A Theory of the Genesis of Self Awareness

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(Entries below are not in the web-posted PDF but are available on request)

Preface

The following essay began as a project to develop and analyze a new type of solution to the mind-body problem. It became clear, however, that the solution under consideration formed a departure point for development of a hypothesis on processes in the genesis of human self awareness. The objective of the essay then became development of what has emerged to be a relatively encompassing hypothesis of processes central to the genesis of consciousness, including genesis of self awareness as it is experienced subjectively and on a moment-by-moment basis.

The essay is highly speculative, and presents a series of new and untested ideas. That should not be surprising. Currently no one knows what a theory able to explain self awareness should look like, and it would be naive to expect such a theory to at first seem orthodox or easy to read.

Indeed, a strong incentive to go ahead and speculate - despite the high risk of small and large errors - has been that no intuitively satisfactory, non-trivial, overarching theory of the processes leading to genesis self awareness has been proposed. That has been despite more than two decades of massive expansion in knowledge of brain physiology and function, and a growing consensus among cognitive scientists and philosophers that human self awareness probably arises in brain-associated information processing systems. The lack of hypotheses proposing information processing systems able to generate a subjective sense of self awareness shows it should currently be useful to offer speculative material, if simply as a stimulus to others.

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A Theory of The Genesis of Self Awareness

1 *Introduction*

Materialist proposals to do with the relationship between mind and body suggest that a report of any subjective experience should be open to complete translation into a report of concurrent and correspondent changes in a subject's brain state. If that idea is sound, then it should be possible to build useful hypotheses of psychology consisting of a brain state dynamics in conjunction with a complementary dynamics of subjective experience. When properly developed, such hypotheses should propose means to translate any specific series of subjective states - for example, a sequence of perceptions, thoughts or emotional responses - into a corresponding brain state sequence.[1]

But any hypothesis describing the fundamental nexus between the inner, subjective life of a person, and the physical life of the brain and body, first should describe the process by which people can attain and practice self awareness.[2] Without that process - that is, without the genesis of self awareness - we each would be incapable of recognizing a dichotomy between physical and mental phenomena. For that reason a theory of the genesis of self awareness should precede a theory of mind and body, and should encompass a brain state dynamics in conjunction with a dynamics of subjective states.

A hypothesis describing the genesis of self awareness as a process involving the flow, processing and storage of information is developed in this essay. The hypothesis deals effectively

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[1] The potential for valid hypotheses of this type has been empirically demonstrated. Subjective states, such as pleasure, or even specific 'memories', can reproducibly be induced by physical - for example, electrical - stimulation of specific brain areas (Kalat, J. W. *Biological Psychology* p14 -15 and p334, Ed. 2, Wadsworth, Belmont CA USA, 1984.). Also, a given drug - that is, a given type of physical substance - reproducibly can produce a specific, predictable physiochemical/mood change when acting on the brain.

[2] By 'self awareness' is meant nothing more than an immediate subjective sense of being; that is, a moment-by-moment sense of one's existence; a sense one is alive, that one is awake; this can be equated with what is popularly known as *consciousness*.

with several aspects of the mind-body problem. Moreover, it establishes grounds for the provision of a single, unified explanation of both the physical and subjective aspects of human experience.

2 *Physical and Social Self Knowledge*

In the hypothesis developed, the process by which a person generates, maintains and uses a dynamic internal representation of self-in-world is considered central. To help describe that process, a distinction will be drawn between *physical self knowledge* and *social self knowledge*. Physical self knowledge is defined here as knowledge of the relationship between one's self as a body and its environment, which is the physical world. Social self knowledge is defined as knowledge of the relationship between one's self as a social participant and its environment, which is the world of interpersonal relationships.

This essay deals with the generation of an internal representation of self in the physical world, and with the associated processes which provide for the genesis and maintenance of physical self awareness. It is important to seek to understand those processes first, since they form a natural foundation for seeking to understand the more complex processes involved in the genesis of social self awareness.[3]

3 *Conscious Manipulation of the Physical Environment*

3.1 *Definition of W_r and B_r*

An initial materialist assumption will be made:

- That there exists independent of any observing subject, a single universe, U, which contains all things, including all human beings.

Now, since U is assumed to exist in its own right, a special component of U can be described - the *absolute world*, W_r - where W_r constitutes the world-in-itself; that is, where W_r is

[3] Appendix 4 contains a discussion of issues to do with genesis of social self awareness.

the observer-independent component of U, or in classical terms, the world underlying appearances and not including appearances.[4]

The component of a person manifest at the level of W_r can be called the *absolute body*, B_r. Any B_r will be a subsystem of W_r, as shown in Figure 1.

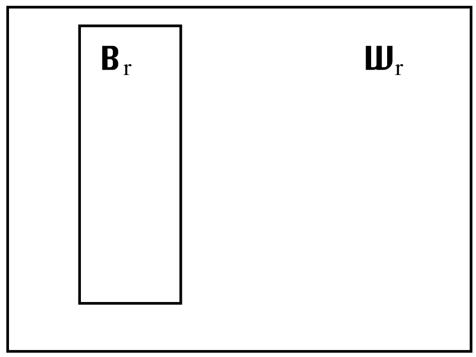

Figure 1

3.2 *Definition of W_i and B_i*

When a person acts consciously[5] to change their physical environment, the information, m, needed to achieve alteration in W_r must cross an interface from B_r into W_r. Moreover, to allow a subject to guide his action, and to monitor the emergence of the desired environmental state, an action must also involve analysis of sense data, s - where s is information passing from W_r into B_r (Figure 2).

[4] Thus W_r is U purely at the level of Kant's *noumena*. (Kemp Smith, N. (trans.) *Immanuel Kant's Critique of Pure Reason* p257-275, Ed. 2, 2nd impression, Macmillan, London, 1990.)

[5] A *conscious* action is considered here to be an action made purposefully (that is, deliberately) by someone who is aware of themselves as wanting, initiating and guiding that action.

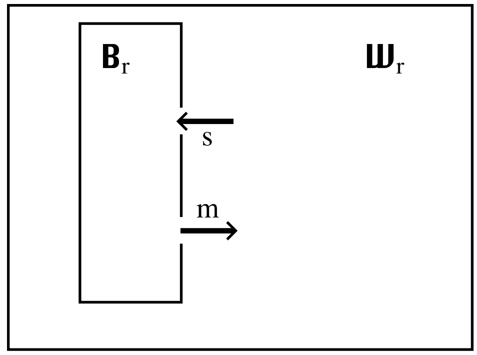

Figure 2

The ability of B_r to guide its action upon W_r through reference to information, s, passing from W_r into B_r, implies that B_r contains a *processor*, call it X, which processes s such that, by some means, a real-time representation of B_r in relation to W_r is produced within B_r. In this representation, sense data referring to W_r would be transformed into a representation of W_r we define as the *world image*, W_i. In that process, that component of sense data referring exclusively to B_r would be transformed into a representation of B_r we define as the *body image*, B_i.

To illustrate:

Study the position of your body, then reach for a nearby object and move it a few inches towards you. Return your body to its original position.

Consider the operations involved in the described action. Once a suitable object has been sighted, the hand is brought forward and configured in a way which is suitable for holding the object. Then, with the aid of touch as well as vision, the object is grasped and moved in the desired direction. With the body returned to its initial position, note that a permanent change in the environment has occurred.

Now consider the flow of information involved in the action. First, in order for you to have produced a change in W_r, there must have been a flow of information, m, from your B_r into W_r. Second, in order for you progressively to have determined the outcome in W_r, the information, m, sent through B_r must continuously have been formed with reference to information, s, emanating from W_r and received by and processed, in X, within your B_r. More precisely, the sensory information, s, must have been processed within your B_r to determine the state of a field of terms progressively *representing* the relative states of B_r with respect to W_r. Preceding this example, the field representing W_r was labeled W_i, and the subfield specifically representing B_r was labeled B_i.

For you, the subject, your view of your own action must be composed entirely of the result of the processing of s within your own B_r. Hence your hand *as viewed* must be part of your body image, B_i, and the object *as viewed* must be part of your world image, W_i. In this sense, in the course of practicing the example, you would have observed a concrete interaction between B_r and W_r by means of a perceived interaction at the *representational* level of B_i and W_i.

3.3 *Overview*

In the analysis given, a person's purposeful physical action is understood to occur at two levels. At the *absolute level* information as m flows from B_r to W_r and, as s, from W_r to B_r. At the *image level,* through operations within X upon s, a dynamic representation of B_r as it acts upon W_r is generated. At the image level B_r and W_r are represented in the form of B_i and W_i respectively. Further, at the image level the dynamic aspect of B_i operating upon W_i yields a representation of the information transfer constituted at the absolute level by m. This representation of information transfer can be denoted m_i.

Figure 3 shows the system described.

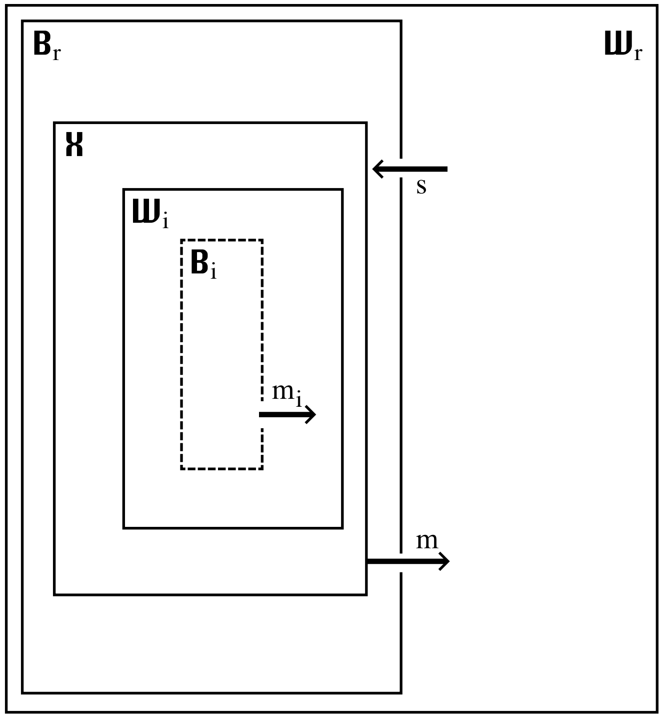

Figure 3

In Figure 3, B_r is shown lying within W_r. The passage of sensory information, s, from W_r into B_r is shown as an arrow. An arrow is also used to show motor information, m, passing from B_r into W_r. The processor X is shown lying within B_r. Since conscious movement of B_r will - as has been discussed - be generated with reference to the disposition of B_i in W_i, X is shown as the source of m, as well as the generator of W_i and B_i. B_i is shown internal to W_i, and the border of B_i is shown perforated to indicate that it is a representation of a boundary rather than a boundary at the absolute level.[6] (It is the representation of the boundary between B_r and W_r.)

[6] Since vision largely is the means by which people receive information about W_r, s here means mainly visual information. W_i can be considered to be made up mainly of what is seen.

4 *The Mind-Body Problem*

Two central questions in the mind-body problem are:

- Where is the mind? Or, where and how can thoughts be physically/spatially located?

- How can thoughts, which appear to have no physical location, and which therefore may be non-physical, interact with the body to give rise to actions?

These questions broadly can be answered in the following way.

4.1 *The Location of Mind and Mental States*

If it is accepted that the self-aware subject represents his physical body, B_r, to himself as B_i, and represents his physical environment, W_r, to himself as W_i, the absence of any obvious physical representation of 'mind' and 'mental states' seems likely to mean that those things relate to processes or conditions in B_r which either are unrepresented in B_i, or which are only poorly represented in B_i - in the latter case, presumably in the cryptic form of brain $processes_i$, $structures_i$ and $states_i$.[7] That is to say, the representation of B_r as B_i may in some ways be incomplete, or may entail *low resolution* representations of some components and processes in B_r. In particular, there may be little or no representation of processes which belong to the $system_r$ which generates the representation B_i - that is, there may be little or no representation of processes in X.

For example, the representation in W_i of a $stone_r$, and the representation in B_i of a $hand_r$ - $stone_i$ and $hand_i$ respectively - are good to the extent that they are adequate in providing information upon which to base action. But the representation $brain_i$ in B_i is a relatively useless one, capable of providing little insight - for the purposes of action or otherwise - into the function of the Br system, brainr, which it represents.

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[7] Henceforth the subscripts 'r' and 'i' will be assigned to words which respectively refer to a component or process in either W_r or in W_i. For example, a hand as observed will be '$hand_i$', and the W_r component it represents will be '$hand_r$'. Where assignment to either W_r or W_i seems obvious or unnecessary, no subscript will be shown.

Put another way, one could say that the 'grammar' by which s is expressed as W_i and B_i - that is, the grammar which expresses s in terms of space and time, and at a certain scale - is elegant for description of many B_r-W_r interactions, but is inadequate - perhaps grossly inadequate - for the description of brain processes$_r$, which are entirely internal to B_r and show up in B_i as microscopic both in terms of space and time.[8, 9]

4.2 *The Relationship Between Mental States and Physical Actions*

If the 'mental states' which drive physical actions are understood to be generated in a subsystem of B_r which is poorly represented in B_i, then the apparent mystery of the 'non-physical' source of changes in B_i, and through it W_i, can be explained as follows.

The information transferred from B_r to W_r actually is m, whereas the information perceived to be transferred is m_i (see Figure 3). If the source of considerable m output is from systems$_r$ in X which are poorly represented in B_i, then m_i will appear to lack a clear physical source. Here again, incomplete or low resolution representation of the source of m_i might exist in B_i - specifically, at the cryptic level of motor regions$_i$ within the brain$_i$.[10]

[8] Under normal conditions a person has no way of acquiring visual, auditory or tactile sensory data on their own brain$_r$. To this extent, a person's brain states$_r$ go entirely unrepresented in the space-time construction of self-in-world as B_i in W_i. This does not, however, preclude processes from occurring within B_r which in some way interpret brain states$_r$ and create an awareness of self with respect to such states. All it means is that the self image to which the potential range of interpreted brain state dispositions are attributed is not an image which can be expressed in terms of space or the 'physical'. Emotional sensation is an example of this type of 'non-physical' self awareness.

[9] Chomsky makes a similar observation with respect to human capacity to understand cognitive processes, pointing out that our capacity to understand such processes may - due to lack of appropriate evolutionary pressures - be severely limited compared to our capacity to understand other processes, for example physical processes. He believes that may explain the relative success of theories of physics compared to theories of learning. (Chomsky, N. *Reflections on Language* p3-35, Fontana/Collins, Glasgow, 1976.)

[10] Some readers may be critical of the relatively free reference which will be made in this essay to objects at the absolute level - for example to a hand$_r$ or a bicycle$_r$. One criticism might be that to refer to objects at the absolute level as if they were well known is unsustainable since things$_r$ should be considered equivalent to Kant's 'things-in-themselves' and should therefore be 'unknowable' (Stace, W. C. *The Philosophy of Hegel* p69-78, Dover Publications, New York, 1955). In fact, the view advanced in this essay is that a key aspect of the development of physical self awareness is development in the individual of a high-fidelity familiarity with objects$_r$ through practical experience with them at the level of objects$_i$. Indeed, in the hypothesis to be developed here, physical self awareness is considered to arise in the course of a progressive - but never quite complete - movement towards an 'identity of knowing

5 *The Problem of Subjective Experience*

The most penetrating criticism made of materialist theories of mind is that they inadequately explain a person's subjective experience of self. A dualist may concede that his brain states are what his mind looks like from the 'outside', but he will insist that from the 'inside' he experiences himself quite differently, and in a way that materialism has been unable adequately to describe.

An arrangement - albeit in broad terms - has been described above wherein a person can have subjective experience of themselves as a physical being. Specifically, it has been contended that B_r contains a processor X which, inter alia, works to generate a representation of self-in-world - B_i in W_i - and that, through monitoring its reflection as B_i in W_i, B_r has a means of experiencing itself. To properly address the dualist concern, this contention must now be enhanced to provide a detailed account of how processes at the absolute level - the level of B_r and W_r - can mesh with processes at the image level - the representational level of B_i and W_i - to generate a subjective sensation of existence as a physical self.

6 *Refining the Model*

In Section 3 a model was introduced to describe processes involved when a person consciously manipulates their physical environment. Since people's ability to conduct such manipulation is self evident, it was possible to assert that B_r must somehow interpret s to generate W_i and, moreover, to imply that W_i must somehow continuously be resolved in X to give B_i as a discrete component of W_i. Such resolution would have to occur, since if B_i could not be distinguished from other elements in W_i, a subject would not know which part of the world, as he perceives it, would represent his own body.

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and being', where identity of knowing and being is achieved when B_i in W_i approaches a perfect representation - for all practical behavioral purposes - of B_r in W_r. For this reason, when objects$_r$ enter into discussion in the essay, the subject - unless it is otherwise stated - is assumed to have considerable knowledge of them. True, it is knowledge at the level of representations, but these are very good representations which, as will be seen, are constantly being operationally tested for their fidelity to the objects$_r$ which they respectively represent.

Part of the key to understanding how a person can experience physical being as a subjective sensation therefore seems certain to lie in understanding how, as B_r develops, it undergoes an internal evolution - driven by $brain_r$ predisposition, and also by interaction with W_r - to acquire, and to then sustain, an operational recognition of B_i as a discrete component of W_i.

In order more exactly to describe this internal evolution of B_r - which essentially will involve the reorientation and development of processes for transferring and transforming information - the following few sections must be given over to development of an appropriate notation.[11]

6.1 *A Notation for Dynamic Fields*

The following notation deals with *fields* which are composed of *terms*, where each term may assume any one of a number of discrete values, or *states*, independently of the values respectively assumed by other terms in that field. Examples of systems fitting this description are computer random access memory (RAM) devices, a television screen, or a living retina. In the case of the television screen, for example, individual phosphor points each represent a term in the field of the screen.

The overall momentary permutation of term states within a field will be the *state* of that field. Using the example of the television screen, the momentary field state of the screen carries the picture information, and consists of the permutation of states, light or dark, of each phosphorescent term in that field.

[11] The relevance of the following definitions might not be immediately apparent, but several are central to subsequent discussion. Others are for completeness. To demonstrate general principals, and to help in familiarization with the concepts presented, additional material is provided in Appendix 5.

Structure Definitions

A	The field A, as a structure (e.g. a TV screen).
a_n	A term, as a structure (e.g. a phosphor point).
$(a_1, a_2, a_3, \ldots . a_n)$	The structure of a field, say A, expressed as its terms.
$a_n \in A$	*Term*. a_n is a term in A.
$a_n \notin A$	a_n is not a term in A.
$A \supset B$	*Subfield*. B is a subfield of A.
$A \cup B$	*Union*. A union B.
$A \cap B$	*Intersection*. A intersection B.
$A \backslash B$	*Difference*. The part of A which is not B.
[A]	*Complement*. All terms not in A.
Π	Is determined by (i.e. is strictly due to).
$\equiv$	Is in identity with (i.e. is the same as).

State Definitions

$\mathbf{A}$	The *momentary state* of the field A (e.g. a picture pattern on a TV screen).
$\mathbf{a}_n$	The momentary state of a term (e.g. the light or dark status of a phosphor point a_n on a TV screen).
$(\mathbf{a}_1, \mathbf{a}_2, \mathbf{a}_3, \ldots . \mathbf{a}_n)$	The momentary state of a field of terms, say $\mathbf{A}$, expressed as the field of momentary states of its terms.
$\mathbf{A} \supset \mathbf{B}$	*Substate*. $\mathbf{B}$ is a substate of $\mathbf{A}$.
$\mathbf{A} \cup \mathbf{B}$	*Union*. $\mathbf{A}$ union $\mathbf{B}$.
$\mathbf{A} \cap \mathbf{B}$	*Intersection*. $\mathbf{A}$ intersection $\mathbf{B}$.

Information Definitions

i	The total information content, *incon*, inherent in the structure of a field (e.g. the information held in the static distribution of phosphor points on a TV screen).
$\mathbf{i}$	The incon inherent in the momentary state of a field (e.g. the information in a picture pattern on a TV screen).
$\mathbf{i}_n$	The incon inherent in a continuous series of momentary states (n=1, 2 . . .) of a field (e.g. the information in a changing picture pattern on a TV screen).
$A(\mathbf{i})$	The incon of **A**.
${}_p\mathbf{i}$	A component of the incon, *subincon*, inherent in the momentary state of a field.
$A({}_p\mathbf{i})$	A subincon of **A**.

$A(\mathbf{i})$ can be expressed as a union of subincons:

$A(\mathbf{i}) \equiv A({}_1\mathbf{i}) \cup A({}_2\mathbf{i}) \cup A({}_3\mathbf{i}) \cup \ldots \cup A({}_p\mathbf{i})$

Where there is always B:

$\mathbf{A} \supset \mathbf{B}$ and $A({}_p\mathbf{i}) \equiv B(\mathbf{i})$

$A[{}_p\mathbf{i}]$	The subincon of **A** which is not $A({}_p\mathbf{i})$; $A[{}_p\mathbf{i}] \equiv [A({}_p\mathbf{i})] \cap A(\mathbf{i})$

Linkages Between Fields

$A \Rightarrow B$	B *maps* A. That is; there is a direct causal *link* between states of A and states of B, where information expressed in the state of A causally determines the state of B; here A is the *sender* and B is the *receiver*, and A and B are *linked fields*.

So where $A \Rightarrow B$, $B(\mathbf{i}) \Pi A(\mathbf{i})$

$A \neg B$	All of B maps a subfield of A. Again, A is the *sender* and B is the *receiver*, and A and B are *linked fields*.

That is; $A \neg B$ when there is C such that $C \Rightarrow B$ and $A \supset C$.

$A \top B$	A subfield of B maps a subfield of A.

That is; $A \top B$ when there are C and D such that $C \Rightarrow D$ and $A \supset C$, $B \supset D$.

$A \ulcorner B$	A subfield of B maps all of A.

That is; $A \ulcorner B$ when there is D such that $A \Rightarrow D$ and $B \supset D$.

Clocked Systems

In *clocked systems* a flow of information, passing as a field state from one linked field to another, can be described using the following notation.

