

Colin Hales

Dual Aspect Science

Abstract: *Our chronically impoverished explanatory capacity in respect of P-consciousness is highly suggestive of a problem with science itself, rather than its lack of acquisition of some particular knowledge. The hidden assumption built into science is that science itself is a completed human behaviour. Removal of this assumption is achieved through a simple revision to our science model which is constructed, outlined and named 'dual aspect science' (DAS). It is constructed with reference to existing science being 'single aspect science'. DAS is consistent with and predictive of the very explanatory poverty that generated it and is simultaneously a seamless upgrade; no existing law of nature is altered or lost. The framework is completely empirically self-consistent and is validated empirically. DAS eliminates the behavioural inconsistencies currently inhabiting a world in which single aspect science has been inherited rather than chosen and in which its presuppositions are implemented through habit rather than by scientific examination of options by the scientists actually carrying out science. The proposed DAS framework provides a working vantage point from which an explanation of P-consciousness becomes expected and meaningful. The framework requires that we rediscover what we scientists do and then discover something new about ourselves: that how we have been doing science is not the entire story. Dual aspect science shows us what we have not been doing.*

Key words: Consciousness, cellular automata, cellular automaton, dual aspect, metascience, neuroscience, neural correlate of consciousness, P-consciousness, phenomenal consciousness, scientific method, underlying universe.

Correspondence:
Colin.Hales@nicta.com.au

Introduction

Given the success of science over hundreds of years and the sophistication of our models of the natural world, an expectation that all problems must ultimately succumb to the wiles of our scientific behaviour would not seem unreasonable. However, if a particular scientific problem remains intractable indefinitely, defying all approaches, at what point do we inherit the latitude to question ourselves as scientists? What level of failure justifies some doubt that we scientists are equipped for solving such a stubborn problem? How would we tell if we were actually part of the problem? Here we will examine the possibility that, in the case of the 'hard problem' (Chalmers, 1996) of the physics of 'P-consciousness' (Block, 1995), there may be a legitimate case for such a situation being our reality. Such a state of affairs would imply that the scientific behaviour that is successful is not the behaviour of the scientists of today. In what ways might the successful scientific behaviour differ from ours?

The term 'P-consciousness' has been defined in Appendix A. When the term 'scientific behaviour' is used here, what is *not* meant is particular skills or processes or method, individually or in groups. What *is* meant is the basic behavioural invariants that apply across all scientists. That is, the literal net/effective external behaviour of a human doing science, which one can confidently say is unique; quite different from other behaviours. Scientific behaviour is very different from non-scientific behaviour like tennis. Scientific behaviour is quite different from day-to-day problem solving behaviour in that it is required to deliver explicit verifiable abstractions predictive of natural world behaviour, independent of any particular scientist. This phrase '*predictive of natural world behaviour*' is key, for it implies 'appearances'; how the natural world will appear when we look. Note that this requirement is the origin of all technology. If we cannot assemble initial conditions of real world material such that the expected or designed 'appearance' (the function of the technology) is the result, then the technology is a failure. Successful technology thus becomes proof of the adequacy of the 'science of appearances' used to establish the initial conditions. No sense of 'ultimate truth' need be construed here and none is claimed. This is the raw, plain human behaviour behind successful science. The fact that many 'laws of appearances' are highly abstract and best captured mathematically is irrelevant in the sense that the abstractions can only logically be claimed to be predictive of appearances. Nothing else. The reader is directed to the nineteenth century science literature, where scientists were quite

aware that what they were doing was ‘organising appearances’ (for example Ernst Mach [1897] and George Henry Lewes [1877; 1879]). We seem to have lost that knowledge. One of the outcomes of this work is to rediscover this old view (which is actually an accurate depiction of ‘single aspect science’) and present it in a modern context.

‘Scientific behaviour’ means something very specific and yet generic in this text. This is obvious when you note that scientific outcomes can be collected into a simple list, a set of ‘laws of appearances’:

$$T = \{t_1, t_2, \dots, t_n, \dots, t_{N-1}, t_N\} \quad (1)$$

An example could be $t_n =$ ‘*The number of aardvarks in the region is 1234*’ or $t_n =$ ‘*F=MA*’ or $t_n =$ ‘*The hippocampal CA1 neural cell neogenesis statistics go like <this> under <these> circumstances*’ or $t_n =$ ‘*Quantum electrodynamics*’. Every cell biology paper ever written could be installed in it, for example. ‘Laws of appearances’ can, using this technique, be abstracted into a set T and referred to in a generic fashion, whether they originate in the mind of a scientist or result from observation. Ultimately ‘appearances’ in the real world external to the scientist qualify it as a member of set T. The point is not that an ultimate truth has been established, but merely that at some point in time a claim was made that seemed to be representative of some kind of regularity in the natural world. As a result it went into set T. If the claim was later refuted then it was removed from set T. ‘Phlogiston’ or ‘phrenology’ science would have passed through set T in this way. In summary: To exhibit scientific behaviour is to populate set T. It is as simple as that.

Science is not done by logically omniscient lone knowers but by biological systems with certain kinds of capacities and limitations. At the most fine grained level, scientific change involves modifications of the cognitive states of limited biological systems (Kitcher, 1993).

Thus set T is equally posed as merely a collection of brain material configurations — beliefs. What makes the members of set T special? It is the simple fact of its empirically testable explicit presentation and the portability of the contents of the set. They have an existence outside the activity of any particular scientist, although they are causally inert unless there is a scientist they can inhabit. Consider if there was only one scientist in the world. Could there still be a set T? What if that lone scientist did not make the laws explicit? According to the

situation of set T the result is not science. However, the scientist need not have a written set T in order that technology might ensue. The beliefs, contained in one solitary cranium and never made explicit, are still potentially causally effective as beliefs enabling technology. Consider that human technology existed for millennia before there was ever any formal documented set T members or any scientists. The word scientist itself was not coined until the nineteenth century. Also consider that some animals can exhibit primitive toolmaking behaviour. One such creature is a chimpanzee. A chimp must therefore have some kind of primitive but *implicit* (virtual) set T_{chimp} sufficient to characterise its natural world. The chimp merely acts 'as-if' it had set T_{chimp} . Is that set T science? Not in the sense meant by humans. In this light it is the size, abstractness and, most importantly, *explicitness/portability* that makes the human set, say T_{human} , a unique feature of the natural world.

Metabelief

Metabelief is belief-about-belief. If my tooth fell out and I subsequently make a claim $t_{100} = \text{'my tooth fell out'}$, that fact is potentially supported by two physical outcomes. Firstly, the observed change in the location of the real matter that is the tooth. Secondly, the altered molecular configuration of my neural material such that it can report the fact. The molecular dynamics of some subset of my brain material has been altered to replay/report the belief t_{100} ; a report of tooth loss. However, that brain reconfiguration, on its own, cannot be scientific evidence for the tooth loss. I can force myself to report the loss without any tooth actually being lost. In contrast, claim t_{100} can be substantiated with physical evidence. A metabelief about t_{100} might be $t_{101} = \text{'The } t_{100} \text{ tooth fell out because the tooth fairy needed it'}$.¹ The only evidence available in support of the claim is the physical configuration of the brain material that enacted the utterance t_{101} .

[1] Another general characterisation of metabelief is 'virtual belief' in the sense that the holder is acting 'as-if' the belief was true. Scientific hypotheses start life as a metabelief in set T. Acting 'as-if' it were true facilitates the testing of the hypothesis (as described in the text). If scientifically falsified or otherwise rendered deserving of sufficient doubt, the metabelief is ejected from set T because, whatever it refers to is not the natural world, but some other belief which may or may not be obvious. It may be merely an artefact of the language used, for example (say, the tooth fairy). Slightly more formally, a metabelief may be written as $\text{'Belief}_Z = \text{'Belief}_X \text{' causes 'Belief}_Y \text{'}$. 'Belief_I means the belief is about I (Its intentional content. Even the word 'causes' represents a belief about a relationship, not a relationship! This is 'doxastic logic'). If X is scientifically proven and Y is not, then Z is a metabelief. Holding Belief_Z is quite viable, but that belief is not a 'law of nature'.

The experimental technique to detect metabelief requires the adoption of a position entailed by its truth followed by measurements designed to detect the logical consequences of it to some acceptable level of doubt. In the case of a metabelief there will be none beyond the verification of the brain material involved in the holding of the belief.

A metabelief about set T as a whole might be '*that members of set T are invoked by the natural regularity pixies*'. Another less tongue-in-cheek metabelief might be that '*the abstractions in set T are that way because the external world is literally made of the abstractions*' or '*the natural world is a big computer running set T as a program*'. Metabeliefs include the entire class of philosophical categories of the generic form XYZism. For example, empiricism: '*a theory of knowledge which asserts that knowledge arises from experience*'. Successful scientific behaviour results in knowledge (set T) and this is *not* causally necessitated by the linguistic category 'empiricism', which is merely a correlate of some portion of actual scientific behaviour. Knowledge actually results from the causal ancestry of the laws of nature driving the scientist. Linguistic categorisation does not necessitate the outcome. To reinforce the point: A scientific knowledge outcome is critically dependent on the involvement of scientific behaviour. Take the scientist away and there is no more set T population activity. Nothing else is necessary. This kind of characterisation of the entire science process is very clear, obvious and testable. Metabeliefs form no necessary part of it and science proceeds perfectly well in their complete absence.

Metabelief is not supported by evidence outside of brain material configuration and therefore cannot be a 'law of nature'. Acting as if a metabelief is true or false when it is not may inhibit access to useful scientific outcomes. For this reason metabelief should be defeated in critical arguments involved in assessment of scientific/technological options. Metabeliefs are not claimed right or wrong, they are simply claimed to be potentially damaging misdirections to the unwary scientist because they predict nothing. This pragmatic position does not entail that metabelief is impossible to discuss or uninteresting. Mountains of philosophy of science attests to that.

Scientists in the basic physical sciences have, throughout the modern era, displayed a practical revulsion for the philosophical categories of the kind XYZism for this very good reason: if they discuss it they undermine their own work because they are speaking of an untestable, scientifically(causally) inert, predictively voiceless concept that will critically damage their work in the eyes of peers. Indeed

that kind of eschewing of metabelief is asserted as applicable here for the very important reason that *this document is intended to result in actual changes to the behaviour of working scientists in the basic physical sciences*. They are the key stakeholders: those most affected and involved. Working scientists must take ownership and live with the revised science model. Metabelief is eschewed here for the very reason that I want scientists in the basic physical sciences to actually read this document and seriously entertain the proposition. Of course, those outside science may comment and offer guidance but ultimately *all* working scientists are directly impacted and are the crucial focus of this proposal.

The possibly confusing self-referential implication here is that *no metabelief can be used in judgement of this work*. Working scientists must hold any metabelief unknowingly and accidentally and must apply their metabelief to this proposition in expectation of the revulsion they apply elsewhere in science in the same circumstances. We scientists cannot have it both ways. We cannot revile metabelief in all science contexts and then use metabelief in support of a scientific view of our own activities. We are a natural phenomenon, like any other. Consistency demands we treat ourselves scientifically like all natural phenomena.

To complete the total disconnection of DAS from all metabelief, it is shown later how DAS can be established through empirical testing. Let us assume that has happened and DAS is running. In a DAS world all manner of post-hoc calibrations of DAS with respect to various XYZisms may occur. I have already done some work on this. All I can pass on is my experience that every XYZism scrutinised to date is ambiguously present in the DAS framework. None are obviously right. None are obviously wrong. A typical example, the ambiguity applicable to those who consider explaining P-consciousness as intrinsically impossible in principle, such as ‘mysterianism’ (for example Colin McGinn [1999]), is discussed briefly below. At the end of ambiguity analysis, working scientists would still behave as before. Others are far better equipped and more appropriately placed to do justice to that activity. I defer to their judgement on the matters. The resulting information actually changes nothing practical in the life of a working scientist.

