THE MENTAL DATABASES

by

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1. Types of Brain and Database Data

It is proposed that there are two types of brain data. They are the material and the mental:-

The material type is used to convey normal neural data around the brain and the body. An example is the movement of pain data from the epidermis to the brain. This is well understood through the actions of calcium ions, readiness potentials and so on. This type corresponds to the computer's raw input data (for the moment I will neglect the possibility that this neural pulse train is already conscious data). This type is also that of the brain's output data conveying instructions to the body after mental processing.

The second type is the mental data (both access and phenomenal, in Ned Block's well-known terms [1]), used by the mind in general and consciousness in particular. At this point the consequence of Chalmer's[2] Hard Problem may be taken to mean that there is no currently visible form of mental data in the material world as it is defined by current physics (and therefore current neuroscience). This article attempts to show that this is in fact the case, implying that the mental type of data exists in a conceptually separate mental domain.

It is also maintained that, except for phenomenality, almost all of the mental domain's capabilities correspond to those of a computer's database (see table 1 below). The relational database was initially conceived to make it easy for our minds to manipulate data, so its structure corresponds closely to our own thinking structure. Treating the brain as a database furnished with a phenomenal capability makes it easier to create models which can be understood by the human mind/brain. Also, by proceeding in this manner, phenomenality is conceptually isolated from material functional considerations, thus clarifying the overall structure, enabling the problem to be approached from a more secure base. A useful help to the understanding of a complex problem is to isolate as far as possible its most difficult part. The less developed and less modularized Turing machine-based reentrant or connectionist models are felt to form a less solid base for subsequent reasoning. Hopefully, the mental domain will prove more accessible some time in the future using the methodology of Science.

As illustrated in fig. 2 below, the following operations are effected in transforming the data from type 1 to type 2 (e.g. to transform red visual data from the eye to a phenomenal red-seeing sensation in the mind):-

- The creation of connecting pointer indexes, relating the different data elements, whether in a brain or in a computer. Data is fundamentally useless without some form of interconnecting indexes (see chapter 3.3, "The Computer's Database Indexes"). Obviously axons and dendrites are materially necessary in this context.

- The bridging between the type 1 material form and the type 2 mental form.

All the data of the second type is in the mental form in which almost all memories and procedures are stored, accessed, executed and coordinated. The method by which this type of data yields consciousness is unknown and in its essentials constitutes the "Hard Problem". The data's indexes must be highly structured in order to answer questions since this requires the interrelating of many different data elements from many lists. In other words, the mind's data is held in a database form. Neurons are interconnected by dendrites, axons, neurotransmitters and so on, but the simple existence of point-to-point connections wouldn't furnish the brain with the necessary complex index structures corresponding to those in a computer's database, for which counterparts must exist in the brain. Thus, as in the IT world, one of the first things to happen to the incoming sensory data arriving at the brain is its translation into an appropriate mental form, constructing pointers to relate the new mental data to existing mental data and supplying phenomenal capability where needed.

The positioning and structure of the bridge where the first type of data is transformed into the second is not known. It is known that the appropriate emotion isn't produced immediately the data enters the brain. Fear isn't excited unless the input data has reached the amygdala and pleasure isn't felt unless data reaches the putamen. Yet an examination of the intra-neural data flow after the putamen doesn't show any new type of spiking or other characteristic which could be ascribed to conscious pleasure. An example of how the system must work is the selection by touch of the warmer of two objects. Touching the first object permits the brain to memorize its warmth in the mental database, building the appropriate indexes. The detail concerning the touching of the second is as follows:-

- The sensory data (type 1) flows up from the finger to the brain.

- Bridging in the brain/mind translates this data into the mental form (type 2). Simultaneously, the indexes necessary to relate the temperature of the new objects to those of the old (already in the mind) are built and/or modified.

- The conscious mind executes the mental procedures which access the preceding warmth data through its indexes.

- The two warmth data are consciously compared and the warmer is selected.

Expressed in IT terms, the sensory data must be uploaded into suitably structured mental databases in the brain, thus permitting mental processing such as conscious thinking to begin.

Following mental processing, the databases may output type 1 motor data which, for example, causes our limbs to move.

The two types of data must present significant differences which would be visible to us if we knew better what they were and possessed the technical means to perceive them.

At this point, two options are open to those who are physicalists:-

A) The "Current Physics" Approach

It is assumed that the mental type of data can be better understood using the physical world as it is currently known – that is, as it is expressed through current physics and all other branches of accepted science, such as psychology and neurochemistry. Physics is the most important since all other branches are dependent on it for explanations at the fundamental level.

B) The "Expanded Physics" Approach

Because of the necessity of accommodating the phenomenal characteristics of the mind Roger Penrose proposes an expansion of physics[3], permitting the co-existence of phenomenal and physical worlds. Penrose does not believe that either a purely mathematical or a "current physics" approach can even simulate consciousness. As he is one of the world's foremost mathematical physicists, his opinion is not to be lightly disregarded[4]. He sees consciousness as uniting the mental ("qualian") and the physical worlds. A famous researcher on time perception, Benjamin Libet, refers to the expansion as a Conscious Mental Field[5]. These approaches imply that the mental type is available only to a physics as yet unknown to us, although it may be suspected that it will eventually appear from fundamental research now under way.

Other arguments supporting the choice "B" approach include Searle's Chinese Room[6] which indicates the phenomenal aspect of the mind while calculating. Penrose maintains a similar position on that subject. As Searle points out, even a trivial conscious computation carries a mental (and therefore phenomenal) aspect, so our brains do not use only computationally oriented consciousness (Block's "access consciousness") while computing. Therefore in this article the Hard Problem is confronted from the start, by declaring that the mental database must support computation as well as sentience.

Again following Penrose, even access consciousness cannot be considered as only computational because it cannot be simulated on a computer, although computation is embedded in a computer controlling a robot[7]. In this view, stances such as 'Property Dualism' are considered as computational or eliminational.

So this paper is written using Approach "B". However, much of it remains applicable to Approach "A", since the brain must possess databases and the format distinction between database and non-database data must still apply.

2. Definitions and Vocabulary

2.1. Primary Terms - Physical, Material, Mind/Mental

The terms "physicalism" and "materialism" are usually looked on as synonyms[8], with the former being used perhaps in a more widely inclusive context. Sir Arthur Eddington, for example, distinguished between the two terms[9]. John Searle in particular inveighs vigorously against dualism's separation of "physical" and "mental"[10]. To him, in effect, the "mental" is part of the "physical", the latter being all-inclusive. This document takes the same monist approach, also used

by almost all those quoted above. The term "mental" is the adjective corresponding to the noun "mind". Put simply:-

Material brain + Mental = Physical brain

The term "material" is used to represent the term "current physical" (as defined above), except where it is necessary to distinguish between the "current physical" and the "expanded physical". Thus "material" corresponds to the ordinary day-to-day use of "physical" and applies to all that is currently available in established concepts of physics

, including relativity and quantum theory. Versions of string theories, quantum gravity and other possible future extensions to physics are included, along with all that is "material", in the term "physical", which is all-embracing. At some time in the future, when they are better understood and integrated, these will perhaps form a solid part of the "expanded physics", as will, hopefully, terms such as "qualia".

Thus type 1 (non-database) activity is material as its operation can be explained using current physics. Type 2, (database) activity is mental and requires the expanded version of physics. In this document, physicalism is viewed as a completed materialism describing the whole of our universe to the extent that it can be incorporated into a unified physics including all forms of consciousness. The completion may involve matters not originally perceived as being physical, as happened with Quantum Theory concerning "spooky action at a distance".

This differentiation between the terms "material" and "physical" is necessary for the purposes of this paper. It has the further advantage of avoiding unproductive discussion concerning personal beliefs, religious or other. Taking things to the extreme, there is nothing in principle preventing the incorporation of either a religious fundamentalist's or an atheist's view into this overall concept of the physical, as long as the view is consistent within itself, with the world as we know it and with the nature of any future expanded physics which is experimentally confirmed (although, in my opinion, religious fundamentalism fails the first two of these conditions).

The view that the term "physical" has historically varied in meaning is not unconventional. Besides those cited above, the Oxford Dictionary of Philosophy[11] remarks on the impossibility of satisfactorily defining it. The concept of 'physical' has been expanding in scope since the time when the mind/body problem was first clearly expressed by Montaigne in the sixteenth century, several decades before Descartes[12]. A century ago, no respectable physicist would have entertained the weird consequences of quantum physics as suitable for a physical or material universe. Further analysis of the differing contemporary views of the terms "physical" and "mental" is given in a recent issue of the Journal of Consciousness Studies[13].

2.2. Secondary Terms:-

These are:

Qualia, Phenomenal, Information, Brain, Format, Database, Procedures and Meaning.

The mind includes both mental "procedures" and mental "memory". A procedure normally has more than one "step" or "process".

The same data on computers may be represented in different "formats". The sequence of the contents of two units of the same data may be different. One may be in English, the other in French, or one may be represented in ASCII code, the other in EBCDIC code. In the mind/brain context, the mental format(s) of anything at all will be completely different to the material format(s) of the same thing, even where they refer to the same unit of data. A trivial example is "finger". No-one knows how a finger is represented in the mind.

In this document, the term "mental" applies to all the types of processing and memory associated with consciousness and unconsciousness. This includes access, phenomenal, procedural, declarative, intrinsic and other forms of consciousness. The mental is treated as being inherently semantic. It is a term taken to be valid and expected to be useful in an expanded physics. The brain itself taken as possessing both material and mental components.

The term "phenomenal" may be said to correspond to the neologism "qualian", the standard example being the "redness" of a red object, impossible to generate in a computer. It implicitly evokes Chalmer's "Hard Problem" (HP).

The Mental Databases

By the definition used by this paper, computers deal in units of material information (as defined by Turing), whereas the mental deals in meaning. By this I mean that there is always a semantic aspect to what the mind performs, and that this aspect is absent from computers, as is argued famously by Searle[14] and Penrose[15]. The semantic itself is looked on as always possessing a phenomenal aspect. This means that access consciousness can coexist with phenomenal consciousness, a position which Block himself entertains.

The context in which these definitions have been determined is given below in the "concept outline" section of this paper. Fig. 2 offers an overall structural view in an "object visualization" situation.

For clarity, the term "mental database" is used in either the singular or the plural, depending on the context. It is to be understood that there is a set of flexible interconnected ("distributed" is the IT term) mental databases in the brain. The question of the likelihood of material (i.e. non-mental) databases is not important in this document. The abbreviation NCC (not NCCs) is used for Neural Correlates of Consciousness.

3. Brain/Database Functional Comparison

3.1. Justification for the Use of Database Terms

Knowledge Engines and Procedures

The computer in this article contains a data management system which is referred to as a database. Obviously one cannot directly compare a database's functions with those of a brain, but certain fundamental capabilities must be present in both, since they are both knowledge engines. Furthermore, given that the material database's structure was conceived and programmed for the storage and manipulation of data by the human mind, it isn't surprising that the structures of the two are so similar (see table 1 for equivalents). This also facilitates comprehension and increases the likelihood of specifying an appropriate model for the mind.

It is better to use a computer with databases in it than to start with computers which possesses no knowledge processing software and rely only on connected base machines. Using a database on which to base one's model means that a lot of the work is already done.

In computing terms, a procedure (or a process or a routine) is a suite of instructions which operates on data to produce a required result. In the case of a computerized robot an external action may ensue. The mind can also be considered as dealing in procedures/processes and data, though of a semantic, rather than a material nature. In this article, it is not meant that the brain is just a kind of stored program executor, as is a digital computer.

Neuroscience limits its use of the term "procedural memory" to the type containing skills, such as bicycle riding. In this document the term "procedure" refers to all those procedures/ processes/ routines which are inherently held in some area of memory. For example, mental processing takes place when incoming visual data of a red object is transformed into the corresponding quale (see Fig. 2). This processing is referred to here as procedure execution. The procedural steps of which a material procedure is composed are, typically, the successive generation and propagation of action potentials, ions and so on, as one neuron processes data and passes it on to the next.

Transactions

Transactions are the data changes which effect changes in the state of the database itself. A transaction may be described as a group of processes which operates on data, moving it from state S_0 to state S_1. Thus, when, say, depolarization opens sodium ion channels in the neural membrane and Na^+ ions are allowed to flow into the neuron, yielding its next state, one may say that this occurs through a succession of material processes, as happens when a row of standing dominos progressively collapses. In this case the transaction is constituted by the group of processes. The data on which it acts is constituted by the initial state S_0 of the neuron.

Interesting Similarities between a Computer and a Brain

John Searle has remarked that any material system can be described as a computer. Agreeing with Block, Searle quotes him as writing that "the irrelevance of hardware realization as to computational description"[16]. Even a window shutter, blown backwards and forwards by an eddying wind can be used as a computer computing wind speeds and turbulence, if one so chooses and connects it up with the appropriate instruments. A more conventional application is a wind-tunnel. Simple educational computers have been made of water pipes and valves, executing the same binary programs as electronic versions. Any material system in motion of some sort may be looked on as a digital computer. But not everything in movement expresses qualia.

A digital computer can be looked on as an analog device or vice versa as one chooses. A computer can be in the von Neumann "step-by-step" form or in the "continuous analog" form, depending on the framing of the question being asked. Of course, almost all the useful questions asked by humans of a computer are framed digitally, but only because that is the best way for us to obtain comprehensible and accurate answers to pertinent questions. As mentioned above, I do not for a moment believe that the brain is *only* a digital computer. The analogy is used only because the computer's database metaphor is as an illuminating mode of expression, possessing so many of the same capabilities and features and sometimes even methods as are found in the brain, as shown in the table below.

