

# A conceptual approach to the hard problem: Engagement of the brain with the wider environment through Attribute Space

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## Abstract

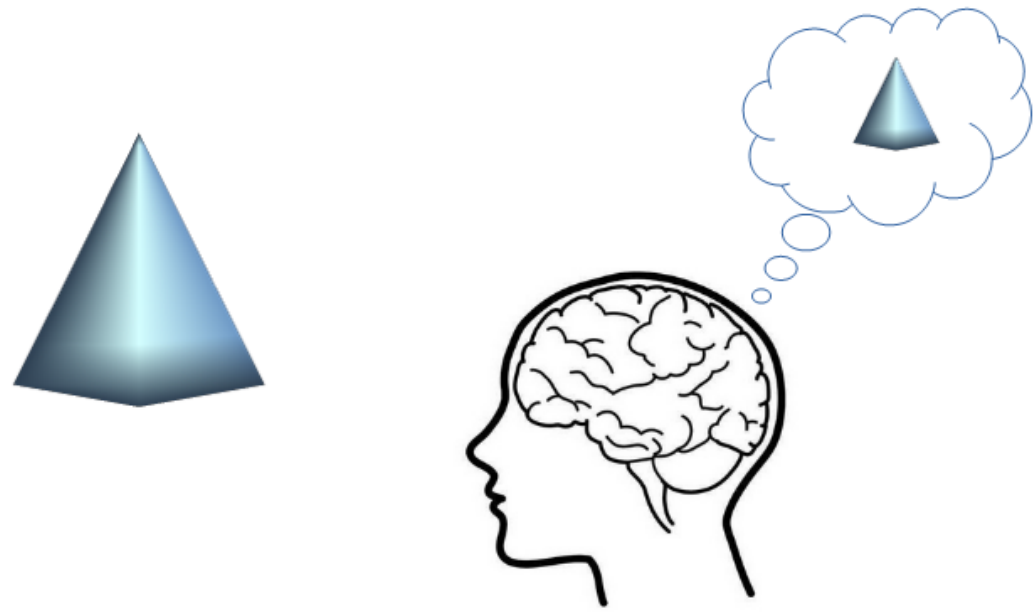
Establishing the fundamental physical principles behind how subjective experience arises from brain activity (the hard problem) still represents arguably the biggest conceptual challenge in consciousness research. Using the tool of Attribute Space, an abstract space of the attributes of physical objects, might help shed new light on the problem.

Each material object in physical space can be described by a number of attributes, such as its shape, size, (colour) and texture. These attributes, while they map to real material objects and are intimately connected with them, are also abstract in nature. Attribute Space is the space of all such object-related attributes which while bound with the physical world, can also be demarcated from it within their own space or layer.

This paper takes as its axiom that the processing/manipulation of attributes plays a central role in the interaction between brain/body and the environment. Attribute Space provides an alternative framework for the analysis of what gives rise to subjective experience and the feeling of self. It sets the brain's mental processes, together with the abstract attributes of the wider physical world, within an "extended continuum" which is tightly coupled with matter.

## Problem and Approach

Physical objects have attributes, such as shape and size, which are intrinsic to them. These attributes are also abstract in the sense that they can be reproduced or associated with (mapped to) other objects.



Our thoughts seem abstract; the mental world seems abstract, and yet, taking the materialist perspective which this paper does, the problem is how this abstractness arises from a purely physical organ, the brain. Somehow the brain manages to create an abstract virtual reality but one which is intimately connected with the physical world.

Supposing there is a *physical* relationship of some sort between the abstract attributes intrinsic to the material world and the abstract experience 'in our heads'. Supposing we extend the way we describe the world so that to dimensions such as mass, length, time and electrical charge we add *form* (form in the general sense, that is, properties or attributes). This extended physical description might be a stepping stone to resolving the hard problem of how subjective experience and the feeling of self arises from brain activity.

This paper explores a simple model of the engagement of a conscious being with its environment, whereby after some preprocessing of information derived from the senses and internal states/memory (to extract attributes), there is a direct mapping between attributes and neural patterns and a visual scene is constructed from those attributes using the brain's parallel processing capabilities. Using this model, combined with the above extended physical description of the world, a hypothesis of what might lead to subjective experience and the sense of self is advanced to illustrate the method.