The Uniqueness of Set T

Is the set T_{human} unique? That is, does set T_{human} contain some kind of singular ultimate expression capturing the essence of the real natural

world, the universal laws of nature, unique, immutable, invariant across space and time? The answer to this must be no. All we can logically claim is how the natural world appears to *humans*. Consider an alien scientist who has P-consciousness that directly perceives only gravitons and neutrinos. Such a bizarre P-consciousness would depict the same natural world totally differently. What we call matter, it would probably call space, and vice versa. The alien scientist, charged to construct its own set T_{alien} , would assemble abstractions – ‘laws of appearance’ – that look totally different from T_{human} . Are they truly different? Each set, T_{alien} and T_{human} , was constructed using a unique P-consciousness and that P-consciousness is *built into the set T*. Consider a simple experiment on Newtonian dynamics where human and alien are expected to predict the location of an accelerating apple. Following their own set T , both scientists point to the same outcome. They are equally predictive. Yet the abstractions in their respective set T might be as different as quantum electrodynamics is to Sanskrit poetry puffed in smoke signals. The sciences of alien and human are utterly different, yet both are identically predictive. It is the *predictive utility* of natural laws that is the true invariant across all sets of the T kind. Nothing else is claimed.

The Self-Referential Set T

There is no point in history where some kind of authoritative body determined, sanctioned, authorised, approved or reviewed the range of fundamental, invariant, minimal behaviours necessary for a person to be validly classified as a scientist in the throes of a scientific act. The minimal necessary scientific behaviour evolved through trial and error and is passed from mentor to novice in the form of the implicit goal-seeking drive to ‘*seek out regularity in the natural world, search it for explicit maximally-universal generalisations and publish*’. This is an empirically derived report of what we do at the most basic level of behaviour. Empirically informed and validated nomothetic activity directed at the population of the set T_{human} captures the essence of the behaviour of those involved in the basic, physical sciences of the modern era. But there is no governing body; indeed the basic behaviour is not actually documented anywhere in the sense that it might be brought out and displayed to the novice scientist at the start of training. This fact is rather startling. What it means is that a regularity in the natural world — the minimal basic behaviour of the scientist — is not in set T_{human} . To put it more bluntly, the minimal behaviour of scientists required to populate set T_{human} is arguably less scientifically

documented than the chimpanzee behaviour used to extract bugs from holes in a tree with a stick. Let us document it ourselves right now. What exactly is this minimal invariant scientific behaviour? The simplest form is a set T_{human} member '*scientists populate set T_{human}* '. The described natural world is simply the appearance of the natural world (a scientist) when it is assembling laws of nature. It seems rather trite and not very useful when put in this form. We can do better. Let us nominate this unusual auto-epistemic member of set T_{human} as set member t_0 . That is, we now have a more complete set T_{human} as follows:

$$T_{\text{human}} = \{t_0, t_1, t_2, \dots, t_n, \dots, t_{N-1}, t_N\} \quad (2)$$

Set member t_0 is another more formal version of '*scientists populate set T_{human}* ' to be delineated shortly. Notice that the alien scientist would have the same form of set:

$$T_{\text{alien}} = \{u_0, u_1, u_2, \dots, u_k, \dots, u_{K-1}, u_K\} \quad (3)$$

Law t_0 is to the human as law u_0 is to the alien. Each scientist populates their respective set T using behaviour characterised by a natural law with index number zero. Being human we can now detail a more accurate t_0 . Any working scientist can measure this because we have access to the evidence needed, which is what scientists actually do, not a report about what we think we do or a non-scientist's view of what we do². This is a report of empirical measurement; a report of what I actually witness as a scientist. To deliver the (averaged³) data in a useful form, first we need to capture the generic form of all members of set T_{human} . This is the rather simple 'generic law of appearance':

$$t_n = \text{The natural world in } \langle \text{insert context} \rangle \text{ behaves as follows: } \langle \text{insert behaviour} \rangle \quad (4)$$

Based on this generic form of all laws the auto-epistemic form of t_0 applicable to existing human science becomes:

-
- [2] You cannot ask us. We scientists must be observed unobtrusively. Evidence that scientists or anyone else provide verbally about what they think scientists do is evidence for some other aspect of the study of scientists.
- [3] The measurement is very noisy. Some examples of the noise are included in Appendix C.

$t_0 =$ The natural world in *<the context of a human being scientific about the natural world>* behaves as follows: *<to create and manage the members of a set T_{human} of statements of type t_n , each of which is a statement predictive of a natural regularity in a specific context in the natural world external to and independent of the scientist arrived at through the process of critical argument and that in principle can be refuted through the process of experiencing evidence of the regularity>* (5)

Note that t_0 makes no reference to the actual particulars of any deliverable science outcomes (set T member) except the very fact of a deliverable. The self-referential nature of t_0 can be misleading if this is not understood. A great deal of qualification of the individual aspects of t_0 could be assembled and I have done some of this privately (unpublished). However the basic minimal behaviour according to equation (5) is exactly what we do and is sufficient for our purposes here. If you take any part of equation (5) away scientific behaviour vanishes.⁴ Equation (5) is the result of an empirical measurement⁵ of scientific behaviour. It is what real physical behaving humans do when acting scientifically. If a human adopts (learns the belief) t_0 , the result is a scientist populating a set T_{human} , not a plumber or a tax accountant. That is all that is claimed here.

The Set T_{human} of the Very Early 21st Century

This work started by characterising a specific scientific problem which is the failure to explain or predict P-consciousness. That failure is so well documented that it even has its own name: ‘the hard problem’ (Chalmers, 1995). The failure is highly suggestive that the existing set T is more than merely missing the set member for P-consciousness. Set T itself is actually faulty or inadequate in some way. That failure can now be discussed rather more formally as a result of the above equations. Indeed the key problematic feature

[4] Note that the nuance in t_0 about ‘critical argument’ fails when there is only one human scientist. In that condition there cannot be argument between scientists. This does not mean that a law of nature cannot be assembled. It merely means that the science may be impoverished. Critical argument is thus not absolutely mandatory. That is, explicit critical argument is not a necessary condition for science to occur. In any empirical validation of the law t_0 , however, the statistical weight of the number of human scientists that are involved in it would demand it be accounted for in any explicit formal definition of basic scientific behaviour. That is why the critical argument clause was left in t_0 . This paper is an example of just such a critical argument.

[5] Notionally this can be taken to be a number in the low hundreds informally sampled during my own personal experiences in Australia and elsewhere around the world.

becomes almost trivially obvious in t_0 . In a scientific context P-consciousness is *literally* scientific observation, which is the act of ‘experiencing evidence’ in equation (5). This is in direct contrast to the ‘scientific measurement’, which is actually located in the external world being studied, say the output of instrumentation and other experimental apparatus. The phrase ‘experiencing evidence’ physically demands that some aspect of the natural world become ‘contents of P-consciousness’. Thus, all scientific laws are assembled and validated under the presupposition of P-consciousness. In that context the expectation of any sort of *prediction* of P-consciousness is fundamentally misplaced *a-priori* in exactly the same way that the process itself (population of set T_{human}) presupposes the existence of a scientist. The set T framework is thus imbued with presupposition.

Further presupposition is evident when you look at the actual status of the members of set T_{human} as forms of ‘explanation’. There is no ‘explanation’ in set T. There is only description. This is meant in the sense that set T_{human} merely depicts appearances (what), not any sort of causal necessity (why). This can be interpreted thus: ‘*behaving as-if set T_{human} delivers explanation results in useful prediction*’. Practical circumstances requiring some kind of ‘virtual explanation’ can benefit from this through the process of extraction and application of set T_{human} members to a context in need of explanation. For example the set T_{human} members that are the laws of thermodynamics may be brought to bear in an explanation of car windscreen condensation. However, there is nothing in this process which involves *why* the laws of thermodynamics exist in the first place. This exact line of argument can be extended to the whole of existing science without exception. Set T can therefore only be claimed to capture causality in an ‘as-if’ sense acquired through isolating observed critical dependencies.⁶ This system works really well. However, as a form of explanation it is incomplete.

This issue of description (critical dependency) versus explanation (causation) is highlighting a more fundamental and widespread problem in set T_{human} . Firstly, set T_{human} presupposes the existence of scientists and their faculty for scientific observation (P-consciousness). Secondly, there is no sense in which the set T_{human} delivers any explanation, as in ‘why’ things should be this way at all. In this light the ‘hard problem’ is merely the tip of a more general ‘iceberg’ problem; a large hole in our epistemic framework for science. Not only do we have no explanation (why) in our scientific laws, we also have no

[6] See Appendix B for a brief look at the causality/critical dependency issue.

'law' in set T_{human} that has ever proved that such explanation, in the sense of causal necessity, is impossible to construct. We merely have hundreds of years of failure to try correlated with a failure to solve the 'hard-problem' of P-consciousness. This quite well defined chronic failure is the logical sweet-spot we can use to directly address our epistemic problems.

A New Epistemic Framework

As a working scientist in the basic physical sciences, there is no official place to go to air the possibility that somewhere in our own behaviour, in a particular skirmish with nature, we are deflecting ourselves from the answer we seek and are unaware of it. In the absence of any governing body it seems reasonable to consider that each of us, as individual scientists, surely has the right and duty to question beliefs inherited from scientific forebears. The beliefs in question are those implicit in the behaviour of mentors, which confine us to the set T and an environment of chronic failure under an implicit t_0 (equation (5)). This is not some esoteric argument about abstract theoretical positions. This is about behavioural options available at the real scientific coal-face. What is at stake is literally, for example, the failure to understand how anaesthesia works or exactly what chronic pain is. Ask the sufferers of chronic pain if we should refrain from certain behavioural options even a millisecond longer than we need, given that limitation is actually causing a failure to fully understand their affliction. This is a rather obvious emotive argument, but it highlights our responsibility as individual scientists to make sure that if we restrict our explanatory options merely through implicit unchallenged metabelief or assumption delivered by our own history, then we deserve to be held accountable and to have them flushed out and made explicitly obvious as such. It is what we expect everywhere else in science. What form of exemption can we claim unique to ourselves?

An experienced experimental or applied scientist knows that at the heart of explanatory failure is usually some kind of assumption. The strategy of isolating and flushing out implicit assumptions is normally a very powerful tool in pursuit of the solution to an unyielding problem. What might that assumption be here? The problem, the delineation and construction of the physics of P-consciousness, is immune to our behaviour. Our behaviour is all there currently is to scientific behaviour. Logically this entails that the scientific behaviour that will succeed supersedes our current behaviour. This makes our assumption obvious: *we are assuming that scientific behaviour itself is*

developmentally completed. The solution is thus very simple: *we must complete the development of scientific behaviour.*

This approach casts light on a unique process of scientific discovery. When scientists ‘discover’ they usually encounter novelty in the natural world ‘out there’, outside the scientist. This novelty is then captured explicitly in set T using equation (5). Here we invert the process of discovery: in this new circumstance we are to discover *ourselves; the ‘external world’ that is the ‘other scientist’.* The discovery is the missing part of the full suite of behaviours available to a scientist in pursuit of the natural regularity of things. The resulting ‘regularity’ is just like any other regularity uncovered by science. The uniqueness is that the regularity pertains to the systematic behaviours expressed by scientists. The key law of nature defining science has been delineated as equation (5). To assume that science is complete is to assume that equations (2), (4) and (5) are the end of the story for science. *Here we are going to directly oppose that view.* We are going to declare the science framework of (2), (4) and (5) as incomplete. The old framework is not claimed wrong. Its huge successes sing its praises. None of its set T members are to be invalidated. However its single chronic failure betrays its limitation: part of the framework is simply missing.