This discontinuous "digitality" of neural operations is further illustrated by the "all-or-nothing" output from a firing axon. Either there is a resultant change in voltage (i.e. potential) or there

isn't, as in a digital computer. One may even go further and say that, as the quantum world (of which the material world is constituted) is essentially discrete, even a so-called analog computer is digital. It proceeds directly from one state to another. Each successive realized quantum state may thus be looked upon as a procedural step. Mental procedures take place in the mental domain, which is seen as in some sense as existing within coalitions of material neurons.

3.2. Capability Correspondences

The perceived fundamental capability correspondences are as follows:-

TERM	COMPUTER	MIND/BRAIN
Database	The structure required to memorize, relate, retrieve and process data. It contains data, indexes and procedures	The mental database structure required to memorize, relate, retrieve and process mental data, whether phenomenal, access or unconscious. There are probably also purely material databases, of less interest.
Unformatted Data	Raw input/output data (e.g. ASCII) not in a database	Material raw data, not in a database (e.g. incoming/outgoing sensorimotor data).
Data	e.g. Oracle data tables	Mental database data (e.g. stored qualia)
Suites of Instructions	Procedures As they are held in memory, these are also considered as data by certain procedures.	Procedures in general, such as those associated with motor skills, thinking and feeling, which operate on data. Since they must be held somewhere in memory, they also constitute a form of data, whether material or mental.
Optimized Procedures	Compiled procedures	These are general procedures which have been optimized to effect a particular skill, such as riding a bike. Neuroscience usually reserves the term "procedures" for this type of case only.
Pointers indicating the locations of data related to that currently being processed	Data indexes, the structure of which gives the structure of the database itself (see Hebbian activity chapter 5.5).	Neural or mental pointers, linking different data elements. The neural connections partially fulfill this role in the material domain and serve as a supporting and bridging platform for indexes in the mental domain (see Hebbian activity chapter 5.5).

Data Conversion Procedures	Interfaces	Bridging facilities, transporting data from one domain to the other, changing data and index formats from material to mental, or the reverse, as required.
Data Denormalisation: The multiple storage location/aggregation of the same data, improving access time.	Occurs frequently, especially in large "Data Warehouses"	Occurs frequently, especially between the conscious and unconscious. For example, riding a bike is conscious during the apprenticeship, then unconscious but conscious control can be resumed when wished.
Overall Coordination an Integration, which can be described as "Binding".	Operating Systems, controlling input/output, priorities and communication and other resource assignment. e.g. UNIX, Windows XP	Consciousness. A similar role as in a computer is adopted by the various types of consciousness, with the enormous that phenomenality is integrated.
"Housekeeping"	Database optimization, done while the computer is not busy on a user request or at night.	Sleep, which rids the brain of unneeded indexes and data while structurally re-optimizing those remaining.
Intermediate data storage region	Working Storage	Working Storage The fact that this is used also by computers supports the notion that the brain handles procedures in a way similar to that of computers
Processing unit itself	CPU. Processes data using Boolean logic on binary data	Neural processing in the mind/brain whose action is not understood.

Notes:

a) To continue to exist when not used, procedures must be stored in memory and so constitute data in this sense. Phenomenal (i.e. mental) procedures require semantic storage space.

b) The phenomenal notion of "feeling" is included in the concept of procedure as it interprets sensory data.

Denormalisation:-

Denormalisation is defined as the holding of the same data in more than one area. Denormalisation is necessary where access time must be short. This is achieved by holding multiple copies of the data in different formats and/or levels of accumulation. An example of its use in the brain's databases is seen in "blindsight". The conscious region has been deprived of its normal access to certain data, but indirect conscious access still exists in another largely unconscious, region where some of the same data is stored. The data has followed both ventral and dorsal paths.

Another example is shown in tennis through the ability of the brain's unconscious perceptual ability to beat the Libet delay of consciousness of about half a second[17] when executing a reaction tennis volley in response to a fast passing shot. All good volleyers watch the ball onto the racquet face, turning their heads to follow the ball. Given that the ball has moved several feet during the half second, the player cannot consciously see the ball onto the strings, but the "grooved" mental procedure executing the volley does receive the visual data where it is used unconsciously. If this were not so there would be no point in the player turning his head.

This is achieved because visual data follows two visual pathways in the brain, one of which bypasses the V1 region. The slowest feeds information-rich consciousness. The fastest feeds the regions used in making fast volleys. The latter is the one which feeds blindsight.

The fact that some denormalisation (i.e. data duplication) is found in the mind/brain in both consciousness and unconsciousness areas shows how earnest was evolution's search for mental processing speed and improved capabilities, as was so valuable to the evolving animal.

3.3. The Computer's Database Index

Since the relational database is not necessarily an expertise of those concerned with neuroscience and the mind/body problem, a brief description of its basics is given below. Anyone at all familiar with database structures is invited to skip this section. The following paragraphs illustrate how such a database works and where the mind must employ similar capabilities, although, of course, not by the same means.

The *raison d'être* of an index is to enable the computing engine concerned to quickly locate and update the required data. It is basically a pointer from one element of data in one list to another element in the same or another list representing the same argument and its value. This pointer itself is, in fact, built from many structured levels of sub-pointers whose organization it is not necessary to describe in this document.

To proceed with an example, imagine that your online bookstore (such as Amazon) wishes you to buy more books of the three authors whose books you have previously purchased. Three lists exist in their computer. List "A" contains the names of your favorite authors and those of their books which you have already obtained from the bookstore. List "B" contains the titles of all their available books and the names of their authors. The necessary computer program must identify the books by your authors which you haven't yet bought. It then recommends these books to you the next time you visit to their site. List "C" is used by the bookstore's warehouse to control stock.

A data/index diagram of the example is given on the next page. The indexes (or pointers) are indicated by arrows. They effectively give the address of related data and take up considerable storage space and processing resources. The structure of the indexes (rather than the data) essentially represents that of the database itself. The example is, of course, only schematic. (To make the figure easy to relate to the above system description, the lists are not "normalized").

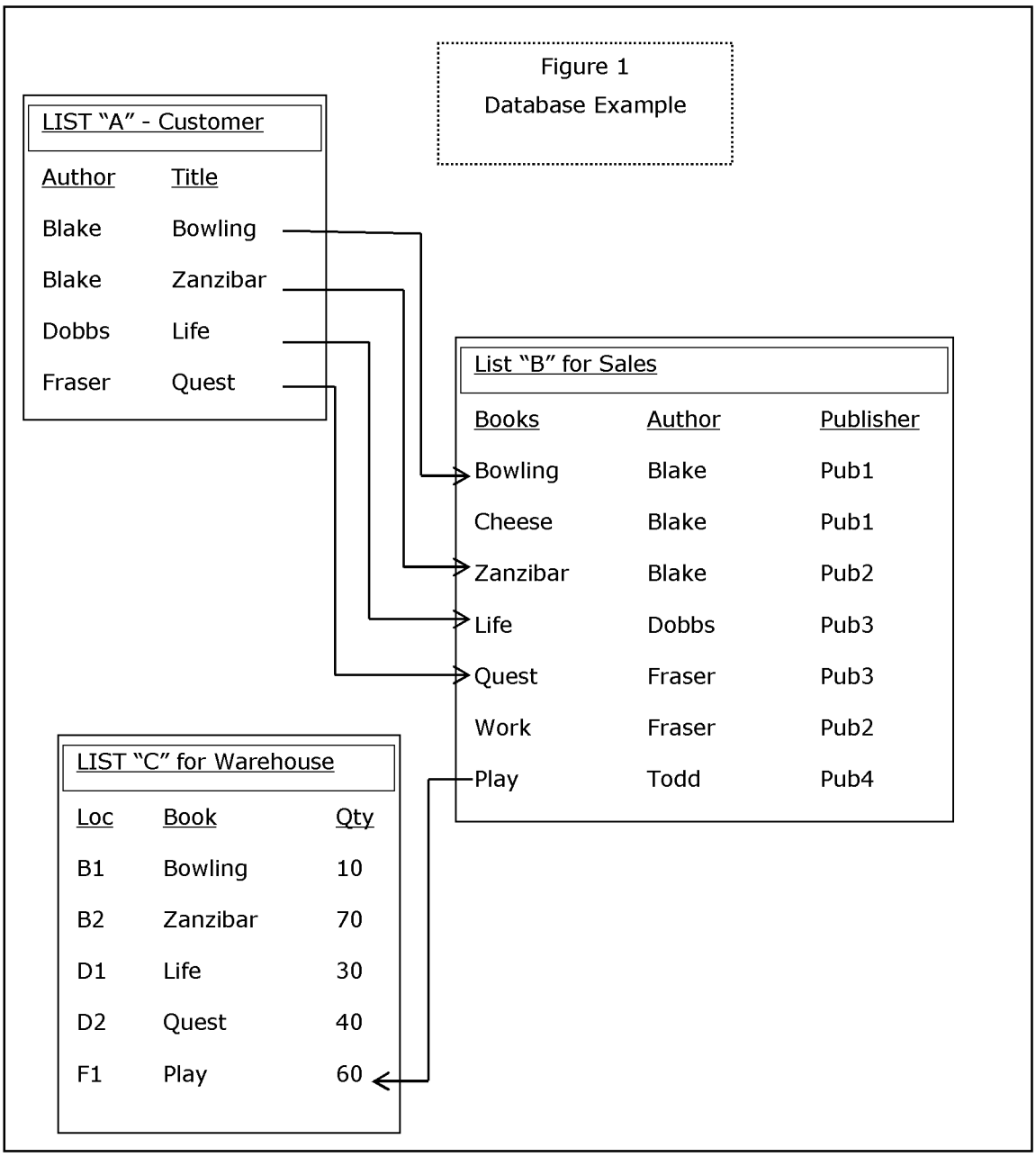


Figure 1
Database Example
LIST "A" - Customer
Author Title
Blake Bowling
Blake Zanzibar
Dobbs Life
Fraser Quest
List "B" for Sales
Books Author Publisher
Bowling Blake Pub1
Cheese Blake Pub1
Zanzibar Blake Pub2
Life Dobbs Pub3
Quest Fraser Pub3
Work Fraser Pub2
Play Todd Pub4
LIST "C" for Warehouse
Loc Book Qty
B1 Bowling 10
B2 Zanzibar 70
D1 Life 30
D2 Quest 40
F1 Play 60

The values of a short selection of data is shown in the list columns. The existence of the lowest List "A" pointer enables the computer program to deduce that Fraser's "Quest" book is not to be recommended because it is already possessed by the customer. The absence of a pointer on Fraser's book "Work" in List "B" enables the program to deduce that this book should be recommended because it is not possessed. The lowest arrow, pointing to List "C", illustrates one value of another index which will let the Sales Department know that there are 60 copies of the book "Play" in stock and that they are in warehouse location F1. Other values for indexes from List "B" to list "C" are not included in order to avoid overloading the diagram.

When the reader is sent the ordered books, the data and indexes of all three lists are updated. When a new book comes on the market it is added to the sales List "B", with its index. Since it must be stocked, its addition must generate an indexed entry in List "C". This means that the data and indexes on Lists "A" and "C" must be updated to reflect changes in the data.

The example shows that data is useless without indexes. As mentioned above, indexes occupy memory space to store the addresses of the desired data in its master list and in the other lists containing the data elements referred to. Although in the figure an index is represented by a single arrow, in reality there are many layers of index accompanied by much code in order for the indexes to function. In a large computerized enquiry "database warehouse" the indexes will frequently take up more space than the data itself. Also, the greater part of the structure of a database is represented by the structure of the indexes, not that of the data itself.

There must be a mind/brain equivalent to the index which relates the mind's data lists, intrinsically representing its structure. The indexing process is resource-intensive. The material part of this work can easily be envisaged as using up the major part of the brain's available memory neurons, the data being held in the associated mental domain.

3.4. Distributed Databases

In an IT environment, there may be several different databases of the same or different types working in parallel within a network of computers or even in a single computer. This is obviously the case for the brain. Presumably there is a database sub-type for each sense and mental type.

4. The Mental Domain (MD) Hypothesis

4.1. Concept Outline

As mentioned above in the "Vocabulary" section, the term "mental" in this document always implies a content which is to be looked on as both "semantic" (and thus "meaningful") and "phenomenal". In his seminal paper on the subject[18], Block himself suggests that the two types of consciousness may be active at the same time. For the purposes of this article there is always a phenomenal component associated with access consciousness. In effect, phenomenal consciousness may be phenomenal only, as when one is assaulted by an unexpected violent pain, whereas access consciousness requires a phenomenal component to provide the mental data in the format in which it operates.

"Access consciousness" pertains to thinking (as distinct from feeling) and is generally agreed to imply a semantic context. Most people see that there is something phenomenal in being in a state of access consciousness, as indicated by Searle's Chinese Room and Block's definition of the two terms.

"Phenomenal consciousness" is associated with the feeling of sensations. One may say that pain and pleasure are meaningful (i.e. semantic) as a consequence of being phenomenal.

Searle's well-known Chinese Room thought experiment illustrates clearly the difference between a state of access consciousness and a state which is robotic.

To illustrate the existence of phenomenality, use is made of Jackson's famous Knowledge Argument (1982), whereby a scientist learns all there is to learn all of the known material scientific knowledge concerning color without ever seeing a red object and is then exposed to one for the first time. The question is "Does she learn anything from this new experience? The answer in most people's opinion is "Yes", thus confirming the existence and importance of phenomenal views.

Many persons go on to state that Mary knew all the physical facts concerning human color vision before her release, so what she learns on seeing red is a non-physical fact. Using the

terminology of this paper a non-physical "red" does not appear, because the term "physical" comprises all science including that which is true even though as yet unknown. In the present terminology, seeing red is a non-material fact. This is of no concern to my thesis, because the material (current physics) is known to be incomplete and, in particular, doesn't explain qualia.

Many workers go on to say that this confirms that Mary didn't know all the *physical* facts about red. According to the definition used in this paper, this is a confusing use of the term "physical". The term "material" could be used instead, but the term "material" represents an incomplete physics, so the result whereby Mary learns something is unsurprising.