Let time pass in discrete intervals from t_1 to t_2, t_3, t_4,. . . t_n, and let the sequence of events occurring in a set of linked fields be expressed as the sequence of field state permutations at each of those times. For example, three fields A, B and C can be such that $A \Rightarrow B \Rightarrow C$ over the interval t_1 to t_4. We can describe the flow of information in the following table:

t_1	$A(\mathbf{i}_1)$	B(-)	C(-)
t_2	$A(\mathbf{i}_2)$	$B(\mathbf{i}_1)$	C(-)
t_3	$A(\mathbf{i}_3)$	$B(\mathbf{i}_2)$	$C(\mathbf{i}_1)$
t_4	$A(\mathbf{i}_4)$	$B(\mathbf{i}_3)$	$C(\mathbf{i}_2)$

This is then one instance of the condition $t_{1\text{-}4}\,\{A \Rightarrow B \Rightarrow C\}$; call it the *serial* instance. For the serial instance we can put $t_{1\text{-}4}\,\{A \Rightarrow B \Rightarrow C\}^1$

Another instance is:

t_1	$A(\mathbf{i}_1)$	$B(\mathbf{i}_1)$	$C(\mathbf{i}_1)$
t_2	$A(\mathbf{i}_2)$	$B(\mathbf{i}_2)$	$C(\mathbf{i}_2)$
t_3	$A(\mathbf{i}_3)$	$B(\mathbf{i}_3)$	$C(\mathbf{i}_3)$
t_4	$A(\mathbf{i}_4)$	$B(\mathbf{i}_4)$	$C(\mathbf{i}_4)$

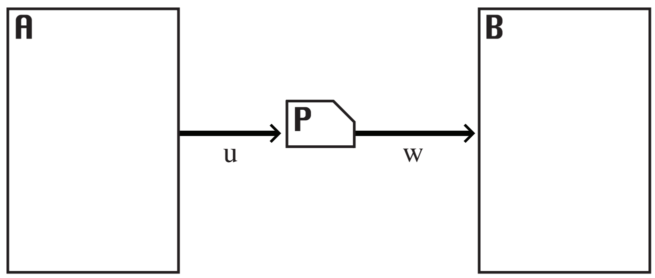
Call this the *parallel* instance, put $t_{1\text{-}4}\{A \Rightarrow B \Rightarrow C\}^0$.

More complex types of linkage between fields can be envisaged,[12] but those given above demonstrate the general concept sufficiently to serve the purpose of this essay.

[12] See Appendix 5.

Processors and Streams

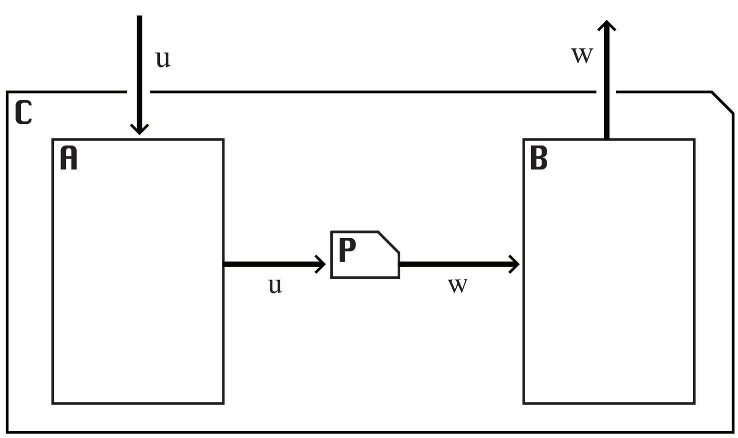
Given that incon, **i**, passes from a sender to a receiver field, and that in passage it may be processed in some way, the following schematic notation can be adopted



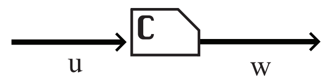
where A and B are fields, P is a *processor*, and u and w are *streams*. Streams show the source, destination and direction of incon flow.

Sometimes it will be important to recognize that to characterize something as either a field or a processor is a way of analyzing it. Hence sometimes a system might be described as a field, while in a different context the same system might be described as a processor.

Where the internal structure of a processor is partly or wholly shown, then streams may be shown passing into or out of a processor, for example



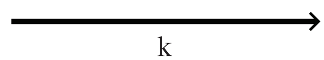
which might otherwise be shown as



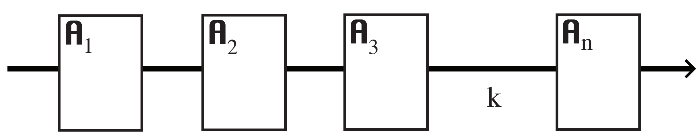
A stream can also be considered to be a series of fields,

$A_1, A_2, A_3, \ldots A_n$, where $A_n \Rightarrow A_{n+1}$

such that



is equivalent to



where **i** flowing through k is reflected in the momentary field states of $A_1, A_2, A_3, \ldots A_n$. Here the field A_n is defined as a *cross-section* of k.

Any subfield of A_n is defined as a *component* of k.

6.2 *Applying Field Notation*

Field notation can be used better to define the model given in Section 3. Figure 3 from that section is given below for reference.

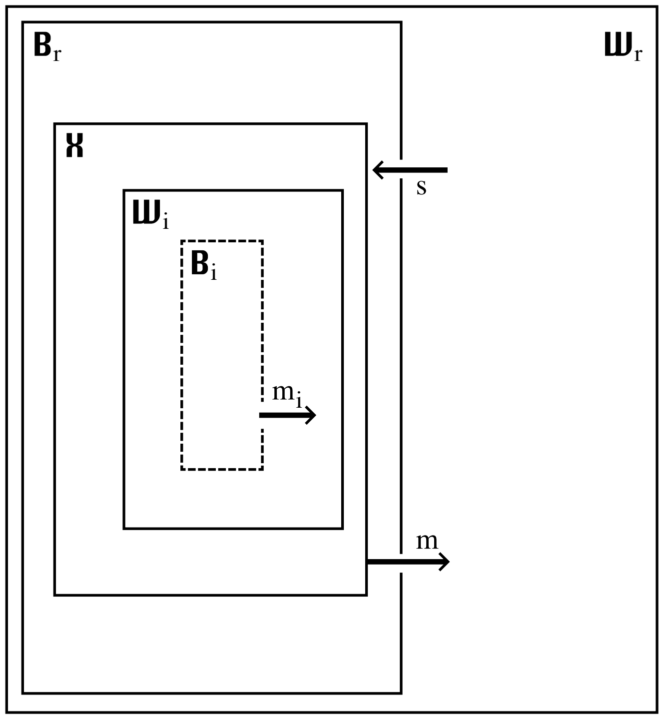


Figure 3

In Figure 3, the subsystem of B_r giving rise to motor output incon, m, is shown as X. Call X the *sensory-motor processor*.

For the purposes of further discussion, we will now extend the structure of X by assuming that within X there exists a field, the *voluntary motor field*, B_m, through whose states incon for all voluntary motor output passes.[13] Incon passing through B_m then is passed from X, via a processor, P_o, out of B_r as m.

[13] By *voluntary* motor output is meant the output which mediates conscious action (footnote 5).

Also, W_i can better be defined as a field receiving incon, κ, determined partly by s incon which has been through a processor, P_1. Say that P_1 performs certain preliminary 'sensory digestion' processes. An example of this would be retinal$_r$ processing in vision.

A diagram showing the refinement described is given in Figure 4.

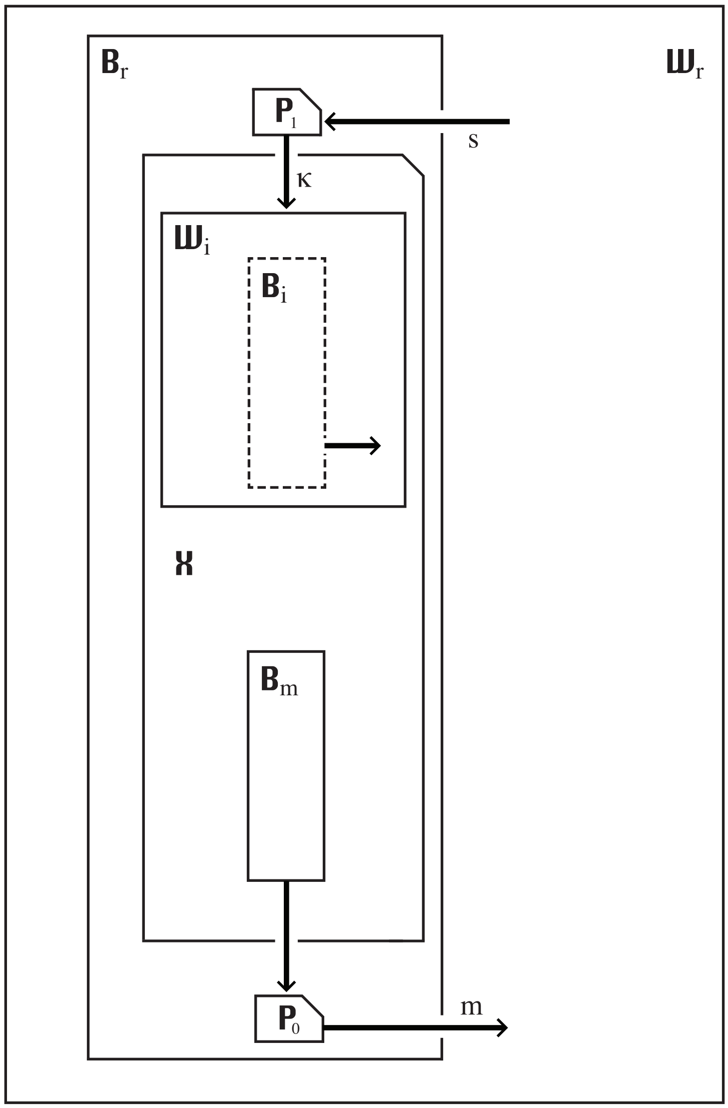


Figure 4

The system shown in Figure 4 can be characterized using field notation.[14] To begin with, W_r, B_r, W_i, B_i and B_m can be characterized as dynamic fields where the following relations apply:

Structural Relationships

$$W_r \supset B_r$$

$$B_r \supset W_i \quad \text{and} \quad B_r \supset B_m$$

Field Linkages

It is proposed that the following linkages exist

$$W_r \neg W_i \qquad \text{(L1)}$$

and

$$B_r \top W_i \qquad \text{(L2)}$$

Definition of B_s and B_i

Since

$$B_r \top W_i \qquad \text{(L2)}$$

there will exist subfields we can label B_s and B_i, where

$$B_s \Rightarrow B_i \quad \text{with} \quad B_r \supset B_s \text{ and } W_i \supset B_i \qquad \text{(L3)}$$

Call B_s the *body surface* and - consistent with earlier usage - call B_i the *body image*.

During the course of an action the terms in W_i falling within the subfield B_i will change. In this sense, B_i cannot be seen as a static structure within W_i, but is defined as the subfield of

[14] Note that in Figure 4, X is shown as a processor since, if its internal structure is ignored, X processes the stream from P_1 into the stream to P_o. B_r could have been shown as a processor since it processes s into m, but for the purposes of the following discussion B_r is best seen as a field. (See Section 6.1, ‘Processors and Streams’.)

terms within W_i which at any given moment exhibits

$$B_i(\mathbf{i}) \sqcap B_s(\mathbf{i})$$

The Relationship Between B_m and B_s

The proposed field B_m is a subfield of B_r which lies in the sensory-motor processor X, and whose states carry that **i** which is also expressed as the voluntary motor output m.

So either

$$B_m \ulcorner B_r \qquad \text{(L4)}$$

or

$$B_m \ulcorner \Delta B_r \qquad (\Delta \text{ is defined in Appendix 5 iii})$$

For the purposes of this model $B_m \ulcorner B_r$ will be adopted, though in some instances of movement $B_m \ulcorner \Delta B_r$ might be a more accurate description.[15]

[15] Evidence summarized by Kalat suggests that neurological fields$_r$ whose state changes lead to movement - and which are summarized here as one field, B_m - may be of a type where $B_m \ulcorner \Delta B_r$ or $B_m \ulcorner B_r$ depending on the type of movement initiated. Nevertheless, $B_m \ulcorner B_r$ serves present purposes. Note also $B_m \Rightarrow \Delta B_r$ is not used here since much ΔB_r is involuntary. (Kalat, J. W. *Biological Psychology* p180-200, Ed. 2, Wadsworth, Belmont CA USA, 1984.) (Note: in some editions of this text the appendices are not included. Reference to Appendix 5 is not required here since it contains ideas which are not essential to the main thesis.)

Now if

$$B_m \text{ ⌐ } B_r \qquad \text{(L4)}$$

and, as shown earlier, $B_r \supset B_s$

then we can propose the further linkage

$$B_m \top B_s \qquad \text{(L5)}$$

That is, we can propose that a part of any change in the state of B_r that maps a change in state of B_m, may also be mapped as a change in state of the subfield of B_r previously defined as B_s; i.e., as a change in state of the body surface.

The Relationship Between B_m and B_i

From the above, if

$$B_m \top B_s \qquad \text{(L5)}$$

and

$$B_s \Rightarrow B_i \qquad \text{(L3)}$$

then

$$B_m \top B_i \qquad \text{(L6)}$$

That is simply to propose that information originally expressed in states of the B_r subfield B_m, and then expressed as movement of B_r, may also partly be manifest in states of the B_r subfield B_s, otherwise called the body surface. The incon carried in this subfield will then be passed, as part of sensory input, s, through to W_i where it will be expressed in B_i.

Thus some of the information emanating from the B_r motor system X will return to B_r as part of s and will be re-expressed as incon held in the states of B_i, a subfield in W_i.

Definitions of W_f,W_s and E_i

Whether an action is intentional or involuntary, a person's motor output almost always produces a change in their environment. We can thus say B_r is in effective contact with a subfield of W_r we can define as W_f, the *world front*. Much of W_f usually is air_r.

Define W_f by the following two relations:

$$B_r \neg W_f \qquad \text{(L7)}$$

and

$$W_r \backslash B_r \supset W_f$$

Since a person often manipulates their environment through conscious actions, and such actions are guided by reference to W_i, it can be assumed that a subfield of W_f we call the *world surface*, W_s, exists such that

$$W_s \ulcorner W_i \qquad \text{(L8)}$$

There will then be a subfield of W_i, E_i, we call the *effect image,* where

$$W_s \Rightarrow E_i \quad \text{with} \quad W_i \supset E_i \qquad \text{(L9)}$$

And since

$$W_f \supset W_s$$

and

$$W_r \backslash B_r \supset W_f$$

then

$$W_i \backslash B_i \supset E_i$$

Now, since

$$B_m \ulcorner B_r \qquad \text{(L4)}$$

and

$$B_r \neg W_f \qquad \text{(L7)}$$

we can propose that

$$B_m \top W_f \qquad \text{(L10)}$$

leading to

$$B_m \top E_i \qquad \text{(L11)}$$

Here again, and in a manner analogous to that described for B_i (see L6), it is proposed that some of the information generated within the B_r sensory-motor processor X will return to B_r as part of s, to be re-expressed as incon held in the states of a subfield in W_i; in this case E_i.

To summarize, L6 with L11 gives

$$B_m \top (E_i \cup B_i) \qquad \text{(L12)}$$

The linkage L12 is a formal description of how motor information generated by, and emanating from, the brain_r is then reacquired by the brain_r in the form of information gathered through the senses_r.

7 *Development of Physical Self Awareness*

7.1 *The Newborn Child*

The waking physical behavior of adults is characterized by voluntary, conscious actions, whereas the waking actions of newborn children are made virtually without consciousness. Figure 5 shows a diagram partially representing the B_r of a newborn child (that is, of an *infant*).

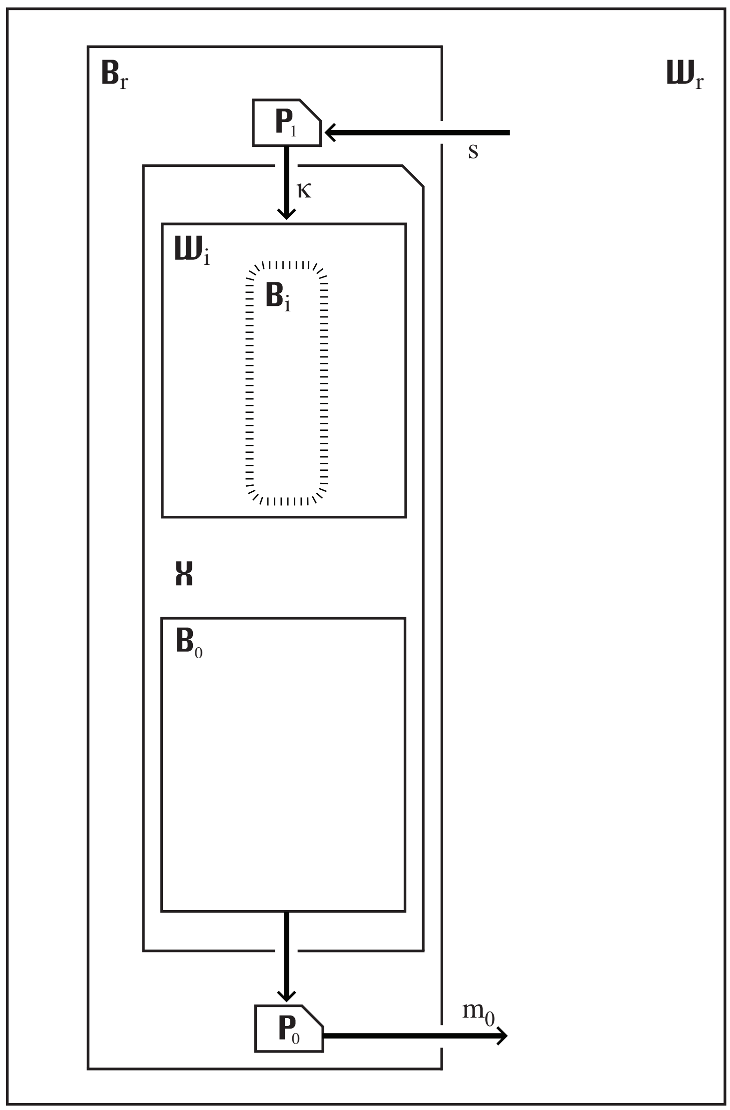


Figure 5

The differences between Figure 5 and Figure 4, which was used to describe an adult B_r, are that:

- the boundary of B_i is represented differently
- B_o is in the place of B_m
- m_o is in the place of m.

In an adult, actions can be guided by reference to a W_i which continuously is being resolved into $W_i \backslash B_i$ and B_i. By that means the subject can coordinate use of his body during voluntary action. So in Figure 4, a clear boundary is shown between $W_i \backslash B_i$ and B_i, suggesting that some processor in X - call that processor D - operates to resolve B_i from $W_i \backslash B_i$.

Infants largely are unable to resolve W_i into $W_i \backslash B_i$ and B_i. D is not well enough developed. For example, when for the first time an infant's hand passes across its field of view, the infant will be unable to 'recognize' the hand-related information represented in W_i as being part of its own physical self rather than as being just another visual pattern. So in Figure 5 the boundary between $W_i \backslash B_i$ and B_i is represented as blurred.

Despite virtual absence of physical self awareness, infants are active when awake. Their senses are operating, so there is no reason to doubt that W_i - earlier defined as causally linked to W_r (see L1) - is undergoing similar changes in state to those it would undergo in an adult exposed to similar stimuli. But because in the infant D is insufficiently developed to resolve out B_i, the infant cannot consciously coordinate its actions. In Figure 5, the *full motor field,* B_o, represents a field whose states carry that **i** which is then expressed as the sum of involuntary and voluntary motor output, m_o. And since no matter how refined a person's capacity for physical self awareness might become, some component of action remains involuntary:

$$B_o \supset B_m \quad \text{(i.e. } B_m \text{ is a subfield of } B_o\text{)}$$

with m subincon of m_o.

In the infant - where virtually all action is unconscious - B_m has yet to emerge, as has an m component of m_o.

7.2 *D; the Emergence of B_m and Resolution of B_i*

So, let the processor D be a system in B_r which, in adults, resolves W_i into $W_i \backslash B_i$ and B_i. Clearly that process of resolution will be central in enabling B_r to monitor its interaction with W_r at the image level of B_i in W_i, and will therefore be central to enabling B_r to execute properly coordinated, conscious actions.

Still, monitoring how one's body is moving with respect to the environment is complementary to another process; the process by which that movement is itself generated.

Indeed, it seems possible that physical self awareness may largely arise through a process in D which identifies a physical self as B_i in W_i, and which then uses that resolved self representation to design and construct substates in B_o which result in actions that bring about a desired change in W_i.[16] To understand how physical self awareness can develop, it would then seem important to understand how, as an infant grows, operations in D might evolve to a stage where B_m and the resolved form of B_i emerge.

On that basis, call D the *sensory-motor association center.*

7.3 *The Role of Linkage between B_o and W_i*

As an infant grows, there is an evolution into voluntary, conscious movement, implying that an increasing part of B_o is being taken up by the emergent B_m. At the same time, the means to resolve B_i out of W_i must also be evolving. Those two evolutionary processes - the emergence of B_m, and improving resolution of B_i - could be interrelated in the following way.

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[16] Such consciously constructed sequences of B_o substates will be states in the previously defined voluntary motor field B_m (Section 6.2), a subfield of B_o.

First, regardless of the infant's lack of physical self awareness, we can propose that part of the incon expressed through involuntary actions, m_o, will be represented in W_i through the linkage

$$B_o \top W_i \qquad\qquad (L13)$$

given that

$$B_r \top W_i \qquad\qquad (L2)$$

and

$$B_o \ulcorner B_r \qquad\qquad (L14)$$

So by using incon passed through the linkage L13, the earliest form of D could begin in some way to 'record' how sequences of states in W_i are affected by states in B_o. Genesis of such a 'memory' could be achieved unconsciously, through use of a pre-established neurophysiological$_r$ capacity in the infant's brain$_r$ to associate sequences of field states in B_o with concurrent sequences of field states in W_i. At the same time, associations could be made between concurrent states of subfields of W_i respectively receiving incon from the tactile, visual and other sensory pathways$_r$.

The physical processes involved in formation of such associations probably will prove extremely complex, and are likely to take years to clarify through neurophysiological studies. Nevertheless, regardless of the exact mechanisms by which such associations are recorded in the brain$_r$, a useful general and illustrative attempt can be made to characterize the evolution and key results of such associations. As will be seen, this attempt will be fundamental to the later description in this essay of an information processing mechanism by which consciousness can arise.

7.4 *Reflexive and Non-reflexive Substates in B_o*

Consider the kinds of movement made by an infant.[17] Say that while all of those movements are made unconsciously and their incon is expressed in the states of B_o, that those states can be divided into at least three substates:

- persistent reflexive
- transient reflexive
- transient non-reflexive.