What might the nature of our shortfall in behavioural options be? What strategy might we adopt to escape from our descriptive prison that is set T? I’d like to suggest that the very method of science in equations (2), (4) and (5) be used self referentially. That is, we shall posit a set T hypothesis that the existing science framework itself is only part of a more complete framework in which real explanation (of P-consciousness and everything else) is to be found. That explanation shall be completely consistent with set T_{human} . This means that a new member of set T_{human} will be constructed which delineates the existence of another form of assembly of ‘laws of nature’. Within this new set shall be statements which capture the essence causal necessity (why) in a fashion consistent with T_{human} (what). To progress more formally let us merely define the unknown epistemic shortfall as a new set of statements:

$$T'_{\text{human}} = \{ t'_0, t'_1, t'_2, \dots, t'_j, \dots, t'_{j-1}, t'_j \} \quad (6)$$

For those readers with a more mathematical bent, the existence of this new set implies that the entire set of human scientific knowledge would become a set union:

$$\{T_{\text{human}}\} \cup \{T'_{\text{human}}\} \quad (7)$$

Without knowing anything at all about the details of members of set T'_{human} , we already have its fundamental character: it shall deliver the causal necessity that drives a natural world in such a way as it appears as per set T_{human} to a human. This means that the descriptions in set T'_{human} shall capture the causal necessities underlying the creation of a human scientist and the faculties necessary to do science, including P-consciousness. This is a very different mode of law construction, for it does not deliver the appearance of a natural thing, it delivers *the underlying structure of the actual thing*. Set T_{human} is to description as set T'_{human} is to explanation. If this is the case, then what empirical justification do we have for allowing this new behaviour? The answer to this is simple: P-consciousness. If the scientist and their P-consciousness, thus structurally constructed under set T' rules, delivers a human and science of the natural world of the kind T then P-consciousness has empirically validated *both* sets of descriptions. In retrospect this is quite logical. If a deliverer of a message '*It is true that X is the case*' is encountered and you accept it, then you have actually taken receipt of evidence in support of two claims. The first is the logically less certain but explicit '*That X is the case*'. The second is the more certain and implicit '*that your deliverer has delivered a message*'. You cannot have one without the other. In the case where (the physics of) P-consciousness is the deliverer, and contents of P-consciousness are the message X , you have evidence in support of both a hypothesis in respect of X and the very fact of P-consciousness itself. The former is scientific evidence for set T and the latter is scientific evidence for set T' . The system is perfectly consistent.

The Uniqueness of Set T'

The uniqueness or otherwise of set T' is a very different kind of issue. The question of uniqueness of set T' begs the question of structural primitives. We have already identified that set T' is a set of statements which result in the actual causal relations driving the natural world. The real question is '*causal relations between what?*' The fact is that we don't know what the primitive structural elements comprising the natural world are. We are doing science to find out! All is not lost, however. Just like we hypothesise or posit tentative 'laws of appearance' in set T , we may posit structural primitives for set T' . The set T' then becomes a collection of rules about interactions between the hypothesised primitive elements. The bad news is that, just like we

can never know for sure of the ultimate truth of any member of set T, we may never know for sure which structural primitive is the right one.

There is an interesting epistemic symmetry here. In set T we literally decide what our 'structural' entities are and for the purposes they become 100% fact; a surety. For example we have T-aspect entities we call 'atoms' or a 'centre of mass' or a 'flock of birds'. We then construct set T members relating these 'certain' facts; relationships about which some doubt may always be constructed. In set T' construction, however, this process is inverted. The structural primitives (entities) are uncertain and the relational laws (set T' statements) are 100% fact because we choose them. To see this let us posit a scenario for science where 1000 scientists posit 1000 different structural primitives. They then construct 1000 individual sets T' which, it is claimed, result in a natural world of some kind with a scientist/observer in it like us. These natural worlds can be simulated and explored for behaviours that might correspond to the entities in set T. The science enacted on the T' side of the framework is very different from the science of the T side of the framework. The first thing that any posited structural primitive and rule set T' must deliver is P-consciousness. Only then can the set T' claim to act in support of our existing T and thereby ride upon its empirical validity. This is the primary demand of any structural primitive and its set T'. The secondary demand of the set T' is that the appearances shall *actually* be completely consistent with our set T. For example, key statistics of the matter comprising a scientist are the universal gravitational constant G, the dimensionality of space and the speed of light c. Still further 'statistics' will be the expression of persistent structure that T-aspect science calls 'atoms'. In the revised framework, if the set T' is accurate, these should be able to be literally calculated (computed) *a-priori*.

We know that T_{alien} and T_{human} (appearance aspect) may be very different, depending on how different their P-consciousnesses are. This is obvious because their referents (the P-consciousness of each entity) are very different. But how does T'_{alien} compare to T'_{human} ? There is one thing we know for sure: the universe, however it operates, literally produces *both* the alien scientist and the human scientist according to the *same single set of structural primitives/rules*. Does this mean that the structure/rule sets T'_{alien} and T'_{human} must come out identically? It seems that may well be the case. In a fully developed science, where most of the tractable mysteries were sorted out, it is hard to imagine how the alien's chosen structural primitives and T' could diverge from the human set and still be able to express both a human

and an alien in a fashion consistent with their own particular P-consciousness and individual set T. It is expected that T'_{alien} and T'_{human} will converge once the T' set members are rendered invariant to the respective symbolic encodings of the alien and the human. This situation is analogous to that of an artist, who can paint two quite different paintings from the same pallet of paints. The paint (structural primitives) is the same. The painter is the same (where the interrelationships are driven by the same expertise/rule set). But the result is two separate, distinct paintings (metaphorically one is the alien, the other is the human) inside the one universe.

We may, in time, learn more and better ways to explore these alternate T' and increase the uniqueness of our T' science. It may turn out that after a huge amount of work, there are still 100 structural primitives and rule sets T', each of which is consistent with our set T and predictive of our P-consciousness. We can do no better. Fundamentally, however, we have a successful outcome: *we have an explanation of some kind for P-consciousness and real explanation has entered our science generally.*

T and T' Framework: Overview

When you step back and take an overview of the DAS situation, you find yourself involved with three fundamental things:

- (a) An actual underlying universe (call it U) made of some kind of structural primitive(s) relating to each other in specific, regular ways.
- (b) A scientist within and generated by (a) populating a set T' with abstractions of the structural primitives and their rules of interaction in such a way as to produce (= predict) the persistent structure we call a scientist, complete with an observational faculty called P-consciousness. Call this science's *structure aspect* or *T'-aspect*.
- (c) A scientist within and generated by (a) populating a set T with abstractions predictive of the way (a) appears to the scientist when (a) is observed using the P-consciousness supplied by (b). Call this science's *appearance aspect* or *T-aspect*.

'Appearance aspect' science (c) is not literally the natural world, but merely 'about it'. 'Structure aspect' science (b) is likewise not the natural world, but merely about it. Currently we do (c) alone.

Note that if the universe U in (a) failed to produce a scientist, then (b) and (c) would never occur. The universe U may exist but will

remain unwitnessed and scientifically unsung. U may as well not exist. Such considerations are moot and of little practical interest. We live in a U that produced P-conscious scientists able to construct the above framework and debate it. This is empirically supported sufficiently to render any debate on the matter a waste of time. At some point in our evolutionary history, U produced an entity with cognitive faculties sufficient to make science possible (Mithen, 2002). Several million years later our behaviour was sophisticated enough to commence populating set T and embark on appearance aspect science. This started somewhere between the time of the ancient Greeks and the renaissance. We have been doing appearance-aspect science ever since and we have failed to explain P-consciousness ever since because we inadvertently configured ourselves so as to not actually explain (in the sense of causal necessity) anything. This is the very obvious picture evident in literature of the entire history and philosophy of science.

The simplest kind of U, and therefore the one least susceptible to the ‘empirical parsimony’⁷ argument, is one made of a large collection of identical structural primitives. This is the U that is recommended as a starting place in T’ science and the one that I have actually been exploring for quite some time. No matter how successful or otherwise my results may be, they are invalid unless a framework exists in which they are meaningfully expressed and discussed. That framework is the ‘dual-aspect science’ framework outlined above. Note that the appropriate practical way to interpret both (b) and (c) is that of neurologically captured human belief. That is, the members of the sets T and T’ can be viewed as manifest in the configuration of the brain material involved in the reporting of the holding of the beliefs and the behaviour ‘acting as if the set members were true’. In the case of real ‘laws of nature’, acting ‘as-if’ the set T and T’ members were true results in verifiable empirical outcomes. The dual (T/T’) aspect framework thus inherits these basic properties of the single (T) aspect framework.

One crucial and striking feature of the framework is that it is U (item (a) above) that delivers P-consciousness. As such an explanation of P-consciousness is actually contained in set T’, *not set T*. Thus the new dual-aspect framework has 2000 years of predictable failure acting in support of it. The dual-aspect science framework tells us that the reason for the explanatory failure is that single aspect science, as practiced by the use of the appearance aspect (c) alone, was never ever

[7] http://en.wikipedia.org/wiki/Occams_razor

able to predict or explain P-consciousness, nor should there ever have been any expectation that it could.

Practical Exploration of Set T': the Natural Cellular Automaton

The cellular automaton is the perfect vehicle for an explanation of T'-aspect science. Figure 1(a) shows a primitive artificial cellular automaton (CA). It depicts exactly how a structure aspect and an appearance aspect coexist. The reality of the universe U is represented by the entire grid of cells. In this case the universe U presupposes the grid and a specific initial condition for each cell. These conditions and the rules of cell interaction comprise the entirety of set T', which is also illustrated in Figure 1(b).⁸ The computational substrate that implements the structure is implicit and the figure represents the state of the universe U at time t. Figure 1(a) shows a CA scientist S(.) doing science on an object C(.). The grid delivers the P-consciousness experience [C(.)] of distal object C(.). To S(.), the first-person percept [C(.)] actually appears projected onto the real external object C(.). In this way the underlying real C(.) grid features are masked. This nomenclature emphasises the role that P-consciousness has in the process of science. The perception of the object C(.) is the focus of the attention of the scientist S(.) in 'appearance aspect' science via equation (5). As a result of the behaviour of [C(.)], S(.) populates a set T with a law of appearance t_n .

In exactly the same way as it has for C(.), the entire perceptual (P-consciousness) world of S(.) masks the reality of the underlying grid and the rules that drive it from one state to the next. In adopting a dual-aspect science approach, however, scientist S(.) also gets to make propositions as to the cells and their rules of interaction *from within it*. It is this expanded form of explicit situatedness which delivers the possibility of dual-aspect science: *we are inside the system we seek to explain, made of it and operating as scientists because of the facilities provided by that circumstance*. Scientist S(.), by experimenting with various hypotheses as to the nature of the grid and the cells, can then make predictions of the appearance of scientist S(.)'s brain when delivering [C(.)]. In this way the real nature of the underlying cells and rules begin to become apparent. As a result scientist S(.) can populate set T *and* set T'. Only when scientist S(.)'s appearance science T becomes sophisticated enough can structure aspect T' commence in

[8] There are many live CA complete with explanations on YOUTUBE. Search for 'Cellular automata game of life'.

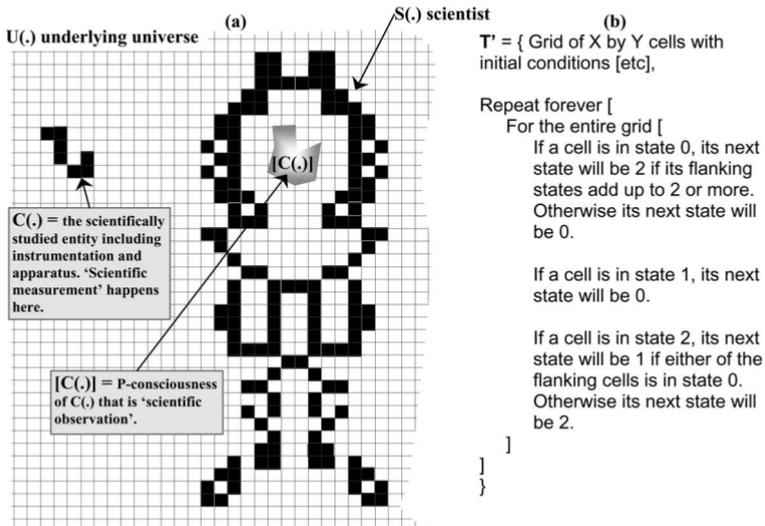


Figure 1. Appearance aspect and structure aspect coexist in scientist S(.)

earnest. Only when set T' makes *successful* novel predictions of scientist S(.)'s own brain appearances does the structure aspect science get full empirical backing equivalent to appearance aspect set T.