This paper maintains that Mary learnt something and that something was "what is the phenomenal aspect of red like".

The implication for this paper is that the term "phenomenal" is used to identify both:-
a) one type of consciousness (phenomenal)
b) an aspect of the other type of consciousness (access)

but I can't find a better way to formulate my arguments using the currently accepted vocabulary, against which Searle inveighs so effectively.

As there is nothing semantic about the robotic (or zombie) material world, all semantic data must be stored in a mental domain. Thus relatively little data, as distinct from indexes, is stored in the mind's material domain. Destroying neurons will in all probability destroy all or much of the relevant mental domain. However, it is suggested below that the "unexpected stability" of memory, is due to the fact that mental data is resistant to material trauma because it is a different domain.

It is likely that intra-mental indexes also exist. Mental data activity, such as that of episodic memory has been localized in the hippocampus in the material domain. However, working memory areas have been proven more difficult to pin down. Working memory is temporary in nature. It is suggested that in many cases working memory has no need for external non-conscious material information – both the working data and the corresponding working indexes are present only in the conscious domain. This would result in faster processing. In computers, working memory is frequently assigned to separate faster cache storage.

Mental data isn't visible to current brain scanning methods such as fMRI. This poses no problem to the hypothesis of a mental domain since the neural unit itself contains material and mental domains which are seamlessly conjoined. In this context it is remarked that in computers the first and last operations on data transactions concern the data's indexes, not the data itself. Thus we may expect to see early and late phases of the transaction's EM activity in the material part of the brain handling the capability (such as speech) in question. It is not data storage activity we are seeing, it is data upload/download achieved through index/bridging activity, as shown in fig. 2.

The following "Principle of Semantic Consistency" is now enunciated in support of the hypothesis:-

"Semantic data and semantic procedures require a semantic mental domain in which to operate".

It is worth noting that even if phenomenality could be explained in a material context (as suggested above in Option "A" in paragraph 1), the semantic sub-domain would remain conceptually necessary; in this case its activity would be, of course, visible on brain scans.

In writing of separate mental and material domains, I am making a distinction appropriate for human understanding, but of no importance to Nature itself. At the time of the appearance of consciousness, physics operated under the same laws as it does now. Humans perceive a difference because it is only recently that it has become recognized as being as significant to science as it always has been to philosophy.

I don't hazard an opinion on whether the unit of the mental domain (the minimal conscious substrate) relates to the sub-atomic, molecular, coalition, sub-Planck or any other level. For the purposes of this paper, the mental domain is simply where mental data and stored procedures (e.g. episodic, procedural) are held and where the various types of consciousness exercise their capabilities.

Taken together, the two hypotheses posit that functions are divided between the domains as follows:-

Material Domain

This contains:-

- the interface relaying data to and from the mental domain.

- the relaying of sensorimotor data to and from the body, activating body systems as necessary.

- the indexes pointing to the addresses of the required data/procedures stored in the semantic mental domain.

- support platform for the mental, supplying energy and other facilities.

The Mental Domain (MD)

This contains:-

- the complement to the material interface, relaying data from and to the material domain.

- the storing of memories: short term/long term, declarative, procedural, episodic, etc.

- running the procedures relating to emotions, decisions, consciousness and unconsciousness, etc.

To resume, the originality of the MD hypothesis depend on the proposition that all of the semantic data is held and processed in a mental domain. This purports to explain why there are no clear signs in the material domain of either phenomenality or of comprehensible memory encoding and processing algorithms, nor any concrete prospect of finding them.

I surmise that the connections between neurons carry the indexes for both mental and material data (see section below on "Joining Neurons").

The diagram below shows the overall structure of the body/brain/mind/ and the flow of data and processing of a visual transaction. Visualization is an appropriate example, since it is naturally "transactional" in nature, because about 25-30 separate sequential "photos" are taken by the eye every second. Each "photo" is considered as a transaction containing data to be processed materially and mentally.

Note: The figure below shows the essentials of the approach taken in this document. The thin dotted single arrow-headed lines indicate the procedural sequence as well as the flow of data; the solid arrows indicate the index and data connections; the rectangular boxes indicate the material/mental functions whose processing determines the updating of the mental databases (i.e. the mind) and their output; the thicker horizontal dotted line separates the mental and material domains.

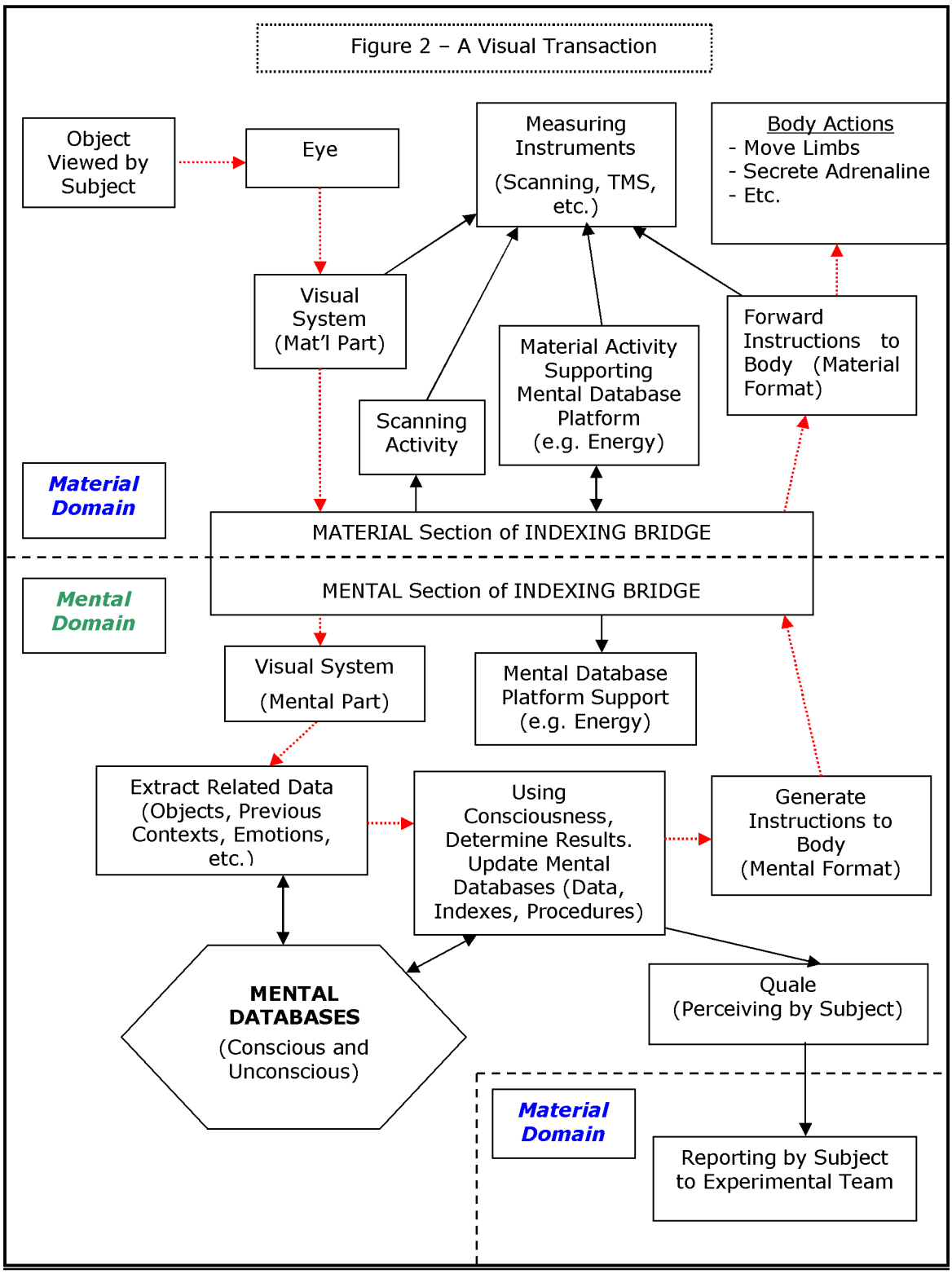


Figure 2 – A Visual Transaction
Object Viewed by Subject
Eye
Measuring Instruments (Scanning, TMS, etc.)
Body Actions
- Move Limbs
- Secrete Adrenaline
- Etc.
Visual System (Mat'l Part)
Material Activity Supporting Mental Database Platform (e.g. Energy)
Forward Instructions to Body (Material Format)
Scanning Activity
Material Domain
MATERIAL Section of INDEXING BRIDGE
MENTAL Section of INDEXING BRIDGE
Mental Domain
Visual System (Mental Part)
Mental Database Platform Support (e.g. Energy)
Extract Related Data (Objects, Previous Contexts, Emotions, etc.)
Using Consciousness, Determine Results. Update Mental Databases (Data, Indexes, Procedures)
Generate Instructions to Body (Mental Format)
MENTAL DATABASES (Conscious and Unconscious)
Quale (Perceiving by Subject)
Material Domain
Reporting by Subject to Experimental Team

Assuming it is correct, fig. 2 shows that we can never see direct neural correlates to consciousness using instruments which function using current physics. The experimental team and instruments receive only the following material data:-

- The material part of the indexes giving access to the mental data. This constitutes the greater part of the scanning activity visible on current measuring instruments. Indexing continues throughout the duration of the visual transaction (just as in a computer database).
- Visual input data.
- Database material supporting needs (such as energy) while it is being updated by the visual transactions.
- Output material instructions from the mental to the body, resulting from conscious consideration of the visual input
- Reports concerning the experienced qualia, expressed by the subject himself.

As shown below in section 4.2, consciousness cannot be epiphenomenal. This implies that in some respects it drives the material brain, so it must itself be changing in a way partially independent of the material brain. This obviously favors free will but in the interests of brevity it isn't explored here.

According to the MD and NI hypotheses and the conclusions described above, there is currently no way of directly comparing the mental and material formats. For example, there is no direct view of the mental emotional activity on our material instruments. Of course we see the corresponding quale and interpret its images, but we see nothing on the measuring instruments of the emotional data in its mental format, nor do we see anything of the mental processing that updates the mental databases (i.e. our mind including our memory). In IT terms, we see the database transaction going in but we can't see the database state itself. If the mind's transaction adds $500 to one's current bank account which we know mentally to contain $2,000, only the material side of the $500 transaction will be visible to the instruments. These instruments will detect nothing of the $2,000, nor of the resultant $2,500, nor even of the mental part of the execution of the material $500 transaction which updates the balance. To obtain material information on the transaction updating, one must express it in some material form - by pronouncing it out loud or writing it down, for example. Of course there will be some visible material index updating, but the mental amounts themselves (i.e. the data itself), which are indexed, won't be visible.

It will be noticed that even numerical data is taken to be mental. Authorities hold that that which can be handled computationally is handled purely materially and computationally, but for reasons given below on the unlikelihood of different data formats and duplicate data storage, this is not so. Duplicate data is allowed only for reasons mental speed through denormalisation, as mentioned above.

Considerations Relating to the Material Probing of a Mental Database

A mental probe is defined as an instrument which reads out mental data from an existing brain and translates it into material data to which the researcher has access. A superior mental probe will retrieve the content of the mental without seriously perturbing the mind/brain during the measurement. Of course, we ourselves accomplish may be said to accomplish such a probing action.

Current exploration of the mental yields only results correlating a material event to a mental one without really giving any biophysical detail concerning the latter. For example, an injection of adrenaline produces heightened awareness or an electrode applied to motor cortex causes a movement and its accompanying sensation.

The central statement of the MDNI hypotheses in this context is that a radical extension to physics will be necessary to produce and understand the probe's biophysics. If this were not so, the probe could be purely material, in which case consciousness would become epiphenomenal, which is impossible as demonstrated above.

The above example of a bank transaction constitutes a first test of the MDNI theses through the probing of a non-material mental domain. It will become a progressively more reliable test as the current methods of scanning gain more and more detail. Either the $2,500 mental database

content will remain invisible to material probing or it won't. In the latter case I will be shown to be wrong (however, it wouldn't constitute a complete invalidation of the MDNI hypotheses because the concept of a mental database with its indexes remains necessary, whether mental or material).

The neonate's brain presumably contains little mental data gathered from experience but this is progressively increased as life progresses. It is suggested that, for example, the $500 mentioned above may perhaps never be visible in its mental form except to the owner of the brain concerned. A new brain/probe can't access the mental database of a pre-existing individual brain, which already possesses its own particular paths to its own particular part of its own mental domain. The inherent subjectivity of this part may mean that it is inaccessible to others. In Nature we don't see any proven examples of brains sharing subjective data.

Pulse Trains

It seems significant that it is not yet possible to detect a key difference between conscious to non-conscious material pulse trains. If this situation persists, then the thesis that the conscious is not material gains further credibility, thus constituting a testable growing in importance. As mentioned elsewhere, any one-to-one correspondence between a material pulse train characteristic and a mental event would imply an epiphenomenal consciousness, which is forbidden by the mental database hypothesis (see the section on "The Impossibility of Epiphenomenality").

Even if it is believed that Option "A" is the correct one (i.e. that the mental database is material; see paragraph 1), one still can't see clearly what is in the database using current instrumentation because we don't know how the database encodes data, and even material interrelated data must be in some sort of database. In the computing world, to obtain a simple data listing one must use a piece of software adapted to the database format and structure in question. Using a low level language program to sequentially print out the machine code data yields gibberish, intelligible only to the compiler/database writers, with perhaps now and again the odd chunk of code which is visibly part of the input data.

Returning to Approach B (i.e. the database is mental), the correlation between the instruments measuring the "Material Indexing Bridge" activity and the "Reporting by Subject" is the most direct to which access can be obtained. The visible correlation with what is happening in the mental database itself will be low. Fig. 2 above illustrates the distance between these two correlated elements, showing how much data manipulation goes on in between.

