston, K. (2003) Learning and Inference in the Brain. *Neural Networks 16* 1325-1352, drawing on Mesulam, M. M. (1998) From Sensation to Cognition. *Brain 121* 1013-1052, as respectively illustrated in Figs 5 and 3 of Working Note A – Part 1. Placement of this processor in D[r], and within the wider context of B[r] in W[r], is shown in Fig. 8.

[11] These are nodes as described by Mesulam at ibid. For greater detail see Sections 9.1 and 9.2 of Working Note A – Part 1.

[12] See Section 9.2 of Working Note A – Part 1 for a full account of what this means.

[13] Where this networking of nodes across the hierarchical processor is via the architecture described in Section 9.2 and illustrated in Fig. 4 of Working Note A – Part 1.

[14] Here the term 'locus' is used to denote a location, where this is a position in the space described. Such a position need not strictly be a point, but could be some form of distribution around a central, highest amplitude point, consistent with probabilistic approaches to hierarchical processing.

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| Θ sub-network | *Theta sub-network*. If $\Theta = \{a^1, a^2, a^3, a^4, \ldots, a^n\}$, where $a^1, a^2, a^3, a^4, \ldots, a^n$ denote each of the nodes carrying an activation state at t = a, then this can also be expressed, $\Theta = \{a^1, a^2, \{a^3, a^4, \ldots\}, \ldots, a^n\}$, where $\{a^3, a^4, \ldots\}$ is a theta sub-network. The idea of a theta sub-network is used as a means of describing subsets of nodes within Θ, where it is proposed that these exclusively will be those nodes that carry momentary activation states where those states have one or more of their properties conferred upon them by some specific type or types of cueing/error signal being brought to balance within the hierarchical processor at t = a. An example of a Θ sub-network will be the network formed by those nodes that carry some component of their momentary activation state resulting from the hierarchical processor balancing a visual input.[15] |
| Ξ substate | A substate of Ξ will be the overall state of some subset of Ξ, say $\{\underline{a}^3, \underline{a}^4, \ldots\}$ where this is the set of momentary activation states of the nodes in a Θ sub-network $\{a^3, a^4, \ldots\}$.[15] |

[15] For further details see Section 9.3.1 of Working Note A – Part 1.

## 3. Some proposed relationships and equivalences

A central idea proposed in Working Note A – Part 1 is that the recognition state, Ξ

- which is the momentary overall state carried by the activated node set of the hierarchical processor in D[r] at those moments when an overall maximum balance is struck between inward propagating cueing signals/errors and outward propagating predictions

will provide for the overall contents of a person's phenomenal experience of reality – i.e. what they are experiencing, physically, emotionally and in all other ways to be real – in that moment.[16]

This allows the following relationships and equivalences to be drawn among the definitions provided in Sections 1 and 2 above, as follows:

Noting from Section 2 that:

$$\Theta = \{a^1, a^2, \{a^3, a^4, \ldots\}, \ldots, a^n\}$$

we can have:

$$\Xi = \{\underline{a}^1, \underline{a}^2, \{\underline{a}^3, \underline{a}^4, \ldots\}, \ldots, \underline{a}^n\} \qquad \text{E1}$$

Now define the Θ sub-network $\{\underline{a}^3, \underline{a}^4, \ldots\}$ as that network made up exclusively of those nodes that carry in their momentary activation state some component due to the hierarchical processor balancing an input/cueing signal that contains information that contributes to inference of spatial location.

On this basis, given the central idea outlined above and drawing upon Section 1, it can be proposed that:

$$\Xi = \{\underline{a}^1, \underline{a}^2, \underline{a}^3, \ldots, \underline{a}^x, W[i], \underline{a}^{(x+y+1)}, \ldots, \underline{a}^n\} \qquad \text{E2}^{17}$$

where

$$W[i] = \{\underline{a}^{(x+1)}, \underline{a}^{(x+2)}, \ldots, B[i], \ldots \underline{a}^{(x+y)}\} \qquad \text{E3}$$

given that we perceive all things that we consider to be *physically real* as existing in space.[18]

Further expressions equivalent to E2 are:

$$\Xi = \{\underline{a}^1, \underline{a}^2, \underline{a}^3, \ldots, \underline{a}^x, \{B[i] \text{ in } W[i]\}, \underline{a}^{(x+y+1)}, \ldots, \underline{a}^n\} \qquad \text{E4}$$

and

$$\Xi = \{\underline{a}^1, \underline{a}^2, \underline{a}^3, \ldots, \underline{a}^x, \{B[i] + W[i] \backslash B[i]\}, \underline{a}^{(x+y+1)}, \ldots, \underline{a}^n\} \qquad \text{E5}$$

Consider also that we know there is a subset of human phenomenal experience that is *not* perceived as existing in space, or perceived as being 'physically real' in the same way as W[i] and B[i]. Such experience includes what we perceive as desires and emotions. These are the contents of what has been defined in Section 1 as the need image, N[i].

