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Form, Qualia and Time: The Hard Problem Reformed

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Abstract

This paper proposes that the hard problem of consciousness is in fact the problem of the origin of our image of the external world. This formulation in terms of the "image" is never seen stated, for the forms populating our image of the world are considered computable, and not considered qualia – the "redness" of the cube is regarded as the problem, not the cube as a form. Form, however, cannot be divorced from motion and hence from time. Therefore we must re-examine the classic *spatial* metaphysics of space and time, initiated by Galilei, wherein the real has been equated with the quantitative and wherein quality has been stripped from the material world. In this metaphysics, which sees form as quantitative or computable, the origin of qualia is problematic, and a problem of even greater primacy is the memory that supports the transforming events of perception.

This article argues that memory is a necessary condition for qualia. The storage of "snapshots" of time-flowing events, a notion which the classic metaphysics engenders, is unworkable as a solution to the perception of these flows. Form, in fact being dynamic and defined over flowing fields, is a quality requiring this memory. Since forms populate the image, the origin of the entire image is indeed a problem. The proposed solution is based on Bergson's *temporal* metaphysics wherein motion is undivided, and the global motion of the universal field itself carries an intrinsic form of memory. In this framework, Bergson provided a unique solution – one that leaves the problem of representation behind – as to how the brain specifies the qualitative image of the dynamically transforming external world.

1. Introduction

The hard problem of consciousness as stated by Chalmers (1995) has dominated contemporary discussion since the mid 1990s. How, Chalmers essentially asked, after you have described your computer architecture and your software programs, or your neural network or whatever architecture, can you account for the qualia of the perceived world? Unfortunately, this formulation with its sole emphasis on "qualia" is only partially correct and ultimately misleading. It has barred, so I claim, an elegant solution provided over one hundred years ago to the real problem. In what follows, I limit the discussion to vision and by simple extension to audition; more general implications for other sense modalities and other aspects of qualia will have to follow.

In my view, the hard problem is, in fact, the problem of the origin of the perceived image of the external world. This straightforward statement is neither grasped nor accepted in the debate, though it has been the formulation of the problem for 2000 years, since at least the Greeks began thinking about it (cf. Lombardo 1987). Some readers might feel that the words "image" and "qualia" are interchangeable – and they should be (nearly), but to my knowledge there are virtually no discussions about qualia in terms of "explaining the origin of the image" in consciousness studies.

In most academic debates it is flatly ignored that this is how the qualia problem should be characterized. One can find three uses of the term "image" in the Wikipedia entry on qualia: They refer to the retinal image, to Tye's dismissal of after-images as a problem for his theory, and to Robinson's defense of the vividness of the mental image. Crane's (2011) entry on the "Problem of Perception" in the *Stanford Encyclopedia of Philosophy* contains plenty of "qualia" but not a single "image". The same applies to Siegel's (2013) entry on "The Contents of Perception", while Tye's (2013) entry on "Qualia" contains "image" in contexts essentially irrelevant to his approach to the hard problem.

For the ancient philosophers of perception (cf. Lombardo 1987), the problem was so strongly couched in terms of the notion of the image that it was in effect an optical problem. But if one were to offer a solution to the problem of the image of the external world today, it would arguably not even be recognized as a contribution to the hard problem of consciousness at all.

The reason for this state of affairs rests in the acceptance of a metaphysics which can be traced to Galilei. Galilei's crucial step was to suggest that the real world is sufficiently characterized by *quantitatively* measurable properties, while other empirical aspects – the qualities of the experienced world – are somehow created by "the living organism". Implicit within this suggestion is the distinction between primary properties and secondary properties, the former related to "real" quantities, the latter related to qualities arising only due to the perspective of mental experience (cf. Manzotti 2008). In other words, Galilei stripped the material world of quality at the formal inception of this metaphysics.[1]

Form itself, for the debaters of the hard problem, has been left to

[1] Both Berkeley (1734/1982) and Whitehead (1920) disputed the primary/secondary disctinction. They could both be seen as questioning whether the classic metaphysics actually possesses any ontological status.

reside in Galilei's quantitative world. Because of this, form has been taken to be computational and the origin of the forms of objects in our perception, or image, of the external world has not been considered an issue. The "redness" of a cube in our vision, not the "cube-ness" of the cube is considered significant. We see this position stated clearly, for example, in an essay on qualia by Nida-Rümelin (2008). She feels forced to differentiate between color as an "appearance property" and shape, which she says is not such a property. In other words, color is regarded as a problem, form is not regarded as a problem – yet forms populate our experienced image of the world.