In the real natural U that is our universe, the 'grid' or 'cells' do not exist separately. Nor is the whole automaton 'computed' on anything. The real, natural cellular automaton 'cell' is actually an intrinsically dynamic structural primitive interacting with neighbours using rules of affinity for neighbours defined by us, commencing at some kind of initial conditions also defined by us. Localised persistent structure emerges naturally. Multiple nested layers of structure form natural super-cells and uniformities which then combine to form more persistent structure, and so on. The entities we call space and the hierarchy of matter (standard particle model⁹) emerge as persistent organisational structure in the dynamic natural cellular automaton. Both space and matter have equal status as entities. Space is just as 'computed' as matter and is comprised of same primitive structural element. It is the fundamental properties of the system as a whole that give rise to the possibility of P-consciousness. We need specify this basic circumstance no more.

[9] See http://en.wikipedia.org/wiki/Standard_Model

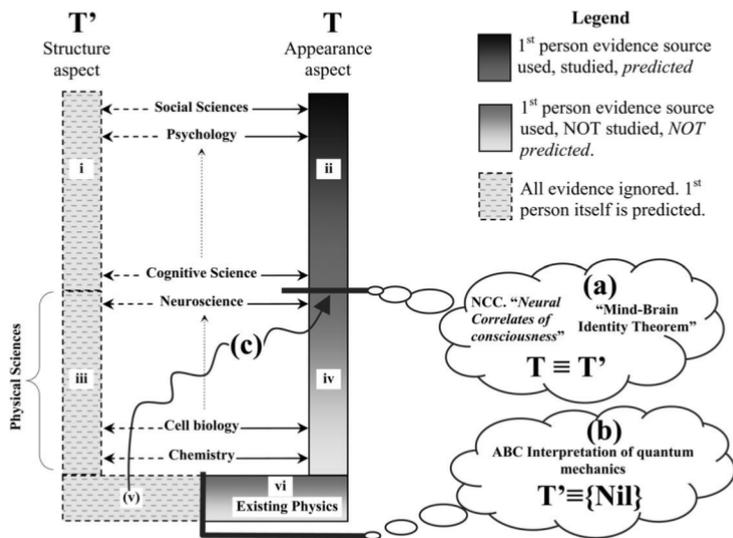


Figure 2. Dual aspect science — waiting for attention

The Current State of Single Aspect Science

Figure 2 regions (ii), (iv) and (vi) are the present configuration of mainstream science. The regions span the hierarchy of the sciences, which mirrors the organisational hierarchy of matter. Physics (cosmology) is the most general and fundamental. At the top are the social sciences and humanities. There is an important boundary at the ‘organ’ (brain) level of the natural hierarchy of biological (condensed¹⁰) matter, where P-consciousness is assembled into its working form in the scientist. Below this boundary is what is traditionally regarded as the ‘basic physical sciences’. This is the boundary between neuroscience (below) and cognitive science (above). Whilst the current science paradigm is best called ‘single aspect’, occupying only the right side of the diagram, it can only be validly called that for the basic physical sciences (iv). In region (ii) sciences, first-person empirical evidence is routinely predicted already, although not to populate an explicit set T' in region (i). The right hand side is the appearance or T aspect and only the basic sciences are entirely confined to ‘objective’

[10] See http://en.wikipedia.org/wiki/Condensed_matter

or third-person evidence (iv) where no prediction of P-consciousness exists. The basic physical sciences have steadfastly rejected the first person perspective. These are the reasons why the T' science of the structure aspect regions (i) and (iii) are unpopulated; the crucial enabling T' science being the structure physics marked (v). This is the real repository of the specification of the 'natural cellular automaton' described above.

Figure 2 regions (i), (iii) and (v) depict the corresponding T'-aspect treatment by science. The interesting thing about the diagram is two structural blockages which perpetuate the single aspect science. At the level separating regions (ii) and (iv) is a black line showing the anomalous science called 'neural correlates of consciousness' (NCC) where neuroscience 'dips its toe' into the region (ii) science for evidence. Here, third-person (iv) neuroscience evidence is correlated with reports of first-person (ii) data,¹¹ without reference to any explanation of its causal origins (Chalmers, 2000; Crick and Koch, 2003; Farber, 2005; Metzinger, 2000). This is marked as Figure 2(a). Also acting in support of this position is a fifty year old philosophical position called the '*Mind-Brain Identity Theorem*', which is roughly that '*to describe the brain is literally identical to describing the mind*' (Borst, 1973; Chalmers, 2000; Churchland, 1988; Macdonald, 1989; Smart, 2004, and Feigl, 1958).¹² In this way a direct attack on an explanation of P-consciousness can be seen to be avoided providing you are willing to pretend that NCC delivers explanation. The unusual nature of this proposition is that at no stage has anyone felt the need to define a '*what-it-is-like-to-be-a-rock/rock identity theorem*', where presumably to scientifically describe the nature of a rock is equally prescriptive of what it is like to be a rock. The explanatory oddity of this situation is there to be seen. In this way the neurosciences maintain single aspect science, but with an anomaly at the heart of it.

At the same time in our most fundamental physics, are various 'positions' adopted as interpretations of the mathematics of quantum mechanics. The interpretations literally erect alternate metabeliefs¹³ which variously accept that certain forms of the mathematical

[11] As evidence, the first person data is actually a unique form of highly managed 'hearsay'. Hearsay is a special metabelief where the belief is about the belief of another agent. The NCC uses careful experimental design to minimise doubt resulting from the unusual presentation of the original studied evidence. Considerable efficacy has resulted from this technique. However, fundamentally (a) it remains hearsay in a science that normally disallows such evidence and (b) it results in description, not explanation.

[12] The same work can be found here: Feigl (1967; 2002).

[13] For example http://en.wikipedia.org/wiki/Copenhagen_interpretation

equations of quantum mechanics have a literal, structural meaning and/or that any attempt at defining or discussing underlying structure is invalid. That is, the equations are in some sense taken to literally be the underlying natural world, thus foiling any attempts at a separate description of an underlying reality that merely behaves quantum-mechanically to an observing scientist within it. David Bohm is one of many such physicists (see details below). Another is Henry Stapp (2007). References therein lead to the early twentieth century origins of such views. This is the way basic physics also blocks a direct attack on P-consciousness, maintains an implicit blindness to all first-person evidence, a failure to predict the existence of a first-person perspective and scientists. This is marked as figure 2(b).

It is interesting to note that in terms of the dual-aspect approach, the Figure 2(a) situation is equivalent to making set T and set T' identities. This is in contrast to the Figure 2(b) situation, which effectively makes set T' the empty set by declaring some set T elements as 'structural'. Equation (7) can be used to depict our confinement to 'single-aspect' scientific knowledge under metabelief Figure 2(a) and 2(b) respectively:

$$\{T_{\text{human}}\} \cup \{T_{\text{human}}\} = \{T_{\text{human}}\} \quad (7a)$$

$$\{T_{\text{human}}\} \cup \{\text{empty}\} = \{T_{\text{human}}\} \quad (7b)$$

With these two blockages, methodologically sustained merely through implicit metabelief within disciplines that are greatly separated, single aspect science is frozen in place. Note that at the same time as Figure 2(a) and 2(b) eschew and effectively deny T' aspect science and all its attention to the first-person perspective, both anomalous sciences are entirely demanding of and dependent on first-person (P-consciousness) for all scientific evidence (observation).

Consider the plight of physicists accidentally working in T' Figure 2(v) area already (example: Reginald Cahill [Cahill, 2003; 2005; Cahill and Klinger, 1998; 2000]). It doesn't take much analysis to realise what happens when they surface with ideas that match the existing empirical evidence and for which there is already a perfectly valid 'explanation' in set T. They are perceived to have a more complex solution (based on structural primitives) which makes the same predictions. In any critical examination such proposals will be defeated with the empirical parsimony argument. The only way to win in this circumstance is for the new T' science (v) to make predictions

along the Figure 2(c) route. Having done that (in effect, predicting scientists) *then* their propositions can go head to head for compatibility with existing science lower down in the organisational hierarchy of matter.

In the dual-aspect framework all the various ABC interpretations of quantum mechanics are abandoned because the underlying reality will be demonstrably seen to behave ‘quantum mechanically’ in set T. As a result the Mind-Brain Identity Theorem is simply false (ejected from set T) because there is a completely different way to describe mind (P-consciousness) via set T’. The dual-aspect framework delivers all the necessary practical needs of a science capable of explaining P-consciousness and how science is possible. The wavy line Figure 2(c) shows how the structure aspect (T’) must be born by making appearance-aspect predictions that neuroscience would otherwise never make. More on this below. Once this has been achieved everything else follows, which means that the wavy line is a kind of ‘bootstrap process’ for dual-aspect science.

Qualification and Implementation of DAS

Here is where we get very practical. The dual-aspect framework does not merely get ‘sanctioned’ by agreement. It has to empirically earn its position as a valid framework. The practical process is a self-referential empirical test on the set T hypothesis; a test on our own behaviour:

$t_{DAS} =$ The natural world in *<the context of a human being scientific about the natural world >* behaves as follows: (8)
<to construct two completely separate but intimately related sets of scientific laws, the first of which is the existing set T becomes the ‘appearance aspect’ and the second aspect is the ‘structure’ aspect (as outlined in document X) which shall populate a set denoted T’ and in which both sets T and T’ are empirically validated through the use of the human faculty of P-consciousness.>

The ‘law of nature’ t_{DAS} must gain its validity via a demand that structure-aspect scientists (physicists) make unique and novel predictions of brain material (neuroscience) ‘appearances’ consistent with a specific model for the delivery of P-consciousness by the chosen structural primitive. This is the link shown as Figure 2(c). Single aspect science has been completely impotent in making any such predictions and specifically denies (albeit implicitly) it is a meaningful scientific act. This test for t_{DAS} bypasses all the single aspect basic

sciences via the Figure 2(c) route. This is no simple feat. However it has logical teeth. It is ironic to see that at the same time a similar theorem t_{SAS} in support of a single aspect science has failed to make such a prediction and yet we act as though it had been proven already! A structure aspect scientist with a novel proposal for brain material appearances based on detailed molecular and cellular biology propositions in an empirical neuroscience context is in a very commanding logical position in support of t_{DAS} that also refutes an implicit t_{SAS} .

What kinds of predictions can be expected? It is easiest to actually deliver real examples. I have been working on the structure aspect for 5 years. The basic third-person (single aspect science) view of my particular P-consciousness model is simple: the full, three-dimensionally expressed electromagnetic field (over the frequency range 0Hz to the sub-visible light spectrum) as generated by brain material is literally responsible for P-consciousness. A subset of the field emerges from the cranium and is responsible for the EEG and MEG waveforms. This kind of proposition is old news. Walter J. Freeman (Freeman and Vitiello, 2005; 2006), Karl Pribram (Jibu *et al.*, 1996; Pribram, 1991; 2004), E. Roy John (2001), Sue Pockett (2000) and J.J. McFadden (2001) have inhabited various incarnations of a field theory of consciousness for years. The dual-aspect science approach merely delivers a perspective from which that claim makes empirically tractable sense. Take note of the interesting evidentiary position the electromagnetic field has under a dual-aspect science framework: When you open up a cranium and are looking at the field (which is 'invisible' to the naked eye) via instruments you *are literally looking at some portion of P-consciousness*. This is the way that the attribution of this observational circumstance to a lack of scientific evidence is, as discussed above, seen to be misplaced under a dual-aspect science approach. It is encouraging to see that, through a particular T', DAS potentially offers such a simple explanation for the traditional difficulties in this area.