Define *persistent reflexive* substates as arising as the determined, causal result of a sensory input. That is to say they result from classical reflexes, and include such involuntary reactions as withdrawal of the hand when something hot is touched. Persistent reflexes remain with a person for life. So we can say that at B_o the substates arising through a persistent reflexive action cannot be 'overwritten' by competing input from a *non-sensory source*.[18]

Define *transient reflexive* substates as occurring through a process similar to that for persistent reflexive substates, except that at B_o the substates arising through a transient reflexive action have the potential to be overwritten by competing input to the respective subfield of B_o from a non-sensory source. So, for example, infants exhibit certain reflexes which fade as they grow older.[19]

7.5 *Definition of the Drive Center, G*

Now, say that *transient non-reflexive* substates occur as a result of input not directly from any sensory source, but from a $brain_r$ site or sites, G, called the *drive center.* Define G as a processor which deterministically and promptly generates outputs to B_o by transforming its

[17] The following categorization of movement types has been made taking account of information provided in Kalat. (Kalat, J. W. *Biological Psychology* Chapter 7, Ed. 2, Wadsworth, Belmont CA USA, 1984.)

[18] Where "input from a non-sensory source" means input to B_O arising from $brain_r$ processes which are not predominantly determined by contemporaneous sensory input, s.

[19] Such reflexes may re-emerge in adults if damage is suffered to certain brain regions, or indeed if those regions of the brain are temporarily inactivated by epilepsy or other impairment. (Kalat, J. W. *Biological Psychology* p185, Ed. 2, Wadsworth, Belmont CA USA, 1984.)

inputs through reference to a physiologically$_r$ predetermined (e.g. genetically$_r$ fixed) set of internal standards. That is, the output from G will depend upon how input to G interacts with a set of fixed 'values'. Also have that the input to G is determined in real time by key physiological$_r$ conditions in B_r. So, for example, information from neurological$_r$ measurement of skin$_r$ temperature, blood$_r$ nutrient levels, B_r cell$_r$ hydration levels, and of other physiological$_r$ parameters, would form most of the input to G.

Now, assume that each of those types of input - call them *visceral inputs,* v - will at any given moment exhibit a specific 'value', and that for each type of visceral input there will exist a value range which interacts with a fixed standard in G to produce a *null output*. Respectively call each of those value ranges a *null range*. For example, if the component of v input due to skin$_r$ temperature lies within its genetically$_r$ set null range, G output to B_o due to that v input will be negligible. But equally, say that if the component of v input due to skin$_r$ temperature lies outside its null range, G sends incon to B_o. Likewise if v input components to G on blood$_r$ nutrient levels, B_r cell$_r$ hydration levels, or other physiological$_r$ states, deviate significantly from their optima, then output goes to B_o. Practically speaking, when the infant's temperature is low, or it needs food, or water, or something else, it acts.

But those actions will be relatively ill-formed. The infant cries or gesticulates in a poorly controlled way. So the motor output resulting from incon flowing from G into B_o takes - at least in the infant - the form of non-specific, undirected physical expression. Only through the help of others, and their guess-work, can the infant's needs be answered.

Still, it can reasonably be proposed that the infant's cries and unorganized actions arise, at least in part, from preliminary flow of incon through those brain$_r$ and nervous system$_r$ streams, fields and processors which eventually will develop to form the manifold through which voluntary movements are expressed.

Based on that assumption, Figure 6 extends the model shown in Figure 5 by including the drive center, G, and some other new features which are explained below. <u>Note that Figure 6 is intended to help describe only those processes associated with production of transient non-reflexive states in B_o.</u>

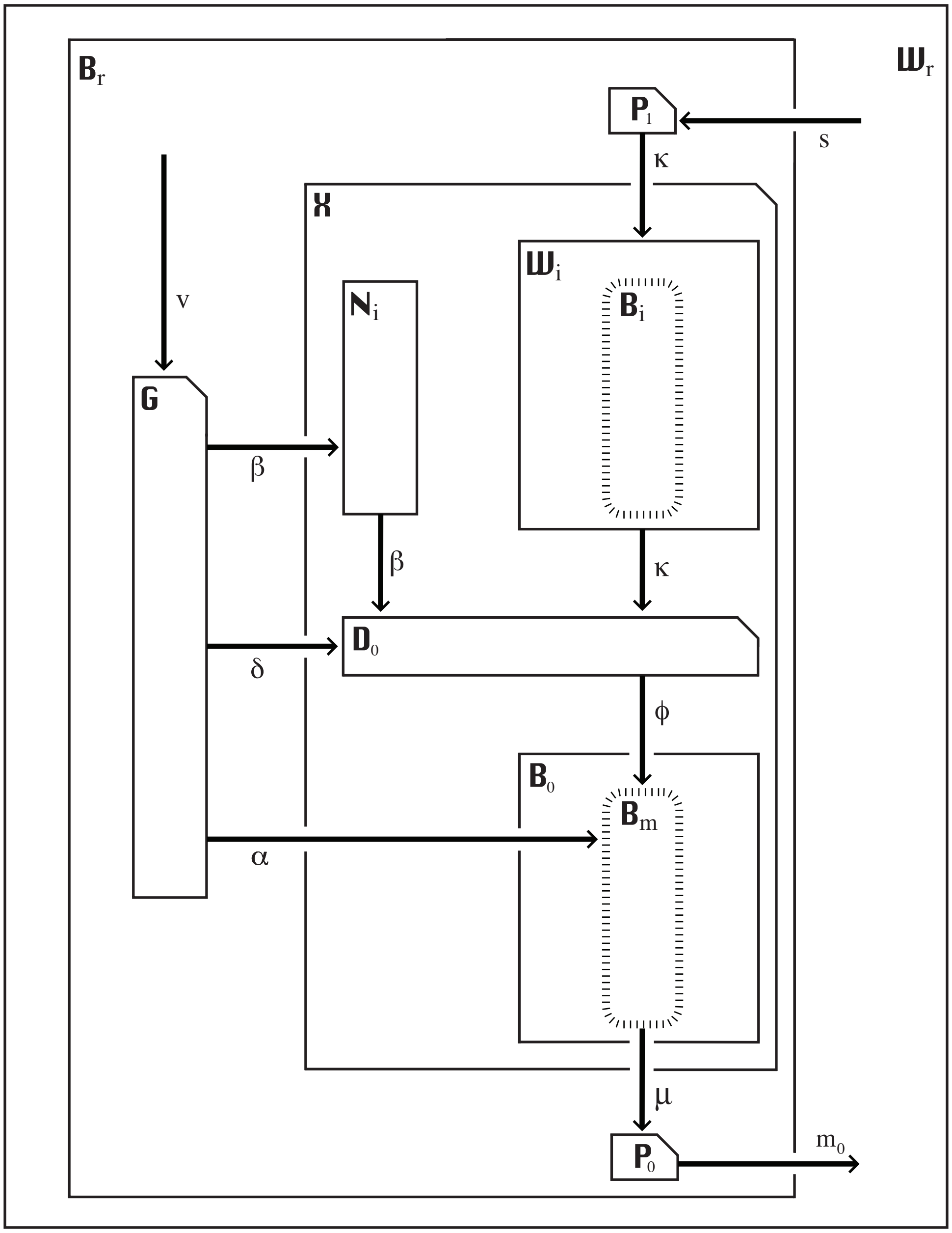

Figure 6

7.6 *Definition of D_o and N_i, and Linkages between G, N_i, D_o and B_o*

In Figure 6, v represents the stream of visceral input components to G, and D_o represents the undeveloped form of D, which in the adult is the processor through which W_i is resolved into $W_i \backslash B_i$ and B_i. As in Figure 5, a blurred boundary is used to represent poorly defined, emergent forms of fields - in this case each of the subfields Bi and Bm.

Now again consider the generation of transient non-reflexive movements in the infant. The incon flow giving rise to such movements will arise as v, undergo processing in G - as described earlier - to give rise to an output stream, α, which will in turn generate states in a subfield of B_o, and so will be expressed as part of m_o. In other words, transient non-reflexive actions of the infant - which are unconscious, and achieve little directly other than to attract assistance - result when incon is passed from G to a subfield of B_o via the stream α.

But say also that under conditions where v induces output from G, and one type of incon is sent from G as α, another type of incon is sent concurrently from G via a separate stream, β. Let β incon be reflected in the states of a field we define as the *need image,* N_i. Also say that for any **i** sent via β, there will be a unique, reproducible and correspondent **i** simultaneously sent via α.

So incon reflecting the momentary 'visceral needs' of B_r will, via β, determine the field states of N_i, and will then form an input to D_o,[20] while via α it will lead directly to transient non-reflexive actions.

7.7 *Function of n-type and p-type δ input to D_o - Basic D_o Operation*

A hypothesis describing part of the early operation of D_o can now be proposed. First, assume that D_o is built such that its level of activity is set by input from G via a third, separate stream, δ, and that when D_o is active it operates to minimize certain subincon of δ input and to maximize other δ subincon. Call those two respective types of subincon *n-type* incon and *p-type* incon. Define the δ *ratio*, $\mathcal{R}$, as the ratio of the momentary magnitudes of n-type to p-type incon and define the δ *magnitude*, $\mathcal{M}$, as the sum of the momentary magnitudes of n-type and p-type incon.

[20] Note that N_i simply is a *cross-section* of β, as defined in Section 6.1.

Now have that when all components of v input to G lie within their null ranges the flow of n-type and p-type incon to D_o will be such that $\mathcal{R}$ equals the *null ratio*, $\mathcal{R}_o$. But have that when one or more components of v incon to G move outside their respective null ranges, then $\mathcal{R}$ will deviate from $\mathcal{R}_o$. Say that the extent to which D_o is activated
by δ incon input will depend upon how far $\mathcal{R}$ deviates from $\mathcal{R}_o$, with lowest activity in D_o
when $\mathcal{R} = \mathcal{R}_o$.[21]

Now consider how the system might operate in the infant. Imagine the infant grows hungry. Input through v - say to do with blood $nutrient_r$ levels - increasingly diverges from a standard held in G. Past a threshold divergence, blood $nutrient_r$ dependent v input moves out of its null range and G begins to output through α and β, and $\mathcal{R}$ - which is the ratio of magnitudes of n-type to p-type subincon in δ - begins to increase away from $\mathcal{R}_o$. The α output results in transient non-reflexive movement of B_r, the β output results in a state in N_i characteristic of hunger, and the δ output increasingly activates D_o by delivering a greater proportion of n-type incon, which is the type of δ subincon which D_o is $neurologically_r$ configured to work to minimize.[22]

How might D_o operate to minimize the magnitude of n-type incon it receives and maximize the magnitude of p-type incon it receives? Possibly in a manner similar to the operation of a 'neural net'.[23] That is, by generating ϕ output when under activation through δ, and then stepping through different ϕ output sequences in 'search' of sequences able best to minimize n-type and maximize p-type input at δ. <u>Note that ϕ output will modify the α induced states in B_o</u>, <u>and so will modify the actions of the infant's B_r</u>.

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[21] Further description of parameters determining the level of D activity, and of what that activity might entail, is provided in Appendix 2 under *Levels of Arousal - Intensity of Desires; Excitement and Depression*. Also, it would seem reasonable - though not certain - that $\mathcal{R}o = 1$.

[22] Note that the distinction between β and δ is that β carries incon determined by the specific need, or combination of specific needs, detected in G, whereas δ carries incon determined only by the non-specific magnitude of the need. So the incon in β will be characteristic of one or more of, say, hunger, coldness, thirst etc., while there will only be a magnitude of n-type incon in relation to a magnitude of p-type incon sent to D_O via δ.

[23] Neural nets, and their training, have been described in general terms by Hinton. (Hinton, G. E. *Scientific American* **267** p105-109, 1992.)

7.8 *Recording of ϕ Output Sequences - Firmness*

Now say that D_o also has a facility for *recording* ϕ output sequences, and that the *firmness* with which a record is laid down

- will depend upon the degree of change - either an increase or decrease - in $\mathcal{R}$ occurring within a short period, call it the *proximal period*, following a ϕ output sequence, and

- will be greater, the greater the change in $\mathcal{R}$ during the proximal period, and

- for a pre-existing record, will increase each time that ϕ output of the type recorded is used and again is accompanied by the same direction of change in $\mathcal{R}$ observed on previous recording.

So, in the case of the hungry infant, receipt and ingestion of food - which would lead to a sharp reduction in the $\mathcal{R}$ value in δ input to D_o - would each time be accompanied by relatively firm recording of proximal ϕ output. Moreover, with time, the set of ϕ outputs most frequently recorded upon receipt and ingestion of food would become firmer.

Specifically to define *firmness*: the more firmly an ϕ output is recorded, the more heavily biased D_o will be either to repeat that output or to avoid repeating that output, when permutations of δ input - and more importantly β and κ input - arise which resemble those permutations in δ, β and κ input which previously arose in the proximal period. Avoidance of repeating a recorded output would accompany recordings which were made where a steep increase in $\mathcal{R}$ induced laying down of the record. Inclination to repeat a recorded output would accompany recordings made where a steep decrease in $\mathcal{R}$ induced laying down the record.[24]

[24] The type of regime described here is consistent with theories of conditioning most notably researched and developed by Pavlov, Thorndike and Skinner. (For example: Pavlov, I. P. *Conditioned Reflexes* Oxford University Press, 1927; Thorndike, E. L. *The Fundamentals of Learning* Teachers College Press, New York, 1932; Catanin, C. A. and Harnad, S. (Eds) *The Selection of Behavior: The Operant Behaviorism of B. F. Skinner* Appleton Century Crofts, New York, 1988.)

7.9 *Recording of Coproximal ϕ and κ Incon Sequences - Association Complexes*

Now let us consider the roles of β and κ inputs to D_o in more detail. So far it has been proposed that D_o is activated by ratios of n to p-type δ input magnitudes which deviate from the null ratio, and that the firmness with which any specific ϕ output is recorded will depend upon the rate of change in the ratio of n to p-type δ input magnitudes within the proximal period for that ϕ output. Now have it that just as proximal ϕ output is recorded, so are κ input sequences over the proximal period, and with the same firmness. Indeed, say that as ϕ output is recorded, the record is laid down as an *association complex* consisting of the proximal κ input sequence, as well as of the proximal ϕ output sequence.

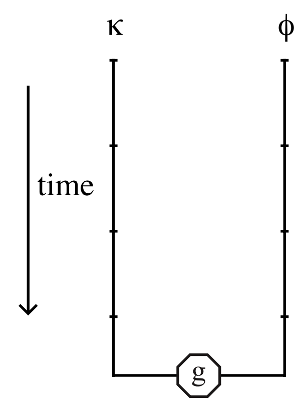

Figure 7

Figure 7 shows a schematic of part of an association complex. The left hand fork - the *κ fork* - shows the recorded proximal κ input sequence, and the right hand fork - the *ϕ fork* - shows its *coproximal* recorded ϕ output sequence. The goal state, or *g state* of κ and ϕ - where a precipitate and enduring decrease in $\mathcal{R}$ will occur - is shown at g.[25] Each *tick* on the κ fork represents a moment of recorded κ input incon, while each tick on the ϕ fork represents the near simultaneous, or *parallel* moment of ϕ output incon for the complex. The time axis gives the direction of events during recording.

[25] Hence moments of satisfaction of thirst or hunger are examples of g states.

7.10 *Operation of Association Complexes - the ρ Fork, and κϕρ Coordination*

Association complexes could be laid down such that they form the functional basis for D_o bias either towards or against repeating a recorded ϕ output. Say that a third fork, the *ρ fork* - a record of the δ input change at g, and of proximal β input - is also recorded. And say that this recording is functional, and is activated by κ input such that:

- when κ input arises resembling an input already recorded on the κ fork, the parallel ρ record acts on the relevant δ input to D_o to induce a smaller but similar change in $\mathcal{R}$ to that achieved at the complex's g state[26]

- the degree to which ρ operates to so modify δ will be greater the nearer its parallel κ tick lies to the complex's g state

- the degree to which ρ operates to so modify δ will be in proportion to how greatly current β input resembles recorded proximal β incon,[27] and

- in instances where κ input arises which resembles that already recorded at a given tick on the κ fork, and where β input matches recorded proximal β incon, but where subsequent ϕ output does not achieve the complex's g state - that is, does not achieve elimination or reduction in relevant β input and a precipitate and enduring decrease in the value of $\mathcal{R}$ - then a record will be laid down on the ρ fork weakening the ρ modification of δ induced by any subsequent round of similar κ input.[28]

[26] Note that since such 'anticipatory' change in $\mathcal{R}$ does not occur with satisfaction of a physical_r need, v won't be modified, and so δ input activation of D_O, though attenuated, will continue, and actually will grow if the physical need underlying v remains unrequited and so intensifies.

[27] Since a given g state will optimally satisfy only one need, or one specific group of needs, the β incon reflecting such need/s will be specific for a given association complex. The provision described will ensure that only association complexes with g states appropriate to satisfying the specific B_r needs of the moment are activated.

[28] This caveat is to ensure that ρ operation cannot lead to increasingly firmly recorded association complexes in

Now given that D_o is built to minimize the magnitude of n-type input and to maximize the magnitude of p-type input, ρ fork operation could act to bias D_o toward attaining g states by inducing operation of association complexes.

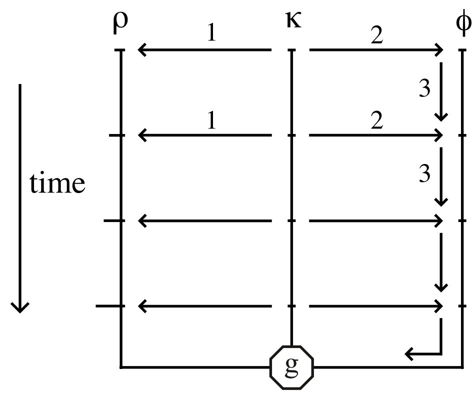

Figure 8

Figure 8 illustrates the operation of an association complex, and includes a ρ fork. The time axis shows the direction of operation of the complex.

To step through operation of the complex:

Initially, have that B_r is generating visceral input to G such that δ input is activating D_o and carries n-type subincon such that $\mathcal{R} > \mathcal{R}_o$. Also, have that from G, β input to N_i, and thence to D_o, closely resembles β as recorded in the ρ fork of the specific association complex considered. Now, say s is received which leads to κ incon which resembles κ incon recorded at some point on that complex's κ fork. Such possible κ are shown as tick marks along that fork. So, say that initial κ incon resembles that recorded at the top tick on the κ fork.

circumstances where operation of those complexes is not repeatedly attaining the 'expected' g state. The caveat is important because the g state is the only state in a given association complex where physical$_r$ needs of B_r are met. The reason for development of association complexes is to provide behavioral pathways reliably to answer such needs.

With input of such κ, activation of the corresponding coproximal ρ record will occur, as denoted by arrow 1. That will result in a relatively mild attenuation in the magnitude of n-type input to D_o such that $\mathcal{R}$ will be reduced. At the same time, with activation at a κ tick, a step of the type marked 2 will be taken, stimulating a *replaying* of the coproximal ϕ output record, where the specific ϕ output sequence induced is shown as a tick on the ϕ fork directly parallel to the activated κ tick. Now if the replayed ϕ output then does its job, it should by the step marked 3 take the B_r-W_r system through to input of s, and hence κ, corresponding to one κ fork tick mark closer to g.

At activation of that next κ tick, the cycle would begin again, but this time with the activation of a coproximal ρ tick which will lie closer to g, and hence will be able to produce a stronger attenuation of n-type input to D_o.[29]

Ideally, each tick mark would be sufficiently close to its neighbor on a fork that movement by the cycle described would allow a smooth, quasi-continuous progression down each fork, with each cycle complete within a short interval. The D_o design feature working to minimize the magnitude of n-type input would then, through that process, drive operation of the association complex through to the g state.[30]

Now, for the purpose of future discussion, call the cycle described through steps 1, 2 and 3, *κϕρ coordination*. Clearly, the repeated success of κϕρ coordination will be critical to the overall success of an association complex. Define one pass of the cycle, [. .1, 2, 3, . .], as one κϕρ *coordination beat*. *Subprocesses* of κϕρ coordination will be κϕ coordination, which will encompass only progression of the cycle insofar as it involves steps 2 and 3; and κρ coordination, which will encompass only progression of the cycle insofar as it involves step 1.

---

[29] Note that in Figure 8, the relative degree of reduction in $\mathcal{R}$ is denoted by the width of ticks on the ρ fork.

[30] The schematic in Figure 8 shows an association complex exhibiting only four sets of parallel ticks along the forks leading into the complex's g state. Native association complexes conceivably would have forks each made up of a great many more ticks.

7.11 *An Example - Animal Training*

The learning model described, while raised in the context of a developing infant, can sensibly be used to describe learning in a wide range of animals having limited, if any, self awareness. Consider learning in a dog.

Dogs can be trained to follow certain behavior sequences on command. Such training can be achieved through repeatedly

- making a command signal,
- then guiding the dog through the behavior wanted,
- then rewarding the dog.

In the proposed model, the dog would begin learning at the time of the first reward.

Define 'reward' as anything which induces the type of change in the magnitude of n and/or p-type components of δ incon which D_o is designed to seek; that is, anything which induces a significant reduction in $\mathcal{R}$. So a reward might constitute a genuine answer to a physiological$_r$ need, that is, a g state; for example food when the dog is hungry. Alternatively, a reward might constitute delivery of a sensory input, s, which would give rise to κ incon which corresponds to a κ tick which lies close to the g state on a very firmly recorded association complex.

For example, if the dog almost always is stroked, and hears the phrase 'good dog' when it is hungry and right before being fed, then that would maintain a very firm association complex such that on even a mildly hungry dog the phrase 'good dog' should, through κρ coordination, induce a 'rewarding' change in $\mathcal{R}$.[31]

After receipt of the first reward, D_o would then relatively firmly record its φ output preceding - that is, proximal to - receipt of the reward. And that φ output - which would have produced a state sequence in B_o leading to B_r movements roughly corresponding to the wanted behavior - would be recorded as the φ fork in an association complex also having a κ and ρ fork recorded and operative as described earlier. The importance of the κ fork would lie in

[31] Feeding might reduce the magnitude of the n-type component of δ input through abatement of hunger, and stroking might enhance the magnitude of the p-type component of δ input.

‘recognition’ of the command, since the top κ tick in the association complex formed due to training would be a record of that κ input arising from s due to the command.

By repeatedly guiding the dog through the wanted behavior and then administering the reward, an association complex eventually should be formed which will, via κϕρ coordination, take the dog from the command signal entirely along the wanted behavior path through to the point of reward.

On the basis of the concept of firmness developed in Section 7.8, it would be expected that with stronger rewards or punishments obedience to a command would be achieved within fewer training cycles.

7.12 *Scope*

Studying the example of animal training provides an opportunity to introduce the idea of *scope*. Define scope as a measure of the maximum range of variability in input and output accepted by D_o as admissible to a single association complex. A concept of scope is needed since:

- command signals, though always similar, will never be strictly identical, so the κ incon flowing from a command will be to some extent variable

- the ϕ output too will need to be variable, because W_r parameters will never be strictly identical.

So all association complexes must have scope at least in their κ and ϕ forks.