For Wright (2008), qualia apply to all "sense fields" in all modalities, but not to "perceived items". In other words, qualia do not apply to objects and forms. The transparency thesis (cf. Kind 2008) holds that our experience does not reveal the existence of any qualia, for our experience is transparent – when we attend to our experiences, our attention goes right through to their objects (e.g., Tye 1995). The formulation "right through to their objects" implies a static object without quality, in particular where form is no quality, ignoring that the time-extended motions of objects may themselves be qualia. Therefore, the origin of the image of the external world, populated with forms, is not considered the problem.

However, the Galilean position is misleading. Form can no more be assigned to the quantitative and computable than any other aspect of the experienced world. Form is a quality. If form is not computable, it can no more be accounted for by any computer or neural network architecture than any of the other aspects of the world that are termed "qualia". This is to say that the origin of *everything about our image of the external world* is a mystery exactly as qualia are.

Form cannot be divorced from motion. "Form", noted Bergson (1907), "is simply a snapshot of change". But the classic metaphysics, given its apparent usefulness in scientific explanation, is incapable of describing genuine motion or change. This is to say, it is incapable of handling genuine *time*. To solve the hard problem, regarded as the origin of the image of the external world, the classic metaphysics must be abandoned, and concommitantly, we must revise our ideas about time and its relation to mind.

2. The Classic Spatial Metaphysics

The classic metaphysics, reprising Bergson's (1896/1912) analysis of it, is a "projection frame", or epistemological framework, for our theories of the real, both in physics and psychology. It is based on an *abstract space* as an imposed and arbitrary static backdrop. It is a framework ubiquitously engrained, and extremely useful for the mathematical theory of matter.

Yet this usefulness is so enthralling that the framework itself is often taken for an ontological reality, i.e. for the actual structure and dynamics of the universe.

Bergson argued that this obscures deeper penetration into the physical world – and some of his physicist commentators, looking back at the nature of what would eventually emerge in quantum mechanics, agreed (cf. Gunter 1969). It is precisely the job of theory, Bergson (1896/1912) proposed, to break through this imposed framework. As he put it, "a theory of matter is an attempt to find the reality hidden beneath ... customary images which are entirely relative to our needs" (Bergson 1896/1912, p. 254).

These needs begin in our perception itself. The body and brain are embedded in, and an integral part of, the surrounding material world (the field of matter). The task of the brain in perception is to identify, in this ever-transforming field, objects upon which the body can act – to lift a spoon, to throw a rock. This is the elementary partition made by perception – objects and motions in the field. The notion of objects is increasingly refined – in the classic metaphysics – with the material field taken as a continuum of points or positions. The motion of any object in this continuum is conceived to follow a trajectory, which itself consists of a set of points/positions. Each point successively occupied (or passed over) by the moving object is seen to correspond to an instant of time. Thus time itself is treated as merely another dimension of this abstract spatial continuum.

The continuum is infinitely divisible. In fact, as Bergson (1896/1912) noted, it can actually be considered "a principle of infinite divisibility". The trajectory of an object is a line in space, and successive divisions of the line reduce it of a set of points. Since two adjacent points on the object's trajectory are just static points, to explain motion between two static points, we must insert a new, yet smaller line of points between the two, leading to the description of motion by successively occupied points yet again.

The result of this infinite operation of division (assuming that it can be conceived to end) would at best be a mathematical point. At such a point, there is no motion, no evolution in time of the material field. Further, as every spatially extended object is subject to this infinite decomposition throughout the continuum, we end up with a completely *homogeneous* field of mathematical points. The continuum of mathematical points then, both spatially and temporally, can have no qualities – qualities at the least imply heterogeneity.

This is an essential case in point for the qualia problem. The matter-field contains no qualities – objects have no coloredness, there is no soundness, etc. Where, on the contrary, the existence of qualities in the field is affirmed, the metaphysical framework for this is rarely (e.g. Strawson,

2006) explicitly declared, including the used model for time and space. As we shall see, raising this framework to conscious awareness is crucial.

Another important point is that the vast preponderance of examples of qualia are static. For example, we note the redness of red, the taste of cauliflower, the feel of velvet, the smell of fresh cut grass. Seldom are qualities of motions ever discussed, e.g., the twisting of falling leaves, the gyrations of a wobbling, rotating cube, the buzzing of a fly. Where a hint of motion and time is introduced – "the conductor waving her hands, the musicians concentrating, patrons shifting in their seats, and the curtains gently and ever-so-slightly waving" (Hardcastle 1995, p. 1) – time is quickly ignored as part of the problem.

This glaring lack indicates the stumbling block that the treatment of motion and time in the classic metaphysics has induced. A time that is merely another dimension of the infinitely divisible space – a set or series of mathematical point-instants – is completely homogeneous. Any motion in this space, logically, has no duration greater than a mathematical point, then another point, then another. How is it possible, then, that any of the time-extended motions – the shifting patrons in the symphony, the gently waving curtains – are perceived by us as *motions*? These are equally *qualities*, as Hardcastle (1995) admits. They arise, just as problematically as the static colors of objects, in the homogenous time dimension of infinitely divisible instants in this continuum.