Let us take the case where a person whose right hand, on touching a warm surface, causes her brain to feel a mild discomfort and causes the withdrawal of the hand in consequence. There will be a certain neural coding/format train corresponding to the feeling of heat sent up to the brain and another neural coding/format for the train corresponding to the muscle movements effecting the removal of the hand concerned. For obvious reasons (one is sensory and the other motor), it cannot be expected that the two events will code the term "hand" in the same way. At least at this point in the development of neuroscience, we won't be able to compare the two codings/formats for "hand", although we may well see an increased activity and more spikes in the neural activities of the two sets of connected brain regions concerned; this may be said to constitute only a weak correlation. In a computerized robot the correlation would be perfect. In a human being the representation of the notion "hand" exists only in the mental domain.

4.2. More Reasons for a Separate Mental Domain

I have drawn upon a wide range of fields. This may give an impression of a lack of focus. However, to demonstrate the likelihood of an initially surprising MD, it must be backed it up by widely available evidence. One may not agree with all the points made below, but if a clear majority of them are judged acceptable then the probability is that a non-material mental domain exists. Up till recently it was generally accepted that consciousness couldn't go very far down the evolutionary scale and was limited to the higher mammals at most. Now one sees its likelihood accepted in respectable contexts, though not everywhere. Christof Koch writes: "Perhaps they too (bees, squids, fruit flies and even roundworms) … can experience pain, pleasure, and sex"[19]. The idea of such early consciousness was widely refused at the beginning of this century. Perhaps the same will happen in the relatively near future with respect to the concept of a separate mental domain.

Plasticity

Plasticity is the capability used by the brain to repair material damage. Its surprising power is an accepted fact. Christof Koch[20], like many others, has remarked "that the brain has amazing powers of recuperation". Even substantial damage to the corpus callosum can be repaired. New neuronal paths may be created to re-establish the broken connections. It seems less surprising if one considers the subject from a database point of view.

The advantage of a database is that the situation before the damage can be re-established. Most, if not all, of the material damage will be to material data indexes, not to the mental domain data itself. Computer data indexes can be completely rebuilt if one still has all the data. The converse is not true. If one loses data there is no way of re-establishing it from the indexes. In a large computer other redundancy methods are used to reconstruct the data.

Thus the surprising plasticity is a supporting argument for a mental database.

The Impossibility of Epiphenomenality

Since epiphenomenalism invalidates my thesis, I will now attempt to rebut it.

The following argument was advanced by William James[21]: If consciousness were epiphenomenal there would be no reason why the emotion should match the action required by the situation. For example, hunger matches a need to eat, fear matches flight, anger matches attack. One does not feel mildly amused while struggling to free oneself from the constricting coils of a python. Following up this line of argument, if epiphenomenalism were operating than there would be much more genetic drift concerning emotion since it would have no survival value, but such drift isn't seen when examining the genome or animal behavior (genetic drift refers to the random genetic mutational changes which occur since they comport no evolutionary advantages or disadvantages). To an epiphenomenalist, it should seem strange that unnecessarily appropriate feelings such as hunger and sexual desire should be passed on, attached to the appropriate action, essentially unchanged in the many thousands of evolved animal species in which we see them.

Another reason for refusing the epiphenomenal option is that calling something an epiphenomenon doesn't absolve one from the obligation to explain it - it merely says that the something is not important in the current context. This is impermissible if the context is the explicating of the something itself - in this case, consciousness. Referring to Huxley's classical example, the train's whistle can be looked as an epiphenomenon with respect to the stationary train's acceleration away from the platform, but not if the subject of enquiry is train whistles.

The property dualism option seems to me to be unnecessarily nomological (i.e. arbitrarily lawlike), in effect maintaining that consciousness is a brute fact dependent on the material configuration of the brain and can't be explained further. If any reasonable explanatory proposition, even incomplete, is put forward, then the *deus ex machina* of property dualism (and substance dualism itself) may seem unnecessary.

If consciousness is not epiphenomenal, it must be useful to the animal that possesses it; otherwise Darwinian evolution would not have selected it and incorporated it into the species genome. This is tantamount to saying that it is causally efficacious. See below under "Evolutionary Advantages of Consciousness" for suggestions on this matter.

Genetic drift occurs spontaneously when there is no particular evolutionary need pushing genes one way or another. If consciousness were epiphenomenal, we would observe different sounds and sights diverging from a primeval standard. For example, hearing might become part of sight, as happens in subjects suffering from synesthesia. Where this mixture of senses becomes too significant it would be felt as a Darwinian disadvantage. The fact that this has not happened in the millions of years available means that there has been no drift.

Personally, I find the above disproof of epiphenomenality, taken together with Searle's Chinese Room, Jackson's Knowledge Argument and Penrose's work to provide a firm base for a causal consciousness with its own domain.

The Impossibility of a Complete Set of Material NCC

The goal of many neuroscientists is to find the complete set of Neural Correlates of Consciousness (NCC) which match all mental activity to corresponding neural activity, visible on brain scans and elsewhere. However, the consequence of the above arguments is that we cannot

see anything that really merits the title of NCC. What we may see is the neural correlates between the different material inputs to, and material outputs from, the Material-Mental Indexing Bridge (see fig. 2).

According to the "Complete Set of NCC exists" hypothesis, all neural activity forms part of a closed material causal chain. Thus emotion is supposedly completely dependent on material events and is physically predetermined. This view leads inevitably to an epiphenomenal consciousness. Identity theories follow on. However, since consciousness has been shown not to be epiphenomenal, the complete set of NCC can't exist. Moreover, since the advent of Quantum Mechanics, physics does not support the notion of a predetermined universe because of the way in which the wave function is collapsed. Physics has been said for several decades through quantum theory to support the concept of a fundamentally random universe[22] but this statement is generally agreed to be open to modification by future discoveries, such as the "Many Worlds" postulate. If consciousness is causal, the universe is not random.

It is perhaps worth mentioning in this context that we may have already isolated a neuronal biochemical sequence which is actually an example of an NCC substrate, without having recognized it as such. This would happen if the animal or object concerned can't or doesn't communicate a quale yielding a material action visible to us when the substrate is activated. The Certainty of an Expanded Physics

New fields, dimensions and forces are being discovered regularly. For instance the strong and weak nuclear forces were discovered within the last seventy years. String theories and their extensions are suggesting several more dimensions of space. The lat two theories and many others under consideration are not yet sufficiently developed for inclusion in the "current physical world". The fact that we feel a pain in a particular region of body space suggests that perhaps there exist at least three dimensions of phenomenal space. If the proposed advanced physics implies further fundamental spatial dimensions in our universe, it seems unlikely that they have no perceptible effect on us.

The whole concept of the "physical world" is evolving. No respectable physicist of a century ago would have entertained the weird consequences of quantum physics, such as the multiverse hypothesis and Einstein's "spooky action at a distance" as referring to a physical universe.

"The LMT Physical Dimensions"

The term "Physical Dimensions" refers to a related but different concept to that used in talking of ordinary "dimensions" when used in physics, as described below:-

Typical physical dimensions are L (length), M (mass), T (time) and Q (electric charge). Nowhere in physics does one find a physical dimension which is even faintly semantic or phenomenal. All the equations in physics must have the same combination of physical dimensions on each side of the equation, e.g. velocity, measured in miles per hour has the dimensions of L divided by T, so v (velocity) = LT^{-1} (the minus sign implies "divided by"). Volume has the physical dimensions of L^3 (i.e. L x L x L) .

However, as Penrose has remarked, special relativity has already enabled us to relate two apparently unconnected basic dimensions, using the well known equation $E = mc^2$. Thus mass can be expressed in terms of energy's dimensions of ML^2T^{-2}. It is suggested that, similarly, we may find a combination of known physical dimensions which proves to be suitable for consciousness. Personally, phenomenality seems to me conceptually much further from the material than E is from M, both of which are material. I suggest that phenomenality is like, say, Q (electric charge), which can't be reduced to any of M, L or T.

"Emergence"

Many scientists, when asked how they expect the consciousness question to be resolved, reply that this will come about through "emergence". These persons expect that the current version of physics will suffice as a base. For them the advance will come through further in-depth examination of the high complexity of the brain. However, as David Chalmers famously remarked, "adding function to function produces only more function", not an entirely new capability such as consciousness.

I don't know of any precise definition of "emergence" in this context. Sometimes it refers to emergence with time, other times it implies emergence from the currently known fact base of the science concerned. I suggest that, only if a new dimension is needed or a radically new view of the

universe (such as that of quantum theory) has had to be discovered, then the new theory can be classed as emergent.

One may say that quantum physics emerged from Maxwell's electromagnetic theory, but it did so only because classical electromagnetism (EM) proved to be incapable of explaining light and other radiations. If this is the emergence criterion, almost all scientific advances were emergent.

Certainly new facts concerning consciousness will appear from the continuing advances in neuroscience. I believe it will be confined to indicators of which direction in which to aim subsequent research on phenomenality. Examples of such target indicators are, of course, the neural NCC and the "observer/observed"[23] phenomenon, whereby the observer and the observed interact.

The Absence of Phenomenality in Computers

The ability of the human mind to experience phenomenality is fundamental to its nature, but no verifiable proposition for materially-based phenomenality has been produced, even as a reasonable thought experiment. Various computerized neural nets purporting to achieve the same material results have been advanced but none contain a phenomenal component. All computers, however massively parallel and interconnected, running software however sophisticated, are nevertheless subject to the restrictions applying to all Turing machines, which are void of any phenomenal or semantic content. No-one pretends to have cracked the brain's material-to-mental bridging code, nor that of phenomenal processing itself. This is understandable if the code depends on a domain not yet handled by physics. The useful work done on computers is limited to the material domain, where, for example, neural circuits round the eye or in the visual center correspond to different data shapes and colors, but not identified as objects in contexts.

The Incompleteness of the Material World.

The current version of physics is agreed by mainstream physicists to be insufficient to describe our universe. There are no explanations for quantum gravity, dark energy and matter, quantum theory implications and many other fundamentals. There is much speculation about how many new dimensions there are to be discovered. Do strings exist? What is time, which is something consciousness feels? Is it a succession of separate states or is it continuous? Did it start with the Big Bang? There seems to be here a vast potential for explication, connected with consciousness.

Except for those who deny its existence, by inference or by outright condemnation (à la Dennett), consciousness is seen to be ineffable. It would not seem overly optimistic to hope that the huge gaps in material physics are openings into which the homeless science of consciousness would fit, thus eliminating the ineffability and helping to complete physics.

It is therefore impossible to consider the material part of the brain as truly representing a causally closed universe, although a future version of physics may possibly do so with a physical version.

The Early Appearance of Consciousness

Consciousness evolved at an early stage of Evolution as is shown below. The concept is supported by important authorities, as quoted below and elsewhere. It means that consciousness cannot be emergent from increasing complexity of the brain, since it was present in the early brain.

The first brains came into being about 500 million years ago. Much the same base neurons and neurotransmitters existed at this time. The neurotransmitters serotonin and glutamates[24] existed before brains emerged. The serotonergic system, for example was in place in our evolutionary ancestors, the chordates, by then[25]). Gazzaniga remarks that many parts of the modern brain were in place long ago[26]. Glutamates were already present in the plant world. That part of the brain by which the phenomenal is represented and on which consciousness depends lies in a relatively primitive part of our brain near the brain stem, not in the later overlay of reasoning regions. It would appear that the functions and roles of those early components all that time ago haven't changed enormously, because much the same functional and biochemical mix persists today. Since primitive emotions, like sophisticated ones, expressed themselves through feeling (i.e. qualia), it is reasonable to entertain the possibility that phenomenal consciousness in some form existed at a time when the brain was much smaller and simpler than now. At that time it was

driven more by phenomenal instinctive needs than by reasoning ones. To quote John Allman, an evolutionary neurologist: *"Remarkably similar results have been obtained in recordings from serotonergic neurons in invertebrates such as lobsters and sea slugs, findings which suggest a basic commonality of serotonergic function throughout the animal kingdom"*[27].

Since evolution advances micro-step by micro-step through mutation, there exists a strong continuity between evolutionary steps[28], as mentioned above. A phenomenal semantic database must have a very different supporting molecular structure to that of a purely computational one, making continuity between the two difficult to envisage. Taken together, these two facts imply that consciousness can't have initially been a product of mere computational sophistication. Even in early times, consciousness was presumably dependent on essentially the same extraordinary convocation of molecules, the same substrate as that of the present day, to produce and support mental activity. It is difficult to imagine a sudden huge discontinuous leap in the evolution of a brain organ such as the putamen (associated with the sensation of pleasure), which would imply that it went from a non-conscious state of a certain structure, function and utility to a conscious state, fulfilling much the same roles as before without an accompanying hugely discontinuous, and therefore forbidden, gap in evolution.

Nature's Pre-existing Evolutionary Sense Nodes

Attempts to simulate the evolution of the brain's computation, let alone phenomenality, through computational simulation evolving towards a living organism have not been at all successful. However, the mental domain(if it exists) almost certainly possesses strong advantages in the form of separate nodes around which it can progress in a modular fashion. The nodes would be constituted of the various types of qualia, such as sight and taste. Such pre-existing, independent nodes wouldn't easily interfere with one another and the very fact of their pre-existence would mean that only *access* to them has to be evolved, not the whole senses themselves. This means that less new code is needed to advance and that it is incorporated into a proven context.

Richness of the Atomic Level versus Bit Level

For the computational approach, the atomic level is that of the basic bit stream, which in itself is devoid of interest or meaning. Binary computation is trivial in content. For matter itself, the situation is the complete reverse. From the atomic level on down below the Planck level, physics descends into the mysteries of quantum, superstring, twistor and other theories whose implications are as yet unknown and which leave plenty of room for consciousness.