This approach is a conceptual one and the model is deliberately simple in an attempt to get closer to an insight into the fundamental principles of what might be going on. However consciousness arises and however it can be explained, the answer cannot *just* be a mechanism in the brain: Given the mind-matter conundrum, the explanation is likely to also require a new *physical principle* of some sort to properly address the question "So how does *that* give rise to conscious experience?"

## Attribute Space

We define Attribute Space to be a layer within the physical world, analogous to the layer containing place names and other descriptive data on an electronic map.

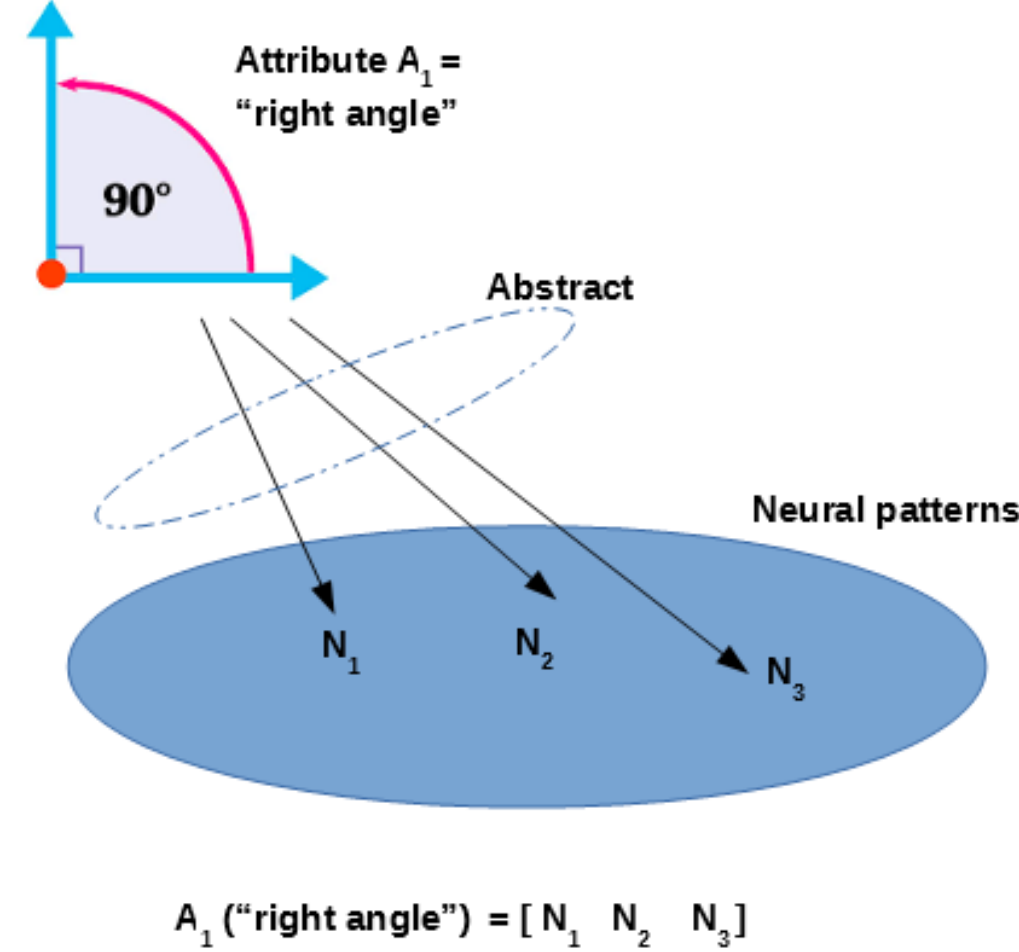
$$\text{Physical world} = \text{All physical objects} + \text{The objective attributes of those objects}$$

Attributes are abstract building blocks, and are already used in studies including object recognition. They are a generic and flexible way for describing the world.

Given consciousness seems to be at the heart of our engagement with the world, attribute space provides a medium or toolkit for describing this engagement, a toolkit which might be a way of linking the 'mental' with the 'physical'.