In the Galilean framework we are immediately thrown into the problem of the memory that connects time instants, for any qualia defined over time, and this is all qualia, must endure over at least two such instants. Appropriating James' (1890, pp. 643–645) term, and driving it to an even more primitive level, it becomes the search for the "primary memory" that supports the elemental, time-flowing, qualia-laden events of perception. The nature of this memory, it can be argued (Robbins 2004), is an integral part of the problem. This is to say that "temporal consciousness" itself (Dainton 2010) is, at its most basic level, a problem of qualia.

The brain, in the classic metaphysics, is an inescapable part of the abstract continuum. When objects like light rays move along their trajectories and strike objects like eyes in the brain, the abstract, homogeneous motions, all reducible in time-extent to mathematical points, simply continue in the brain. Nowhere in the brain, taken as part of the continuum, can there be anything but more homogeneous points/instants. There can be no actual coherent time-extent of motions through the nerves, no "continuity of time-extended neural processes" – again, the logical time extent of any neural process is never more than a mathematical point, then another, then another... However one conceives of these motions, whether as firing connectionist networks, symbolic manipulations via neural programs, or resonance to invariants over a structure of field motions relative to the bodys action systems, one will never find qualities.

We cannot explain how we experience a cube *rotating*, let alone a *blue* cube. Therefore, all qualia are logically expelled out of the continuum into the non-physical, the experiential. But the step by which the expulsion of events into another realm can occur remains a dilemma. The structure of the metaphysics leaves the nature of realms outside the material – e.g., the conscious experience – undefinable for science, for science operates within this (classic) metaphysics. The notion of qualia is the symbol for this problem. What is the origin of the perceived qualities of the matter-field of the classic spatial metaphysics?

3. Form as Flow

Form, as noted above, has been exempted from this problem by philosophy, but not only there. The approach to form has typically been as to a static subject. An object recognition model due to Hummel and Biederman (1992) is illustrative. Introducing their model, the authors argued that form recognition, for example, of a standard cube, cannot follow a straightforward model of decomposition into, and re-assembly from, sets of features – edges, vertices, straight lines. This is due to the fact that once the features are separately identified (disassembled), the actual spatial relations are lost and the features can now be recomposed in any number of possible ways where the results look not at all like the original cube (Figure 1). To solve this problem, they used "geons", elementary solids such as cones, wedges, cylinders or bricks, which are recognized by features such as straight or curved contours and cross-sections, and into which the forms are analyzed so that the original spatial relations are retained.

In a review of the problem of dynamic form (Robbins 2004), I noted that Hummel and Biederman's approach suffered on several points. For one, the classic fields of Hubel and Wiesel (1959, 1979), with their implication of detected, static features, cannot be regarded as the building blocks of a scene (Nakayama 1998). Another issue, by their own admission, is that the "fast-enabling links" needed for the model have yet to be found. Worse, the model is subject to the "correspondence problem", a problem inherent in assuming that the visual system matches corresponding points or features in successive frames of an event. This problem is deemed intractable. If Hummel and Biederman's example of the cube and the cone were rotating, a model would not only have to deal with the feature jumbling, it would have to explain how the features (edges, vertices) are tracked (their identity preserved) from frame to frame. This holds too for the features of the geons. In essence, the primary problem is the static conception of form. As I described in the context of yet another problem, namely the concept that a *rigidity constraint* is employed by the

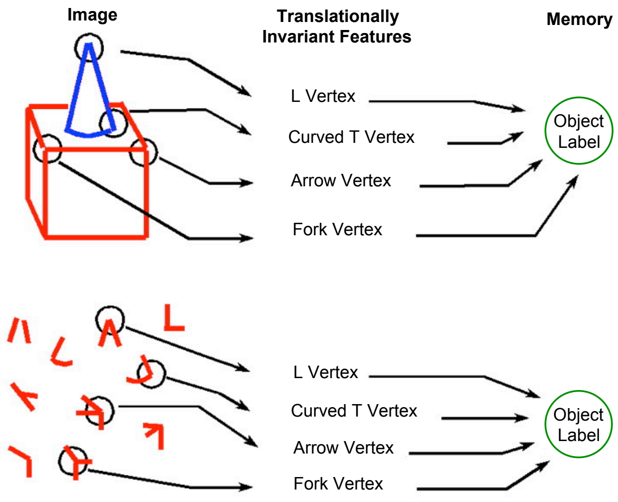

Figure 1: Both objects, the cube and the cone, have the same features, and therefore can be recognized on the basis of a feature match (after Hummel and Biederman 1992).

brain (Ullman 1979, 1986) to compute form (such as the rotating cube) under dynamic transformations, this concept was abandoned as well. The current conception of the derivation of form is very different; it is based on velocity flows.