Probably the clearest link between physics and consciousness is the weird quantum theory interaction between the observer and that which is observed.

The Binding Question

The fact that no single region has been found in the brain where the data from all the senses is brought together, enabling the necessary coordination to take place and a fully informed decision to be made. For example, touch, visual and olfactory and associated non-sensory data such as experience have to be brought together to identify the nature of an object held in the hand. Some puzzlement has been expressed that no brain area can be identified as fulfilling this need.

It is suggested that the area can't be seen in the material brain because the operation takes place in the mental domain, where all the pre-qualia data co-exist and are assembled into one view. It is obvious from introspection that consciousness's primary role is that of coordination.

The Non-Identification of a Material Feeling Region

It is well-known that pain It is well-known that pain involves many brain sites including the thalamus. Pain impulses (action potentials) being conveyed from the area in which pain is felt (e.g. a toe) up to the brain may be supposed to be in the material non-conscious format as it is understood by current science. The pulse train continues to proceed through different areas in the brain, notably the thalamus and anterior cingulate cortex. Eventually pain is actually felt, but nowhere along the processing line can a particular pulse train, or other material situation, be said to constitute "the minimal necessary substrate" possessing the property P, directly causing/feeling pain. P would seem to be expressed in something more than pulse timing and length, voltage, ions, neurotransmitters or whatever. This indicates that when pain occurs, prompted by the necessary convocation of particular molecules in the required particular state, the causal influence

is likely to be invisible to us on our current range of instruments and thus cannot be identified by us as being the essential substrate. If this continues to be true despite the rapid progress in neuroscience, then the experiential percept and its cause become more and more likely to be taking place in a mental domain.

There are then two possibilities:-

- The conveying of fear along dendrites and axons is invisible because it is not detectable using current technology. The normal electromagnetic (EM) pulses convey only part of the conveyed data.
- Each separate neuron is a kind of "consciousness micro-processor" whose input and output are in a normal material EM form; within the neuron's cell body the incoming EM activity is converted to the conscious form, processed, then the output is converted to the EM form and forwarded on to the next neuron.

The fact that material neurotransmitters, functioning in the gap between neurons, can provoke fear indicates that the second alternative is more likely. The fact that we are able to position pain in space (e.g. at a fingertip) favors the same stance.

In Fig. 2 it was shown that the material input and output data cannot currently be seen to be related to the same mental data in its database. This constitutes a further difficulty in recognizing conscious data transport. The proposition that non-database data won't be recognizable as related to the same data in a database format constitutes a testable for the MDNI hypotheses.

Is Every Mental Event Accompanied by a Material Event?

As mentioned before, to state that every mental event is accompanied by a particular material event is tantamount to espousing epiphenomenality, which has been disproved above. It also severely limits the likely capabilities of a mental database, such as intra-mental indexing and a causal consciousness. The exceptions to the rule concern platform support, such as energy supply, which may be needed for reasons not concerning the character of the mental event.

Conclusion

The above points converge to indicate the existence of a semantic mental domain, whose nature will hopefully be clearer to future versions of physics, neuroscience and psychology.

5. The Neural Index

Further detail on the neural index is to be found below. It seems probable that non-material internal mental indexes exist as well as partly physical ones. The former relate mental data to other mental data.

5.1. The Effect of an Antidepressant

The following describes the expected effect of serotonin. This neurotransmitter occurs naturally in the brain and affects the biochemical processes taking place at synapses. In depressed persons there is frequently a deficiency of serotonin. Neurologists have expressed puzzlement that serotonin takes several days at least to produce any effect. This means that serotonin itself is not the "holder" of serenity. A frequent treatment for depression consists in supplying a daily supplement of serotonin, which helps about half of the patients. According to the Neural Index hypothesis, this has the effect of changing the state of the interface indexes, thus progressively orienting new data towards areas associated with serenity in the mental domain. These areas color the perception of the depressed subject in general and progressively change her whole attitude towards her environment. Ensuing mental processing will be different from that which it was before. The globality, durability and integration of the overall change implies that many brain indexes have to be changed materially and mentally. The usual explanation for the mechanism of antidepressants has been that changes at the synapses mediate the mood, although it has been suggested recently that it is connected with the observation that certain neurons grow during the few weeks that it takes for the antidepressant to begin to have an effect. It is perhaps worth noting that the improvement due to a tranquilizer is transitory and diminishes certain faculties, so large scale neuronal changes are not needed, whereas an antidepressant must update the whole system in a harmonious manner and so takes longer.

5.2. Hebbian Activity

Hebbian activity of neurons involves the following properties and results from their repeated stimulation:-

- the reinforcement of neuron firing.
- the extended branching and thickening of dendrites.

This is how indexes react in a computer and how one would expect dynamic indexes to behave in the mind. Repeated access to existing data and the incorporation of new data generate faster access through the improvement of existing paths to data and the creation of new ones.

The tree-like structure of database indexes is sometimes referred to as an "arborescence". The structure of the neuronal assemblies known as dendrites is also tree-like. However, there is nothing evident in the visible structure, as obtained through the several neural investigatory tools, indicating the presence of phenomenality.

When a small area of the brain is damaged, this normally degrades rather than eliminates the capability concerned. Again, this is what we would expect of indexes but not of data. The damage forces the brain to take a longer path, or to build a new one, to the data.

5.3. Multiple Object Referrals and Primary/Secondary Indexes

Researchers have remarked that the same object may be referred to in neurons belonging to different brain regions. This is what one would expect from relational indexes.

In most database systems there is a difference between primary and secondary indexes. The primary ones are usually stored with the data and determine its placement. In a more sophisticated version of the example shown in fig. 1 above, the primary key for a book list would be the universal ISBN, identifying each individual book in a clear and unique manner, even if it has the same title. An example of a secondary key would be the data element "author", since the system often needs to find out which books were written by a particular author. The primary key is the data element best identifying the list concerned. It possesses its own type of index. It usually constitutes the most efficient index for accessing the data. For example, for a book it would effectively be its ISBN. Changes in the index of one list will frequently cause indexes in other lists to be updated. Referring back to the example in fig. 1, a new book input into List "B" (the master book list) must also be introduced into list "C" (the warehouse inventory file). The point here is that the mind shows a similar behavior in adjusting easily to important search key changes.

5.4. Neural Indexes and Libet's Work

As was mentioned above, it is suggested that, since what we have called the primary indexes are partly material in nature, they participate in their mutual updating through the use of the neural network which joins the appropriate neurons participating in mental activity. This is one of the types of activity seen on brain scans. Other types of connection are those interfacing with the material body and those acting as platform support for intra-mental domain activity.

Material neuronal stimulation is seen through scanning to occur early on in thought processing, even predating it, as is maintained by Libet[29]. The fact that electromagnetic neural activity occurs before consciousness of the scene is consistent with the Neural Index hypothesis, because:-

- The event is initiated by mental activity. This is invisible to current scanning and thus to Libet's apparatus.

- Indexes (material and/or mental) must be activated before data is processed in order for the data itself to be retrieved, inserted or updated. Also, as mentioned elsewhere, optimally prepared rapid action favoring survival requires preparation in the material domain, which is closest to the body's muscles, endocrine systems and other material participants in the action.

- I suggest that Libet is not necessarily measuring only Reaction Times (RTs). He seems to be implicitly including the additional time it takes to be conscious of the fact that one is conscious of moving a wrist. This isn't a trivial remark since many mainstream neuroscientists and philosophers maintain that animals other than ourselves are not conscious of being conscious - that is, they are not self-conscious (e.g. Joseph Le Doux[30]).

- I also suggest the possibility that we are conscious of an event within the first few ms, but that the memorizing of that event comes into operation only after 500 ms, so we don't remember that we were aware of the event at the time it occurred. This would have a Darwinian advantage in that consciousness could been used right away. This may be said to occur if one flings one's self into a ditch to escape an oncoming car and then, when questioned, replies "I don't remember reasoning on how I got here". That doesn't mean that one didn't reason before the actual action. If there had been a wall instead of a ditch one would have tried some other escape route, so more than instinct is in play.

An interesting situation to consider is that of the nature of the interconnections between the neurons linked with the mental domain where manipulation of conscious data takes place. It could be supposed that the transport of data from one cell body to the next is purely material and is understood in terms of today's physics. However, transport is done via axons and dendrites which are parts of the neuron. This implies that the axons and dendrites are carrying conscious-containing data as well as EM data. This would help account for the fact that one's conscious feels what one's finger is touching, although this sensation could be accomplished by the tectum placing of the neural connection concerned.

Libet succeeded in causing a patient to feel a tingling sensation by direct material stimulation. He placed an electrode on a patient's brain from whom part of the skull had been removed. This seems tentatively to indicate that the incoming data is converted within the cell body to the conscious form for conscious processing and on exit is converted back again to the material form for transport to the next neuron.

It is agreed that a certain biomolecular substrate (or substrates) is necessary for the existence of consciousness.

This seems to mean :-

- that cell bodies may be said to function as separate "microprocessors of conscious data". In between cell bodies the required non-conscious data is transported in material EM form. This would seem to be possible because the first neuron in the line communicating touch data from the finger tip to the brain can't be receiving conscious data, although such data may be generated in the finger tip where the neuron begins. This would be consistent with having intra-neural connections convey conscious data.
- that the connecting dendrites/axons transport consciousness data invisible to us.
- that only EM data need to be fed from one neuron to the next.
- that something like Libet's Conscious Mental Field exists to transport conscious data.

As it is not obvious which alternative to choose, the question is not pursued further in this article.

6. Implications of the MD/NI Hypotheses Taken Together

It is suggested that Mental Domain/Neural Index (MDNI) hypotheses taken in conjunction encourage new interpretations of known facts. They further support the hypotheses. A few are given below:-

6.1. The Evolutionary Role of Emotion

The very fact that emotion was chosen by evolution to implement decisions demonstrates that in some respects it is more efficient than reasoning without emotion, otherwise natural selection would not have chosen it to do so. These advantages come partly from a short response time in making an appropriate and coordinated response, thanks to the parallel processing in the separate material and mental domains, facilitating the rapid coordination of several different decisions and actions.

Due to a brain injury or deficiency in a part of the brain used in emotional processing, certain patients suffer from an incompatibility between their prudent reasoned evaluation and their subsequent inappropriate, emotion-less actions. Damasio's well-known patient EVR[31] underwent an operation removing tissue from the ventromedial region of the frontal lobes, causing him to lose the normal harmonious match between emotion and reason. Although his IQ remained high and he could draw clear rational deductions as to the likely consequences of an action, he

invariably yielded to unprofitable temptation when confronted in a situation requiring a short-term decision. For example, when choosing a card from a deck, he would always choose the one which could give the most spectacular reward in the short term, while knowing that it was guaranteed to be unprofitable in the medium term. Considered with similar results from damage to other regions of emotion in other patients, this indicates that emotion is the most efficient means that evolution has found for responding to demanding situations in which reflexes are too limited and reasoning takes too long.

This efficiency may reside indirectly in ease of evolution rather than directly in emotion speed, as described below. In this case emotional processing is being compared with that of a zombie.

It seems that rational evaluation plus instinct plus learnt behavior contribute to the generation over time of an emotion appropriate to the situation. Emotion's value is that in complicated cases it reacts more quickly than reason. There is a solid experimental base for showing that fear is initiated and experienced before the subject is conscious of the reason for it. The amygdala is a brain region which is a base for fear processing. Naccache[32] of the Salpêtrière Hospital in Paris has shown that if an emotionally loaded word such as "murderer" is fleetingly inserted into a neutral text, the amygdala reacts strongly as is seen via the electrodes implanted in the brain. A twinge of fear is felt, even though the brevity of the display of the loaded word prevents the word itself from being consciously seen, identified or remembered. So emotion would seem to be the trigger.