Interestingly, it seems possible to train animals to narrow scope in ϕ. For example, a horse may first be trained to go loosely through a dressage routine, and then further trained to fine tune its performance.

Conversely, though it is not a feature of animal training to broaden scope in association complexes, it would seem reasonable to expect that D_o mechanisms to facilitate such broadening would be useful to animals learning to operate under natural conditions.

Indeed, broadening scope in association complexes would allow:

- optimization of response to sensory stimulus (by ‘exploring’ across the scope of ϕ output, thereby finding optimum $\kappa\phi$ coordination paths to optimum g states)

- adaptation to environmental changes (again, by ‘exploring’ across ϕ output and thereby re-optimizing $\kappa\phi$ coordination paths to a ‘moving’ g state[32]).

7.13 *Limits of Association Complexes*

Animals must be limited in their capacity to develop D_o. It is useful to explore such limits, since in human beings a capacity for a relatively complete sense of physical self awareness is likely to result from capacity to transcend one or more of those limits.

At least four types of limit could exist:

- **Scope**-related; a limit on the breadth of scope in κ and ϕ which could be incorporated into any one association complex. The broader the scope, the more adaptive and generally useful an association complex will be.

- **Proximity**-related; a limit on the length of the coproximal ρ, κ and ϕ forks which may be recorded proximal to a given g state. That is, the retrospective temporal length of the trail of β[33] and κ inputs, and ϕ output, able to be recorded at the time a g state is attained.

- **Volume**-related; a limit on raw $brain_r$ capacity to store association complexes.

- **Susceptibility**-related; the threshold degree of change in $\mathcal{R}$ needed before significant firmness of recording is achieved.

It is likely that the less limited an animal’s capacity in these areas, the more adaptive, or *impressionable*, it will be.[34]

[32] An example of a literally moving g state would be a moderate change in the location of a food source.

[33] That is; β input recorded in the functional form of a ρ fork.

[34] Clearly there will be some interdependence between capacities. For example, it would be unprofitable for an animal with limited $brain_r$ capacity to operate at high susceptibility and long proximity since it would run out of $brain_r$ capacity before developing the optimum mix of association complexes for survival. Better for such an animal strictly

7.14 *Evolution of D_o - Association Matrices*

The human infant differs from other newborn animals in the following key ways:

- It is relatively ill-equipped with instinctive behaviors
- It has relatively massive brain capacity.

Those differences suggest that in human young, more than in other animals, formation of association complexes is likely to be an important and extensive process.

Moreover, in humans a facility for forming association complexes providing for especially complex κϕ coordination is likely to be needed since a large part of human behavior requires effective manipulation of the $hand_r$ - an ability which depends upon particularly subtle and sustained control.

Apart from expected superior development of κϕ coordination in human infants, their relative brain volume and their failure to be born equipped with much in the way of immediately useful instinctive behaviors, suggests there may be a compensating major enhancement in some or all of the scope, proximity, volume and susceptibility of human association complexes. In other words, compared to other baby animals, human infants should be highly impressionable.

Enhanced impressionability could lead to the following as D_o develops:

- From proximity; highly extended κ, ϕ and ρ forks

- From scope; relatively generalized and heavily *branched* κ, ϕ and ρ forks

- From volume and susceptibility; a multiplicity of association complexes, with κ, ϕ and ρ forks covering a wide sample of possible κ inputs and ϕ outputs.

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to dwell in an environment containing limited possibilities (that is, limited possible κ) wherein only relatively few and simple association complexes would be needed to cover most environmental eventualities.

Now, consider the potential consequence of this if W_r - or at least all possible s incon from W_r - is bounded in its variability, and if the impact of B_o output on W_r also is bounded in its variability.[35] Capabilities in scope, proximity, volume and susceptibility might together pass a point where a *coalescence* of association complexes could begin to occur.

Moreover, increasingly extensive coalescence might lead to a point of *transcendence* past which a single, *global association matrix*, could be formed, composed of three *submatrices*; a κ submatrix, a ϕ submatrix, and a ρ submatrix.

Figure 9 shows a step-wise schematic of branching, coalescence, and transcendence of association complexes to form a global association matrix.[36]

[35] Where *bounded variability* means that there is an 'envelope' of possibilities within which s incon will always lie, and within which the variability of s incon within a given short time interval will always lie.

[36] To avoid clutter, the coalescence of ρ forks is not shown.

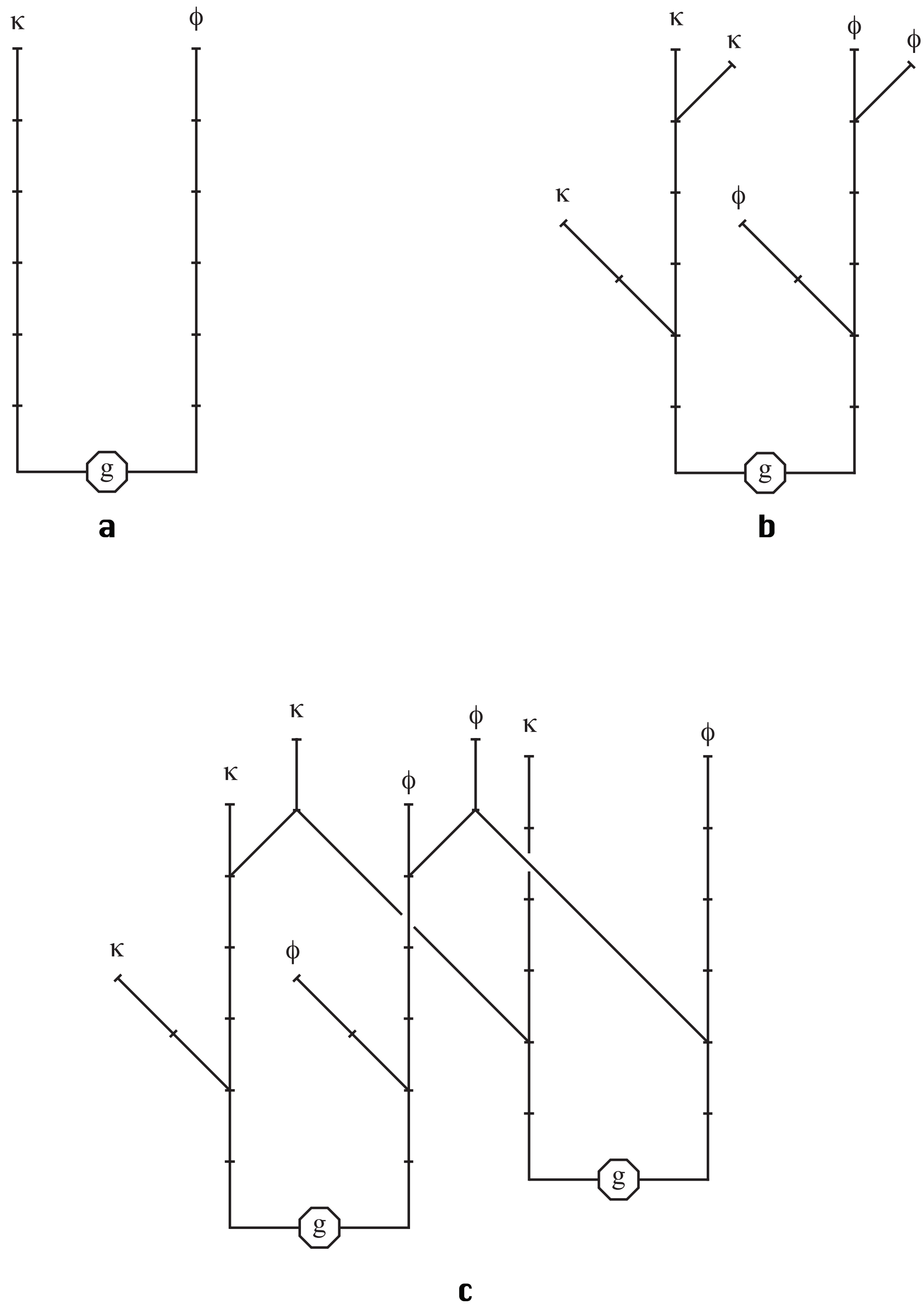
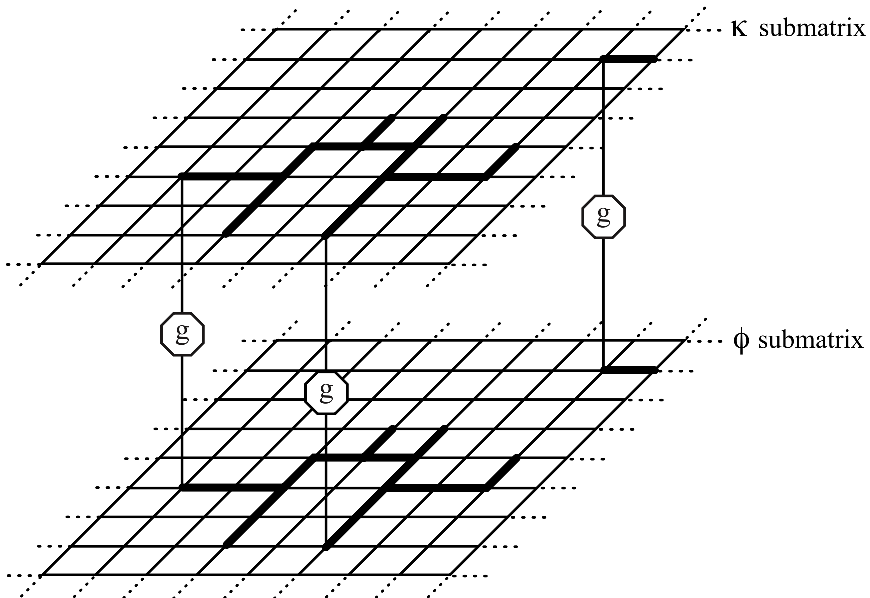


Figure 9



d

Figure 9 (cont.)

In Figure 9a a simple association complex is shown with κ and ϕ forks, and a g state. In Figure 9b, branching of the κ and ϕ forks is shown. Parallel branch patterns are shown for the forks to indicate that capacity for κϕ coordination is retained.

In Figure 9c, coalescence of two association complexes is shown. The capacity for a $brain_r$ structure to form association complexes capable of eventual coalescence would have to reflect some level of $physiological_r$ predisposition to record and organize forks in a manner compatible with, or enabling, coalescence. The $physiological_r$ foundation for such an achievement could have developed under Darwinian evolution of the nervous $system_r$, and would reflect an evolutionarily derived set of 'expectations' as to the range and boundaries of possible interactions between B_r and W_r (B_r-W_r interactions).

In Figure 9d, coalescence of association complexes is taken to the limit; transcendence. Here the ensemble of complexes in D_o are shown to have joined to form a global association matrix composed of two submatrices, a κ submatrix and a ϕ submatrix, interspersed with g states.

The bolded patterns are to indicate how association complexes like those in Figure 9c could be incorporated into the matrix. To keep Figure 9d legible, the third submatrix contributing to the association matrix - the ρ submatrix - is not shown.

Though in Figure 9d submatrices are shown as two-dimensional, a better representation would show them as many-dimensional, yet still with the parallel ρ, κ and ϕ branching needed for retention of κϕρ coordination. And rather than being alike - as suggested by the similarity of the two grids shown in Figure 9d - each submatrix would have its own specific properties. Those properties, and their operational intermeshing in the association matrix, are described next.

7.15 *Coalescence - κ Global Variables and κ Submatrix Continuity*

Assume that in human children precocious capacity in scope, proximity, volume and susceptibility quickly leads to accumulation of large, heavily branched association complexes and that coalescence then occurs. And assume that as D_o develops into D in humans, coalescence of association complexes proceeds to the point of transcendence; that is, it proceeds to formation of a single global association matrix.

Some of the properties of such a matrix may be forecast by considering in more detail:

- the mechanism by which coalescence could occur, and
- the consequences of the 'globality' of such a matrix.

First, let us examine the coalescence of κ forks. As mentioned, the capacity for a $brain_r$ structure to form κ forks capable of eventual coalescence would have to reflect some type of $physiological_r$ predisposition to record and organize forks in a manner compatible with coalescence.

Such compatibility might be achieved if, in recording κ fork incon, processes in D_o format that record to allow its expression as a set of values taken on by a finite number of independent variables. In other words, compatibility might be achieved if each unique κ tick recorded could be expressed as a unique value set in a finite number of independent variables, where all κ ticks could be described using those variables.[37] Call such a group of independent variables *κ global variables*.[38]

Now let us consider a consequence of the globality of the κ submatrix; namely that if it is ideally global, then once it has formed all κ incon entering D should fall somewhere within the boundaries of the κ submatrix. For this to apply - given that to a greater or lesser extent all subsequent κ input will be new - then for each κ tick, each of the κ global variables would need to be able to take on one of a potentially continuous range of values. In other words, in order to accommodate all potential κ, the submatrix would need to have the potential to interpret new - either intermediate or 'extramediate' - values in each κ global variable.

From this perspective, the κ submatrix can then be considered to be a continuum having dimensions equal to the number of κ global variables, and where each momentary κ incon input will correspond to a position, or *locus*, in the κ submatrix continuum. So defined, the κ locus defined by a momentary κ input will be either at:

- a *real* κ tick; that is, where that current momentary κ incon closely matches κ incon previously recorded as a κ tick

- a *near-real* κ tick; that is, where that current momentary κ incon is a modest match to κ incon previously recorded as a κ tick

- a *synthetic* κ tick; that is, where that current momentary κ incon matches a tick in the κ submatrix which can be derived only through substantial extrapolation or interpolation from real κ ticks.

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[37] The possibility of reflecting any κ input in terms of a limited number of such variables would reflect an evolutionarily derived set of 'expectations' as to the range and boundaries of possible B_r-W_r interactions, as suggested earlier.

[38] Strictly, the set of κ global variables will be a set having as its elements a finite number of independent variables whose momentary values are sufficient to describe the momentary state of a field K, where K is a cross-section of the stream κ.

Figure 10 extends Figure 9d to show at 1, a real κ tick; at 2, a near-real κ tick; and at 3, a synthetic κ tick.[39]

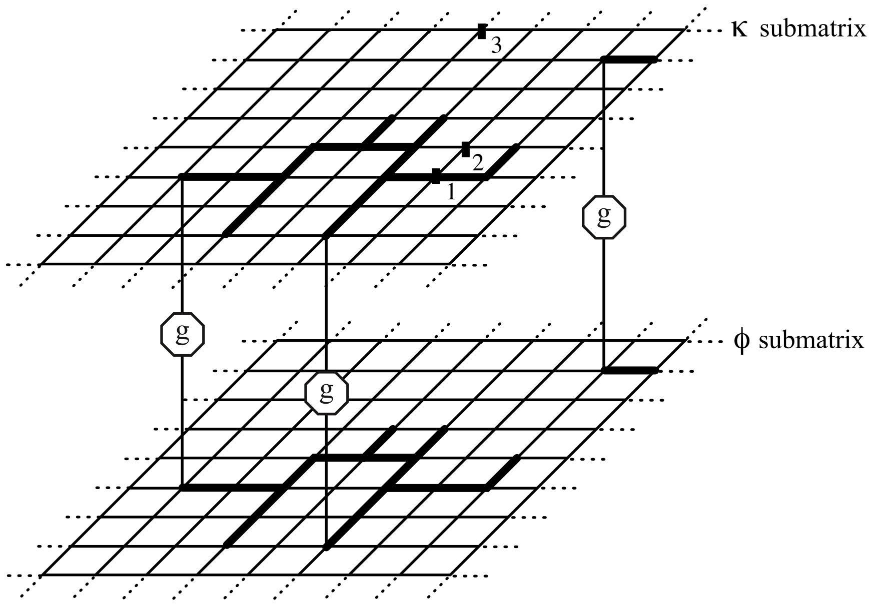

Figure 10

Figure 10 also illustrates the idea of *distance* between κ ticks. For example, the synthetic κ tick at 3 is shown as more distant to the bolded κ fork than is the near-real κ tick at 2.[40]

7.16 *Coalescence of ϕ Forks*

Transcendence to give a κ submatrix is possible only if κ input is bounded in its variability. Otherwise there could be no effective finite number of κ global variables, and so no effective coalescence of κ forks. Similarly, transcendence to form a ϕ submatrix would require that possible variability in ϕ output is bounded.

[39] N.B. In viewing Figure 10 - and other figures, including Figure 9d - the κ submatrix should be understood to be a continuum of κ ticks. The use of a grid to represent the submatrix is only a device. Accordingly, the idea is not that there should be clear cut boundaries between regions of real ticks, near-real ticks and synthetic ticks, but that there should be a smooth gradient leading from one to the other.

[40] It is reasonable to talk of distance in the κ submatrix, since transcendence has been based on the premise that any κ can be expressed as a value set for a finite number of global variables. Hence, the distance between any two κ ticks will be an expression of the difference between their respective value sets.

Accordingly, extended scope and progressively heavier branching of ϕ forks will lead to a multiplication of the range of ϕ output possibilities for most ϕ ticks. But say that extension in scope in ϕ forks reaches a point where the range of possible ϕ outputs for any given ϕ tick is no longer scope-limited, but instead is limited by bounded variability in the range of effects B_o output can have on B_r-W_r interaction.

This boundary would arise due to $physical_r$ limits on B_r. For example, dexterity is limited by $finger_r$ shape; distant objects cannot be reached immediately; levitation is not possible; some objects are too heavy to move; movement is restricted in confined spaces and on difficult surfaces.

At the stage then, where for a substantial number of ϕ ticks scope extends to the point where the range of possible ϕ outputs covers much of what is $physically_r$ possible for B_r, ϕ fork transcendence could occur. For ϕ ticks, transcendence would entail extrapolation and interpolation from ϕ output previously recorded for a tick, to give a continuous range of ϕ output options limited only by the broad $physical_r$ limits placed on B_r.

Given concurrent transcendence of κ forks to give a global κ submatrix, transcendence of ϕ forks would also allow for interpolation and extrapolation to give new, synthetic ϕ ticks, parallel to the synthetic κ ticks interpolated and extrapolated upon κ globalization. In the ideal case then, after transcendence, no matter what the κ input and the locus of its corresponding tick in the κ submatrix, there would be a parallel ϕ tick in the ϕ submatrix offering a range of ϕ outputs tailored to be $physically_r$ possible.

Essentially that would mean that from one $environment_r$ to another - that is, from one κ locus to another - the variation in $physical_r$ restraints on B_r would be reflected in the record at the parallel ϕ locus, regardless of whether that locus was real, near-real or synthetic. For example, a given κ locus may involve a specific B_r posture. Its parallel ϕ locus should then reflect only the range of possible movements out of that $posture_r$. This example is salient to the important case of κϕρ coordination for shifts in the posture of the $hands_r$. It is also relevant to whole-of-B_r κϕρ coordination, an important example being movement through difficult $terrain_r$.[41]

[41] Note that proprioceptive incon, p - that is, incon coming from the $muscles_r$, $tendons_r$, and $joints_r$ etc., and amounting to a report on the disposition of B_r - is considered in this essay to be processed in P_1 along with s to form part of κ. Despite its importance, the p stream is not shown in Figure 6, or in earlier figures, because at the stage those figures are introduced, discussion of proprioception would have been premature and possibly confusing. Proprioception has been described by Sherrington. (Sherrington, C. S.*The Integrative Action of the Nervous System* Cambridge, 1906.)

With respect to these considerations then, coalescence of ϕ forks should lead to a ϕ submatrix composed of real, near-real and synthetic ticks each providing for a range of possible ϕ outputs formed from the full complement of possible ϕ outputs less those outputs disallowed in the light of B_r disposition indicated at the parallel κ tick.

Figure 11 extends Figure 10 to show real, near-real and synthetic ϕ ticks parallel to the κ ticks described for Figure 10.

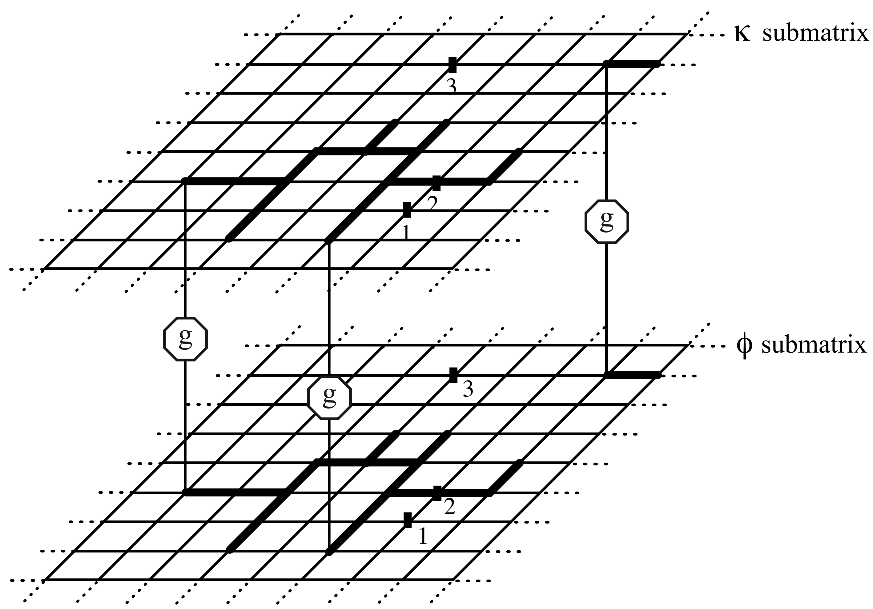

Figure 11

7.17 *The ρ Submatrix*

In association complexes, ρ fork function took D_o to a given g state by driving κϕρ coordination. Movement to a g state was dependent on reversible ρ-tick provision of a reduction in $\mathcal{R}$ as operation of κϕρ coordination homed in on a g state.

Ideally, in transcendence to a global association matrix, a ρ submatrix would form such that for each pair of parallel κ and ϕ ticks a new ρ tick could be derived by extrapolation or interpolation such that during κϕρ coordination the new tick would give the same type of return as nearby real ρ ticks, though attenuated as a function of its parallel κ tick's distance from the g state.

So transcendence would give a ρ submatrix continuum composed of sets of contours, each surrounding a g state, where the contour values correspond to the degree of reduction in $\mathcal{R}$ returned by ρ ticks on that contour. The idea is illustrated in Figure 12.