Gibson (1950, 1966) pointed to the significance of texture gradients and optical flow fields (Figure 2). Driven by a desire to bypass the correspondence problem, current perception theory sees perceived form as derived from velocity fields in conjunction with Bayesian constraints. The

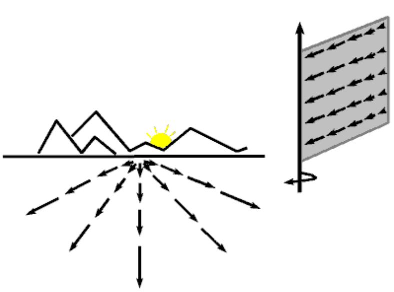

Figure 2: A gradient of velocity vectors is created as an observer moves towards the mountains. The "optical flow field" expands as the observer moves. At right, the flow as a flag rotates towards the observer (Robbins 2004).

models, known as "energy" models (Adelson and Bergen 1985, Watson and Ahumuda 1983), are built upon arrays of elementary spatiotemporal filters. Such filters, because of their limited receptive fields, are subject to the *aperture problem* (Figure 3). As such, the estimate of velocities is inherently *uncertain*, forcing a probabilistic approach (Robbins 2004).

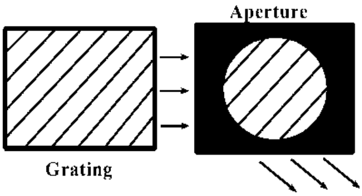

Figure 3: The aperture problem. The card with the grating is moving to the right, and passes beneath the card with the circular aperture. The ends of the moving lines are now obscured, and only the downward motion of the lines is seen in the aperture (Robbins 2007).

One of the fundamental (Bayesian) constraints used by Weiss *et al.* (2002) is that "motion is slow and smooth". This constraint explains a very large set of "illusions". The authors argued that due to the inherent measurement uncertainty *all* perception, "veridical" or otherwise, must be viewed as an *optimal percept* based upon the best available information. Applied to the velocity fields defining a narrow rotating ellipse (Figure 4), for example, the violation of this "slow and smooth" constraint ends in specifying a non-rigid object if the motion is too fast (Mussati's illusion; Mussati 1924).

If we were to consider a rotating "Gibsonian" cube, its form becomes a partitioned set of these velocity fields. As each side rotates into view, an expanding flow field (like the flag of Fig. 2) is defined. As the side rotates

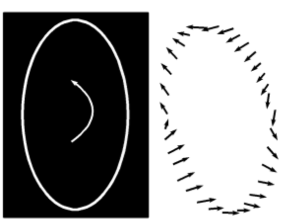

Figure 4: The normal velocity components (right) of the edge of a rotating ellipse (left) tend to induce non-rigid motion (after Weiss and Adelson 1998).

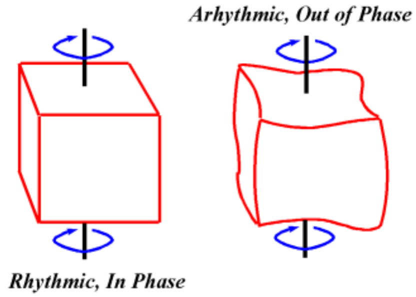

Figure 5: Rotating cubes, strobed in phase with, or out of phase with, the symmetry period of the cube (Robbins 2004).

out of view, a contracting flow field is defined. The top of the cube is a radial flow field. The edges and vertices of this cube are now sharp discontinuities in the flows. The implications are concretely displayed in a demonstration discussed by Shaw and McIntyre (1974) with a rotating wire cube (Figure 5).

A cube naturally has a symmetry period of four – it is carried into itself by rotations of 90 degrees. (Symmetry, it should be understood, is *invariance*). When the cube is strobed in phase with or at integer multiples of its symmetry period, it appears indeed as a cube in rotation. But when it is strobed out-of-phase, it becomes a distorted, wobbly, plastic or non-rigid object. In this wobbly "non-cube" case, the constraint that a regular form displays a regular periodicity in time is likely violated via the arhythmic strobe.

The strobe essentially takes snapshots of the cube. Yet these snapshots are not sufficient to specify the rigid cubical form we would expect; they are not sufficient to specify the straight lines, straight edges, corners or vertices – the standard static, geometric features of a cube.