6.2. Steps Associated with Olfactory Sensation

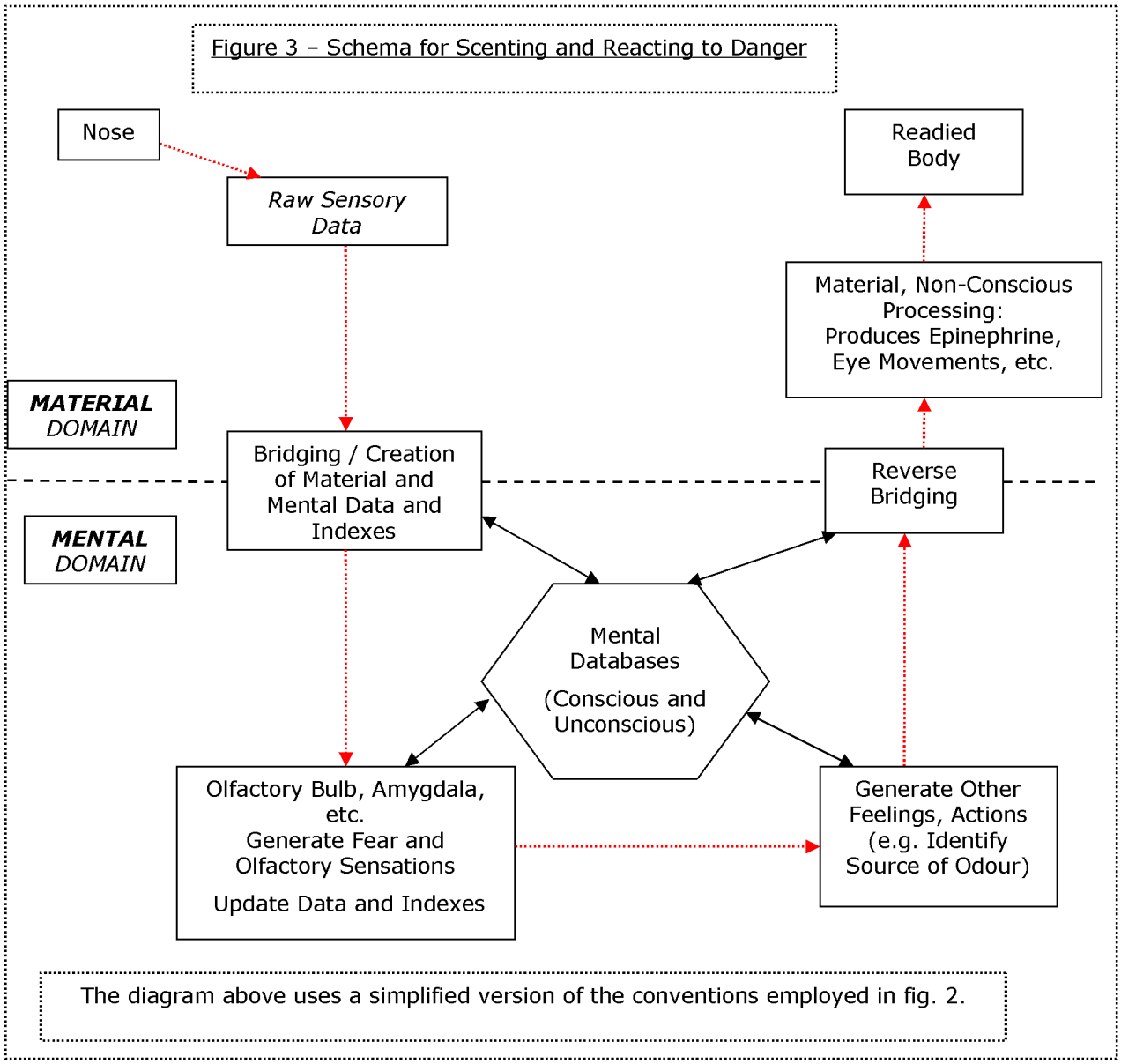
The following example clarifies the concept of emotion in this context by describing the suite of events set off by the fear reaction to an odor associated with danger, including readiness. It is, of course, simplified. The most important unknowns concern the domain selected by the olfactory bulb outputs – which are mental and which remain material?

- The odor activates the nose's olfactory receptors.
- Nerve impulses are passed to the brain's olfactory bulb
- The olfactory bulb produces the:-
  - material substances such as epinephrine to prepare the body for attack.
  - mental data necessary to react appropriately (e.g. fight or flight), which will produce a further group of material substances.
- Appropriate biochemical/electro-magnetic signals are relayed from the olfactory bulb to the amygdala. Whether or not they already possess a mental component is unknown.
- The amygdala uses the bridging indexing capability to locate the appropriate "addresses" in the mental domain and passes data up to the appropriate mental regions.
- Swift mental domain processing takes place, in the form of emotional activity which takes into account, among others, the known dangers associated with the odor and the manner to avoid them. The manner may be instinctual or have been consciously learnt and grooved, so becoming largely unconscious.
- Interface signals are generated which pass back from the mental to the material domain through the reverse interface.
- These signals activate appropriate neurotransmitters in the material domain.

(The last four steps are perceived as a single step in the material world of brain scanning. It could be expressed as: "processing in the amygdala and associated areas causes the activation of appropriate neurotransmitters").

- Material domain neurotransmitters activate epinephrine (adrenalin) production, motor response and other immediately appropriate activities involving both mental and material processing.
- The corresponding material brain areas are activated and the actions taken recorded in episodic memory, requiring activity in both domains and their databases. If the situation has not already demanded bodily action, the material brain/body is now optimally "readied" for "fight-or-flight".

- The slower regions of the brain dealing with consciousness are by now well aware of the situation and have started the relevant material and mental processes, including those concerning access consciousness and procedural skills. A conscious decision on what to do next is made.



If epinephrine (adrenaline) is directly injected into the bloodstream in the absence of a fear stimulus, the body will nevertheless prepare the material and mental processing needed for a fight/flight reaction. In this case, obviously the olfactory data and fear of something specific will be missing. Readiness will be felt but will lack a specific direction. Uneasiness will be felt because the body/mind is in a self-contradictory situation where the body/mind has been readied for a non-existent danger. This may generate feelings such as unease at being unable to detect the danger or a "high" of stimulation such as that obtained on drinking a coffee.

The material database(s) in the brain (if indeed they exist in a true database form) are relatively simple. They act as a kind of buffer where mentally generated decision instructions are held in the material domain prior to action, minimizing the reaction time required. For example when comfortable in a warm bed on a cold morning but aware of the necessity to get up in time, one suddenly finds one's self standing up without having been conscious of implementing the decision to do so – in fact the decision had been taken some time ago and the body has been readied to take the action at the moment of its choice. This faculty of early preparation would have been critical to survival on the savannah as it gains a vital fraction of a second with respect to the predator or prey (who of course may also possess it).

6.3. Considerations of Stability

Stability of the Domains

Recent discoveries concerning the instability of the brain's constituents (microtubules, synaptic connections, etc.) have been reported by John McCrone[33] to show that many of them have a lifetime measured in minutes or hours.

The fact that the material domain is subject to so much instability is that it consists largely of indexes which reflect the constant permanent and fleeting changes of access to data which is much more stable. Multiple varying and new enquiries on relatively fixed data are common. For example, one must frequently think of a child to mind in different contexts – has he brushed his teeth, gone to school, etc. This results in multiple enquiries being made, each enquiry requiring multiple new indexes; but little change is made to the data entity "my child", stored in the mental domain. So, in general, one sees an unstable index area but not the domain where the relatively stable data resides. If one could see both simultaneously the balance would seem reasonable.

Unexpected Stability of Qualia

Many qualia are oddly resistant to aging. Vision declines materially with age, but the red we perceive when old is the same red as we perceived when young. In very few, if any, people does red decay to, say, pink or brown, although red objects can no longer be seen so clearly because of material effects such as astigmatism or an increasing opacity of the eye lens. The same is true of hearing. For clear material reasons it becomes less acute, but once the sound enters the mental state, it seems oddly stable in comparison to the years before. The same is true of the other senses – balancing on a gym bar still feels like balancing on a gym bar although one is less capable of maintaining a stable position.

The last two paragraphs, taken in conjunction, indicate that perhaps one of the reasons for the mental database to exist is that it contributes to the stability of memory.

Conclusion

It is suggested that the instability of the material brain, considered together with the apparent stability of the data in the phenomenal domain, constitute a further confirmation of the existence of a mental database.

6.4. The Transaction Hypothesis

I suggest that much of the fleeting activity to which John McCrone is referring is composed of the short-lived data transactions which update the longer-term integrated mental database which is the "master". A material transaction may contain only a few, or conversely a huge amount of mental data coming from the material domain. The transaction might, for example, be: "bend a finger". The detail activity of the material transaction would be visible as action potential spikes, neurotransmitters acting at synaptic junctions and so on.

As the transaction progresses the appropriate part of the mental "master" database itself is updated. Activity data, such as the bending movement, is dropped or memorized after being made. The material transaction unit that is replaced or freed up may vary, being anything from an ion to a coalition of neurons. The replacing/freeing up is necessary as the brain is finite in size and in neural connections. Of course, much data is deliberately dropped from the mental database because of its obsolescence.

An Implication for the NCC

Trans-cranial methods have also been used. For the reasons given above and below, this article permits itself the deduction that, since no-one can point to a neuronal connection in a subject and say "this neuron is carrying conscious information at this instant and is manifested in this material event", consciousness traffic is as yet effectively unidentifiable using currently available instrumentation. This is so even if the corresponding EM signals have passed in turn through all the organs such as the amygdala, which is known to be associated with the type of consciousness which is currently being experienced by the subject if she is afraid. The observer is thus entitled to propose that the ongoing conscious data flow is taking place somewhere along a path which she can't see. Progressively finer and finer axon and dendrite EM flow will become perceptible to current technology's improving brain scanning. The longer this finer EM detail resists molecular correlation with detail aspects of consciousness, the more likely it becomes that consciousness is provoked only in the cell body, as was argued in the section entitled "Neural Indexes and Libet's Work", where Libet caused sensation in a subject by applying only a voltage to his cortex surface. This same phenomenon has been realized in many other experiments. This further confirms the "Mental Domain" thesis.

It is also possible that conscious activity may use a certain path even when none of that path's neurons are firing. This might be the case in purely mental processing. Nevertheless, perhaps some neurons fire just to supply energy to the mental domain.

6.5. Mirror Neurons and Place Cells

It is well known that the same mirror neurons are activated when one is:-

- performing an action[34] (and/or feeling an emotion),
- imagining that some one else is performing the same action (and/or feeling the same emotion).

This is frequently taken to indicate the production of empathy, which is true. However, as someone with a computer background, it appear to me that its origin may lie only in the benefits of using the same code to perform the same function in two or more different cases. In IT, the common coding economizes both space and coding effort. In the case of the brain, space is also economized. The coding effort corresponds to darwinian evolutionary effort, which won't need to evolve the same function a second time. It is worth remarking that, although the same capability is fulfilled by the same coding module, the input to the module comes from different regions, according to whether one is feeling the sensation oneself or imagining it to be felt by someone else. The same is true of the output.

The same neurons are excited when one feels a pain and when one imagines someone else feeling the same pain. It is interesting that the same excitation of the same neurons does not visibly yield more or different activity when one feels the pain. This implies that the pain is felt somewhere else. Inevitably, this paper proposes that it is felt in the mental domain.

6.6. Plasticity of Neural Placement and Tagging

Below is an extreme example of plasticity[35]and perhaps of tagging-

"Sur is a neuroscientist who managed to reroute the auditory data down the visual tract in ferrets to the auditory cortex. Surprisingly, the ferret learned to see anyway! Prominent features from the visual cortex appeared in the ferret's auditory cortex, and the ferret was actually able to visually distinguish between different stimuli. This seems to indicate that the cells in the visual and auditory cortex are not very specialized for their task; they seem to do some analysis of the input that is independent of their location in the brain."

If the above has been confirmed to be true, it is difficult to see how the actual mental processing can take place in a set of neurons placed in an area evolved to process auditory data.

Similar, if less extreme, experiments have led to the same results.

In an IT context, "tags" are sometimes placed in data streams to give information on the nature of the data and its required processing. The tag may take the form of an "escape character", which when encountered causes processing to take a different processing path from the normal one. Applying this to the brain, an alternative view of the ferret's brain plasticity is that the visual data itself is tagged by the eye's neural complex as being "visual" in nature. Although fed to the auditory neurons, through use of the tag the data stream is oriented by indexes to the visual processing area in the mental domain. In any case, it would seem that the nature of the input data may influence its subsequent processing, since it appears to have some knowledge of where to go. If the data can choose which path to use, it must be able to choose which set of indexes to use.

6.7. Four Levels of Reaction in a Situation of Urgency

I suggest the following MD/NI interpretation of our successive reactions in an emergency.

When we react swiftly, it would seem that we do so in a sequence of four levels if we have the time to do so. They are:-

- Reflex (as in a knee-jerk): this type is simple and is driven by few neurons.
- Non-conscious procedural: readied well beforehand in the material mind. This was preceded by a conscious decision made perhaps a long time ago (e.g. to participate in Libet's finger-bending experiments).This is what Libet's scans show. It also readies the material brain in a way appropriate to the anticipated urgency. For example, it is advantageous to have epinephrine present in the bloodstream in advance of the bodily reaction to the danger. Muscles and balance should be readied for deployment.
- Emotional conscious: a fast, efficient, though complex reaction built up during previous related situations. It also includes instinctual procedures and data.
- Reasoning conscious: usually yields the most appropriate response, but is also the slowest.

If we don't have more than a fraction of a second available, no conscious decision can have the time to take place. We react according to a pre-established schema, built on emotions which are either instinctual or have been implanted through the consequences of reasoning and experience. As shown elsewhere in this document, a conscious emotional reaction can take place in less time than a reasoning access conscious event, but brain scanning may not show this clearly because it isn't taking place wholly in the material domain. Reasoned and emotional decisions take time and lag the production of the first neural action potentials to occur in response to a particular stimulus. The conflation of fast instinctual, conditioned and emotional reactions followed by slow conscious decisions may lead to the mistaken conclusion that the action potential must precede a decision if access consciousness is to be causal (see "Irrelevance of the Libet Delay"). There is a fundamental difference between a reaction (which is a fast event (both mentally and physically) and a decision (which is a slow, mentally conscious event). By preparing events in the mental and then the material domains as far as is possible a valuable few tenths of a second may be gained – the slack is taken up in the right muscles as they are tautened, the eyes and balance are facing the right way, the endocrine system readied and so on. The wrist/finger bending Libet experiments were made maximizing the preparation. The related decisional events were the ones which took place when the subject agreed to participate in the experiment and then readied his mind/body accordingly, thus setting up the material domain to which control is passed by the mental domain. Indexes were involved with both the material and mental events.

7. Common Conscious/Unconscious Database Structure

This section is intended to show that the conscious and unconscious are so inextricably intertwined that they must be using the same "semantic database" structure and sometimes share the same data.

7.1. Evolutionary Continuity Principle

Evolution progresses one small step at a time. This principle entails a common origin for the conscious and the unconscious – it would be truly remarkable that, say, the unconscious evolved first and that the brain's subsequent evolution just happened to supply an appropriate data-sharing platform for the incorporation of consciousness.

7.2. The Simultaneous Use of Conscious and Unconscious Data

A person who has successfully learnt the grammar of a language unconsciously, even as an adult, is frequently unable to consciously explain how it works when he uses it. Yet he must know unconsciously because he makes use of it when constructing grammatically correct sentences. I live in French-speaking Geneva, but my written French is not as good as it might be. When I have to decide on the spelling of a particular conjugation of a verb such as "marcher", I hesitate between "je suis allé *marché* près du lac" and "je suis allé *marcher* près du lac". They are both pronounced in the same manner. To find the correct spelling, I substitute the verb "vendre" for "marcher" as an unconscious yet meaningful reference, because its infinitive and its past participle are pronounced differently, unlike those of "marcher". "Je suis allé *vendre* près du lac" sounds correct but "je suis allé *vendu* près du lac" just sounds wrong. I don't consciously consult the grammar, I just rely on the unconscious feeling for spoken French which I have acquired unconsciously through experience over the years.