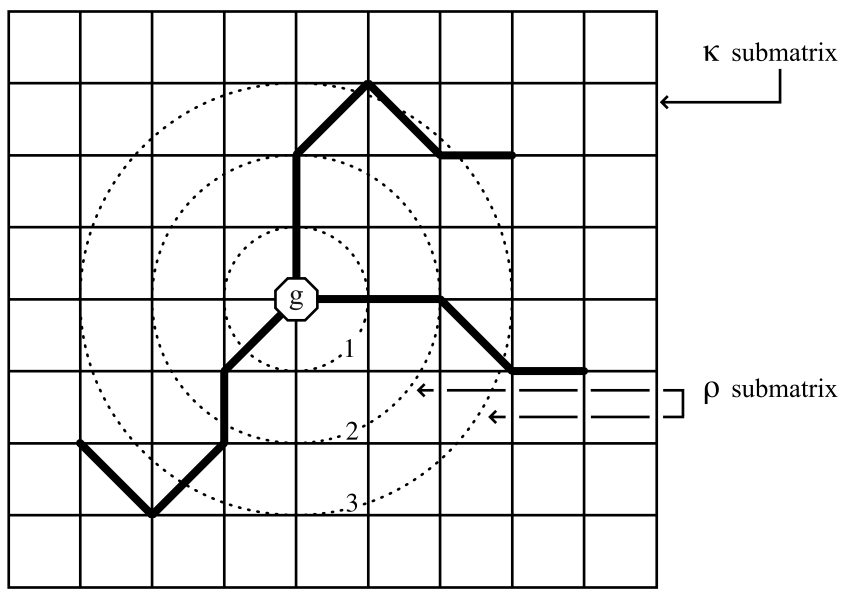

Figure 12

Figure 12 shows a section of κ submatrix containing a g state which has three branches of real κ ticks leading to it (bolded).[42] The ρ submatrix is shown superimposed as contours. As described, in this ideal association matrix, ρ submatrix contours arise purely as a function of the distance of parallel κ ticks from the relevant g state, so they are shown as concentric circles around the g state, with the order of strength of ρ-tick modification of $\mathcal{R}$ falling with distance from g, in the order 1, 2, 3.

[42] The ϕ submatrix is not shown in Figure 12 to avoid clutter.

7.18 *κϕρ Coordination in an Ideal Association Matrix*

In future discussion, the importance of describing the non-ideal character of each of the submatrices, including the ρ submatrix,[43] will be made clear. But for the time being it is instructive to describe how κϕρ coordination might operate in an ideal association matrix.

If D_o development into D were to proceed to formation of an *ideal* association matrix - that is, to an association matrix where interpolation and extrapolation worked to produce synthetic ticks as reliable as real ticks, and where real ticks performed perfectly - κϕρ coordination could consistently achieve optimum progress to any recorded g state, and more particularly to a sequence of g states corresponding to the most efficient satisfaction of the changing $physical_r$ needs of B_r.

B_r activity, including operation of the matrix, would be as described in the following example, and is a straightforward extension of the operation of association complexes described earlier.[44]

A. **Selective submatrix sensitization**

Initially, have that B_r is generating visceral input, v, to G such that δ input is activating D and carries n and **ρ**-type subincon such that $\mathcal{R} > \mathcal{R}_o$. And say that in the instance considered, the activating v were to arise purely due to B_r $dehydration_r$.

Then, from G, β input (cross-section N_i) to D, would - consistent with points made in Section 7.10 - *selectively sensitize* the δ incon record at ρ ticks in the ρ submatix near to those g states in the association matrix which were formed during past $drinking_r$; that is, during past alleviation of $dehydration_r$.

By that process, β input would selectively sensitize the whole ρ submatrix such that the highest contours (reflecting the greatest ρ tick capacity to reduce the value of $\mathcal{R}$) would lie concentrically about only those g states recorded during past $drinking_r$.

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[43] Section 7.20, 'Anisotropy in the ρ Submatrix'.

[44] Section 7.10, 'Operation of Association Complexes - the ρ Fork, and κϕρ Coordination'.

Such selective sensitization would leave other potential ρ submatrix contour patterns - for example, those sensitized by need for $food_r$ - 'turned off'.

B. Transcendent κϕρ coordination

Now consider the operation of κϕρ coordination in such a 'thirst sensitized' association matrix.

First, sensory information, s, would arrive at D as κ input. And, given the global capacity of the κ submatrix, that input would correspond to some κ tick, either real, near-real, or synthetic.

From there on, by the same process as described for operation of association complexes, κϕρ coordination would unerringly, through ϕ output operation of B_r, take D by the steepest, and therefore most direct, route up the ρ submatrix contour gradient into a g state satisfying the need for water.

C. Multiple needs

In a more complex situation, B_r might simultaneously have more than one need. For example B_r could require both $food_r$ and $water_r$.

The β incon input to D would then contain two components, one emanating from G interaction with v subincon due to $dehydration_r$, and another emanating from G interaction with v subincon due to low blood nutrient $levels_r$.

The relative magnitudes of the subincon components in β, as sent by G, would depend on which need was the most pressing. And in turn, the relative degree of ρ tick sensitization would reflect that relative magnitude.

So the ρ submatrix would then consist of the sum of two regimes of contours, one regime giving its highest contours concentrically about g states formed during past $eating_r$, and the other about g states associated with past $drinking_r$.

Again, under these more complex circumstances, κϕρ coordination would, through ϕ output operation of B_r, take D by the steepest, and so most direct route up the ρ submatrix contour gradient and into a g state.

Whether that would be a g state satisfying the need for $food_r$ or $water_r$ would depend on a number of factors beside the relative magnitude of sensitizations. Those would include:

- the ρ submatrix *geography* lying parallel to the κ submatrix region from which D began its operations. For example, if by far the closest g state was one formed by $drinking_r$, then that would be the g state reached first since it would lie at the center of the highest local ρ contours, even if distant ρ contours were much higher, and were centered about g states formed by $eating_r$

- the relative firmness with which the association complexes proximal to relevant g states had been recorded. For example, if D began operating at a κ tick equidistant in the κ submatrix to two g states, one formed by $drinking_r$, and the other by $eating_r$, the steepest ρ contour gradient could lead to the most firmly recorded of the two rather than to that proximal to the greatest degree of ρ contour sensitization.

Once a g state was reached which fulfilled one of the two B_r needs under discussion, the v input leading to sensitization of the ρ submatrix due to that need would cease. The remaining need would then be the sole focus of D activation.

Clearly, the process described for dealing with two simultaneous needs could be extended to a larger number of needs, with the potential upper limit being determined ultimately only by the number of different kinds of standard held in G. Moreover, the process would also deal efficiently with dynamic situations where different kinds of need arose at various rates, and at various times which sometimes overlapped.[45]

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[45] Note: Appendix 3 describes substance abuse and other anomalous forms of behavior as due to formation of *artificial* g states. $Heroin_r$ is described as perhaps acting directly on $neurological_r$ systems to diminish the relative magnitude of n-type δ input to D, while $cocaine_r$ is described as perhaps acting directly on $neurological_r$ systems to increase the relative magnitude of p-type δ input to D.

7.19 *Non-ideal Association Matrices*

The preceding section described operation of an ideal association matrix.

In the ideal case - that is, where evolutionary preconstruction of the neurological architecture$_r$ supporting the association matrix is perfect, and where the sample provided by κ forks recorded prior to transcendence is entirely sufficient for extrapolation and interpolation - the κ submatrix should consist of a continuum of synthetic κ ticks laced with forks of real κ ticks, where the synthetic κ ticks, and their complement of parallel synthetic ρ ticks and ϕ ticks, would be perfectly reliable for the purpose of κϕρ coordination.

Operation of such an ideal matrix would allow navigation to g states to be perfectly predictable and reliable. Essentially, after some uncertainties at the beginning of its operation - that is, after a finite sampling period for initial collection of association complexes - transcendence to D would provide an association matrix able to anticipate perfectly the outcome in κ input of any ϕ output, no matter how novel, and thereby consistently provide for flawless κϕρ coordination.

But for at least the following reasons transcendence cannot lead to an ideal association matrix:

- **Sample limit**. The sample provided by accumulation of association complexes prior to transcendence will not be large enough, or typical enough, to allow for precise extrapolation or interpolation of synthetic κ ticks. So the association matrix will contain errors. In regions near real κ ticks the errors will be small, but they may be very large in synthetic regions.

- **Unique present.** B_r-W_r conditions will never perfectly repeat themselves. So, though a κ input may to a greater or lesser extent resemble some previously recorded κ input, it will almost never exactly correspond to it - even in familiar environments$_r$. Therefore, all κ input will at best correspond to a near real κ tick. And often B_r-W_r conditions will be new, and will correspond only to synthetic κ ticks.

- **Recording limit**. The capacity of D_o and D to record κ forks, to record association complexes as a whole, and to retain such records will have limits. So unless they are revisited at some frequency, error levels may well rise even in regions of the association matrix with a high density of real κ ticks.

For those reasons, the κ submatrix - despite cumulative improvement - will never be ideal. It will, in effect, remain a working hypothesis. And the hypothetical character of a region of the matrix - that is, the probable extent of a region's imperfection - will be greater, the greater its distance from real κ ticks.

7.20 *Anisotropy in the ρ Submatrix*

The preceding discussion suggests that when a person embarks upon κϕρ coordination which takes them into a synthetic region of the κ submatrix, coordination errors will be more frequent, and probably will be more severe. Such errors could be expected to beset κϕρ coordination in both synthetic interpolated, and synthetic extrapolated, regions of the κ submatrix.

To help compensate for that reliability problem, it is reasonable to expect that some anisotropy would be built into the ρ submatrix. That anisotropy - illustrated in Figure 13 - would serve to bias κϕρ coordination paths towards regions of the association matrix rich in real κ ticks and therefore less prone to error. Figure 13 should be compared to Figure 12, which illustrates a ρ submatrix appropriate to an ideal association matrix.

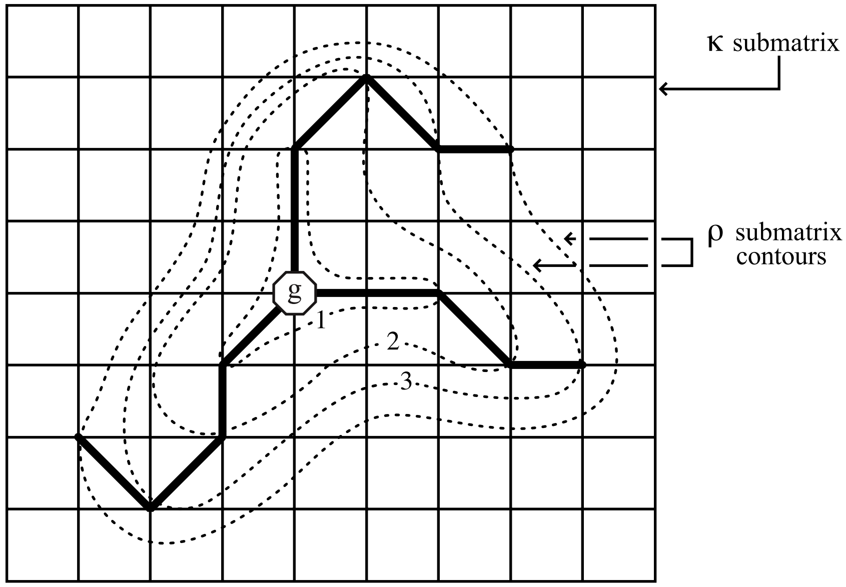

Figure 13

7.21 *Real-time Operation of Non-ideal Association Matrices - the Action Cycle*

Apart from ρ submatrix anisotropy, which is a means of avoiding exposure to matrix imperfections, let us also assume that there exist processes to 'correct' such imperfections in real time. A process for real-time correction of a non-ideal association matrix would be invaluable in enabling κϕρ coordination to get B_r through synthetic, imperfect, regions of the association matrix.

Call the process of κϕρ coordination in combination with the process of real-time matrix correction the *action cycle*. Key steps in the action cycle are outlined below. Note that the *tables* described simply are labels for memory sites, where large blocks of information can be stored, retrieved and overwritten.

Step 1) **Output from the ϕ submatrix**: defined as a ϕ incon quantum, or ϕ *phrase*. Output of this incon results in a change in B_r in its relation to W_r. (S1)

Step 2) **Input to the κ submatrix**: where s incon from W_r is received by B_r as s, and within B_r by D as a κ incon quantum. (S2)

Step 3) **Locus update**: where that κ incon quantum is used to define a new κ locus. That is, the κ incon quantum is processed into a set of values in κ global variables. (And held in table 1.) (S3)

Step 4) **Error assessment**: where the new locus (table 1) is compared to the *projected* locus (table 2), and an *error field* generated (table 3). (S4)

Step 5) **Matrix recalculation**: where, using the error field (table 3), the association matrix (table 0) is recalculated, 'pivoting' about the new locus
(table 1) which will be held as true. The freshly recalculated, *nascent* association matrix is stored momentarily in table 4, and is then passed to table 0, overwriting the previously held association matrix. (S5)

Step 6) **Next locus projection**: where the recalculated association matrix held in
table 0 is used along with the new κ locus to generate a set of possible next κ loci (multiple tables 10, 11, 12, . . . , n). The range of available next κ loci would be derived by estimating transformation of the new locus under various known ϕ output phrases enabled by the new κ locus's parallel ϕ tick. The ρ submatrix will then be used to select the optimum next κ locus, which will then be sent to table 2 and held there as the projected locus. (S6)

Step 1) **Output from the ϕ submatrix**: where the ϕ output phrase found to give the optimum next κ locus actually is sent as a ϕ incon quantum. (S1)

Define one *beat* of the action cycle as one pass through S1 to S6; i.e. [. .S1, S2, S3, S4, S5, S6, . .]. Since one beat of the action cycle corresponds to progression from one κ tick to the next, it represents the transcendent form of one κϕρ coordination beat.[46]

Let us now examine steps in the action cycle in greater detail.

[46] The definition of a κϕρ coordination beat is given in Section 7.10.

S1 will be dealt with both first and last. A quantum of ϕ output - that is, a ϕ phrase - is expressed at this step. In other words, this is the step which directly results in a change in the state of B_m and hence, via m, a change in the position$_r$ of B_r in relation to W_r. S1 corresponds to step 3 in the κϕρ coordination beat.

S2 is where a quantum of s input is received consisting of incon on the new disposition of B_r with respect to W_r. This incon, processed and combined in P_1 with a simultaneously collected quantum of proprioceptive incon, p, is received by D as a quantum of κ incon.[47] S2 corresponds to step 1 in the κϕρ coordination beat.

S3 is where D processes the quantum of κ incon delivered in S2 into a set of values in κ global variables, and then stores that set in table 1.

S4 is an important part of the matrix correction process. Here the value set defining the new κ locus (which was put into table 1 at S3) is compared to the value set defining the projected κ locus (which was put into table 2 at S6 in the previous beat of the action cycle). Say that this comparison is a computation which gives as its result an error field describing the discrepancy between the new κ locus and previously projected κ locus. And say that this error field is then stored in table 3.

S5 is the core of the matrix correction process. Here the error field in table 3 is used to recalculate the association matrix. For people experienced enough to be competent in their movements the correction will almost always be small, meaning that only ticks fairly proximal to the projected κ tick would be significantly changed. But for toddlers, these corrections could very often be large.

S6 is not a matrix correction step, and corresponds to step 2 in the κϕρ coordination beat. The idea that a whole range of possible next loci could be generated, each stored in a table, and each tested for its potential to reduce the value of $\mathcal{R}$ in δ input to D, extends of the idea of reversibility which was described in Section 7.10 with respect to κϕρ coordination.

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[47] As described in footnote 41, proprioceptive incon, p - i.e. incon coming from the muscles$_r$, tendons$_r$, and joints$_r$ etc. and amounting to a report on the disposition of B_r - is considered in this essay to be processed in P_1 along with s to form part of κ.

Returning to S1, it is appropriate now to point out that the ϕ output phrase made at this step is selected from a range of possible ϕ phrases on the basis that the association matrix predicts that that specific phrase will best reduce the value of $\mathcal{R}$ in δ input to D.[48]

Define the range of ϕ phrases available for testing at S6, and so for potential selection for expression at S1, as the ϕ submatrix vocabulary or *ϕ vocabulary.*

7.22 *Operational Resolution of W_i into B_i and $W_i \backslash B_i$*

In Section 7.2 it was proposed that physical self awareness could involve a process, in D, which identifies a physical self as B_i in W_i, and which then uses that resolved self representation to design and construct substates in B_o - specifically, states in the subfield B_m in B_o - which then result in B_r actions that bring about a desired change in W_i. Let us re-examine that suggestion.

First, consider the evolution of processing of κ incon as D_o develops into D. For each real κ tick, some component of the κ incon quantum recorded in forming the tick will be determined by incon from the ϕ output phrase immediately preceding that κ incon quantum. The relevant linkages are described in Section 6.2. The most important is

$$B_m \top B_i \qquad \text{(L6)}$$

where for conscious movements B_m will most predominantly contain a cross-section of the ϕ stream (with an α component which will be increasingly subsumed as experience accumulates); and where B_i is that partial cross-section of the κ stream which encompasses p, and all s emanating from the surface of B_r. Under L6, the component of the κ stream whose cross-section is B_i - call it the B_i component - is the component which carries back to D the effects of ϕ output on B_r posture_r.

The part of a κ-tick record which is made from the B_i component will be especially relevant to transcendence to form a ϕ submatrix. For to say that transcendence to form a ϕ

[48] In adult humans, which will have a highly developed, 'experienced' association matrix, an extended forecasting process probably occurs at S6. Such forecasting would entail assessment of the likely outcomes for whole sequences of alternative ϕ output quanta and their parallel κ incon quanta. Note that the hypothesis being developed does not preclude an indefinite degree of forward forecasting of this type. But the computational power_r needed to manage such forecasting would impose limits. The likely existence of such limits suggest that people's ability for long-range physical planning must entail other processes. Suggestions about the nature of those processes - which are likely to involve application of what can be called *semantic processing* - are provided in an essay currently in preparation.

submatrix occurs as a full vocabulary of ϕ outputs is attained - that is, where phrases in that vocabulary reliably can take B_r from any initial well-defined κ tick to any other selected from a range of possible well-defined next κ ticks - implies at least a latent capability to 'recognize' in the κ incon defining the initial tick, that incon specifically describing initial B_r posture.[49]

Development of such a latent capability could arise as follows. As coalescence and then transcendence of association complexes proceeds, the vocabulary in D_o of recorded ϕ output phrases grows larger. Each of these ϕ phrases will, as described, be recorded along with parallel κ incon to make a parallel ϕ tick. Eventually a stage will be reached where the vocabulary of recorded ϕ outputs approaches completeness[50] and must also be the stage at which - operationally - resolution of W_i into B_i and $W_i \backslash B_i$ approaches completeness. Such resolution will be attained because as the recorded vocabulary of ϕ outputs approaches completeness - that is, as the record of possible transformations from one B_m state to another approaches completeness - so will the associated record of the effect of each of those transformations on W_i (since W_i essentially will be a cross-section of next κ incon).

The accumulated record of those effects on W_i will be one of *tight*, high-fidelity association between specific, well-defined ϕ output phrases and specific, well-defined state changes in W_i. And - since L6 will be the dominant linkage between B_m and W_i[51] - most of the specific, well-defined state changes in W_i which will consistently arise in response to ϕ output will occur in the W_i subfield B_i.

Other changes in W_i (that is, changes determined by changes in $W_r \backslash B_r$ and not B_r) will be more weakly associated with any specific, well-defined ϕ output.[52]

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[49] To put it in more general terms, D will have to have a well-defined initial 'knowledge' of the disposition of B_r with respect to W_r in order to construct ϕ outputs which can alter that disposition in a well-defined way.

[50] As described in Section 7.16, the potential to approach recording a complete ϕ vocabulary depends upon bounded variability in the set of possible B_r postures.

[51] See Section 6.2, 'The Relationship Between B_m and B_i'.

[52] As described below, a partial exception will be recorded state changes in the subfield E_i.

7.23 *Relative Orders of Reliability in the B_i and $W_i \backslash B_i$ Components of κ Ticks*

A feature of the non-ideality of the association matrix will be that the extent to which the action cycle has to correct for inaccuracy in synthetic ticks will be greater with respect to the $W_i \backslash B_i$ component of next κ incon than for the B_i component.

That will be because - as described in the previous section - transcendence will involve the progressive recording of a relatively complete and well-defined set of associations between the B_i component in any κ tick, and its parallel ϕ tick. Associations between ϕ output and the $W_i \backslash B_i$ component of a synthetic κ tick will be less complete.

In other words, while the association matrix's experience (via B_i) of ϕ output effects on B_r can approach completeness, its experience (via $W_i \backslash B_i$) of that κ incon which does not emanate directly from the surface of B_r (or from within B_r via p) will remain relatively incomplete. This relative incompleteness will arise because the environments which B_r finds itself which correspond to new κ loci can be far more variable than can new B_r postures.

In terms of the action cycle, this means that each time S4 occurs, the error field generated will show relatively large errors in the $W_i \backslash B_i$ component of the projected κ locus, and relatively small errors in the B_i component. Put differently, the action cycle will at S6 be able more accurately to forecast the change in B_i due to a given ϕ output phrase, than to forecast the concurrent change in $W_i \backslash B_i$.

7.24 *The Utility of the E_i Component of κ Ticks*

One specific reason why the association matrix's experience (via B_i) of ϕ output effects on B_r can approach completeness, while its experience (via $W_i \backslash B_i$) of that κ incon not emanating directly from the surface of B_r, or from within B_r via p, cannot approach completeness, is that in going from one κ tick to the next, some - and possibly a great many - of the changes in the $W_i \backslash B_i$ component of κ incon will be due to changes in W_r not caused by changes in B_r; that is, not caused by ϕ output.

For example, natural phenomena such as $wind_r$, will lead to such changes in W_r - and therefore in some part of $W_i \backslash B_i$ - from one beat of the action cycle to the next. Such changes, because they will arise randomly in relation to any concurrent ϕ output phrase, will create records only negligibly associating them with any ϕ output. Therefore, the association matrix will be unable to predict such changes when engaging in next locus projection at S6.

But there will be a subfield of $W_i \backslash B_i$ whose states are determined by ϕ output phrases. That is because B_r movements will change the states of the subfield of $W_r \backslash B_r$ which is in direct contact$_r$ with B_r. That subfield previously was defined as the effect image, E_i.[53] The important linkages are

$$B_m \top E_i \qquad \text{(L11)}$$

where

$$W_i \backslash B_i \supset E_i$$

The utility of the association matrix lies in its capacity to generate behavior to satisfy B_r needs. This, in turn, will rely considerably upon the strength of the action cycle's ability to take B_r to g states through highly synthetic regions of the matrix; that is, to successfully reach g states when B_r is in quite new environments in W_r. So possession of a vocabulary of ϕ outputs sufficient to move B_r through a fairly full range of its possible postures$_r$ will be of critical importance - especially to enable manipulation of objects$_r$ using the hands$_r$. Equally, it will be important to be able in various ways to manipulate a large range of such objects$_r$ by acting on them through shifts in B_r posture.