As Gibson (1966, 1979) long argued, the concepts of Euclidean geometry – straight lines, curves, vertices, families of forms related by geometrical transformations, even geons – have little meaning to the brain. They are not the elements by which the brain constructs a world.[2] Rather, the forms being specified are functions of the application of constraints on flowing fields. The structure of the forms reflects invariants existing over these time-extended flows.

[2]The fact that we find cells that are sensitive to the motion of straight lines in the small area of their receptive fields does not mean that the brain works, or is programmed, as though space were Euclidean, i.e. that this construct – itself a derivative of perception and human conceptual development – is inherent in or built into the brain. As I noted earlier, elements of Euclidean space are no longer considered the building blocks of a scene (Nakayama 1998).

4. Form and the Scale of Time

All form is a function of the time scale imposed on this continuous flow. The cube, rotating at a certain rate and perceived as a cube in rotation, is a function of a scale of time imposed by the dynamics of the brain. We could increase the velocity of the cube's rotation. With sufficient increase, it will become a serrated-edged figure, and at a higher rate, a figure with even more serrations. Finally, it becomes a cylinder surrounded by a fuzzy haze. Each of these figures has $4n$-fold symmetry – 8-edged, 12-edged, 16-edged, and so on – with the cylinder it becomes a figure of continuous symmetry (Figure 6). This transitional series of forms reflects the scale of time in which we normally dwell.

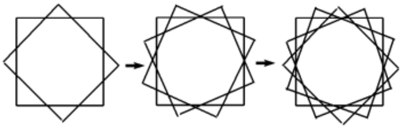

Figure 6: Two-dimensional view of successive transformations of the rotating cube through figures of $4n$-fold symmetry as angular velocity increases.

Let us now perform a thought experiment. We envision the dynamics of the brain as a hierarchy of levels – atomic, molecular, neural, etc. But the brain is a *coherent* biological system – introduce change at one level and the whole is changed. One level in this dynamics is the chemical level, and thus the chemical velocities support the brain's computations. Their range and complexity, considering the various local velocities, is vast, but at least in principle it can be argued (Hoaglund 1966) that the global process velocity could be changed. We could introduce some catalyst or set of catalysts to effect this. Even raising the temperature in such a system is sufficient to affect the chemical velocities.

Suppose then two observers, A and B. Observer A, dwelling in our normal scale, is gazing upon a cube rotating rapidly enough to be perceived as a 16-edged serrated figure. Observer B has his global process velocity raised. His scale has been shifted. He perceives the same cube, but as a cube of normal four-sided construction slowly rotating. Both perceive by the same law of invariance – a figure of $4n$-fold symmetry. Or suppose A and B are watching a time-lapse film of the growth of a human head in profile (Figure 7). At a given film rate, the head is transforming very rapidly for A; for B it is a much slower event. Both perceive the transforming head by the same law – a strain transformation applied to a cardioid.

Were we to borrow from physics, we might say that we have performed

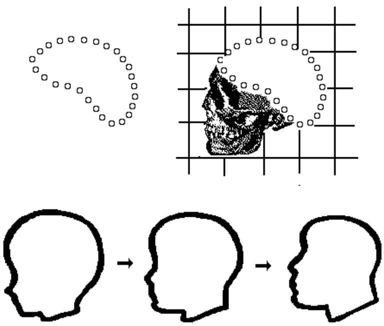

Figure 7: Aging of the facial profile. A cardioid is fitted to the skull and a strain transformation is applied. Strain is equivalent to the stretching of the meshes of a coordinate system in all directions. Shown are a few of the possible profiles generated (adapted from Pittenger and Shaw 1975).

an operation analogous to changing the "space-time partition". From this perspective, a deeper significance of Gibson's (1966) insistence on invariance laws defining events can be understood. In such transforming partitions, it is only invariance laws (e.g. $d = vt, d' = vt'$) that hold.

Now let us extend the scale transformation. Raising the process velocity entails a corresponding decrease in the time scale. If a fly passes before both observers, for observer A it is a "buzzing" fly of our normal scale; for observer B the fly is now flapping its wings slowly, like a heron. As the process velocity of B is raised further, the fly transforms to a near-motionless fly with wings barely moving, then to a motionless fly, then to a vibrating, crystalline form, then to a collection of waves.

At the very minute scale of time we are now considering, we realize that even the most stable form – a book, a cup, a picture – is nevertheless a sea of motion. Going "right through to the object" takes us only to this sea of motion. A rotating cube is only one form of the cube as a continuous *event*. Form is indeed a snapshot of change. It is within this sea of motion that the brain actually dwells. The brain too is a form within the very same sea of motion.[3]

[3]All of these facts showing that forms are time-scale and constraint specific *qualities* speak against hypotheses such as that by Hameroff and Penrose (1996) where qualia are virtually little atoms residing in microtubules just waiting to be "configured" for appearing as the external world. Are there going to be "form qualia" residing in the microtubules for every possible time scale for the fly or the cube as well as for all the possible constraints operating in the specification of these forms? What could form qualia be other than the forms themselves?