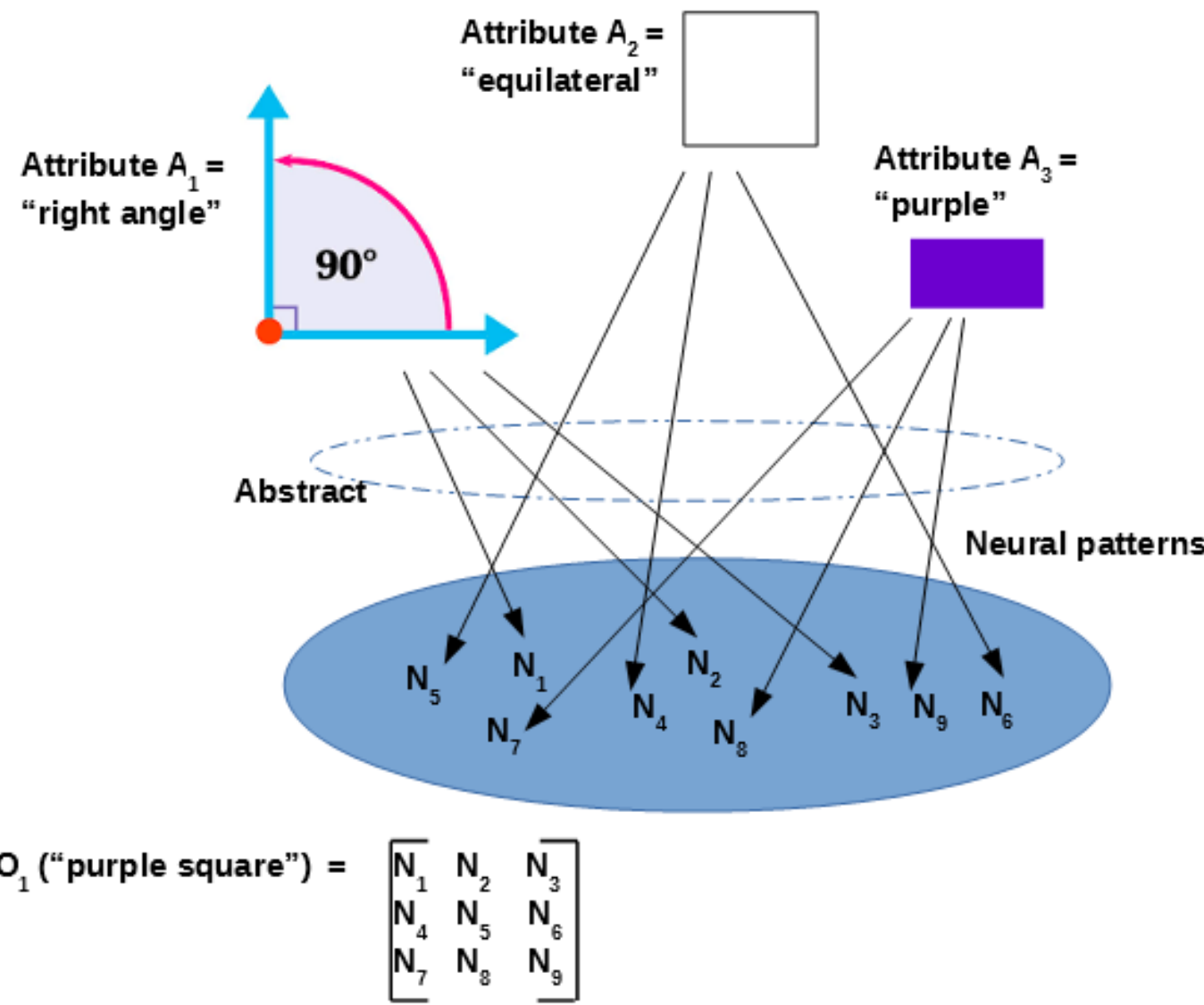
## Model of brain/environment interaction

This model assumes that throughout the engagement of a conscious being with its environment, following preprocessing to extract attributes from sensory information, there is a direct mapping of attributes to neural patterns. Each physical attribute ( $A_i$ ) is mapped to a 'signature' for that attribute [ $N_{i1}$   $N_{i2}$  .....  $N_{in}$ ] in the brain.



The representation of the attribute has an abstract element (e.g. a particular aspect of the object's shape) and a physical one (set of corresponding neural patterns).