Drawing upon the central idea outlined above, N[i] can be defined as that substate of Ξ which is made up of the activations across a Θ sub-network of nodes where those activations have *no* component contributing to an inference of spatial location.[19] So within Ξ, N[i] will be complementary to W[i]. That is:

$$N[i] = \Xi \backslash W[i] = \Xi \backslash \{B[i] + W[i] \backslash B[i]\} \qquad \text{E7}$$

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[16] This is taken from Section 9.3.1 (and see footnote 79) of Working Note A – Part 1.

[17] Where x and y are just further positive whole numbers.

[18] Where this is the phenomenal space we each perceive as containing as a distribution the contents of our world image, W[i], which has as a subset of those contents our phenomenal body, B[i].

[19] See Section 9.3.2 and 9.3.3 of Working Note A – Part 1 for examples of types of inputs to the D[r] hierarchical processor that, when balanced through predictive processing, may give rise to substates of Ξ that can contribute to inference of spatial location, or that may contribute to substates of Ξ that cannot contribute to inference of spatial location (for this latter see esp. footnote 90 in Section 9.3.3). Very broadly, inputs from exteroceptors, proprioceptors and some types of interoceptors may contribute to the former, whereas inputs from some other types of interoceptors may contribute to the latter.

## 4. Subspaces of Ξ

Recalling from Section 2 above that recognition space – Ξ space – is the space defined by the number of degrees of freedom required to express any possible momentary recognition state, Ξ, as a unique position in that space, the following subspaces of Ξ space can be defined:

κ subspace — *Kappa space, κ space*. The subspace of Ξ space defined by the number of degrees of freedom required to express any possible momentarily activated W[i] substate of Ξ as a unique position in that space. Any such unique position can be called a *κ locus*.[20]

σ subspace — *Sigma space, σ space*. The subspace of Ξ space defined by the number of degrees of freedom required to express any possible momentarily activated B[i] substate of Ξ as a unique position in that space. Any such unique position can be called a *σ locus*.[20]

ω subspace — *Omega space, ω space*. The subspace of Ξ space defined by the number of degrees of freedom required to express any possible momentarily activated W[i]\B[i] substate of Ξ as a unique position in that space. Any such unique position can be called a *ω locus*.[20]

Note then that ω space will be that subspace of κ space that excludes σ space, and σ space will be that subspace of κ space that excludes ω space; i.e.:

$$\kappa \text{ space} = \sigma \text{ space} + \omega \text{ space}$$

given that

$$W[i] = \{B[i] + W[i]\backslash B[i]\} = \{B[i] \text{ in } W[i]\}$$

noting E3, E4 and E5 above.

Similarly, a further subspace of Ξ can be defined:

ρ subspace — *Rho space, ρ space*. The subspace of Ξ space defined by the number of degrees of freedom required to express any possible momentarily activated N[i] substate of Ξ as a unique position in that space. Any such unique position can be called a *ρ locus*.[21]

As defined, all of the above subspaces are in the following relations to each other:

$$\Xi \text{ space} = \kappa \text{ space} + \rho \text{ space} = \sigma \text{ space} + \omega \text{ space} + \rho \text{ space}$$

[20] See Section 9.3.2 of Working Note A – Part 1 for a more detailed version of this definition.
[21] See Section 9.3.3 of Working Note A – Part 1 for a more detailed version of this definition.

To ground these definitions in broad terms:

a. Ξ space is a space wherein any moment of a person's total phenomenal experience – i.e. all of their perceptions in that moment, both physical and emotional – can be expressed as a position – a Ξ locus – defined by the specific Ξ state attained within the hierarchical processor within their D[r] as all of the nodes in its momentary Ξ network attain a state of upward, downward and lateral balance.

b. κ space is a subspace of Ξ space wherein any moment of a person's phenomenal experience of things distributed in phenomenal space – i.e. *all* of their perceptions of things they hold to constitute physical reality in that moment – can be expressed as a position – a κ locus – defined by a specific Ξ substate within their hierarchical processor within their D[r] as all of the nodes in its momentary Ξ network attain a state of upward, downward and lateral balance.

    i) σ space is a subspace of κ space wherein any moment of a person's phenomenal experience of their body as distributed in phenomenal space – i.e. *all* of their perceptions of their body that they hold to be physically real in that moment – can be expressed as a position – a ρ locus – defined by as a specific Ξ substate within their hierarchical processor within their D[r] as all of the nodes in its momentary Ξ network attain a state of upward, downward and lateral balance.

    ii) ω space is a subspace of κ space wherein any moment of a person's phenomenal experience of all things distributed in phenomenal space *other than* their physical body – i.e. *all* of their perceptions of things other than their physical body that they hold to be physically real in that moment – can be expressed as a position – a ω locus – defined by a specific Ξ substate within their hierarchical processor within their D[r] as all of the nodes in its momentary Ξ network attain a state of upward, downward and lateral balance.

c. ρ space is a subspace of Ξ space wherein any moment of a person's phenomenal experience of things *not* distributed in phenomenal space – i.e. *all* of their perceptions of such things as desires, appetites and emotions in that moment – can be expressed as a position – a ρ locus – defined by a specific Ξ substate within their hierarchical processor within their D[r] as all of the nodes in its Ξ network in that moment attain a state of upward, downward and lateral balance.

The main utility of the definitions provided in this section should become clear in Working Note A – Part 2.