5. The Undividedness of Motion

An invariant defined over motion cannot exist in an "instant" of time. This is to say there is no instantaneous local or global state of the brain in which such an invariant exists. Hence, the uncertainty introduced by the aperture problem is simply an expression of the fundamental uncertainty introduced by the flow of time itself. Psychology then shares a problem with physics. The root of the problem for our theories is the conceptual framework of the abstract space of the classic metaphysics in which the very notion of an instant takes its meaning. Physics has steadily been dissolving this framework.

The classical description of motion is an infinite regress. Between each pair of static points occupied by a moving object, to account for the motion, we must insert another trajectory or line, itself divisible into a set of static points – *ad infinitum.* This principle of infinite divisibility, Bergson argued (1896/1912), is the root of Zeno's paradoxes. If the steps of Achilles are viewed in terms of the infinitely divisible space he traverses, they can be successively halved – he never catches the turtle. The arrow in flight, occupying successive spatial points, never moves. Motion, Bergson argued, must be treated as *undivided.* We must not confuse the space traversed – the trajectory – with the motion. The arrow is in a state of undivided motion. It is never at a particular point.[4]

It is often held that quantum physics applies only at the microlevel, not at the level of processes which psychology addresses (Simon 1995, Pinker 1997). But I think this fails to appreciate the implications for time in modern physics. Physics has gradually rid itself of the notion of a trajectory. DeBroglie (1947/1969), commenting on Bergson and on the implications of Heisenberg's uncertainty, already noted that in essence the attempted measurement of a velocity projects the motion to a point in our abstract spatial continuum, and in doing so we have lost the motion.

Feynman and Hibbs (1965) provided a proof that the motion of a particle is continuous, but not differentiable. Nottale (1996) argued that we must abandon the notion that space-time is differentiable. Nottale referenced the geodesics that describe the motions of all particles in space-time – obviously a huge, sweeping scope – and his theory treats these curves as fractal, i.e. they are irregular and constantly changing at every scale; there are no straight lines. "At every scale" means that anywhere

[4]There is a common conception that these paradoxes have been resolved by Russell (1903) and/or modern mathematics. However, this is far from correct. Good discussions of the actual issues are due to Huggett (2010), Lynds (2003b), and Bergson (1907/1912, pp. 335–340). For Bergson, all Zeno's paradoxes arise from the misidentification of an undivided motion with the infinitely divisible space traversed, evidenced ultimately even more clearly by the fourth paradox, where Zeno declares a motion "the double of itself". Russell, having missed the point, actually accepted the fourth paradox as a physical reality.

one looks at one of these curves, at the most infinitesimal of scales, one will find an inflection point, hence these curves are non-differentiable – there is no velocity derivable at an instant. In Nottale's words, "space-time is non-differentiable". This is also an overturning – along with the critique of Bergson – of what has hitherto been a mainstay of the theory of motion in classic metaphysics.

The essence of differentiation is division, say of a motion from A to B, into successively smaller units, finally taking the limit of unit size toward zero. To state that space-time is non-differentiable another way, we may say the global evolution of the matter-field over time cannot be treated as an infinitely divisible series of states. Thus Lynds (2003a) argues, echoing Bergson, that there is no precise, static instant in time underlying a dynamical physical process. If there were such, motion and variation in all physical magnitudes would not be possible, as they (and the universe itself) would be frozen static at that precise instant.

At no time, then, is the position of a body (or edge, vertex, feature, etc.) or a physical magnitude precisely determined in an interval, no matter how small, as at no time is it not permanently changing and undetermined. There is a tradeoff between precisely determined values and continuity through time. As Lynds (2003a) states, it is only the human observer (mentally immersed in the abstract space) who imposes a precise instant in time upon a physical process. There is no equation of motion in physics that is not subject to this indeterminacy.

The brain is *integrally* embedded in a matter-field transforming in an undivided flow. It cannot use in its computations what, to it, does not exist. There are no static features – edges, vertices, angles – found at an instant within the brain. There are no instants. A set of cell assemblies, each capturing a feature of a rotating cube, and phase-locked with other assemblies, firing "instant" by "instant" to register to a higher order brick/geon cell, is not only begging a solution to the correspondence problem, it is an illusory architecture. It describes nothing actually existing in the brain. The brain is not operating in the classic metaphysics.