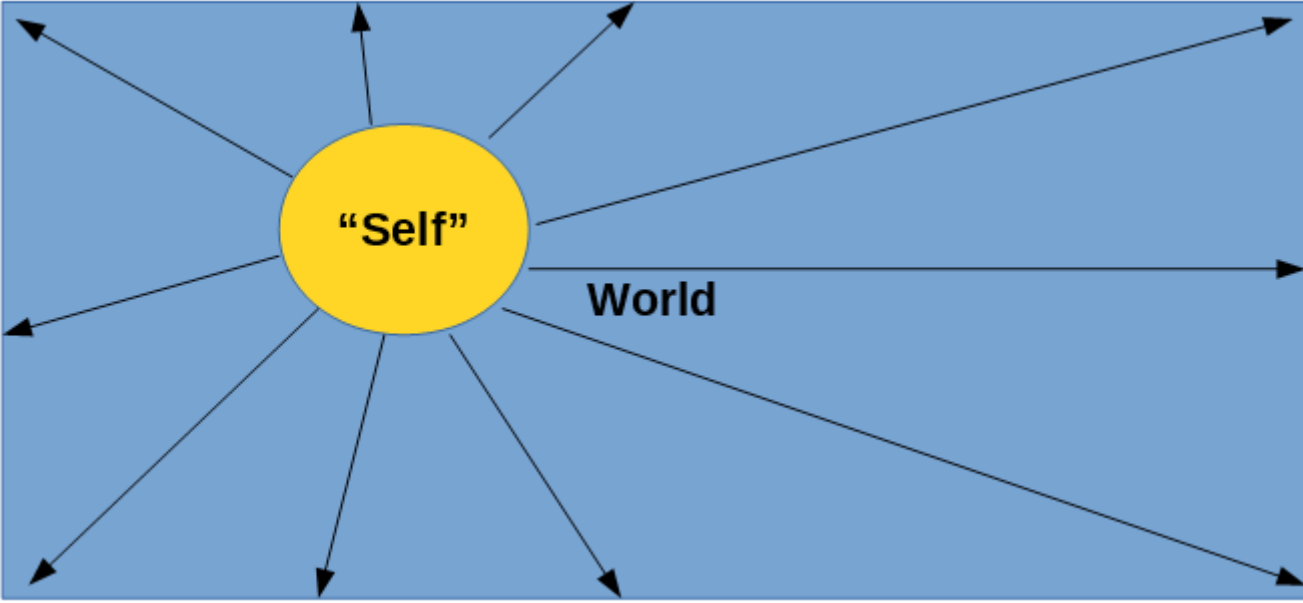
Attribute integration into objects (such as the purple square below) and the overall visual scene might be achieved through a *superposition* of neural patterns. This would likely to be done asynchronously, within a limited time window (a few hundred milliseconds around 'now') and would exploit the brain's parallel processing capabilities.



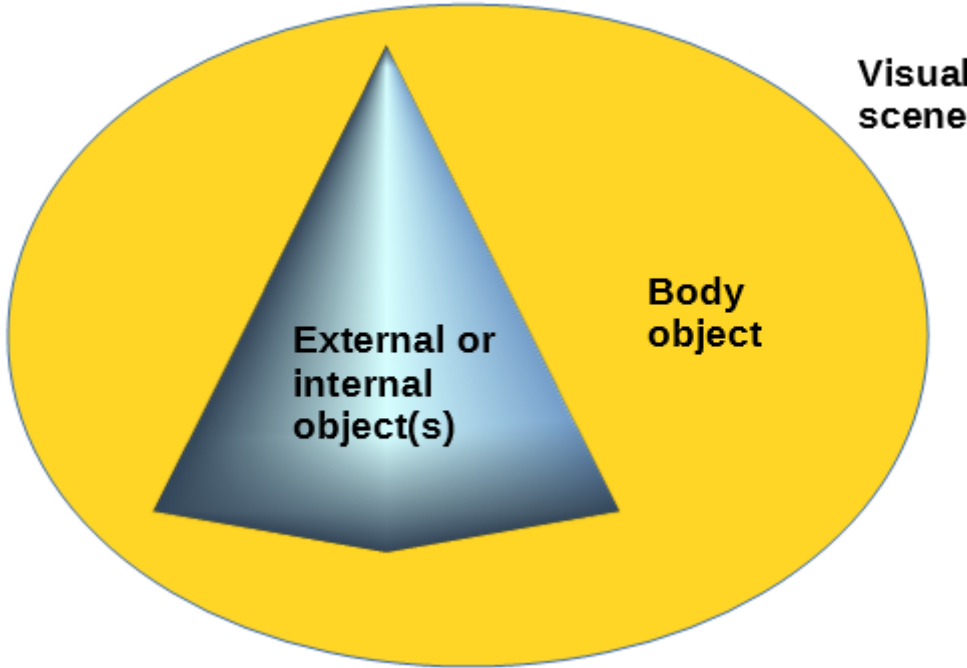
Given attributes are processed by the brain at different speeds (first colour, then shape, then motion), the brain might bind/synchronize attributes from a temporal perspective by capturing each attribute and storing it in short-term working memory (say for 100-200ms) then would perform a preconscious 'best fit match' to bind sets of attributes into objects. Object recognition (matching/linking with stored attributes in memory) is likely to be an integral part of this binding process.