In this document we have no need for proof that the electromagnetic field is responsible for P-consciousness. It is irrelevant to the task at hand. Any scientist can make their claim for a set T'. The fact is that without dual-aspect science all such claims are completely impotent. Only from the dual-aspect science perspective can the claims even begin to be discussed. The sensible appraisal of dual-aspect science is a prerequisite to the dissemination of particulars of a proposed set T'. In passing I can say that my set T' structural primitive is the 'reciprocating process', an elemental 'event' in the

form of a simple loop¹⁴. I later found this to have already been proposed by Nicholas Rescher. Also I can say that my ‘structure aspect’ is best characterised as the ‘process physics’ depicted by the Rescher books and all the references therein (Rescher, 1996; 2000; 2002).¹⁵

At this stage of the proposal, however, there is no need for anyone to presuppose that my particular T’ is correct and I do not claim any such thing. The non-uniqueness of T’ tells us that there may be 100 physicists around the world, all of which might be able to construct their T’ physics of some kind and *none of them* will be heard unless dual-aspect science, or at least the process of examining its validity, provides the background epistemic framework. It is for this reason that my own preferences as to a specific T’ and related structural primitive are moot to this argument. What is important is the viability of the framework itself. I can now outline the kinds of neuroscience prediction that my particular T’ makes. It includes but is not limited to the following:

- It predicts that the appropriate physical structure for an entity with a P-consciousness must be a cellular electromagnetic syncytium and that the most important structural/substrate member of this syncytium corresponds to the astrocyte in cranial brain tissue. It predicts that syncytium interconnections in the form of neural/astrocyte, astrocyte/astrocyte and neural/neural gap junctions have a specific role in the generation of P-consciousness
- It predicts specific differences between the neural morphology in the cranial central nervous system in contrast with the peripheral nervous system and the spinal central nervous system. The morphology distinction applies to cell soma and processes.
- It predicts that the nature of brain operation is intrinsically dynamic at all levels and both in structure (cell neogenesis included) and function. For example, there is no single ‘place’

[14] The structural primitive can be imagined to replace one of the cells in the Figure 1 grid although this is not strictly accurate and could be misleading. The ‘space’ in the primitive CA is also produced by the natural CA.

[15] Through Rescher the lineage traces through A.N. Whitehead all the way back to Heraclitus. It is interesting to note that the T-aspect origins roughly trace back to Aristotle whereas the T’-aspect traces back to Heraclitus. The DAS framework is a way in which both are represented. Additionally, because T’-aspect (process physics) has more resonance with eastern approaches, the DAS framework also provides a vehicle for some kind of unification of eastern and western approaches to accounting for the natural world. Perhaps the T’-aspect is to YIN as the T-aspect is to YANG? These are fascinating considerations, but further discussion is well beyond the scope of this work and is also left to others better qualified to the task. The activity has no impact on the DAS framework itself.

where a memory exists, but the dynamic recall of a memory itself is the memory.

- It predicts that brain structure is a literal metaphor for the deep structure of matter as outlined in T'.¹⁶
- It predicts that ion channel population type/density inhomogeneities in the plane of all external cytoskeletons play a specific role in P-consciousness.
- It predicts that sub-threshold soma excitability and instability is involved in certain stages of the generation of P-consciousness of different kinds.
- It predicts that the ultimate natural structure for the active excitable cell populations involved in P-consciousness be roughly laminar and columnar.
- It predicts that *dynamic* soma membrane lateral molecular composition including, but not limited to, what is called 'lipid rafting' is involved at a very basic level in generation of specific P-consciousness.
- It predicts the relevance of synapses, synapse type, relative spatial orientation and density in relation to aspects of P-consciousness.
- It predicts that self-similarity of the generation of P-consciousness extends from the sub-cellular (soma cytoskeletal) level to the 'whole tissue level'.
- It predicts that P-consciousness is causally effective in mediating encounters with experienced novelty through exerting of forces on local chemistry motion via the Lorentz equation in volume electrodynamic effects.
- It predicts that non-locality is involved in the operation of the electromagnetic syncytium that is responsible for some of the properties of P-consciousness in connection with mental representations of the distal natural world. The non-locality cannot be understood outside the set T' and the structure aspect. As such P-consciousness is the solution to the 'symbol grounding problem' (Harnad, 1990; Taddeo and Floridi, 2005) where the symbols are literally localised portions of P-consciousness perceptual fields.
- It predicts (suggests) implicitly acting fundamental principles ultimately underpinning the existence and the 'what it is like' of P-consciousness. The fundamental principles are inherent

[16] This idea can be traced to Leibniz via the Rescher books.

(implicit) in the structure of the T' aspect. The fundamental principles have nothing to do with 'organisation', 'function', 'representation', 'epiphenomenon', 'emergence', 'complexity', 'computation', 'information' or other such concepts that currently may inhabit the realm of metabelief in single aspect set T .

At this stage these claims are made without the details of a T' . Nor should I have to deliver a set T' . The list above merely suggests the kinds of issues and outcomes any posited T' should address, with cogent reasons, to gain acceptance. Ultimately the claims only make sense within a dual-aspect science. This fundamental quandary is why this paper has become necessary.

DAS Miscellany

For completeness let us assume that dual-aspect science is adopted and running. What might be the form of t'_0 ? Here is one possibility:

$$t'_0 = \text{The natural world in } \langle \text{in the context of a human operating in the structural aspect of descriptions of the natural world} \rangle \text{ behaves as follows: } \langle \text{to construct laws of nature of type } t_n \text{ labelled } t'_n \text{ that populate a set of such laws } T \text{ and that define the initial conditions and interrelationships of instances of a hypothesised structural primitive which shall be entirely consistent with the 'appearance aspect' natural laws contained in set } T \text{ by provision of the actual mechanism for creation of an entity capable of populating set } T \rangle \quad (9)$$

Equation (9) is a merely place to start. Given that even t_0 is not explicitly formalised at the moment in mainstream science, the specifics of t'_0 are hardly in a position to be argued as in need of any more than equation (9) at this stage. Equation (9) will suffice for now. Others can argue the exact forms of t_0 and t'_0 . This is a matter for a more formal body with a specific mandate, not my personal preferences.

Implicit in (a), (b) and (c) are interesting possible interpretations of words that appear often in the consciousness discourse. In DAS, that which is 'physical' seems to refer to that which is in U and described by set T' . This might act in contrast to the word 'material', which could be construed to refer only to that part of the physical world which has 'appearances' and is described by set T . When something is 'non-physical' it might mean that it is utterly non-existent in U . Therefore consciousness and space are as 'physical' as anything else under

DAS. This would imply that such views of P-consciousness as being non-physical or ineffable are misplaced. Furthermore, DAS clarifies the relationship between the attributes 'physical' or 'material' and their status as 'scientific evidence'. Again I defer to the judgement of others as to word usage. The issues will arise in the reviews of the XYZisms discussed above and have the same status. None of these judgements alter the DAS proposal.

DAS provides an interesting view of 'scientific evidence of P-consciousness'. According to DAS, 'scientific evidence of P-consciousness' been delivered non-stop since the beginning of science and is more evidenced than anything else! This is because the clinching evidence of P-consciousness is 'the scientist'. It is based on the critical dependency on P-consciousness already outlined in equation (5). All the dual-aspect approach does is take notice of it. In DAS, 'scientific evidence' has been solidly disconnected from the property 'visibility' in respect of P-consciousness. In retrospect it does seem rather perverse for we scientists to be completely dependent on P-consciousness for all scientific evidence and then deny that P-consciousness has been evidenced in the science process. The dual-aspect system thus endows science with a consistent knowledge of when it is in possession of valid evidence and when not.

In DAS the underlying universe U remains intrinsically unknowable other than to the extent delivered by (b) and (c). In one sense the boundary of mystery has receded because P-consciousness has an explanation of some kind. But in another sense the unknowability is actually more pervasive because it applies to *everything*, not merely consciousness. The limits of 'knowability' need a little more detail. The basic questions P-consciousness raises are (Q1) '*Why is to be human "like something" at all?*' and (Q2) '*Why do the experiences take on the particular qualities they do?*'. There are those that regard either or both questions to be intrinsically and fundamentally intractable. At this stage of proceedings DAS only addresses (Q1) by providing an empirically viable framework for propositions in answer to it. Question (Q2) is left untouched at this stage. What can be said, however, is that (Q2) will make no sense until (Q1) has some kind of set T '. Note that to answer (Q2) is not to deliver the actual qualities of the experience! That is a nonsensical expectation. However, when we have sufficient understanding of (Q1) we may be able to sensibly state the circumstances behind a particular phenomenal 'feel'. The answers to (Q1), (Q2) and the limits of what is knowable will require review by those people that have addressed these things in the existing

'single-aspect' framework. The revisions will have no effect on the DAS proposal.

One final prediction by dual-aspect science is worth mentioning. Note that as physicists doing 'appearance-aspect' science strip away more and more layers of organisation in a quest to get to more fundamental particles (= 'appearances'), the appearance must begin to approach, at least in some kind of asymptotic sense, the appearance of the underlying structural primitive. Consider the appearance–aspect hierarchy Population → Human → Brain → Cell → Molecule → Atom → Atomic particle → Subatomic particle → and so forth. The limit to the depth of the hierarchy is not defined. What the dual-aspect framework tells us, however, is that the appearance aspect and the structure aspect must converge in some way. The convergence does not invalidate the dual-aspect approach. Apart from noting that the correct T' should *a-priori* predict the outcomes in supercollider experiments, there is little point in detailing this issue further at this stage.

Historical Connections

A historical note from 300 year old philosophy is that the idea of an underlying reality U of Figure 1 had its modern-era birth in Emanuel Kant as the 'noumenon' (Kant and Hatfield, 2004). In the same work the 'appearance aspect' is called 'phenomenon'. In a world devoid of any neuroscience or any significant cell biology, Immanuel Kant declared the noumenon impossible to know. Science at the time, in the process of divesting itself of its philosophical roots, configured itself as single aspect and it remains in that mode today in a world of exquisite neuroscience and cell biology carried out by millions of scientists who have never heard of Immanuel Kant. We must note that our enrolment in single aspect science is implicit; not explicitly chosen by any living scientist. It has been shown above that single aspect science is maintained by the widening stratification of the science specialisations also created in the eighteenth century, when the 'abstract' philosopher and the 'natural philosopher' parted company (Gaukroger, 2006). The natural philosopher became what we now call a scientist. In the framework of (a), (b) and (c) above, the structure of a 'noumenon' is most definitely knowable to no more or less extent than the 'phenomenon'. As discussed above, under the DAS approach the Kantian noumenon corresponds to (a) and retains a remnant 'unknowable' component.

A notable recent example of an extension to science designed to attend to the 'structure'/'appearance' dichotomy is in the work of

David Bohm and his ‘implicate’/‘explicate’ order (Bohm, 1981), which traces back to the work of Niels Bohr (Bohm and Hiley, 1993). Bohm’s original proposition was delivered in an era well before the ‘decade of the brain’, the rapid growth of neuroscience, the pervasive use of computational physics and rapid progress in the language describing features of consciousness such as the ‘hard-problem’ and ‘P-consciousness’. The unqualified word ‘consciousness’ was used most:

Our proposal in this regard is that the basic relationship of quantum theory and consciousness is that they have the implicate order in common (Bohm and Hiley, 1993, p. 381).

The Bohmian discourse involves the idea is that there is a single indivisible whole which is unknowable in the sense of Kant’s noumenon.¹⁷ This was described as ‘implicate order’. This is in contrast to the ‘explicate order’, which is basically the T-aspect (or mainstream single aspect science). Quite a deal of work was done by Bohm and colleagues on formulating a revision to quantum mechanics. That revision was in some sense held as literally ‘being’ the implicate order. An extension to quantum mechanics was constructed to seamlessly mesh with existing quantum mechanics in the same way that Einstein’s relativity meshes with Newtonian dynamics. As such it fits into the T-aspect and was merely assigned a structural status. There is no justification of structural claims by mainstream quantum mechanics, so is unclear how an extension to mainstream quantum mechanics should suddenly deserve claims to structural primacy.