[53] See Section 6.2, 'Definitions of W_f, W_s and E_i'.

For that reason, capacity of an association matrix to accumulate a record of association between ϕ output phrases and the E_i component of next κ incon quanta will be critical to the utility of the matrix and the useful operation of D.

The following example illustrates the point. Consider crawling, walking and running. In each case the action cycle operates to produce iterative cycles of ϕ output which lead to types of cyclic posture change in B_r which, in turn, change B_r's relation to W_r. Specifically, these types of cyclic posture change move B_r into new/alternative environments in W_r.

Now for B_r successfully to crawl, walk or run, operation of the action cycle must deliver $\kappa\phi\rho$ coordination within certain error tolerances. Ability to do that will be determined by the completeness and definition of a set of associations lying almost entirely within the set of associations between ϕ ticks and the B_i component of κ ticks. That is because the B_r posture changes involved do not involve more than a rudimentary interaction between B_r and W_r.

But consider riding a $bicycle_r$. Just as for walking, the action cycle operates to produce iterative cycles of ϕ output which lead to types of cyclic posture change in B_r which in turn change B_r's relation to W_r. And, as with walking, to successfully ride a $bicycle_r$ operation of the action cycle must deliver $\kappa\phi\rho$ coordination within certain error tolerances. But in the case of riding a bicycle, ability to do that will be determined by the completeness and definition of a set of associations lying not simply within the set of associations between ϕ ticks and the B_i component of κ ticks, but within the set of associations between ϕ ticks and part of the $(E_i \cup B_i)$ component of κ ticks. That is because, as long as B_r posture changes are affecting it - which is especially the case when it is being ridden - the $bicycle_r$ will give rise to incon which forms part of the E_i component of κ incon.

7.25 *Learning to Manipulate Objects and Use Tools*

The preceding discussion of E_i serves to introduce a broader discussion of B_r capacity to manipulate $objects_r$, including use of tools.

For the purpose of this discussion, define an *absolute object*, O_r, as being any specific subfield in the *absolute object field* T_r, where T_r is the subfield in W_r made up of all virtually discrete subfields[54] capable of being changed by interaction with B_r. (So any O_r will be a virtually discrete subfield of W_r.) Now, during any given beat of the action cycle the subfield of W_r defined in Section 6.2 as W_s may include part or all of one or more O_r subfields. And E_i is the κ incon component reflecting states in W_s (since L9). So, define as O_i the subfield in E_i reflecting the state of an O_r subfield which is in W_s.

To return to the example of the bicycle$_r$, note that successful use of a bicycle takes practice, as does successful manipulation by a B_r of any object$_r$ or tool$_r$; that is, of any O_r. Accordingly, the readiness of an association matrix to deliver κϕρ coordination within the error tolerances needed for successful manipulation by B_r of any O_r will always be at one of three possible stages:

- **Naive**. Where B_r has not had significant contact with a given O_r.

- **Incompetent**. Where B_r has had sufficient contact with that O_r for one or more association complexes, or for the association matrix, to have accumulated a partial record of association between ϕ output phrases and ($O_i \cup B_i$) components of next κ incon to do with manipulation of that O_r.

- **Competent**. Where B_r has had sufficient contact with that O_r for the association matrix to have accumulated a record of tight association between a relatively complete and well-defined vocabulary of ϕ output phrases and a set of relatively complete and well defined ($O_i \cup B_i$) components of next κ incon to do with manipulation of that O_r.

[54] Define a *discrete field* as a field where alteration of the state values of any of its terms will be accompanied by alteration in all other state values within the field, but will have no effect on the state values of terms not in that field. Define a *virtually discrete field* as a field which reasonably approximates a discrete field.

Only when the association matrix is competent with a given O_r will it be able to deliver κϕρ coordination within the error tolerances needed for relatively complete, successful manipulation by B_r of that O_r.[55] Nevertheless, it should be emphasized that attainment of competence with a given O_r would not mean attainment of ideal competence. Rather, it would represent attainment of sufficient competence to allow useful manipulation of that O_r.[56]

7.26 *Trends in Competence with Objects and Tools*

Now, consider the status of a given association matrix with respect to all O_r in T_r. Define ${}_cO_r$ as O_r for which the matrix is competent, ${}_iO_r$ as O_r for which the matrix is incompetent, and ${}_nO_r$ as O_r for which the matrix is naive.

Clearly, as B_r's - specifically D's - experience of W_r grows, the association matrix accumulates ${}_cO_r$; that is, there is a net trend

$$ {}_nO_r \longrightarrow {}_iO_r \longrightarrow {}_cO_r \qquad \text{(F1)} $$

Still, as described in Section 7.19, the association matrix will have recording limits, including a limit to its capacity to retain records at real κ and ϕ ticks. That means the matrix literally may 'get out of practice', and lose some ability to deliver κϕρ coordination within the error tolerances needed for competent manipulation by B_r of a given O_r. Accordingly, with time, there will always be some reverse flow

$$ {}_cO_r \longrightarrow {}_iO_r \qquad \text{(F2)} $$

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[55] N.B. Assigning these stages is a useful device, but it should be understood that the boundaries between stages will be rather indefinite, with earlier stages merging into later stages. In other words, improvement in κϕρ coordination is best regarded more as a continuous rather than stepped process, with the assignment of stages being made simply to mark improvement past a certain point. In some cases, however, where balance proprioception is involved - such as riding a bicycle - the distinction between competent and incompetent may be pronounced.

[56] Where 'useful manipulation' is manipulation entailing a larger sequence of κϕρ coordination, involving start to finish use of a given O_r, which takes B_r along a projected route to a given g state.

Combining F1 and F2 gives the equilibrium expression

$$ {}_{n}O_{r} \longrightarrow {}_{i}O_{r} \rightleftharpoons {}_{c}O_{r} \qquad \text{(F3)} $$

With aging there may be deterioration in the physiological$_r$ substratum supporting the association matrix, or in parts of B_r needed for the effective expression of ϕ output, or in parts of B_r needed for effective reception of s and/or p, or for s and/or p preprocessing into κ incon. Such deterioration will, with increasing age, reverse the earlier trend towards the right-hand side of the equilibrium in F3.[57]

7.27 *$_cO_r$ as an Extension of $_cB_r$*

If the definition of T_r is widened slightly to make it the subfield in W_r made up of all virtually discrete subfields capable of being changed by interaction with D_o or D (rather than by interaction with B_r), then B_r itself can be considered an O_r. In those circumstances, development to form an association matrix could be described as involving

$$ {}_{n}B_{r} \longrightarrow {}_{i}B_{r} \longrightarrow {}_{c}B_{r} \qquad \text{(F4)} $$

and be seen as a critical stage in the more general process by which D accumulates $_cO_r$.

Indeed, if successful overall κϕρ coordination involving posture changes in B_r is seen as the sum of a large number of successful, but relatively discrete κϕρ coordination sequences, each giving rise to individual B_r posture changes, but each in itself far from constituting $_cB_r$ then, statistically, we can say

$$ {}_{n}B_{r} \longrightarrow {}_{i}B_{r} \rightleftharpoons {}_{c}B_{r} \qquad \text{(F5)} $$

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[57] In other words, in early and middle life a progressive shift of equilibrium towards the right hand side of F3 will be the dominant trend, and in later life a shift back to the left-hand side of F3 will be the dominant trend. But at all stages there will be a dynamic equilibrium.

That is because while F5 will always lie far to the right-hand side for an association matrix which has attained ${}_cB_r$, there will nevertheless always be some improvement in the competence of κφρ coordination to carry out certain individual, often-used posture changes, and a decline in the competence of κφρ coordination to carry out other, neglected or physiologically_r inhibited posture changes.

Now successful κφρ coordination involving any O_r must occur in conjunction with successful κφρ coordination involving B_r; that is, there must be successful κφρ coordination involving $(O_r \cup B_r)$. And, as previously noted, attainment by the association matrix of competence with a specific O_r occurs where B_r has had sufficient contact (that is, practice) with that O_r for the association matrix to have accumulated a record of tight association between a relatively complete and well-defined vocabulary of φ output phrases, and a set of relatively complete and well defined $(O_i \cup B_i)$ components of next κ incon, to do with manipulation of that O_r. So we can say that in learning to manipulate any O_r

$$ {}_n(B_r \cup O_r) \longrightarrow {}_i(B_r \cup O_r) \longrightarrow {}_c(B_r \cup O_r) \qquad \text{(F6)} $$

and that, as for F2, there will always be some reverse flow

$$ {}_c(B_r \cup O_r) \longrightarrow {}_i(B_r \cup O_r) \qquad \text{(F7)} $$

So

$$ {}_n(B_r \cup O_r) \longrightarrow {}_i(B_r \cup O_r) \rightleftharpoons {}_c(B_r \cup O_r) \qquad \text{(F8)} $$

The idea that attainment by an association matrix of competence with a specific O_r is equivalent to attainment of competence with a specific $(B_r \cup O_r)$ is an expression of the more general idea that in some respects ${}_cO_r$ is an extension of ${}_cB_r$. Examples of where ${}_cO_r$ forms particularly obvious extension of ${}_cB_r$, are where gloves_r or shoes_r are competently used.[58]

[58] A great many other examples come to mind. Sports abound with them in the use of racquets, bats and clubs. Driving a car can also be considered in this way.

7.28 *Projection Diagrams*

Figure 14 schematically describes operation of the action cycle for an association matrix where accuracy of projection of the B_i component of next κ incon is non-ideal. Call Figure 14 a *projection diagram.*

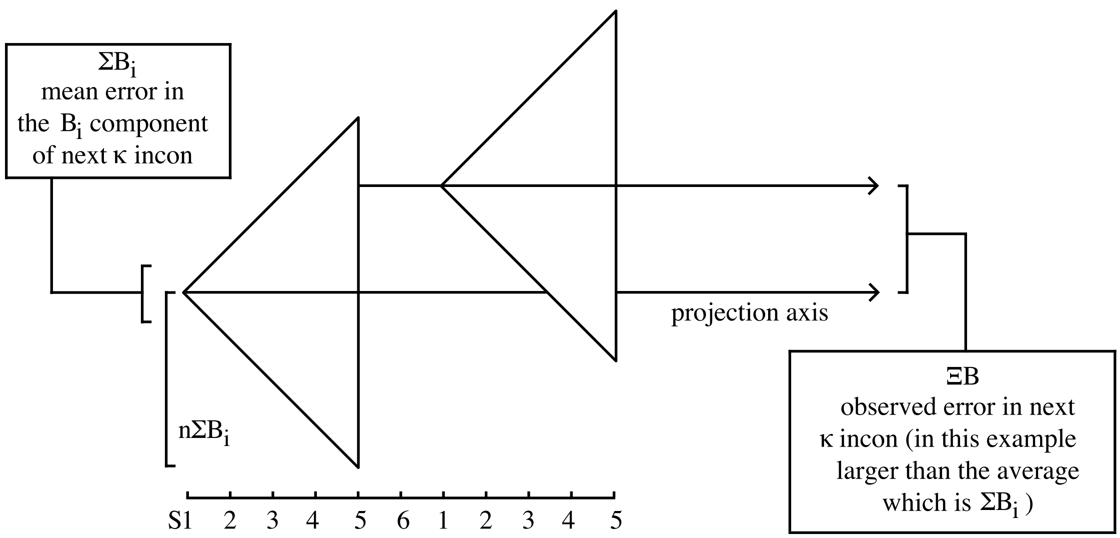

Figure 14

In the diagram, the projection axis represents the orientation of change in the B_i component of next κ incon expected on the basis of next locus projection, and following expression of the ϕ output phrase expected to give the optimum next κ locus (see S6 then S1 of the action cycle).

Since operation of a non-ideal association matrix will not deliver ideal κϕρ coordination, there will always be an observed error, the *projection error*, ΞB_i, which will be the difference between the projected next κ locus, (S6: held in table 2), and the κ locus subsequently observed (S3: held in table 1). Also, say that over a preceding period of many action cycles an average of successive ΞB_i can progressively be estimated and held in
table 5. Call that average the *mean projection error*, ΣB_i.

The far left of the figure, at S1, corresponds to a point of certainty about the B_i component of the κ locus - that is, it corresponds to the condition of the association matrix prevailing from immediately after S5 (matrix recalculation) and up until S1 (ϕ phrase output) in the action cycle. Moving to the right, from S1 to S5, the diagram forms a triangular shape, call that a *projection cone*. Projection cones illustrate the range of potential projection error which can reasonably be expected in relation to each beat of the action cycle. The long vertical line forming the base of the first projection cone corresponds to the reasonable potential range of error in the B_i component of next κ incon in the following way. The length of the base is $\pm n\Sigma B_i$, where statistically $\pm n\Sigma B_i$ is the range within which say 98% of projection errors will fall. We can then say, albeit somewhat arbitrarily, that $2n\Sigma B_i$ will correspond to the momentary degree of uncertainty in the association matrix immediately before S5.[59]

Now note that to say, that for the interval between S1 (ϕ phrase output) until S5 (matrix recalculation) there will be an uncertainty in the vicinity of $\pm n\Sigma B_i$ in the degree of competence of the association matrix with respect to B_i, is to say by implication that for that interval there will be a small, momentary shift to the left of $2n\Sigma B_i$ in the equilibrium in F5,

$$_{n}B_{r} \longrightarrow {_{i}B_{r}} \rightleftharpoons {_{c}B_{r}} \qquad \text{(F5)}$$

and - extending this analysis to the whole action cycle - that all, or nearly all, of this momentary shift to the left will be reversed at S5, and a period of relative certainty will prevail for the interval S5 to S1. It will be shown later that this cyclic ‘refocusing’ phenomenon is a key process in delivering to a B_r a subjective sense of self awareness; that is an experience of consciousness.

7.29 *Further Projection Diagrams*

Figure 15 shows a projection diagram illustrating the idea of competence.

[59] Note that the quantitative character of these values is notional - so, for example, 98% is notional - but note also that notional values are useful in descriptions such as these, which call for reference to relative magnitudes.

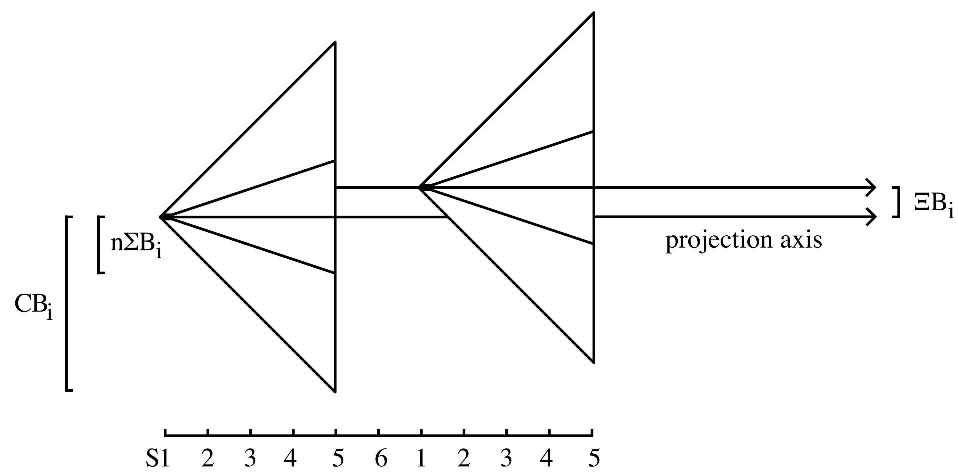

Figure 15

Figure 15 shows overlaid projection cones, two for each of two successive beats of the action cycle. The outer, larger cones have a base radius of CB_i, and represent that limit of error in accuracy in next κ locus projection beyond which κφρ coordination could not deliver competent manipulation of B_r for the type of posture$_r$ change being attempted. The inner cones have a base radius of $n\Sigma B_i$. $n\Sigma B_i$ is shown as much smaller than CB_i, indicating that competence has been attained for that type of posture change.

In Figure 16 a similar projection diagram shows the action cycle for an association matrix manipulating a given O_r where D has attained $_c(B_r \cup O_r)$.

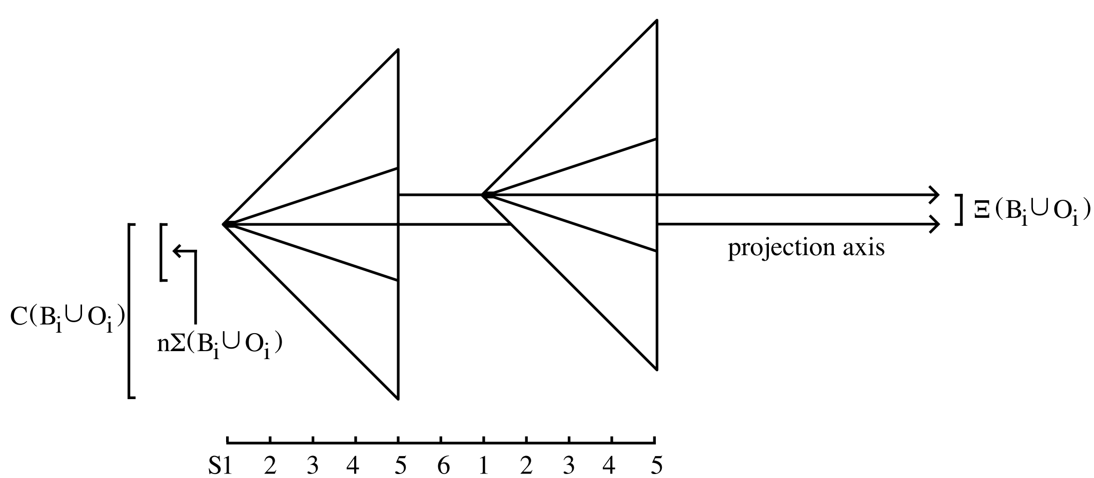

Figure 16

7.30 *Extended and Critical Physical Self Awareness*

Using ideas developed in preceding discussion it is possible directly to address the mechanism by which a subjective sense of physical self awareness can be generated within B_r; specifically, in D. But it is first useful to distinguish between two types of physical self awareness. Call those types *extended* self awareness and *critical* self awareness.

Extended self awareness has in many respects already been discussed. It is accumulated, operational self knowledge held in the association matrix in the form of the tight associations needed for the matrix to attain $_cB_r$. Attainment of $_cB_r$ is attainment of self awareness to the extent that with it practically all κϕρ coordination involving manipulation of B_r as a virtually discrete field can be predicted (at S6 of the action cycle) and executed (at S1) to within error tolerances needed to successfully make a complete group of basic (normal/routine) changes in B_r posture. So, for example, B_r ability to walk, run, and so on, are attained as part of attaining extended self awareness.

Attainment of $_c(B_r \cup O_r)$ also makes a major contribution to attainment of extended self awareness. That is because such attainment clearly moves F5 to the right as part of moving F8 to the right, since a particular type of refinement in competence beyond rudimentary $_cB_r$ is needed to attain any new $_cO_r$.

Extended self awareness is relatively durable. That is, it is not lost during sleep, or to any major degree during extended periods of general or specific inactivity. So, for example, a person will not forget how to walk, even though through injury, or for some other reason, they might not actually have walked for weeks. Similarly, after years without practice people can remember how to ride a bicycle, or how to play the piano, though they will need practice to attain previous levels of competence.

Despite its importance, the presence of extended self awareness - even where F5 is very far to the right - cannot on its own be responsible for delivering a subjective sense of physical self awareness, or *critical* self awareness. Introspection suggests that critical self awareness - commonly described as consciousness - is delivered in real time (that is, moment-by-moment), and that essentially it is part of being awake. Extended self awareness persists during sleep and other forms of unconsciousness.[60]

7.31 *Genesis of Critical Physical Self Awareness*

Critical self awareness could be delivered through operation of the action cycle. First, recall from Section 7.28 that for the interval between S1 (ϕ phrase output) until S5 (matrix recalculation), there will be an uncertainty of about $2n\Sigma B_i$ in the degree of competence of the association matrix with respect to B_i - that is, for that interval there will be a momentary shift to the left of $2n\Sigma B_i$ in the equilibrium in F5.

Then, through S5, that uncertainty largely will be eliminated as the nascent association matrix is derived, and then overwrites the previously held association matrix. In other words, the momentary shift to the left in the equilibrium F5 will be reversed at S5, and the renewed level of certainty thereby achieved will be maintained through S6 while the nascent association matrix is used to generate a set of possible next κ loci. To complete the cycle, the launching of a new ϕ phrase at S1 will begin another period of relative uncertainty.

Figure 17 shows a graph - call it an *action diagram* - illustrating the expected momentary fluctuation in the position of the equilibrium in F5 as the action cycle proceeds during part of a typical sample of a $\kappa\phi\rho$ coordination sequence for which the association matrix is competent.

[60] With respect to processes identified by cognitive psychologists, extended self awareness would appear to be a property of *associative memory* while critical self awareness would appear to be a property of *working memory*. (Goldman-Rakic, P. S. *Scientific American* p73-79, September 1992.)

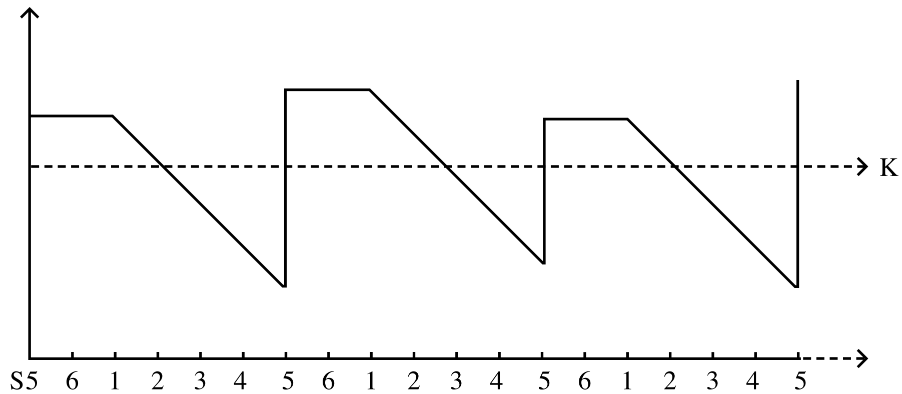

Figure 17

In Figure 17, the y axis is in units proportional to the degree to which F5 lies to the right. Steps of the action cycle are shown along the x axis. K is the mean degree to which F5 lies to the right for the period of the κϕρ coordination sequence sampled.

To understand how this process might deliver critical self awareness it should be recalled that, because it is non-ideal, the association matrix may be considered to be a form of working hypothesis.[61]

Accordingly, at S6 the association matrix can be seen as a hypothesis being used to predict the outcomes of various ϕ output phrases in terms of possible next κ loci and, by reference to the ρ submatrix, to select an optimum next κ locus. At S1, the ϕ output made is that which the hypothesis predicts will deliver that optimum next κ locus. Then, from S1 to S5 the hypothesis is put to the test, and the results analyzed. This interval during which testing and analysis occurs corresponds to the period of uncertainty described earlier, where the position of F5 momentarily moves to the left. To complete the action cycle, at S5 the outcome of the hypothesis testing process is used to adjust the hypothesis.