## The body and the visual scene

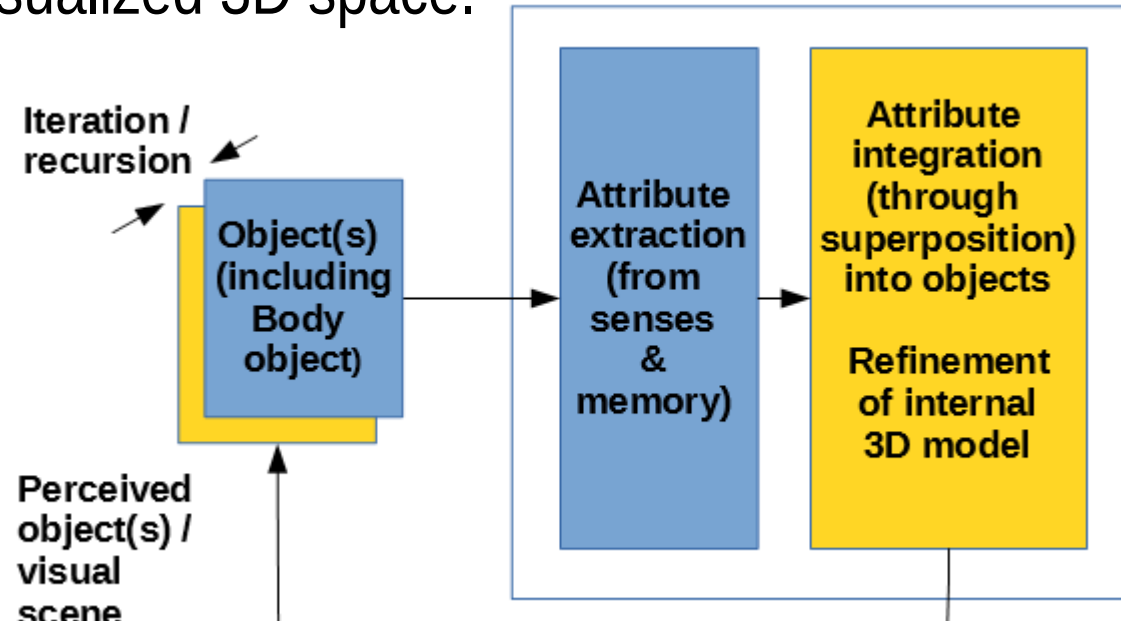
At a conscious level, when we experience the world, we do so with our own body as one of the objects in the field of experience or visual scene: We observe ourselves in relation to objects in the environment.



Preconsciously, when perceiving an object, the brain does not simply represent the object, it *represents (a view of) the body in relation to that object* within the overall visual scene.



For the brain to build up sufficient information on the environment and the body's relation to it, several iterations would be needed within a short time frame. Each iteration would involve sensory processing, attribute integration (through superposition) and refinement of an internal model which maintains the body as one object within a perceived or visualized 3D space.