The ‘implicate order’ is clearly an underlying reality. In line with the Figure 2(a)/(b) metabelief, the Bohmian assumption seems to have been either that the description of the implicate order and the explicate order are the same description or that the underlying structure is unknowable in any way. The same kind of blinding conflation of ‘knowability’ with ‘scientific descriptions of the single aspect kind’ seems to have prevailed. In contrast, DAS shows us that an underlying reality is quite easy to describe independently. A separately-scientifically-described implicate order conceptually corresponds quite well to the T’-aspect. In DAS, in place of the Bohmian quantum mechanics is the T’-aspect ‘natural dynamic cellular automation’ exploration of systems of putative underlying structure. As a T-aspect description, the Bohmian quantum mechanics is consistent with the asymptotic approach of T-aspect to T’-aspect described above. It seems that the vice-like mental grip of the T-aspect by an inherited single-aspect

[17] http://en.wikipedia.org/wiki/Implicate_and_Explicate_Order

science meant that the Figure 2(b) metabelief ultimately prevailed. Bohm's passing left the ideas in stasis although there has been a some interesting computational physics done on 'Bohmian dynamics' or 'Bohmian mechanics'. In a way, this work on DAS could be considered a redevelopment of Bohm's work, where the separate description of an underlying reality is the novel contribution.

Interestingly, Bohm's long-sought 'verb' (event, action or process) account of reality, in contrast to the traditional 'noun' (thing) account, is fully embodied in the DAS model. The T-aspect rules relate human-nominated 'nouns'. The T'-aspect rules relate human-nominated 'verbs'. The two aspects enmesh consistently when the T'-aspect 'verbs' create appearances that behave 'noun-ly'. The T-aspect takes on the adverbial appearance of virtual-nouns. David Bohm might have found this concept appealing. He may also found appealing the idea that the remnant 'unknowability' (delineated above) of the underlying structure is better understood in the DAS framework. In the same way that the T-aspect rules are forever uncertain, the T'-aspect structural primitives are forever uncertain.

Philosophy has had a discourse on dual-aspect approaches for over 300 years. The most recent and very instructive incarnation is Max Velmans' *Reflexive Monism* (Velmans, 2008). Velmans provides a very useful connection to the history of dual-aspect approaches. Connections of dual-aspect concepts to physics can be found in Atmanspacher (2007). Velmans couches dual-aspect concepts in a modern 'hard problem' context with links to all the best literature. The difference between the Velmans paper and this proposal is that he proposes a framework for cognition in which P-consciousness is supposed to make sense in unspecified ways, with no practical recommendations. This work applies Velmans' approach specifically to scientists, delivering a practical framework for *science* suitable for immediate implementation by working scientists and with a method for its empirical validation and a route to applicable fundamental physics. There is no necessary correspondence between the term 'dual-aspect' as used herein and any particular flavour of dual-aspect in the literature. No attempt has been made to calibrate the usage of the term. Here, the usage of the term 'dual-aspect' derives from the fact that it has two 'aspects' describing a single underlying reality — the T-aspect and the T'-aspect as detailed above. The simplest possible T' suggested above involves a large collection of one type of 'structural primitive', making it a monism. The use of the term 'dual-aspect monism' seems quite applicable, but again I defer to the judgement of

others in this. Such calibrations were not prescriptive of, nor do they impact, the DAS framework.

This T/T' dual-aspect proposition already appears in the literature. The article in question focuses mainly on inconsistencies in present-day science (Hales, 2006). The publication has not reached the attention of anyone impacted by the work. The model in the article is precisely the model presented above although far more practical detail is presented here.

Another delightful piece of connective-tissue in the physics literature is the work on hierarchy and emergence by James Crutchfield (1994). In that work the 'dynamic modeller' is an agent explicitly located inside and interacting with the dynamic universe/environment. That agent is expected to innovate regularity-models that capture the differences between order (as made apparent through sensory/motor signals mediated by the boundary of the agent) and its alternative: randomness. The most relevant, interesting feature of the work is that, in pursuit of the study of the dynamical structure of matter, Crutchfield explored the cellular automaton. In related work are simple 1-dimensional CA examples displaying complex, persistent entities that were labelled 'particles' undergoing annihilative interactions ($x+y \rightarrow 0$), reactive interactions ($x+y \rightarrow z$), spontaneous decay ($x \rightarrow y+z$) and symmetry breaking (Mitchell *et al.*, 1994). CA seem intrinsically expressive of easily recognisable physics processes. Crutchfield clearly *but implicitly* noted the difference between the T-aspect and the T'-aspect thus: '*This spatial discrete hierarchy is expressed in terms of automata rather than grammars*' (Crutchfield, 1994). However, as with Bohm, because the discourse on consciousness was in the midst of rapid progress that had not made it into the general lexicon of physics, the crucial distinction between 'scientific measurement' (which happens outside the scientist) and 'scientific observation' (which happens inside the scientist as contents of P-consciousness) was not made at that time. This happened despite implicitly establishing the precise situation of a scientist (a modeller embedded in and dynamically interacting with an environment, as a single system) for analysis. The fledgling NCC neuroscience of the time did not impact the work. Hopefully that link has now been made.

It is quite striking that recently Stephen Wolfram published a monumental work on cellular automata called *A New Kind of Science* (Wolfram, 2002). The book investigates traditional CA of the kind shown in Figure 1 and not natural (dynamic) CA of the kind suggested as the actual contents of set T'. Notably absent from the book is attention to how cognition might be explained or how science might be explained.

There is no mention of subjective experience, qualia or the ‘hard problem’. Nor was the question ‘*Under what circumstances might it be ‘like something’ to be an entity inside a cellular automaton?*’ asked. The same lack of distinction between scientific measurement and scientific observation pervaded the work, even into the early twenty first century. Such is the power of the interdisciplinary gap. Nevertheless, Stephen Wolfram intuited the important distinction between the kind of science that a CA represents (T’) and the kind of science currently carried out by physics (T). The contrast is made very clear in the dual-aspect framework. Thus, in a rather indirect manner, science has already some exposure to dual-aspect without actually being aware of it. Stephen Wolfram’s work therefore gets support from the unexpected quarters of a dual-aspect science framework. Whatever conflict there may have been between Stephen Wolfram’s approach and mainstream single aspect science, that conflict evaporates under a dual-aspect framework.

Note that the holy grail of physics, the so called ‘Theory of Everything’ (TOE) is literally the rules of the natural cellular automaton which are captured in set T’ (in Figure 2(v) as discussed elsewhere). The dual-aspect science proposal puts an interesting slant on the theory of everything. Remember, in order that it be created, the *first thing* set T’ has to explain is subjective experience; something that single aspect physics normally ignores (as per Figure 2). The nuance here is that all physicists that have worked on ‘strings’ e.g. (Sen, 1998), ‘loops’ e.g. (Rovelli, 2006), ‘branes’ e.g. (Ne’eman and Eizenberg, 1995), ‘dynamic hierarchies of structured noise’ e.g. (Cahill and Klinger, 1998), ‘quantum froth’ e.g. (Swarup, 2006) and so forth finally have a potentially viable home in dual-aspect science under set T’. For a light introduction to the concepts see (Greene, 1999; Randall, 2005). For a real working (but non-CA) attempt at a T’ set member which produces a ‘structured noise’ construction of almost three-dimensional space see (Kitto, 2002). All the various models have to do is find a context enabling predictions in *brain material* related specifically to production of P-consciousness and they become a viable contender for the structural primitive in the real T’. Single aspect physics will be unable to criticise their result, for single aspect science can never make any such a-priori prediction. It is actually meaningless for the ‘appearance aspect’ to criticise the ‘structure aspect’ or vice versa in any context other than their mutual compatibility and consistency at all levels. Any inconsistency is revealing of some kind of error. Science under the T/T’ framework will thus be on an arguably more solid foundation than with T alone.

There will actually be *two* kinds of TOE. One in set T (appearances) and one in set T' (structure). In contrast to the examples of T' science cited above, a working example of a set T TOE is '*An exceptionally simple theory of everything*' (Lisi, 2007). This T-aspect TOE can be seen in its very first paragraph to be imbued with single-aspect metabelief of the Figure 2(b) kind. It may actually be an accurate set T TOE. However, as discussed here in detail, the dual-aspect framework predicts its obvious impotence in any sort of prediction of a first person perspective or any explanation of how science is possible. This is rather ironic in a 'theory of *everything*' where '*everything*' actually means *everything except P-consciousness and scientists*.¹⁸ Nevertheless it is a theory of everything that a set T can be a theory of. Note also that just like in set T' there could be 100 set T TOEs. The non-unique set T' TOEs, however, make neuroscience predictions. The dual-aspect framework therefore predicts the historical dichotomy in TOE styles and their unresolved, ongoing conflict. That conflict ceases under the dual-aspect framework in the knowledge that, just like all other set T/T' membership correspondences, the basis of their conflict is misplaced. The clarity that emerges under the dual-aspect framework is remarkable.

To conclude this section we note that DAS can be seen as an amalgam/extrapolation of the work of Velmans (psychology, cognitive science, neuroscience) and Crutchfield/Bohm/Wolfram (physics). Many other originators are spread over hundreds of years, each touching upon separate portions of the work presented here. The recent works are tantalisingly close to dual-aspect science. The ingredient added here is the explicit use of 'the scientist' as a specific, testable¹⁹ instance of a form of cognitive agency in need of explanation whose behaviour is critically dependent on P-consciousness in a verifiable way. The lack of an explanation of scientists is as old as the failure to explain P-consciousness, which in turn is as old as the absence of all causality in our traditional laws of nature (T-aspect science). Indeed these intractable problems seem to actually be symptoms of the one basic problem. The history can thus be viewed as laying down the initial segments of a conduit between neuroscience and fundamental physics needed to complete the Figure 2(c) link delineated above.

A diagrammatic delivery of the above historical connection between psychology (Velmans) and physics (Crutchfield) is shown in

[18] These are the presuppositions of the T-aspect identified at the start of this work.

[19] Through artificially testing for discovery and delivery of an artificially created 'law of nature' (see Hales, 2009).

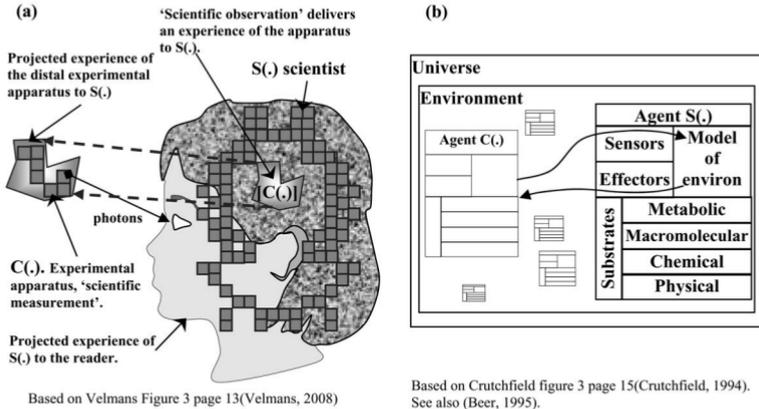


Figure 3. The situated 'dual aspect' scientist emerges from the literature

Figure 3. The original figures have been customised to make DAS impacts obvious. Figure 3(a) is from psychology. Velmans' original cat has been replaced by a scientific experiment which becomes contents of the visual P-consciousness field of the scientist S(.). The contents are represented as [C(.)]. It is a brain-generated (occipital lobe) product whose private presentation uses the distal natural world C(.) as a kind of 'projector screen'. To emphasise the DAS approach the underlying universe appears overlaid on the appearances in a form based on Figure 1 but very exaggerated so that the difference between underlying structure and appearances is obvious. The underlying structure of the space surrounding and pervading C(.) and S(.), through which photons are depicted to flow, is implicit. Figure 3(b) shows the scientist S(.) merely as a 'black box' interacting with the 'agency' of the scientific apparatus C(.) via the sensory/motor faculties. Figure 3(b) shows the Figure 2(b) anomaly in that there is no recognition of [C(.)], which is how S(.) actually deals with C(.)