It will now be argued that at S5, at the moment when the recalculated, nascent association matrix is passed to table 0 to overwrite the previous association matrix - that is, where F5 condenses back to the right, and where effectively a new hypothesis of B_r's relation to $W_r \backslash B_r$ is achieved - that a pulse of subjective self awareness; that is, a pulse of critical self awareness, is generated.

[61] Recall Section 7.19, 'Non-ideal Association Matrices'.

7.32 *Objects, Space, Time, the Self-as-Body and the Self-as-Center*

In order to show that delivery of a pulse of critical self awareness may accompany matrix recalculation at step S5 of the action cycle, it is useful to examine more closely some central aspects of the subjective experience of physical self awareness.

Physical self awareness is manifest subjectively as a continuous series of *instances* of perception - that is, as moment-by-moment perception - of the self as a body which exists at the center of a region of perceived, infinitely extended space. Define the *center* as the position, or vantage point, from which space is subjectively perceived.[62]

The space surrounding the perceived self, as center, is populated by perceived *specific objects*, including the body. Any particular specific object is perceived either as a closed surface, extended surface, closed volume or as an extended volume.[63]

A key characteristic of the described moment-by-moment perception of the physical self is that it entails an implicit understanding that the physical self as perceived - that is, the body as perceived - as well as other specific objects as perceived, each have a unique, continuous history within a single, infinitely extended arena of space and time.

In other words, while the self-as-body and its environment are always perceived on a moment-by-moment basis, those moment-by-moment perceptions implicitly are conceived of as being specific instances, each occurring in a single (i.e. absolute) arena of space and time within which all specific objects to be perceived have existed, exist or will exist.

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[62] Note that this vantage point is not identical to the body, but is closely identified with the body and, especially and understandably, with the location of the body's eyes.

[63] As perceived, discrete objects are enveloped in a *closed surface*. Extended objects, such as the sea, a railway line, or the surface of the earth are perceived locally as *extended surfaces* which extend beyond the immediate range of perception. A further group of specific objects includes flames and other light sources, mirrors, and transparent/translucent liquids and solids, where the object surface can be hard to perceive. These relatively rare objects are what are meant by *closed volumes* and *extended volumes*.

Define the *specific characteristics* of an instance as being composed of the specific objects perceived in that instance together with their perceived relationships to one another and to the self-as-body. Then, in respect of specific characteristics, note the generality that all specific objects (including the self-as-body), along with their inter-relationships, are perceived to arise, change and disintegrate through continuous transformations of form within a single space-time arena.

Bearing that in mind, let us now re-examine salient features of the conditions under which it was proposed, in Section 7.14, that transcendence to form a global association matrix could occur. First, transcendence was viewed as possible only if W_r - or at least all s incon from W_r - is bounded in its variability, and only if the impact of B_o output on W_r also is bounded in its variability. Then, under those conditions, it was envisaged that human association complexes might form with application of sufficient capacity in scope, proximity, volume and susceptibility to allow a complete coalescence of those complexes to give a single, global association matrix.

It was envisaged that transcendence to give an association matrix would involve formation of three submatrices; the κ submatrix, the ρ submatrix, and the ϕ submatrix. In Section 7.15 it was proposed that a key requirement for coalescence to form a κ submatrix was that all κ incon be recorded, at each κ tick, as a set of specific values taken on by a finite number of independent variables called κ global variables. The κ submatrix was then described as a continuum having dimensions equal to the number of κ global variables, where each κ incon quantum would correspond to a locus in the κ submatrix continuum.

With reference to this, a relationship can be inferred between the subjective characteristics of the moment-by-moment perception of the self-as-body in its environment in space-time - that is, in its environment of spatio-temporily distributed specific objects - and the processing in D of κ incon quanta as sets of specific values for κ global variables.

That relationship is that:

- For any κ incon quantum, the set of specific values in κ global variables contained in that quantum will define the specific characteristics of a corresponding subjective instance.

In other words, the set of specific values contained in a given κ incon quantum will define the form and distribution of the specific contents of space as perceived in that instance; that is, it will define the specific objects present - including the body - and their relationships to one another as subjectively perceived.

Now if the set of specific values for κ global variables in a κ incon quantum define the contingent, specific characteristics of a corresponding subjective instance, we can then say that the necessary, general characteristics of a subjective instance - that is, the arena of space within which such specific characteristics are always perceived - will be defined not by the specific values for κ global variables, but by the number and type of κ global variables - that is, by the dimensions or degrees of freedom - uniformly used to define all loci in the κ submatrix,[64] in conjunction with the architecture of the data-handling $system_r$ in B_r supporting and containing the κ submatrix.[65]

Let us now examine the subjective experience of time. We can say that during any interval of self awareness the subjective experience of time is built up of a continuous series of subjective instances. Each of these instances has contingent, specific characteristics as described, as well as the necessary, general characteristics of being perceived in relation to a self-as-center of a space continuum.

[64] Put in more fundamental terms; since a key requirement for the possibility of coalescence to form an association matrix was that W_r - or at least all s incon from W_r - be bounded in its variability, then the subjective experience of space, as a general and necessary condition for perceiving all forms of B_r in W_r, must be a reflection of the number of degrees of freedom needed for *practical* purposes (i.e. for an effective range of competency in κϕρ coordination), under that bounded variability, to describe in terms of any possible unique κ incon quanta, any possible unique state of B_r in relation to W_r.

[65] In other words, if, to allow coalescence, the requirement is that each specific loci in the κ submatrix be defined in terms of unique specific values in the same, finite number of κ global variables, then each κ incon quanta corresponding to each loci in the κ submatrix will be expressed in that same number of dimensions, and all real, near-real and synthetic loci in the κ submatrix will share a common dimensional structure. The contention here then, is that at least part of the dimensional continuity of the κ submatrix is experienced subjectively as space.

The most obvious subjective means by which the passage of time is marked is by perception of change in the specific characteristics manifest over a series of instances.[66] That is, by perception of transformations in specific objects either in themselves, in relation to, or by interaction with, other specific objects. In this, the self-as-body is perceived as an object enmeshed in, and often driving, such interactions and transformations and, as such, is perceived as a part of the specific characteristics of perceived instances.

While the specific characteristics of perceived instances - including the self-as-body - change in time, the general characteristics persist. Thus, the arena of space is perceived as single (i.e. as absolute) in time. In this sense the *self-as-center*, center, or vantage point, from which eternal absolute space is perceived, is by implication also perceived to be single and eternal.

An interesting and key inconsistency in human subjective experience is thus exposed. Clearly, as opposed to perceiving the self as eternal, it is generally understood that the self-as-body ages and dies. Nevertheless, it remains virtually intuitively inconceivable that the self as a center of perception, or self-as-center, might cease to exist.[67]

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[66] A second means subjectively of marking the passage of time seems not to be tied to perception of transformations in specific characteristics of surrounding space, since introspection shows time is felt to pass even in conditions of virtually perfect physical inaction and environmental stillness. This second subjective means of marking time may rely on input from some form of counter tied to beats of the action cycle. Existence of two or more methods of marking time would help explain the subjective sensation that time can ‘fly’ or ‘crawl’ depending on ‘state of mind’.

[67] In the history of ideas, the idea of cessation of existence as a center of perception is a relatively new and abstract concept, and when put forward it is presented as a logical necessity rather than as a matter which is, or even can be, subjectively self-evident. Indeed, consistent with the view being developed, it can be argued that the concept of ceasing to exist as a subject is so alien to our subjective intuition that no-one is consciously capable of imagining non-existence, just as no-one is consciously capable of imagining existence in an environment which has no extension in space. Of course, ready acceptance that the body can die, alongside great resistance to the idea that the ‘mind’, as a center of perception, may also die, is a key provider of intuitive impetus to religious and other claims for the existence of a soul and for life after death, and for dualist hypotheses of mind and body.

Another distinction between the subjective experience of self-as-body and self-as-center is that while the self-as-body is perceived to be experienced indirectly, through the senses (including the proprioceptive senses), the self-as-center is experienced directly as an aspect of one's 'mind' and is experienced as being close - if not identical to - the core of one's being.

7.33 *The Primary Associative Argument*

Observations made above on the subjective experience of physical self awareness, and about its possible relationship, at the level of specific and general characteristics, to the receipt and processing of κ incon by the association matrix, are consistent with the idea that D is involved in the genesis of critical self awareness. What is needed now is a description of a specific process in D which can generate a sense of subjective self awareness such that an understanding of that process may form a basis for deriving, from the operations of D, key aspects of the subjective experience of physical self awareness.[68]

The process in D which is responsible for the subjective sense of physical self awareness is not perceived by the subject, but it is relatively straightforward and is implicit in the operation of the action cycle. It can be described as an implicit assumption or *argument*.

The implicit argument which gives rise to a subjective sense of physical self awareness is sustained through operation of the action cycle and, in its objective form, is:

- That B_r, as it stands in relation to $W_r \backslash B_r$, is a single entity in identity with that entity defined at any moment by B_r, via D operation, as the B_i component of κ incon as it stands in relation to the $W_i \backslash B_i$ component of κ incon.

In other words, the argument - call it the *primary associative argument* - is an assertion that the component of the κ locus defined by B_i as it stands in relation to $W_i \backslash B_i$ (the self as it

[68] In other words, with respect to physical self awareness - and with respect to the introductory section of this essay - understanding such a process should provide ideas on how to translate brain states into subjective states.

senses itself) is one-and-the-same as B_r as it stands in relation to $W_r\backslash B_r$ (the self as it acts).[69] (Another way of saying this is to say that in delivering competent κφρ coordination, operation of the action cycle enforces a quasi-continuous superimposition of B_i-in-W_i onto B_r-in-W_r.)

Now because the association matrix is non-ideal, the primary associative argument cannot perfectly be sustained to be true.[70] But it will be held virtually to be true at S5 in the action cycle where, during any κφρ coordination sequence for which the association matrix is competent, the equilibrium in F5 moves its furthest to the right. At that moment, where the association matrix has just been recalculated to form a nascent association matrix corrected to agree with the most recently determined κ locus, B_i will be held - to a best reckoning based on all information available to the D processor at that moment - as indistinguishable (in its relations with $W_i\backslash B_i$) from B_r (in its relations to $W_r\backslash B_r$), and therefore to be in virtual identity with B_r.

Another way of putting this is to say that, with respect to the D processor's state of 'knowledge' immediately following S5 - that is, immediately at completion of the vertical upstroke shown in Figure 17 (reproduced overleaf) - B_i becomes operationally indistinguishable from B_r, and the primary associative argument is at that moment, in respect of information held in D, held to be true.[71]

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[69] Fundamentally, the primary associative argument is a transformation of the assertion that there is an identity of knowing and being. (Stace, W. C. *The Philosophy of Hegel* p69-78, Dover Publications, New York, 1955.)

[70] If the association matrix were ideal, the primary associative argument could be perfectly sustained to be true because in those circumstances the set of potential relationships between B_i and $W_i\backslash B_i$ anticipated in the association matrix would be complete and perfectly correspondent to the set of possible relationships between B_r and $W_r\backslash B_r$. In that case, with respect to the action cycle, B_i operationally could be held to be identical to B_r, and therefore could be held without means of challenge to be in identity with B_r.

[71] By the same token, immediately prior to the upstroke in Figure 17, at the point where equilibrium in F5 lies farthest to the left, the capacity in D to hold the primary associative argument to be true must be suspended. That is because the process of recalculating (correcting) the association matrix is inconsistent with sustaining an assertion of identity in relations between B_i to $W_i\backslash B_i$ and B_r to $W_r\backslash B_r$. Given the consequences for D of assuming the primary associative argument to be true - and these are elaborated below - it becomes apparent that the moment of upstroke is the moment at which a pulse of subjective self awareness will be generated.

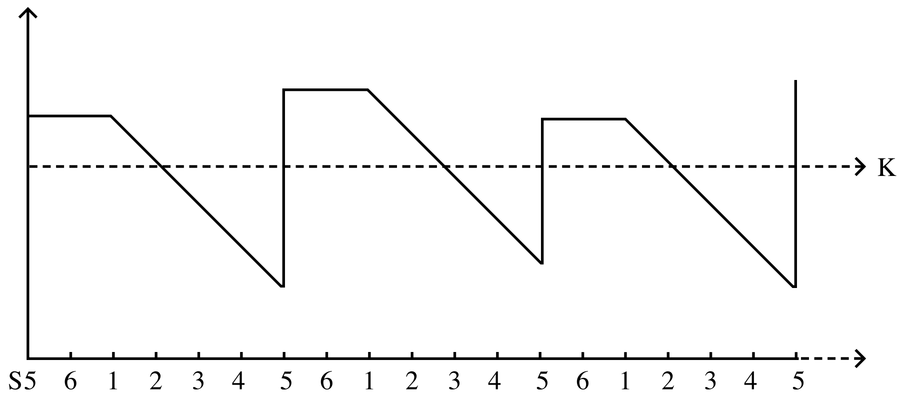

Figure 17

Assertion of the primary associative argument can be shown to imply genesis of subjective self awareness by reasoning provided in the following dot points and paragraphs.

- Number a series of consecutive beats of the action cycle

  n, n+1, n+2,..., n+x

- Label steps in those cycles

  ${}^{n}S1$, ${}^{n}S2$, ${}^{n}S3$,..., ${}^{(n+1)}S1$, ${}^{(n+1)}S2$, ${}^{(n+1)}S3$,..., ${}^{(n+x)}S1$,...

- For any given beat, n, of the action cycle, the momentary B_i specific to that beat - call it ${}^{n}B_i$ - will be defined by a component of that incoming κ incon quantum received at ${}^{n}S2$

  - That quantum will define a κ locus within the κ submatrix, which lies within the association matrix, which itself is a subfield of D.

- Now at ${}^{n}S6$, next locus projection will predict an optimum next B_i. Call that predicted B_i, $*B_i$. Now to predict $*B_i$, ${}^{n}S6$ will formulate a ϕ output phrase predicated on the assumption that:

$${}^{n}B_i \equiv B_r \qquad \text{(primary associative argument)}$$

- If then, after expression of that ϕ phrase at ${}^{(n+1)}S1$, matrix recalculation at ${}^{(n+1)}S5$ shows that to within the requirement of competent κϕρ coordination

$$ {}^{(n+1)}B_i \equiv {}^{*}B_i $$

  the working assumption made at ${}^{n}S6$ that ${}^{n}B_i \equiv B_r$ will be verified as sound.

- Consequently, in the course of competent κϕρ coordination, the following logic holds: That because

$$ B_r \supset D $$

  (i.e. because D – which contains the association matrix – is a subfield of B_r) then ${}^{n}B_i \equiv B_r$ implies that from ${}^{n}S5$ to ${}^{(n+1)}S1$

$$ {}^{n}B_i \supset D $$

- That is to say that operationally, from ${}^{n}S5$ to ${}^{(n+1)}S1$, the association matrix can – and does – logically treat itself as if it is a subfield of ${}^{n}B_i$. For that reason, the association matrix can be said to *capture* itself at ${}^{(n+1)}S5$, which is the step at which ${}^{n}B_i \equiv B_r$ is verified.

- Thus we can say that the association matrix will repeatedly capture itself (it will capture itself at each successive S5) for the course of an indefinite series of consecutive beats of the action cycle provided B_r exhibits competent κϕρ coordination for the duration of that series.

To summarize; from S5 until S1 - through holding the primary associative argument true - the association matrix will represent B_r, and with it itself, to itself, as being the B_i defined component – call it simply B_i – of the current κ locus. This locus will in turn be defined by the κ incon quantum received at the preceding S2. In practice, this will mean that from the moment of matrix recalculation, throughout next locus projection at S6, and up until the point of sending out a ϕ incon phrase, the association matrix will operate with respect to itself as if it were within B_i. In other words, as next locus projection is occurring - and for human beings with mature sensory-motor skills that may be an extended process - association matrix operations will be performed with respect to themselves on the basis that they are located within B_i, that is, on the basis of self location in a component of a locus in the κ submatrix.

In relation to the discussion of space given in the previous section, it can be seen that in this way the association matrix arrives at a representation of itself to itself (i.e. it arrives at a subjective perception of itself) as being a self surrounded by a space continuum - that is, this is how one comes to see one's self physically, on a moment-by-moment basis, as B_i - the self-as-body - at the center of a region of infinite, absolute space: Thus the subjective perception of space derives from the structure of the κ submatrix which, as a condition of its formation through coalescence and transcendence, requires that any κ locus be defined in terms of specific values in a finite set of κ global variables. Space can then be seen as the arena, derived from the way D processes all sets of κ global variables, within which all potential κ loci can be accommodated. The subjective perception of space is then a 'view from the inside' - that is, a view taken from the perspective of a B_i component of a κ locus 'surrounded by' the κ submatrix.[72]

On that basis let us call from S5 to S1 in the action cycle the *reflective sequence*. During the reflective sequence then, the association matrix operates on the basis that the primary associative argument is true, and for that reason a sense of subjective physical self awareness prevails throughout this sequence. In other words, during the reflective sequence the association matrix operates on the basis that it is within (that is, perceives itself as being within) the self-as-body at the center of an environment of specific characteristics in an arena of absolute space.

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[72] With respect to concern that this view might imply that space bears no relation to anything at the absolute level, it is worth repeating a fundamental idea raised earlier, in footnote 10. That is, that the architecture of neurological$_r$ systems in D will be a product of Darwinian evolution, and will thus have developed to allow the representation of B_r in W_r used operationally to be as close to fully analogous to what exists at the absolute level as possible. Moreover, the condition under which transcendence is possible is that κ incon permutations, which are determined by permutations of B_r in W_r, are limited in their variability. So it can be asserted that the capacity for transcendence - which leads to a sufficiently good representation of B_r in W_r to allow assertion in D of the primary associative argument, is a 'proof through use' that the representation of the self-as-body in space must bear remarkable fidelity, albeit as an analog, to reality as it prevails at the absolute level. (See also Appendix 6.)

Note that planning of κϕρ coordinated action is made at S6 in this sequence, so such planning should be a self-aware process; that is, the hypothesis predicts that planning for competent κϕρ coordinated sequences will be conscious.

Call from S1 to S5 the *expressive sequence*. During this part of the action cycle the equilibrium in F5 moves to the left, and the assumption that the primary associative argument is true - an assumption prevailing during the preceding reflective sequence - is put to the test; that is, how truly B_i represents B_r is put to the test. The likelihood of the success of this test will depend upon the competence of the association matrix with respect to κϕρ coordination sequence being attempted. In turn, and as described in sections 7.21 to 7.27, that level of competence will depend upon the fidelity of those associations held in the matrix - that is, upon the fidelity of associations between ϕ output phrases and their effects on state changes in B_i in W_i - which are relevant to the coordination sequence being attempted.

This means that as ϕ output is made, there should arise a relative weakening of subjective awareness of the self-as-body. Moreover, consistent with footnote 71, at the point of matrix recalculation and overwriting of table 0 at S5, assertion of the primary associative argument must be suspended entirely. So with respect to subjective self awareness, a subject should experience a 'defocusing' of self awareness going into the expressive sequence. This should culminate in a complete momentary suspension of self awareness at S5, at the moment where the nascent association matrix overwrites the previous matrix. At completion of this overwriting, a surge of renewed subjective self awareness should then arise as the new, 'correct' association matrix renews B_r capacity to assert the primary associative argument. At this point the subject should experience a sharp refocusing of self awareness.[73]

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[73] Personal experience shows that this subjective sense of refocusing can be pronounced where the error registered at S4 is large. That is most likely to happen for a sustained period when relatively synthetic regions of the association matrix are being traversed; that is, when B_r is operating in an unfamiliar environment (performing an unfamiliar task). Consistent with that, it also seems that a pronounced sense of physical self affirmation is experienced where a κϕρ coordination sequence for which the association matrix is only borderline competent is being successfully managed. Enjoyment of that sensation would explain the popularity of sports like skiing, where people take their skills in physical coordination to the limit.

7.34 *Minimum Frequency of the Action Cycle*

If the hypothesis presented is valid and operation of the action cycle proceeds in two alternating sequences:

- the reflective sequence, which begins with a pulse of physical self awareness at completion of S5, and which persists through S6 until the onset of S1, and

- the expressive sequence, which begins at S1 with expression of a ϕ output phrase, and which entails a defocusing of physical self awareness culminating in a momentary suspension of physical self awareness at onset of S5,

then the level of physical self awareness experienced by a subject should approximate the profile shown in Figure 18

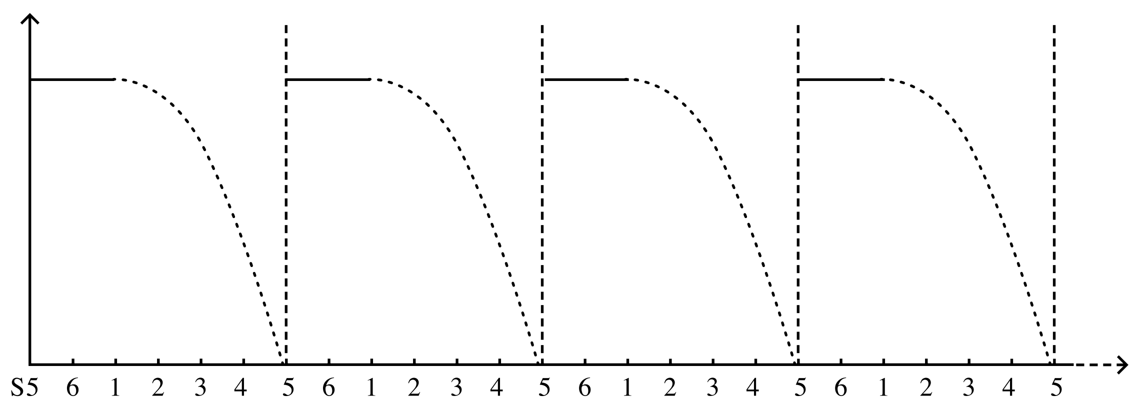

Figure 18

where the y axis gives the level of physical self awareness, and the x axis, which is at y = 0, is in steps of the action cycle.[74]

[74] At first glance the discontinuous character of self awareness illustrated in Figure 18 may seem incompatible with subjective experience, where the sense of physical self awareness seems continuous. But the subjective sense of seamless continuity is compatible with the discontinuous regime proposed under conditions where the minimum interval of time capable of subjective perception is greater than the period of the action cycle. That circumstance would provide for a perceived continuity of self awareness.