The grammatical structure held in my unconscious is available to my conscious if I perform some grammatical analysis, which is a further argument for a common database structure and common data in some databases.

Another example is that conscious learning has to be transformed into unconscious through frequent use to become optimally useful. For example, when one learns to read as a child, one first has to consciously learn which shapes correspond to which letter. Having finished this apprenticeship, one interprets the shapes unconsciously while reading. However, at any moment the unconscious can called back to examine the same text. One may even unconsciously over time improve one's performance of a particular task involving logic, then one day realize consciously that one has done so and the reasoning behind it.

Further examples of the availability of knowledge acquired by one type of consciousness being used by the other can easily be found. It is theoretically possible that there are different structures for the conscious and unconscious types of the mental, with an interface converting one form to the other as required. But this would have the consequence that the shared data is held twice (once in each domain) and would have to be converted when needed by the other type. This "emulation" (to give it its IT name) has proven to be extremely inefficient on computers, consuming much memory space and processing time. There is no reason to believe that the same wouldn't be true in the brain.

The unconscious is no more material than is the conscious. Therefore the distinction is made between the unconscious (in the mental database) and the non-conscious (such as incoming material sensory data). The conscious and the unconscious must have completely compatible structures to be able to interact easily. They pass data from one to the other without problem and are procedurally compatible as well. The latter is shown by the way in which a skill such as riding a bicycle passes smoothly from the phase of intense conscious concentration to that of unconscious ease. The two are nevertheless so fundamentally different that evolution can't have produced one and then relied on chance mutations to produce the other. There must have been a strong compatibility pretty well from the start.

Access and phenomenal consciousness must have evolved at almost the same time because what use would it be to scent danger if one lacked the means to flee from it? A purely material means of sensing and fleeing may well have existed before any consciousness arrived on the scene. Its initial decisive advantage was presumably a better integration with its phenomenal counterpart. The other advantages which would soon have permitted it to oust a mechanical activation have been mentioned above.

8. Rebuttal of Objections to the Mental Domain

The Libet delay of about a third of a second (between the start of neural activity and consciousness of that activity) does not invalidate the notion of a causal consciousness, as is

frequently claimed, though not by Libet himself. Since a causal consciousness is necessary to my concept, I give a rebuttal using a thought experiment with the Neural Index hypothesis:-

The subject of one of the Libet experiments had familiarized himself with finger/wrist movements in the normal course of her life. She had taken all the time-consuming relevant decisions consciously hours before initiating the tested action. All procedures and indexes in both the material and unconscious areas were therefore optimally readied in preparing to initiate the required movement soon afterwards. To be optimally fast, this movement had to be initiated by the unconscious and material parts of the brain. Thus the fact that consciousness is aware only after movement initiation does not constitute a problem, since the sequence of the chain:- "decision->reaction->consciousness of the result of the reaction" is preserved. Mental domain activity isn't accessible to fMRI or other current brain scanning techniques, so wouldn't show up anyway. In any case, whether or not a non-material mental domain exists, there is no problem for a causal consciousness intervening after the initial "Libet delay", as he himself remarks.

Another possibility is that the subject was entirely conscious from the beginning of the wrist bending action but that this beginning wasn't memorized and so couldn't be recalled. The diversion of part of the brain's resources to the memorizing the of initiation of the action would not be acceptable. Such a diversion would consume valuable electromagnetic biochemical resources just at the moment they are most needed for action. One hears from individuals who had been caught in a situation of extreme urgency: "I reacted before I could think of what I was doing". What he is really saying is "I don't remember what I was conscious of doing for the first fraction of a second".

When we were evolving on the savannah, the animal with the fastest reactions and reflexes, albeit by a tiny fraction of a second, had a huge advantage – watching a mongoose toying with a venomous snake demonstrates the point. So evolution has a strong interest in possessing a reaction method that functions faster than full consciousness.

8.1. Rebuttal of the "Enlivening" Objection

It has been proposed that there is no need for the notion of a mental domain. A phenomenal event could be memorized by a material operation using a particular algorithm/procedure which performs the appropriate encoding. Then, when the memory is to be called back up into the conscious, it is enlivened (i.e. recalled phenomenally) by the application of the reverse algorithm/procedure.

There are two observations to be made here:-

- If neither the storing/enlivening procedure nor the memory of the data itself possesses phenomenality, then where does it come from? Unless one accepts that consciousness is nomological (i.e. a brute fact which is true but for which in effect no explanation exists) and that there is a complete set of NCC (which was rejected above on logical grounds), this proposal won't work. Just as the computer's programs must always held somewhere in its memory, so the brain's enlivening algorithmic procedure must be held somewhere in the material brain. So the attempt to eliminate the phenomenal mental domain has simply displaced the problem from the data area where data is stocked to the data area where procedures are stocked. Procedures require memory just as does data. In a computer, procedures are regularly treated as data by the computer's operating system.

- The very fact that material can be enlivened at all means that a mental domain exists at least fleetingly. And if it exists fleetingly, then why shouldn't it exist more permanently, if this is evolutionarily useful? That it is in fact useful is shown below in this document in the section on Darwinian advantages.

9. Evolutionary Advantages of Consciousness in a Mental Domain

One frequently hears the argument that the functions of a phenomenal consciousness can be supplied by a purely computational brain. This may or may not be true but is, in any case, beside the point. Nature undeniably did furnish us with a phenomenal consciousness, as John Searle so conclusively demonstrates[36], at least to my satisfaction and that of many others more illustrious. However, there are very good reasons for Nature to have chosen the mental approach. A selection of them is listed below:-

9.1. Material Resources Economy

Qualia are held in the mental domain, where capabilities take up no material weight or volume, apart from that required for their support, such as the furnishing of energy. This brings clear advantages to the animal concerned.

That the brain goes to great lengths to minimize the number of events and objects to be held is shown by the existence of "inattentional blindness" type functions. We are surprised by them but in practice the sort of situation in which it occurs would rarely be found on the savannah where we evolved and where one knows all the members of one's own tribe and most of the neighboring ones.

9.2. The Darwinian Reason for the Aesthetic

As shown above, in memorizing data the brain gives it a phenomenal aspect. A high proportion of strong memories are associated with emotion which is by its nature phenomenal. Things that are felt to beautiful are treated as being fundamentally phenomenal and are thus more easily because of the "material resources economy". Also, this enlarges the amount of data a material brain can hold for a given skull volume, as mentioned above.

This does not mean that the aesthetic exists only for evolutionary reasons. A possible interpretation is the reverse: the material exists only because it helps express aesthetic values.

9.3. Malleability and Modularity

The fact that we intellectually relate so easily to the structure of the relational data base suggests that this is an important part of the way our minds work. The mental appears to be more malleable than computation in the hands of Nature. An important barrier to a computational brain is that step-by-step neuronal evolution is ill-equipped to produce so efficiently structured an engine as the mind/brain. Experience with artificial neural networks shows that after an initial spurt, they have difficulty in generating radically new structures. To possess a tree structure, computers have to have a database embedded by the persons building it. A database is fundamental for the human way of thinking. Despite the promise foreseen for them thirty years ago, Artificial Intelligence (AI) systems are still limited largely to university labs and the tuning of the data output by conventional systems. I don't personally know of one which spontaneously constructed an equivalent to the homeotic gene, for example. Even for simply analyzing data on a computer, tree systems produced by humans are superior to evolved neural nets[37], let alone for generating viable organisms. The reason we built databases is that we find it easy to think in its terms, such as entities and relations. The very fact that neural nets don't seem to be capable of autonomously generating tree structures (let alone a structured database) argues that there is something important lacking in the computationally evolving approach, even in its own non-phenomenal terms. We couldn't think at all clearly if our minds lacked hierarchy and relational capabilities. Nature favored the establishment of a base system of laws and substances which made structured Darwinian evolution possible. One may imagine that an expanded physics contains new laws and structured substances for each sense, thus providing evolution with a modular capability right from the start.

Below I suggest certain advantages derived from the modularisation and variety perhaps available from Nature.

Undesirable secondary effects

In considering this matter we can use the analogy and terminology of IT. "Spaghetti Coding" is the undesirable complex program branching which occurs when "if … then …","go to …" branching statements proliferate and the system ends up by becoming incomprehensible even to the programmer who wrote it. This is the result if the system isn't subdivided into functional modules. If the whole mind system consisted of one module, then the mind's equivalent of spaghetti coding would be generated, whereby any single mutation having a beneficial effect would frequently spark multiple harmful changes throughout the whole system. The ideal is to have many modules with separate functions and few interactions between the modules. This is favored by having the mind modularized through latching on to pre-existing separate and sub-divided mental and material domains. These modules are then further subdivided into different mental modules, databases, emotions and sub-domain senses existing in the structure of the universe, not from some single-domain material coding. For example, the body possesses several different endocrine sub-systems.

One can see an exceptional occurrence of the spaghetti problem in the material body when a gene useful in fighting malaria unfortunately gives rise to anemia, which has nasty, even fatal, side effects. Presumably evolution hasn't had time to optimize the genes' defense. Although one can see that the gene structure of DNA is effectively modularized within the limits possible, the modular type of mind would be very difficult for evolution to develop harmoniously using only the material domain available to material evolution. As mentioned above, the problem is even more severe in computerized neural nets, where only one type of module medium (the material) exists, as in the single material domain approach proposed by Stephen Pinker[38].

Change and Inattentional blindness

These seem to me to be only examples of the necessity to economize resources which the brain is forced to respect. The examples given wouldn't occur on the savannah during evolution. To take one of the examples frequently given, a gorilla appearing in the middle of a basketball game is not perceived by someone whose attention is taken up by an assigned task. A harmless gorilla walking around some distance away and separated from us by a barrier has no immediate priority for our attention, but at ground level in the Central African rain forest our reaction would be swift. There, if feeling in danger from approaching gorillas, one might be excused for not noticing a basket ball player among them.

9.4. Protection from Viruses

As the mental is segregated from the material world, it is protected from the harmful parasites which inevitably try to attach themselves to any entity available, whether it be a computer or a brain cell. Such parasites present a serious problem for both computers and the eukaryotic cells of which the material brain is made.

10. Further Comments

10.1. The Efficiency of a Semantic Memory

Words which are arbitrary labels, such as proper names, are the first to be forgotten through age or Alzheimer's disease. This may be so because they aren't by nature semantic. Frequently we can remember an object or event or face although we can't remember the name it's attached to. Names are evolutionarily recent. We see advertisements for systems guaranteed to significantly improve our memories. They usually rely on associating arbitrary labels with a meaningful object, such as a number with a picture of a house. This is a further indication that our memory is fundamentally semantic.

10.2. Non-Evanescence of Memory

The desired long term data in the mental domain can't be evanescent because that would imply that it would be lost during the night.

10.3. Memory Retention Capability and Cascading Indexes

The brain contains some ten billion neurons. As an IT person, my gut reaction is surprise that so much can be held in so few neurons. This is not due just to the volume of data, it is also the volume of indexes and the image processing capabilities involved. The latest computerized security systems, which can't even reliably recognize a human face from different angles, take up an enormous amount of resources in failing to do so. These systems need several orders of magnitude more resources than that required to simply display a face represented by an bitmapped photograph.

It has been advanced recently that, in fact, we remember little of a given scene when asked to recall its details. I believe that this estimation takes into account only primary indexed memory (that which we access without using more than the original primary indexes). If we take the example of a friend's face, it is true that there are stringent limits to how much detail we can recall on paper through writing down a description. But this omits the huge amount of passive secondary data that springs to mind when we have the face of the familiar person in front of us, permitting us to easily distinguish between most identical twins, though having been incapable of describing their differences beforehand except in the vaguest of terms. This passive data must have been stored somewhere. A competent artist will apparently remember much more than an ordinary

person. He is helped in doing this by first drawing an outline of the face's features, than using the information indexed by the outline to successively index and access more and more secondary detail, rather in the successive approximation method used by the police in building photofits. The brain can't afford to assign primary indexes to every detail any more than can the computer's database. A series of cascading indexes is necessary to both engines.

The brain, like the computer, isn't large enough to hold all possible indexes, linking every data element value with all its occurrences. This is illustrated in the way in which the brain has been obliged to economize when we try to recall an almost forgotten word. We find it much easier if we know with which letters, or syllable, the word begins. Knowing the letters in the middle or end of the word is less useful. This is a use of "partial indexes". The primary index consisting of the first part of the word gives access to all words beginning in this manner, from which the secondary indexes select the appropriate word. Again, the database and the brain act in much the same manner.

11. Testables

11.1. Summary of Previously Mentioned Testables

(i) The temporary intermediate data in a mental calculation can't be detected as it only ever exist in a mental state (as described above in the $2,000 probe example).

(ii) Material non-database data can't be related to the same data in its mental database format.

(iii) If it is not possible to distinguish between visible conscious and non-conscious pulse trains it would seem that the conscious is not materially or mentally present outside the neuron's cell body.

(iv) Comparison between normal and non-conscious vegetative responses: there are many unfortunates living in a vegetative state. Some show clear signs of almost normal mental activity on brain scans. These persons are clearly unconscious. It is suggested that a detailed comparative examination of the two types of brain should be able to point up where consciousness manifests itself in the brain. If it can't be found, then the conscious domain exists and is invisible.

(v). If the probe for mental content can't be built the conscious domain is invisible. If this situation lasts, then to see it will need a significant advance in physics, showing a mental domain.