The amalgamation and generalisation of Figure 3 (a) and (b) appears in Figure 4 as a practical starting point suited to the ongoing discussion of dual-aspect science. Consistent with the Bohm portrayal of the implicate order, the universe is considered a single indivisible whole. The blocks in the diagram represent notional boundaries delineating regions of the underlying reality and are considered *nested*. Each block usually, but does not necessarily have, an 'appearance'. The photon traffic from the experiment through space to the scientist shown in Figure 3(a) is part of M(.). Blocks I(.) and O(.) are the

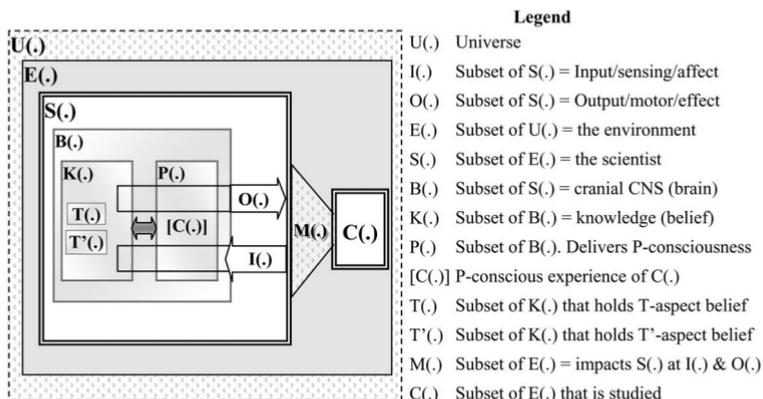


Figure 4. The situated scientist doing dual aspect science

peripheral nervous system. If the scientist $S(.)$ adopts behaviour t_0 then that brain $B(.)$ portion holding set $T(.)$ belief is modified accordingly. Similarly behaviour t'_0 modifies brain $B(.)$ portion $T'(.)$. The scientist's brain $B(.)$ has within it $K(.)$ and $P(.)$, which represent actual brain material delivering A-consciousness and P-consciousness respectively (see appendix A). The diagram is a little misleading because $K(.)$ and $P(.)$ are shown separately. In reality they are inside each other. The complete P-consciousness experience of $S(.)$ would be designated $[P(.)]$. Because $S(.)$ is studying $C(.)$, the specific content which is the experience of the distal object (experiment) is $[C(.)]$. Metascience happens when $C(.)$ is another scientist. The problematic evidentiary status of P-consciousness can be seen in that special circumstance, where $S(.)$ opens up the cranium of $C(.)$ (another scientist). In that circumstance the $B(.)$ (including the $P(.)$) of $C(.)$ is seen, not the $[P(.)]$ of $C(.)$.

Summary and Conclusion

This work examined the idea that the chronic failure to predict and explain P-consciousness may be a problem with science itself. In an investigation of alternate science models that have at least the prospect of eliminating the problem, the simplest revised science model, dual-aspect science, was constructed. It was contrasted with existing 'single-aspect' science. The revised model predicts the explanatory poverty that generated it and is simultaneously a seamless upgrade;

existing laws of nature remain untouched. In addition the model delivers a route to dealing with other less well known issues: the lack of causal necessity in all existing scientific laws and the absence of an explanation of how science is possible. The resultant dual-aspect science framework constructs two separate and radically different but rigidly enmeshed sets of 'laws of nature'. One set T is the existing 'laws of appearances' and the other set T' is a set of 'laws of underlying structure' of an appropriate structural primitive(s) that is best understood and characterised using a computationally explored 'natural (dynamic) cellular automaton' model. The problem a DAS proposition addresses is ultimately systemic; an artefact of science history which affects the whole of science equally. By recognising an epistemic split (bifurcation) of scientific knowledge into two separate but highly enmeshed domains we have been able to provide a natural setting under which an explanation of P-consciousness (through an explanation of how science is possible) is to be expected as a natural, normal outcome.

DAS delivers a novel view of the 'hard problem'. In applying to the whole of science (not merely neuroscience or psychology or physics), the 'hard problem' is more than merely involved in predicting the '*what it is like*' subjective aspect of a brain. It is (and always was) an equally 'hard problem' to *scientifically* describe the '*what it is like*' to be a rock, a computer or a chimp. We have intuitions that it might not be 'like anything' to be a rock. However that intuition is a long way from a supportable scientific claim to that effect. DAS provides a basis for claims in that regard for all persistent structure in the universe.

The dual-aspect framework is destined for use by working scientists and has been constructed based on empirical metascience by a working scientist. The science framework, like most other 'discoveries' of the natural world, also acquires its validity as a result of an experiment. The observed behaviour of the natural world (the scientist operating under the hypothesis T_{DAS}) is decisive. The entire process is thus normal, everyday empirical science applied self-referentially.

Ultimately, our choice is either to (a) continue with single aspect science or (b) to upgrade to dual-aspect science. If single aspect science is to continue to be our way of operation then we should all (the entire hierarchy of the sciences shown in Figure 2) be explicitly aware of it as a choice we make and that we have therefore chosen all the logical consequences of that choice. We should list out the reasons why we make the choice and *explicitly* educate ourselves accordingly,

making sure dual-aspect science is at least understood, if not actually used. This can be seen as science's due diligence in action in a mature discipline capable of self-application of rigour applied everywhere else in the course of the day to day business of science.

The change to dual-aspect science is most profound for physicists and neuroscientists. It requires their action more than debate. Once permitted to collaborate to investigate structure (as per the natural cellular automaton concept above) independent of but correlated with appearances, all the other intermediate sciences may follow their lead. Existing scientific laws become very valuable evidence allowing the DAS framework to self-validate. Ultimately the important change is that the anomalous metabeliefs Figure 2(a) and 2(b) are flushed out of the existing set T . An empirical examination of the 'bootstrap' t_{DAS} hypothesis is commended to science generally and to physics and neuroscience in particular. To implement the changes all we need to do is listen to scientists making structure aspect claims and hold them appropriately empirically accountable for neuroscience predictions of the kind listed above. The change thus involves only standard scientific approaches and seems a small price to pay to finally make sense of P-consciousness and to unify science in a seamless, consistent framework for the twenty first century and beyond.

Acknowledgements

It is the encouragement that I received in the JCS online forum that resulted in the generation of this paper. Thanks are due to two anonymous reviewers for their commentary. It helped me make the work significantly more accessible. NICTA is funded by the Australian Government as represented by the Department of Broadband, Communications and the Digital Economy and the Australian Research Council through the ICT Centre of Excellence program.

Appendix A: P-Consciousness Defined

P-consciousness is a technically specific term referring to the subjective qualities of human internal life experienced in the first person. Specific subjective qualities are described more accurately by saying *it is like something* to be in receipt of them (Nagel, 1974). The main objective here has been to provide a way in which the *like something* (such as the redness of red, the sensation of hunger and so forth) can become part of physics. This aspect of our subjective lives has been variously named 'P-consciousness' (Block, 1995), 'phenomenal consciousness' (Chalmers, 1996), 'qualia' (Tye, 2008) or

'phenomenality' (Block, 2003). The oldest term is qualia (singular quale, pronounced 'kwah-lee'). Introduced by C.I. Lewis, he described qualia as '*recognizable qualitative characters of the given*' (Lewis, 1929). From the point of view of this document all these terms refer to the same thing. 'P-consciousness' is used because it seems to have become acceptable in recent artificial intelligence literature (Bringsjord, 2007). P-consciousness is contrasted by Block with A-consciousness (for Access), which indicates those aspects of learning/behaviour which co-exist with P-consciousness, but on their own have no subjective qualities (Block, 1995). For example, the learnt capacity to play tennis contributes nothing to subjective life until you 'access' the 'tennis playing faculty' by imagining tennis or actually playing tennis. In place of A-consciousness, Chalmers used the term 'psychological consciousness'.

For more grounding and detail, a recent review (Zeman, 2001) and a Blackwell monograph (Velms and Schneider, 2007) are recommended. Steven Lehar produced a good example of the struggle neuroscience has had in the quest for an explanation of P-consciousness. It touches upon all the troublesome issues which dual-aspect science clarifies (Lehar, 2003). For a quick way to appreciate the technical specificity of the term P-consciousness, the reader is directed to 'phantom limb syndrome' (P-consciousness depicting nonexistent body parts) and 'blindsight' (successful visually guided manipulation of body parts without any visual P-consciousness) (Velms and Schneider, 2007; Zeman, 2001). The key physiological fact is that all P-conscious fields (vision, touch, audition, olfaction, gustation, internal imagery of all types, situational emotions and primordial emotions) are delivered by quite localised subsets (Crick, 1994) of cranial central nervous system (CNS) excitable cells. This means that P-consciousness is *not* delivered by spinal CNS or by the peripheral nervous system(s), which includes the gut. Put most simply in the context of vision: you do not see with your eyes. Vision is a brain process *projected* to appear centred on the location of your eyes. The non-cranial peripheral nervous system signalling is experientially inert. This is decades (in some cases century) old physiology. The primordial emotions are those associated with the ancient basal brain regions involved in homeostasis such as hunger, breathlessness, thirst and so on (Denton, 2005). These contrast with the situational emotions of sadness, happiness, anger, disgust, fear and so forth.

Appendix B: Causality vs. Critical Dependency

All else being equal, a critical dependency of Y on X is revealed if it is necessary for X to occur before Y can be observed. Some writers use the term ‘constant conjunction’. Some use the term ‘concomitance’. Others might say that ‘Y supervenes on X’. The scientist’s main objective is to distinguish critical dependencies from mere correlations. ‘*Correlation is not causation*’ is the chant of the working scientist. A critical dependency reveals the outward signs of a causal relationship, but not what necessitates that it is so. This basic position was established hundreds of years ago by David Hume (Hume and Steinberg, 1993). An example of correlation is metabelief as described above. Another example of a correlation is a computer program.²⁰ To see how completely science has submerged itself in T-aspect science, consider a very nice summation of the position by Ernest Nagel:

No science (and certainly no physical science), so the objection runs, really answers questions as to why any event occurs, or why things are related in certain ways. Such questions could be answered only if we were able to show that the events which occur must occur and that the experimental methods of science can detect no absolute or logical necessity in the phenomena which are the ultimate subject matter of every empirical enquiry; and, even if the laws and theories of science are true, they are no more than logically contingent truths about the relations of concomitance or the sequential orders of phenomena. Accordingly, the questions which the sciences answer are questions as to how (in what manner or under what circumstances) events happen and things are related. The sciences therefore achieve what are at best only comprehensive and accurate systems of description, not of explanation (Nagel, 1961, p. 26).

Having nicely described, in effect, T-aspect knowledge (in that it delivers only description), the position is taken that therefore $t_x =$ ‘*to do science is to create knowledge which describes concomitant appearances (=phenomena)*’. This is based in a limited view of evidence discussed at length above. In contrast, the DAS framework would support: $t_y =$ ‘*to do science is to create knowledge supported by empirical evidence*’, where *all* the evidence provided by appearances (including the deliverer of appearances, P-consciousness) is used in support of it. Modern science tells us there is more evidence available

[20] The computer program does not cause the computer to act the way it does. The physics of the computer, configured as per the program, necessitates the behaviour of the computer). There are a potentially infinite number of different ways that the computer could have become identically configured.

than used in a science defined by t_x . The dual aspect science framework shows exactly how science defined by t_y can be done through an explanation of how physical humans with a mental life do science. The omission of activity by scientists aimed at handling causal necessity (through confinement to t_x by tacit denial of t_y) has the practical status within working scientists of an implicitly held convention of the kind ‘man cannot fly’.

Appendix C: Noise in Measurement of t_0

Incidental and ancillary circumstances and behaviours are encountered when measuring actual scientific behaviour. These correspond to measurement noise and are averaged out when assembling a final minimum invariant set of behaviours common to all scientists. There is an enormous amount of literature on these facets of science outcomes and scientific behaviour. This noise includes as a minimum:

1. Physical location, institution type, gender, ethnicity, academic qualifications, career stage, scientific discipline.
2. Scientific era.
3. Form, content and media of deliverables (Book, journal, maths, prose, technology and so forth).
4. Usage of particular physical devices, skills or processes or procedures such as the use of a PCR machine, surgery or a telescope.
5. Usage of particular mental skills or processes or procedures such as statistics, decision/rational choice theory, theory formation (theory-theory), analogical and imagistic reasoning, mental modeling and visualisation. Handling spurious correlations. The logic of establishing grounds for belief. Anomaly resolution. Computational methods. In-vivo vs normative/prescriptive/a-priori science method. Science as problem solving. Serial/Parallel processing. Heuristic searching. Use of induction/abduction/deduction. Handling mental ruts. Confirmation bias. Coordination of evidence with multiple theories. Conceptual change. The ‘aha’/insight moment. Idea incubation. Scientific progress as a result of a creative act versus an act of reasoning. Handling and interpretation of insufficient/disconfirming/mixed/ambiguous evidence, metaphor, limiting case experiments, thought experiments.
6. Motives for doing science and the personality type and social/political circumstances of scientific behaviour such as competition, life goals, authorities, prestige, entrepreneurship, tradition,

- fashions, eminence, mentoring, preferences, prejudices, favourites and so on. Personal styles such as ‘back scratching’, Collaborative science. Group and team based science. Personality traits in such things as secrecy, branding, peer association and relationships with sources of funding.
7. Developmental issues (the child-scientist, the gifted, the mid-twenties discovery cusp).