Now if this proposal approximates reality, then it may be possible to estimate the frequency of the action cycle by experiment. That is because the predicted periodic alternation between self awareness and suspension of self awareness should mean that certain kinds of state change in W_r will be incompletely represented in W_i, and therefore should be incompletely represented to consciousness.

One set of state changes in W_r of interest in this respect will be those which are stepped and rapid. For example, let us consider the forward movement of the long hand of a stop watch.

As I write this I have before me a stop watch whose long hand moves forward in stepped increments of 0.1 second. I note that as the hand steps rapidly forward I can easily subjectively mark to myself the moment it passes each calibration indicating a time increment of 1 second. Doing so is easy. Doing this for each increment of 0.5 seconds takes more effort, but is still within my ability. I find, however, that I am unable to keep up consciously marking increments of 0.25 seconds.

This result provides an idea of the time it takes to run through a cognitive routine where one marks to oneself that the stop watch hand has advanced by a certain interval. The maximum possible rate for this process will at most be the sum of maximum rates of several subprocesses operating serially to provide the subjective outcome. Be that as it may, the rate of none of those subprocesses can be slower than the summed rate of the whole series. Therefore if - as expected - the frequency of the action cycle is one of those processes, then in my case, it must have a frequency of greater than 4 cycles per second.

A more developed experimental approach - designed to go some way towards demonstrating the existence of the action cycle and estimating its frequency - is described in Appendix 1.

8 *Implications of the Means of Genesis of Physical Self Awareness*

8.1 *The Contents of Perception and the Perceived Contents of Space*

Let us further examine the consequences of assertion of the primary associative argument.

We have seen that for the duration of the reflective sequence B_i is held through the primary associative argument to be one and the same as B_r. This is achieved through an act of *superimposition*, where the κ locus components B_i and $W_i \backslash B_i$ as they relate to one another and to the κ submatrix (the self as it senses itself) are operationally superimposed on B_r as it relates to $W_r \backslash B_r$ (the self as it acts). The assertion has been that genesis of a sense of physical self awareness then flows from the subjectively rapid (≥4 cycles/sec) operation of the action cycle, which at each S5 sharply realigns superimposition of the image level with the absolute level. Such realignment will follow a greater or lesser degree of *drift* from alignment during the expressive sequence.[75] In this way, the subjective perception of being physically self aware can be understood to flow from a continuing fast series of . . . , sharp realignment, drift from alignment, sharp realignment, drift from alignment, . . . which will maintain a quasi-continuous state of superimposition between the image level and the absolute level.

Now, as shown in Section 7.33, assertion of the primary associative argument - which is made possible at each sharp approach to perfect superimposition of the image level (B_i in $W_i \backslash B_i$) onto the absolute level (B_r in $W_r \backslash B_r$) - means that for any interval where the argument is held true, the association matrix operationally will place itself inside itself. Call this 'self capturing' by the association matrix, which is attained at the apex of each sharp approach to perfect superimposition, *projection inversion.* The subjective perception created through projection inversion - which is perception of the self-as-body positioned at the center of an arena of infinite, absolute space - can then be understood to be a 'view from inside'; that is, a view taken from the perspective of a B_i component of a κ locus 'surrounded by' the κ submatrix.[76]

[75] In truth this will not be an absolute drift from alignment, but - through operation of the expressive sequence - a relative drift in alignment brought about by a change in the conditions under which the alignment is tested. This change in conditions - leading to a new test of alignment - will always lead to discovery of some degree of misalignment.

[76] Note that under these circumstances - where in the course of the action cycle there is rapid alternation between collapse and then reconstruction of projection inversion - there may be some subjective inkling of the self recursively capturing, or passing into, itself. This would correspond to the alternation of the reflective and expressive sequences

These observations bring us back to the arrangements of representations which are described in Section 3, ‘Conscious Manipulation of the Physical Environment’, and in Section 4, ‘The Mind-Body Problem’, and which are summarized in Section 3.3. A reading of those sections shows that the essay’s subsequent development of a deeper approach - that is, its development of an approach describing the means of genesis of physical self awareness - calls for little, if any, amendment to the observations provided in those earlier sections. We are now, however, in a better position to predict and explain - rather than simply to assert points made in Section 4.1, which deals with the difficulty people have in locating in space the mind and mental states.

The relevant specific observation made in Section 4.1 is:

- That representation of B_r as B_i may in some ways be incomplete, or could produce *low resolution* representations of some components and processes in B_r. In particular, there may be little or no representation of processes which belong to the $system_r$ which itself generates the representation B_i - that is, of processes in X.

This possibility with respect to B_i can now be confirmed. The perception of the self as B_i - that is, as the self-as-body at the center of space - is perception from the perspective of a B_i component of a κ locus ‘surrounded by’ the κ submatrix. More specifically, the genesis of this form of self perception (which is through assertion of identity between the image level (B_i in $W_i \backslash B_i$) and the absolute level (B_r in $W_r \backslash B_r$); that is, through projection inversion) excludes from representation as specific characteristics in space all aspects of B_r - and therefore of D structure and processes, including incon inputs and outputs - which are not part of the κ submatrix, or are not presented to the κ submatrix in the form of κ incon input.

Importantly, however, this is not to say that those aspects of B_r, and of D structure and processes, which are not capable of representation in the κ submatrix are not capable of being

in the action cycle. (A personal observation is that this inkling strengthens to palpable perception as one approaches the unconsciousness induced by the anesthetic diethyl ether - that is, as one approaches a state where the processes generating self awareness begin to falter.)

perceived. It is only to say that those aspects cannot directly be perceived as existing in space. So, for example, states of selective sensitization in the ρ submatrix, corresponding to β input specific to a given B_r physiological$_r$ need, seem likely to be presented directly to consciousness as perceived physiological *desires,* such as thirst and hunger. Though such desires are directly consciously perceived, they are not perceived as entities or processes which exist in space. Satisfaction of a given desire will nevertheless be strongly associated in the association matrix with attainment of a given type of g state, which in turn is perceived as that specific type of relationship, or highly proximal group of relationships, between B_i and $W_i \backslash B_i$, which are specific to satisfaction of that particular desire.

An extended description of the genesis of subjective perception of physiological desires, pleasures, pains and aversions is provided in Appendix 2. Suffice it to say again here, however, that projection inversion, while it is responsible for generation of a subjective sense of physical self awareness in the form of perception of the self-as-body in space, logically requires that those aspects of B_r - and of D structure and processes, including D incon inputs and outputs - which are either not part of the κ submatrix, or which are not presented to the κ submatrix in the form of κ incon input, cannot be perceived directly as existing in space.[77]

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[77] Physical desires, and perhaps all D structures, states and processes, may quite possibly be capable of being perceived indirectly as existing in space - i.e. at the image level - in the form of brain$_i$ structures, states and processes. But such indirect perception, through κ incon, is clearly *second order*. In other words, one will never actually 'see' the subjective perception of physical desire within one's brain$_i$, even though one might find neurons$_i$ which induce that sense of desire if they are stimulated. Moreover, such second order perceptions are cryptic - it would take a great deal of thought and work, as well as a range of relatively unnatural acts, to identify and characterize the neurology$_i$ associated with generation of one's own desires. For that reason, such second order perceptions play no role in the genesis of human physical self awareness.

8.2 *Others; the Role of Language in Supporting Projection Inversion*

As discussed, the very process by which physical self awareness is generated will exclude some important B_r processes and states from being directly perceived as specific characteristics in space. Even so, a number of such spatially unrepresented B_r processes and states - for example ρ submatrix sensitization - are directly perceived. The existence of such perceptions in the absence of their direct representation in space has led people to believe them to have some kind of non-physical origin which nevertheless is felt somehow to exist 'within' the self-as-body. Thus people tend to understand their feelings - including sensation of pain and of physical desires - as arising from within themselves as 'mental' events, and as being part of their private 'mental reality', rather than as being 'physical' events.

On the other hand, people tend to view the environment they perceive to surround their self-as-body - that is, the space-time environment populated by changing specific characteristics - as being 'physical reality', and as being outside the self. That is entirely consistent with the idea that, in the process of generating physical self awareness, projection inversion makes B_i the vantage point from which conscious perception is experienced.

Projection inversion then, in the same stroke that it generates critical self awareness, leaves the subject perceiving themselves as being surrounded by an environment composed of dynamic objects, surfaces, fluids and so on - that is, of specific characteristics - distributed in a continuous and infinite space-time.

Now while space itself may be an artifact of the architecture of the κ submatrix and of the way in which κ incon is recorded, the actual specific characteristics of any particular perceived instance will be causally determined in real time by changes in state at the absolute level of B_r in $W_r \backslash B_r$. That is since:

$$W_r \neg W_i \qquad \text{(L1)}$$

Hence the specific characteristics perceived by a person to be manifest in the spatial environment surrounding them will be directly determined by certain specific contents of W_r which are in interaction with B_r and which are the source of s incon. In this sense, the physical world perceived strictly at the level of specific characteristics can only reflect information which emanates directly from entities, and their relationships, which exist at the absolute level.[78]

It is this property of the perceived physical world, W_i, which provides the essential common framework allowing development of people's ability to communicate with one another on matters to do with their respective physical$_i$ environments.

Before discussing that assertion, however, let us consider - in terms of the hypothesis developed - some fundamentals to do with the physical existence of others. First, if the hypothesis is correct, each individual B_r carries within it a D processor which in turn contains a κ submatrix. Due to projection inversion, each physically self aware B_r will then perceive itself from the vantage point of a B_i operating in a space continuum created through operation of projection inversion with respect to its own κ submatrix. To this extent, each individual will generate their own, discrete, image-level representation of themself as a self-as-body at the center of a region of infinite space.

Accordingly, any given B_r - call it ${}_1B_r$ - when it perceives any other B_r - call it ${}_2B_r$ - will perceive ${}_2B_r$ as being among the specific objects surrounding it in space. That is, ${}_2B_r$ will be perceived by ${}_1B_r$ as a component in ${}_1B_r$'s W_i (i.e. as a component in ${}_1W_i$).

Now call the component of ${}_1W_i$ which is determined by s incon received by ${}_1B_r$ from ${}_2B_r$, ${}_{(2,1)}B_i$. Likewise - logically to extend the notation - call the component of ${}_2W_i$ which reflects s incon received by ${}_2B_r$ from ${}_1B_r$, ${}_{(1,2)}B_i$. To complete the scheme, call the component of ${}_1B_r$ κ incon which ${}_1B_r$ perceives to be its self-as-body, ${}_1B_i$, and call the component of ${}_2B_r$ κ incon which ${}_2B_r$ perceives to be its self-as-body, ${}_2B_i$.

Figure 19 uses this notation, and shows the system for two mature B_r in sensory contact with each other,[79] and with an object$_r$, O_r.

[78] In reality, in reaching D in the form of κ incon, this information is likely to be incomplete and in some senses distorted, but it seems likely that evolutionary pressures to maximize human survival potential would ensure that, from the point of view of planning the vast range of behaviors linked to safety, the physical environment as it is perceived (i.e. as W_i) will be a *true* representation of the physical environment at the absolute level (i.e. as W_r) to the extent that it will be an *effective* representation of that environment for the purpose of assisting B_r survival behaviors. (Here the concept of distortion can be understood to refer to certain kinds of selective processing emphasis in P_1 placed on particular 'survival-important' types of s incon, and processing de-emphasis placed on survival-irrelevant s incon. This idea of distortion could even be extended to include the omission from conscious perception of types of W_r event which unaided human senses cannot detect; for example, neutrino flux or radio waves.)

[79] The stream p into P_1 simply denotes proprioceptive input, consistent with footnote 41.

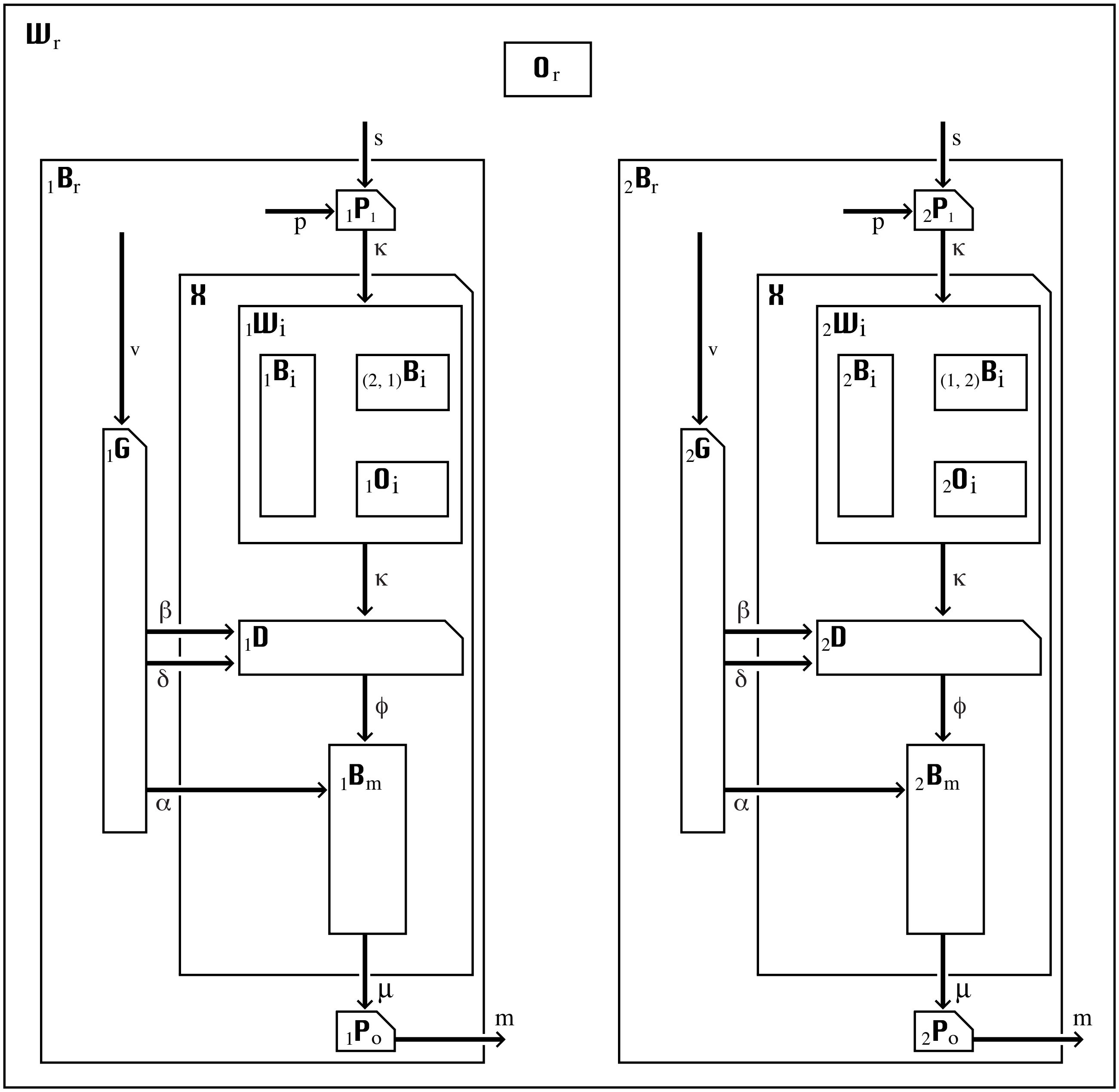

Figure 19

The relationships shown in Figure 19 can be extended to describe systems involving any number of B_r receiving s incon arising from common sources in W_r. Perhaps the most important feature of such systems is that any ${}_nB_r$ will subjectively operate from the perspective of being a self-as-body, ${}_nB_i$, surrounded by an environment in space, ${}_nW_i$, which is populated by perceived objects, ${}_nO_i$, and other perceived specific objects.[80] This feature is important because it means that each individual literally 'lives inside' their own representation of W_r. That is, as stated earlier, each individual will generate their own, discrete, image-level representation of themselves as a self-as-body at the center of a region of infinite space.

People do not, however, believe themselves to be living within their own private, subjective space. Rather, we believe ourselves to be living within one objective, *universal* space which we share with all others. The perception that we all inhabit a universal space is made possible through use of language, because use of language allows each of us to bring our individual respective W_is into *register* [81] with the W_is of others. Language use brings W_is into register by enabling people to agree on a common, real-time perception of the specific characteristics making up their respective W_is.[82]

This may be the most important and fundamental capability conferred on humans by language use. Clearly language is tremendously important in allowing specific, detailed day-to-day agreements and exchanges of information on matters to do with commonly perceived specific characteristics in what is understood to be a shared physical environment in space. But this utility can only arise as an on-going manifestation of the capacity of language use to bring respective W_is into register. In this sense, language use 'creates' the shared subjective perception of a universal space containing all people and things.

The capacity of routine language use to generate and sustain in each of us a working understanding that we are all operating within a universal space will greatly reinforce the process of projection inversion and will help stabilize the sense of self awareness which is the outcome of that process.

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[80] Note: O_i are only one of the kinds of perceived specific objects described in Section 7.32. For completeness, we can call <u>all</u> entities in W_r capable of giving rise to perceived specific objects, J_r. Hence, J_r will not only will include O_r, which are objects_r perceived as closed surfaces_i, but also will include the sources_r of perceptions of extended surfaces_i, closed volumes_i and extended volumes_i.

[81] Here *register* is used in analogy to its meaning in the context of photography and printing.

[82] As pointed out earlier, the potential for the genesis and use of language for this purpose derives from the fact that for any B_r, its W_i, strictly as perceived at the level of specific characteristics, can only reflect information which emanates directly from entities, and their relationships, which exist at the absolute level.

9 *Conclusion*

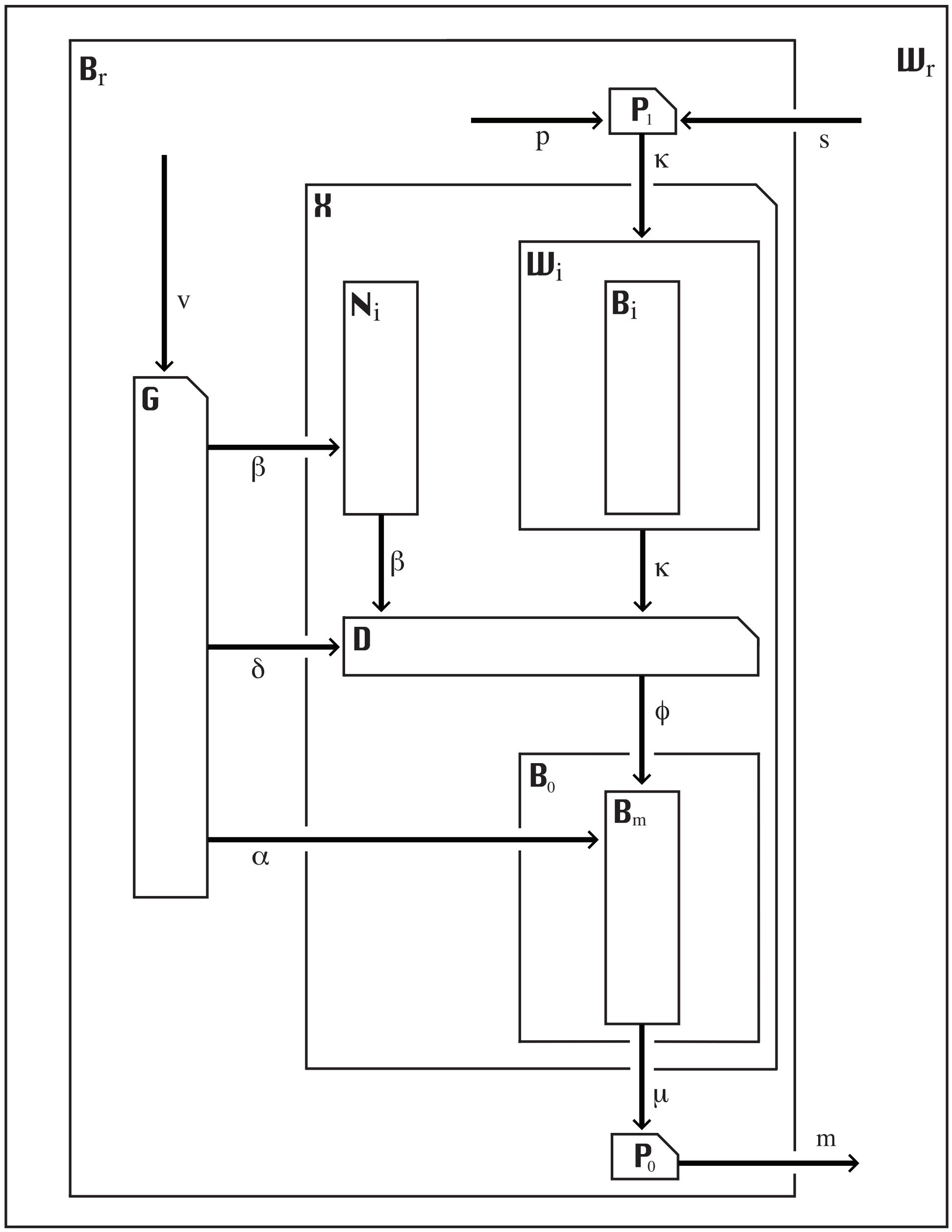
The preceding essay has been written with a view to shedding some small light on the processes by which human self awareness - broadly known as *consciousness* - may be generated.

One of the challenges in drafting so speculative a piece of work has been to resist the temptation to over-elaborate or to explore interesting but non-central implications of the ideas advanced. Hopefully that challenge has been met.

One area of subsidiary speculation which it has been particularly difficult to set aside has been that of the operational relationship between critical self awareness and extended self awareness. Preliminary work suggests that an understanding of that relationship will provide some explanation of the subjective experiences associated with the strategic planning of physical actions (long-range planning), and shows that such planning will, at least in part, be a conscious activity[83] and will involve a second way of processing κ incon which can be called *semantic processing*.

In conclusion, Figure 20 shows a full schematic, under the hypothesis developed, for a physically self aware adult.

[83] The hypothesis developed has already shown that for the duration of the reflective sequence (S5, S6, S1) the association matrix will sustain a subjective perception of itself as being within a self-as-body, which in turn it will perceive as surrounded by a space continuum populated by specific characteristics. That implies that critical self awareness, or consciousness, will prevail throughout the 'planning' step in the action cycle, which is S6 (next locus projection).



$\mathbf{B}_r$
$\mathbf{W}_r$
$\mathbf{P}_1$
p
s
κ
$\mathbf{X}$
v
$\mathbf{W}_i$
$\mathbf{N}_i$
$\mathbf{B}_i$
G
β
β
κ
D
δ
ϕ
$\mathbf{B}_0$
$\mathbf{B}_m$
α
μ
m
$\mathbf{P}_0$

Figure 20