In such a scheme, each point (or spatial view) in a succession of points on the curvilinear trajectory of the cube's rotation would correspond to synchronous firing of the phase-locked assemblies, each instant specifying the geon underlying the cube's structure. But the result of the out-of-phase sampling of the strobe is sufficient to back the assertion that no such structure exists in any given instant. Even within an "instant" there is flow. Were a sample sufficient, a rigid cube would always be specified. Further, a brain-driven sampling mechanism, to allow the specification of a cube-in-rotation, would have to be pre-adjusted to the symmetry period of the cube. This would require a form of pre-cognition. And what if there were two or more cubes rotating at different rates?

A constraint applied to velocity fields expresses an invariance. The series "rotating cube → figures of increasing serrated edges → fuzzy cylinder" expresses an invariance defining figures of $4n$-fold symmetry. The forms being specified are functions of the application of constraints on flowing fields. The basis of form, as noted earlier, is invariance over the time-extended, flowing field.[5]

The treatment of motion via an abstract space can provide no explanation for our everyday perception of *rotating* cubes or *twisting* leaves, i.e., for the very continuity and time-extension of the events we perceive. If the "present" instant of the leaf's twisting instantly becomes past, we must store it in the brain to preserve it, for the "past" is, for the classic metaphysics, *the symbol of non-existence.* In this scheme, only the always "present" brain can store the past.

In this way, cognitive science faces the consequences Zeno forced his contemporaries to face. Ignoring all the problems of sampling already noted, if we presume the brain takes and stores samples of the rotation or the twisting over time, we re-initiate the logical regress. The samples are static points – immobiltities – like successive photographs of the twisting leaf laid out upon a desktop. If we imagine there is an "internal scanner" of the samples, we must now explain how the scanner perceives motion. Similarly, the logic of the abstract space prevents us from invoking the "continuity of neural processes" to explain the time-extension of the perception.

But then, how are the "instants" held together to support a perception of a stirring spoon or a falling leaf? There is theoretical work on how the brain might "integrate" instants to support these perceptions, i.e. support temporal consciousness or the experience of flow, often involving some sort of memory storage such as working memory (cf. Wittmann 2011). There are several problems with this effort. Firstly, as we have seen above, the classic metaphysics actually denies the possibility of flow as primary. If logically nothing exists but an infinitely small instant, unless you are explicitly appealing to a different metaphysics, or some other realm in general (such as "consciousness"), integration processes avail nothing.

Trying to be brief here on a topic that requires greater discussion (Robbins 2007, 2012a), when it comes to events, the theory of memory has little idea what is actually stored in the first place, i.e. in the working memory. The "snapshots", it is well understood, cannot be photograph-like copies in the brain, say of slices of the moving fly or rotating cube, nor for that matter is there any principle on which such slices are selected. This leads to the notion that there is storage of the "features'" of an event. There are no principled theories as to what these features actually are, or how they would be reassembled as the original event, let alone

[5]For the fundamental role of invariance laws in scientific explanation see Wigner (1970) for physics, Woodward (2000, 2001) for biology, and Kugler and Turvey (1987) for perception and action.

dealing with the fact that this disassemble-reassemble process must occur continually, repeatedly, to construct the fly in motion (at some scale of time).

And yet, the moving fly is integrated into a static storage area, so we wonder how this equals the perception of a motion? Perhaps we are visualizing the creation of a four-dimensional extended structure. But this – problematic as to where such a structure would exist – is still a static structure, and requires, again, a "scanner" to create "motion". Finally, none of these models, to my knowledge, have even thought of attempting to deal with form where features exist only over flowing fields. How are these flowing fields stored?

6. The Temporal Metaphysics

That the classical treatment of motion is an infinite regress is one problem, yet there is another: in the abstract continuum, the motion of any object is relative – I can move the object over the continuum or the continuum (or coordinate system) beneath the object. Motion now becomes rest or *immobility* purely on perspective. But in the material field, there must be real motion – trees grow, stars explode, coffee is stirred, couch potatoes get fat.

A real motion such as the growth of a tree taken as a set of points, is a system of simultaneities, a *simultaneous causal flow* (Robbins 2010). No arbitrary part of this motion can be relativized – declared at rest or motionless relative to the remainder of the moving (growing) system, nor can the motion of the whole of this flow be relativized. It is a *real*, not a relative motion. This motion or growth can be modeled via the abstract space and its point-continuum, but the continuum has properties which are meaningless to the *real* motion of the tree. Nor, we would quickly discover, can the tree as an object be isolated from the rest of the dynamic flow of the universe. In this sense, Bergson (1896(1912, p. 225) noted:

> Though we are free to attribute rest or motion to any material point taken by itself, it is nonetheless true that the aspect of the material universe changes, that the internal configuration of every real system varies, and that here we have no longer the choice between mobility and rest. Movement, whatever its inner nature, becomes an indisputable reality. We may not be able to say what parts of the whole are in motion, motion there is in the whole nonetheless.