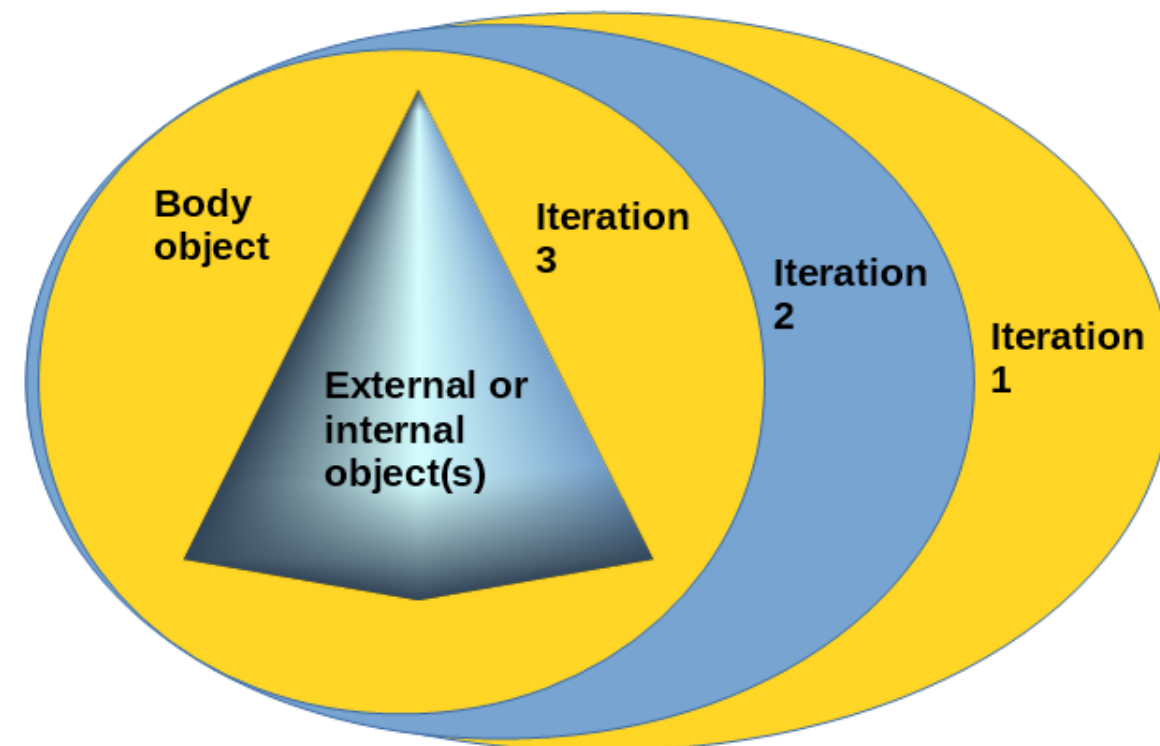


## Physical principle (hypothesis)

To recap: The attributes of physical objects are an intrinsic part of the physical world. The model described involves the brain processing attributes from sensory and memory inputs, integrating them into objects and an overall visual scene through a direct mapping with (and superposition of) neural patterns.

But how could subjective experience and the feeling of 'Self' arise? The underlying hypothesis here is with the brain manipulating and integrating attributes which are integral to the material world, a *Self* object comes into existence as a *direct consequence* (not an emergent feature) of this process. *The Self is the outcome of a physical process which is governed by physical law.* Once we better understand the process and the governing law, the Self might be objectively observable through the behaviour of neural patterns in the brain.

A possible, basic mechanism is proposed here. The visual scene is built up through a series of iterations which are held in short-term working memory.



Every iteration involves a change to the set of active neural patterns in the brain.

The "body object" within the visual scene is being continually refreshed during this (recursive) process.

The real feeling/experience of consciousness arising from the iterative manipulation of attributes by the brain might be a direct consequence of physical law, just as is the force experienced in the hand when a baseball is caught by the fielder. That force is a real one and is a consequence of Newton's second law relating force, mass and acceleration ( $F = ma$ ).

Using this analogy by way of illustration, subjective *feeling* at a basic level (analogous to "force") might result from the 'changes in direction' or rotation ("acceleration") of coherent sets of neural patterns (objects, visual scene - "mass") from moment to moment within the recursive process outlined above. The process itself might be expressed using matrix algebra in terms of a transformation of attributes (neural patterns) such that

$$S_n = S_{n-1} E_{n-1}$$

Where  $S$  is the matrix of all attributes within the brain at any instant (as encapsulated in long-term memory, working memory, learned behaviours and so on) and  $E$  is a matrix (encapsulating interaction, preconscious experience) which when multiplied by  $S$  provides a transformation in attributes as a result of engagement with the world.

The spirit of the above equation is to represent an iterative and recursive change from one state to the next, an *iterative/recursive modification of the Self through moment to moment experience.*

## Discussion and Conclusions

This paper has presented an alternative approach to addressing the hard problem based on the attributes of physical objects being intrinsic to them, and using a simple model of the brain/body interacting with the environment through a direct mapping between attributes and neural patterns. An equation which encapsulates (at a high level) the process of consciousness is proposed for illustration purposes.

It might seem there should be a fundamental difference in type between the attributes intrinsic to physical objects and those attributes which, as this hypothesis states, are the building blocks of our mental life. But if the latter are directly mapped to neural patterns there is only ever a physical process going on, a process which is governed by physical law.

Certain aspects of this hypothesis can be directly tested, such as the mapping of attributes to neural patterns. Other aspects, and in particular how the Self arises from the engagement of a conscious being with its environment, need further development to be testable.

Discussion with colleagues from all disciplines will be very welcome.

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