References

- Atmanspacher, Harald (2007), ‘Editorial on dual aspect approaches’, *Mind and Matter*, **5** (1), pp. 3–6.
- Beer, R.D. (1995), ‘A dynamical-systems perspective on agent environment interaction’, *Artificial Intelligence*, **72** (1–2), pp. 173–215.
- Block, N. (1995), ‘On a confusion about a function of consciousness’, *Behavioral and Brain Sciences*, **18** (2), pp. 227–47.
- Block, Ned (2003), ‘Consciousness, philosophical issues about’, in: *Encyclopedia of Cognitive Science*, ed. L. Nadel (London: Nature Pub. Group).
- Bohm, David (1981), *Wholeness and the Implicate Order* (London & Boston: Routledge & Kegan Paul).
- Bohm, David & Hiley, B.J. (1993), *The Undivided Universe: An Ontological Interpretation of Quantum Theory* (London ; New York: Routledge).
- Borst, C.V. (ed. 1973), *The Mind Brain Identity Theory* (London: Macmillan).
- Bringsjord, S. (2007), ‘Offer: One billion dollars for a conscious robot; if you’re honest, you must decline’, *Journal of Consciousness Studies*, **14** (7), pp. 28–43.
- Cahill, Reginald T. (2003), ‘Process physics: From Information Theory To Quantum Space And Matter’, *Process Studies Supplement 2003* (Centre for Process Studies Online Publication).
- Cahill, Reginald T. (2005), *Process Physics: From Information Theory to Quantum Space and Matter* (Nova Publishers).
- Cahill, Reginald T. & Klinger, C.M. (1998), ‘Self-Referential Noise and the Synthesis of Three-Dimensional Space’, *General Relativity and Gravitation* (32), pp. 529.
- Cahill, Reginald T. & Klinger, C.M. (2000), ‘Self-referential noise as a fundamental aspect of reality’, in: *Proc 2nd Int Conf on Unsolved Problems of Noise and Fluctuations (UPoN’99)*, ed. D. Abbott & L. Kish (American Institute of Physics).
- Chalmers, D.J. (1995), ‘Facing up to the problem of consciousness’, *Journal of Consciousness Studies*, **2** (3), pp. 200–19.
- Chalmers, D.J. (1996), *The Conscious Mind: In Search of a Fundamental Theory* (New York: Oxford University Press).
- Chalmers, D.J. (2000), ‘What is a neural correlate of consciousness?’, in: Metzinger (2000).
- Churchland, Paul M. (1988), *Matter and Consciousness : A Contemporary Introduction to the Philosophy of Mind* (Cambridge, MA: MIT Press).
- Crick, Francis (1994), *The Astonishing Hypothesis: The Scientific Search for the Soul* (London: Simon & Schuster).
- Crick, Francis & Koch, Christof (2003), ‘A framework for consciousness’, *Nature Neuroscience*, **6** (2), pp. 119–26.
- Crutchfield, J.P. (1994), ‘The calculi of emergence: computation, dynamics and induction’, *Physica D*, **75** (1–3), pp. 11–54.

- Denton, Derek (2005), *The Primordial Emotions: The Dawning of Consciousness* (Oxford University Press).
- Farber, J. (2005), 'How a neural correlate can function as an explanation of consciousness', *Journal of Consciousness Studies*, **10** (4–5), pp. 77–95.
- Feigl, Herbert (1958), 'The "mental" and the "physical"', in: *Concepts, Theories, and the Mind-Body Problem*, ed. H. Feigl., M. Scriven & G. Maxwell (Minneapolis, MN: University of Minnesota Press).
- Feigl, Herbert (1967), *The "Mental" and the "Physical": The Essay and a Postscript* (Minneapolis, MN: University of Minnesota Press).
- Feigl, Herbert (2002), 'The "mental" and the "physical" (excerpt)', in: *Philosophy of Mind: Classical and Contemporary Readings*, ed. D.J. Chalmers (New York: Oxford University Press).
- Freeman, W.J. & Vitiello, G. (2005), 'Nonlinear brain dynamics and many-body field dynamics', *Electromagnetic Biology and Medicine*, **24** (3), pp. 233–41.
- Freeman, W.J. & Vitiello, G. (2006), 'Nonlinear brain dynamics as macroscopic manifestation of underlying many-body field dynamics', *Physics of Life Reviews*, **3** (2), pp. 93–118.
- Gaukroger, Stephen (2006), *The Emergence of a Scientific Culture: Science and the Shaping of Modernity* (Oxford: Oxford University Press).
- Greene, B. (1999), *The Elegant Universe: Superstrings, Hidden Dimensions, and the Quest for the Ultimate Theory* (New York: W.W. Norton).
- Hales, C. (2006), 'AI and Science's Lost Realm', *IEEE Intelligent Systems*, **21** (3), pp. 76–81.
- Hales, C. (2009), 'An empirical framework for objective testing for P-consciousness in an artificial agent', *The Open Artificial Intelligence Journal*, **3**, pp. 1–15 <http://www.bentham.org/open/toaij/>
- Harnad, S. (1990), 'The Symbol grounding problem', *Physica D*, **42** (1–3), pp. 335–46.
- Hume, David & Steinberg, Eric (1993), *An Enquiry Concerning Human Understanding; [with] A letter from a gentleman to his friend in Edinburgh; [and] An abstract of a Treatise of human nature* (Indianapolis: Hackett Pub. Co.).
- Jibu, M., Pribram, K.H. & Yasue, K. (1996), 'From conscious experience to memory storage and retrieval: The role of quantum brain dynamics and boson condensation of evanescent photons', *Int J Mod Phys B*, **10** (13–14), pp. 1735–54.
- John, E.R. (2001), 'A field theory of consciousness', *Consciousness and Cognition*, **10** (2), pp. 184–213.
- Kant, Immanuel & Hatfield, Gary C. (2004), *Prolegomena to any Future Metaphysics that will be able to come forward as Science: With selections from the Critique of Pure Reason* (Cambridge & New York: Cambridge University Press).
- Kitcher, Philip (1993), *The Advancement of Science: Science Without Legend, Objectivity Without Illusions* (New York: Oxford University Press).
- Kitto, Kirsty (2002), 'Dynamical hierarchies in fundamental physics', in: *Workshop Proceedings of the 8th International Conference on the Simulation and Synthesis of Living Systems (ALife VIII)*, ed. E. Bilotta (Univ. New South Wales, Australia).
- Lehar, S. (2003), 'Gestalt isomorphism and the primacy of subjective conscious experience: A gestalt bubble model', *Behavioral and Brain Sciences*, **26** (4), pp. 375 seq.
- Lewes, George Henry (1877), *The Physical Basis of Mind* (Bristol: Thoemmes Press; Tokyo: Maruzen).
- Lewes, George Henry (1879), *Problems of Life and Mind* (London: Trubner).

- Lewis, Clarence Irving (1929), *Mind and the World-Order: Outline of a theory of Knowledge* (New York: Dover Publications).
- Lisi, Gary (2007), 'An exceptionally simple theory of everything', in: <http://arxiv.org/abs/0711.0770> [hep-th].
- Macdonald, Cynthia (1989), *Mind-Body Identity Theories* (London; New York: Routledge).
- Mach, Ernst (1897), *Contributions to the Analysis of the Sensations* (La Salle, IL: Open Court Pub. Co.).
- McFadden, Johnjoe (2001), 'The conscious electromagnetic information (CEMI) field theory', *Journal of Consciousness Studies*, **9** (8), pp. 45–60.
- McGinn, Colin (1999), *The Mysterious Flame* (New York: Basic Books).
- Metzinger, Thomas (ed. 2000), *Neural Correlates of Consciousness: Empirical and Conceptual Questions* (Cambridge MA: MIT Press).
- Mitchell, M., Crutchfield, J.P. & Hrabner, P.T. (1994), 'Evolving cellular-automata to perform computations: Mechanisms and impediments', *Physica D*, **75**, pp. 361–91.
- Mithen, Steven (2002), 'Human evolution and the cognitive basis of science', in: *The Cognitive Basis of Science*, ed. P. Carruthers, S.P. Stich, M. Siegal (New York: Cambridge University Press).
- Nagel, Ernest. (1961), 'Patterns of Scientific Explanation'. *The structure of science : problems in the logic of scientific explanation*. (London: Routledge).
- Nagel, Thomas. (1974), 'What is it like to be a bat?' *The Philosophical Review*, **83** (4), pp. 435–50.
- Ne'eman, Y., Eizenberg, E. (1995), *MEMBRANES AND OTHER EXTENDONS ("p-BRANES")*. *Classical and Quantum Mechanics of Extended Geometrical Objects* (Hong Kong: World Scientific).
- Pockett, Sue (2000), *The Nature of Consciousness: A Hypothesis* (iUniverse.com).
- Pribram, K. (2004), 'Consciousness reassessed', *Mind and Matter*, **2** (1), pp. 7–35.
- Pribram, Karl H. (1991), *Brain and Perception : Holonomy and Structure in Figural Processing* (Hillsdale, NJ: Lawrence Erlbaum Associates).
- Randall, Lisa (2005), *Warped Passages: Unraveling the Mysteries of the Universe's Hidden Dimensions* (New York: Ecco).
- Rescher, Nicholas (1996), *Process Metaphysics: An Introduction to Process Philosophy* (Albany: State University of New York Press).
- Rescher, Nicholas (2000), *Process Philosophy: A Survey of Basic Issues* (Pittsburgh, PA: University of Pittsburgh Press).
- Rescher, Nicholas (2002), 'Process philosophy', in: *The Stanford Encyclopedia of Philosophy*, ed. E.N. Zalta: <http://plato.stanford.edu/archives/sum2002/entries/process-philosophy/>
- Rovelli, C. (2006), 'Graviton propagator from background-independent quantum gravity', *Physical Review Letters*, **97** (15).
- Sen, Ashoke (1998), 'An introduction to non-perturbative string theory', in: arXiv:hep-th/9802051v2.
- Smart, J.J.C. (2004), 'The identity theory of mind', in: *The Stanford Encyclopedia of Philosophy*, ed E.N. Zalta: <http://plato.stanford.edu/archives/fall2004/entries/mind-identity/>
- Stapp, Henry (2007), *Mindful Universe: Quantum Mechanics and the Participating Observer (The Frontiers Collection)* (Springer-Verlag).
- Swarup, Amarendra (2006), 'Sights set on quantum froth', *New Scientist*, **189** (2539), p. 18.
- Taddeo, M. & Floridi, L. (2005), 'Solving the symbol grounding problem: a critical review of fifteen years of research', *Journal of Experimental & Theoretical Artificial Intelligence*, **17** (4), pp. 419–45.

- Tye, Michael (2008), 'Qualia', in: *The Stanford Encyclopedia of Philosophy*, ed. E.N. Zalta:
<http://plato.stanford.edu/archives/fall2004/entries/qualia/>
- Velmans, M. (2008), 'Reflexive monism', *Journal of Consciousness Studies*, **15** (2), pp. 5–50.
- Velmans, M. & Schneider, Susan (ed. 2007), *The Blackwell Companion to Consciousness* (Malden, MA ; Oxford: Blackwell Publishing).
- Wolfram, Stephen (2002), *A New Kind of Science* (Champaign, IL: Wolfram Media).
- Zeman, A. (2001), 'Consciousness', *Brain*, **124**, pp. 1263–89.

Paper received November 2008.