11.2. The Addiction Testable

Early consciousness supports the MDNI hypothesis. It shows that consciousness doesn't emerge from increasing complexity.

An important barrier to understanding animal behavior is that it is difficult to communicate with the animal concerned. It is suggested that addiction can be used as a way of obtaining feedback from the subject organism on the qualia it perceives.

The regular ingestion of cocaine by a human being soon results in dependence. This is observed as a fixation on the consumption of cocaine to the detriment of essential activities such as foraging and taking shelter from danger. Humans become cocaine addicts because it gives a "high". Other animals as disparate as elephants and dogs are well known to also be potential addicts to cocaine. A high (or a low) is expressed as a quale, since it yields a phenomenal percept such as pleasure or pain. It would be interesting to see just how far down the evolutionary ladder we would see this addiction. For example, we could set out two small dishes of sugared water, one of which also contains cocaine. The subject, a moth, can choose either. If it spends an inordinate amount of time with the drug dish, to the detriment of normal activities such as flight and mating, we can justly entertain the notion that it is "hooked". If this is so, we can reasonably speculate that the moth has a brain which supports some kind of consciousness in some way resembling our own. To confirm this we can test the animals evolutionarily intermediate between ourselves and moths. We could then follow up other factors, such as the need for sleep, the continuity of neurotransmitters, which are present in early brains such as those of the chordates of hundreds of millions of years ago and of which we are descendants, as mentioned above.

It is important to identify the lowest point in evolution at which qualia exist as the simplicity of the brain involved will significantly help in identifying the minimum substrate needed for consciousness to exist.

11.3. Particle Accelerator Bombardment

The mind and the material brain are constantly interacting in the ways given by Quantum Theory. Many physicists working or having worked (Walter Stapp, Stuart Hameroff, Alwyn Scott[39], etc.) in the field of consciousness, probably even the majority, believe that the explanation for consciousness will require the application of Quantum Theory, either in its current or in an extended form. This being so, it is tentatively suggested that bombarding actively conscious neural tissue with the various types of sub-atomic particles and fields at the disposition of the different types of accelerator might show up something novel in terms of the particles themselves, their paths, their collisions, their energy interchanges, the effects on the behavior of the animal involved, etc. Ethical standards wouldn't be violated because the choice of animal whose neural tissue is to be examined would fit the rules laid down for experiments of this type. It would have potential medical applications.

12. A Parsimonious Approach

Many of my neuroscientist and computational colleagues find it difficult to accept that physics doesn't impose a necessarily mechanistic view of the universe. So, below, I further belabor the subject of the limits of current physics in an attempt to convince the reader that the non-material mental domain is not improbable. The reader informed in physics may wish to skip it.

12.1. Difficulties with Materialist Theories of Consciousness

To summarize, important difficulties with current proposed materialist solutions for the question of consciousness include:-

- The bridging problem which faces all forms of dualism. The fundamental lack of phenomenality in these theories is faced with the Hard Problem itself. Furthermore, phenomenality can be located in body-space. Through the connecting nerve, I feel a pain in my right big toe when I stub it. How is this achieved given that the pain sensation is presumably generated in the brain?

- The lack of a satisfying justification in Darwinian terms for the existence of consciousness. Materialism almost always turns consciousness into an impossible epiphenomenon.

- The lack of explanation in nomological and eliminationist propositions which state that the consciousness problem is solved by stating that consciousness is either an irreducible natural consequence of the brain's make-up or that it simply doesn't exist. Both are in effect saying that there is nothing important in this context left that can be discovered by science. This seems pessimistic given that physics and neurobiology in general have only recently begun to apply themselves seriously to the mind/body question.

12.2. Difficulties with the MDNI Hypothesis

- The only important difficulty is the fact that current physics doesn't currently include the notion of a mental domain.

My answer to this is that there is also nothing in current physics to say that a mental domain can't exist in an expanded physics and a lot to say that it can. The incompleteness of current physics (see below) shows that there is plenty of room for new concepts. Once the notion of a mental domain is accepted, the neural index/interface becomes necessary.

Even in current physics, a mental domain and neural indexes must exist for the reasons given at the beginning of this paper.

12.3. Relative Importance of the Difficulties

In my opinion, the difficulties with current theories concerning NCC are significantly greater than those with the MD/NI hypotheses.

Darwin was faced with what appeared to be an unanswerable objection to his theory concerning evolution. The rate of cooling of a thermally hot sun wouldn't support an age of the

solar system greater than a few thousand years – much too short a time for natural selection to operate. Darwin himself was mystified, but took the right decision in saying there must be an as yet unknown mechanism for heating the sun. He was seen to be right when thermonuclear fusion was discovered. I suggest that we are now in a somewhat similar position with respect to the existence of the mental domain.

12.4.The Incompleteness of Physics

The following list includes some of the huge physical questions which mainstream physicists agree that current physics hasn't answered and may involve consciousness:-

- What is the explanation for the effect of mere observation on observed material quantum states? Furthermore, what is the explanation for quantum theory in general, which has been pronounced by its most eminent practitioners to produce astonishingly accurate results but to be incomprehensible?

- The universe started with the Big Bang. What came beforehand? What came before that? Obviously our notion of time itself is deficient.

- Major questions and possible answers to problems in physics vary from year to year. What are dark matter and dark energy? This year's explanation is that the force of gravity may be a variable, not a constant. Which of the many String Theories is correct, if any? What is the situation on spinors?

- Why something rather than nothing (Heidegger's question)?

- Almost all of the values of the important constants of physics can't be deduced. They have to be found experimentally and then plugged into the equations. An example is the masses of the different particles. Furthermore, current physics cannot deduce the number of dimensions our universe possesses, with the exception of string theories still in the process of formulation.

- The "Grand Unified Theory (GUT)", unifying General Relativity and Quantum Theory, has not yet been found. Nor has the "Theory of Everything (TOE).

It is often said that some of these questions are not for physics. The reply I think is that any physicist who found the answer to any one of these questions would be top of the short list for the next Nobel physics prize, as, for example, were those who confirmed the Big Bang[40] and its indication of the beginning of time as our universe knows it .

Many neuroscientists[41] believe that consciousness will prove to be *emergent* from the material (i.e. current physics), through a better understanding of the possibilities of increasing complexity. However, the best current physics (which, although dependent on randomness, is computational) can do is to explain in reducible terms a Turing machine. A bigger and better Turing machine is still a Turing machine, incapable of the phenomenality produced by 1.3 kg of brain. John Searle's "Chinese Room" expresses vividly that even while calculating, let alone feeling an emotion, we are in some sense phenomenally conscious and not Turing machines. Most neuroscientists have much more faith in the completeness and depth of knowledge of current physics than do the physicists themselves working on the fundamental aspects of Nature.

[1] Block, Ned, (1994), *On a Confusion about a Function of Consciousness*

[2] Chalmers, David (1996), *The Conscious Mind, p. xii-xiii*

[3] Penrose, Roger (1995), *'Shadows of the Mind', p. 39*
"we are trying to grasp [consciousness] in some way – a genuine scientifically describable phenomenon, playing an active … role in the physical world".
The thrust of Penrose's work on consciousness is in this direction.

In *The Large, the Small and the Human Mind (1997)* p.102
"Maybe future science will describe the nature of consciousness but present day science does not".

[4] Penrose, Roger (1995), *'Shadows of the Mind', pp. 12-17*. The purely computational approach corresponds to Penrose's viewpoint ***A***.

[5] Libet, Bernard (2004), *Mind Time,* pp. 157-84

[6] Searle, John R. (1980a), *The Rediscovery of the Mind (1994)*, p. 45

[7] Penrose, Roger (1995), *'Shadows of the Mind',* pp. 14-15

[8] Blackburn Simon(1996), *Oxford Dictionary of Philosophy* pp. 233, 287

[9] Eddington, Arthur, as quoted in *Quantum Questions,* p. 195, edited by Ken Wilbur(2001)

[10] Searle, John R. (1994), *The Rediscovery of the Mind*, pp. 12-13

[11] Blackburn, Simon (1994), The Oxford Dictionary of Philosophy, p. 287

[12] Gauna, Max (2000), *'Montaigne and the Ethics of Compassion', pp. 26-27 in English.*
The original French is: *"Mais comme une impression spirituelle face une telle faucée dans un subject massif et solide, et la nature de la liaison et couture de ces admirables ressorts, jamais l'homme ne l'a sçeu"*. (II xii 520, A)

[13] Strawson Galen et al (2006*), Journal of Consciousness Studies*, 13(2), No.10-11.

[14] Searle, John R. (1992), *The Rediscovery of the Mind*, p. 45. "The Chinese Room" demonstrates the semantic, phenomenal aspects present in a mind performing a data comparison action involving consciousness.

[15] Penrose, Roger, (1989), *The Emperor's New Mind*, pp. 23 – 29.

Penrose comes down on the side of Searle in commenting on "The Chinese Room"

[16] Searle John R, (1992), *The Rediscovery of the Mind,* pp. 206-8

[17] Libet, Benjamin (2004), *Mind Time* (Harvard University Press) pp. 70-73

[18] Block, Ned (1994), *On a Confusion about a Function of Consciousness*

[19] Koch, Cristof (2004), *The Quest for Consciousness, p.13*

[20] Koch Cristof (2004), *The Quest for Consciousness, p. 34*.

[21] James, William (1879; 1890), quoted from the *Stanford Encyclopedia of Philosophy:- Epiphenomenalism* … offered an intriguing variant of the argument from natural selection. If pleasures and pains have no effects, there would seem to be no reason why we might not abhor the feelings that are caused by activities essential to life, or enjoy the feelings produced by what is detrimental. Thus, if epiphenomenalism (or, in James' own language, automaton-theory) were true, the felicitous alignment that generally holds between affective valuation of our feelings and the utility of the activities that generally produce them would require a special explanation. Yet on epiphenomenalist assumptions, this alignment could not receive a genuine explanation. The felicitous alignment could not be selected for, because if affective valuation had no behavioral effects, misalignment of affective valuation with utility of the causes of the evaluated feelings could not have any behavioral effects either. Epiphenomenalists would simply have to accept a brute and unscientific view of pre-established harmony of affective valuation of feelings and the utility of their causes.

[22] Penrose, Roger (1997), *The Large, the Small and the Human Mind*, p. 59

[23] Mills, Robert (1994), *Space, Time and Quanta.* See Chapter 15 on "The Observer", pp. 359-375

[24] Chiu J., De Salle R., Lam H.-M., Maisel L., Coruzzi G. (1999). Molecular evolution of glutamate receptors: A primitive signaling mechanism that existed before plants and animals diverged. *Mol. Biol. Evolution* 16 : 826-838

[25] Allman, John (1999), *Evolving Brains*, Scientific American Library, 1040-3213; no. 68, p. 20-21, 68-71

[26] Gazzaniga, Michael, Richard B. Every, George R. Mangun (2002), *Cognitive Neuroscience* (New York and London: W.W. Norton), p 578 'The human brain is a unique amalgamation of evolutionary old areas and

new areas that have been modified in predictable ways through expansion or reduction of existing parts, formation of new connections and adaptations …', *Cognitive Neuroscience p. 578*

[27] Allman, John (1999), *Evolving Brains*, Scientific American Library, 1040-3213; no. 68, p. 23

[28] Gould, S. J ., Eldredge, N. (1977), Punctuated Equilibria*, Paleobiology,* **3**: pp. 115-51.

This theory doesn't mean less steps per useful mutation; it only indicates that most of the steps are taken within short bursts, so continuity is conserved.

[29] Libet, Bernard (2004), *Mind Time,* pp. 72-73

[30] Gazzaniga, Michael, Richard B. Every, George R. Mangun (2002), *Cognitive Neuroscience, p. 543*

[31] Churchland, Patricia (2002), *Brain-wise*, pp. 224-229 is the most easily accessible reference.

[32] Naccache, Lionel et al (2005), *Proceedings of the National Academy of Sciences vol. 102, p. 7713*
Cited in the New Scientist of 21 May 2005, p.20

[33] McCrone, John (2004) *Science and Consciousness Review*, who cites:-
Star EN, Kwiatkowski DJ and Murthy VN. Rapid turnover of actin in dendritic spines and its regulation by activity, Nature Neuroscience 5:239-246 (2002)

Ehlers MD.(2003), Activity-dependent regulation of postsynaptic composition and signaling by the ubiquitin-proteasome system. Nature Neuroscience 6:231-242
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Lisman JE and Fallon JR. What maintains memories? Science 283:339-340 (1999)

Wittenberg GM, Sullivan MR and Tsien JZ (2002),. Synaptic Reentry Reinforcement Based Network Model for Long-Term Memory Consolidation Hippocampus 12:637-647

[34] Becchio C., Bertone, C, (2005*),* Beyond Cartesian Subjectivism, *Journal of Consciousness Studies*, 12 (7), pp. 20-24.

[35] www.cs.rochester.edu/users/grads/jshaw/neural/node4.html, *Views from Artificial Intelligence*

[36] Searle, John (1997), *The Mystery of Consciousness,* p.45*,* containing his famous *Chinese Room* thought experiment, (1980a)

[37] Two studies came to the conclusion that the "*decision tree (symbolic) approach yields more accurate results than the neural network (subsymbolic) method*." They were by:-
- Saedler and G. Theißen (www.inb.mu-luebeck.de/publications/ publikationen-d.html)
- Werner Dubitzky, Martin Granzow, Daniel Berrar (www.infj.ulst.ac.uk/~cbbg23/papers/camda00_02.pdf)

[38] Pinker Stephen, (2002), *The Blank Slate*, (Viking Adult)

[39] Scott, Alwyn (1995), *Stairway to the Mind*, p.16

[40] Penzias and Wilson (1978), *while working as electrical engineers for Bell Labs*.

[41] Koch, Christof (2004), for example *"The Quest for Consciousness", p. 3*