We must view the entire matter-field as in *global* motion over time. We must see the *whole* changing, Bergson argued, "as though it were a kaleidoscope". We want to ask if an individual object X is at rest, while another individual object Y is in motion. But both objects are arbitrary partitions, phases in this globally transforming field. As such, the motions of objects are seen as *changes or transferences of state* – rippling waves if you will – within the dynamic motion of the whole. Bergson's positive characterization of this motion is that each instant, like a note in a melody, permeates and penetrates the next and reflects the entire preceding series – an organic continuity. In this characterization, time is clearly irreversible.

Undivided and non-differentiable motion is an elementary property of *memory* in the field's motion – each (now past) instant does not cease to exist as the next (the present) instant appears. It is this "primary memory" – an intrinsic attribute of the time-evolution or transformation of the material field – that supports our perception of "stirring" spoons, "twisting" leaves, "rotating" cubes. Quality is now inherent in this motion of the material field. At a time-scale of about zero, the field is near the homogeneity envisioned by the classic metaphysics, but at ever larger scales of time, where the oscillations of the field (e.g., the 400 billion/sec oscillations of the field associated with "red" light) are "compressed" in the experience of a moment, more and more differentiated qualities emerge.

We are then led to realize that the time-extent of events in perception in fact must derive from the undivided motion of the material field. The reliance on this property of the motion of the field is true not only for the "rotation" of the cube, but also for its "coloredess", both qualities now seen as "optimal specifications" of the undivided motion of the field.[6]

[6] Dainton (2010) provides an excellent in-depth discussion of various philosophical stances on the consciousness of time and the experience of succession, while Wittmann (2011) reviews the research on the subject. Among Dainton's three classifications, the "cinematic" model corresponds most closely to the concept discussed here: that the brain is taking a series of "snaphsots", with the consequent difficulties for actually explaining the experience of motion. The "retentional" model has "episodes of consciousness which themselves lack temporal extension, but whose contents present (or represent) temporally extended intervals and phenomena". The "extensional" model has episodes of experiencing that are themselves temporally extended and are thus able to incorporate change in a quite straightforward way. There is no space here to embrace and fully comment on Dainton's wide-ranging examination of various philosophical positions. The discussion proceeds under the concept of explaining "temporal consciousness", but lurking under all these theories is the physical brain, and thus physics and its concept of time.
What I emphasize, and this is missing in Dainton's comment on Bergson, is that we are always driven to the metaphysics of physical motion, and this takes us to Zeno's paradoxes, to Nottale, and to Lynds. Firstly, it is the structure of this metaphysics, that provides the framework in which the problem of qualia is (unfruitfully) discussed. Secondly, realizing that the motion of the universal field is undivided, we obtain the primary memory that marks consciousness itself, derived from the brain's being an integral participant in the flow of that field. Our model of the motion of this field accounts for the experience of flow. We are not dealing (at least not solely) with a realm of temporal consciousness regarded as separate from physics. This separate realm brings up the fact that the phenomena of temporal consciousnessas are nothing else than the problem of qualia itself. This was the message of Robbins (2004).

7. The Origin of the Image of the External World

Grasping the true nature of a problem, it is often said, is to see the solution. The problem of consciousness is the origin of the image of the external world. Yet, we know that nothing is stored or going on in the brain that even vaguely resembles an *image* of the external world – in the brain we see just neural-chemical flows. We can only ask, unsuccessfully, how these neural processes somehow "represent" the external world or "encode" it, which is to say, represent or encode our image of the world. If it is a neural code, then as per any code, three dots "· · ·", can be an "S" in Morse code, the three blind mice, or da Vinci's nose. What is the domain that the code is mapped to? And how could the brain map anything to this domain – the external world – without already knowing what the world looks like?

This "coding" (or "representation") problem for the image of the world has been as much a hard problem of consciousness as that of qualia. But regarding forms as qualia, in fact invariants defined over flowing fields, requires the abandonment of the classic metaphysics of motion and time. We need undivided global motion of the universal field as in Bergson's temporal metaphysics. For the origin of this qualitative image of the dynamically transforming external world, Bergson had an elegant solution.

Already in 1896, he anticipated the essence of holography, a prescience that obscured the nature of his theory to his contemporaries. He realized that the dynamically transforming field is holographic – the state of each point in the field is the reflection of, and carries information for, the whole. The mutual interrelation, of which every object in the field is a nexus, cannot be *represented* in its entirety. Thus, Bergson noted, every aspect of our notion of the material world is necessarily an "image", i.e. inescapably only a part, a limited representation, of the whole. The "atoms" of the material world are an image. The "brain" and its "neurons" are an image.

How does one such image – the brain or its atoms – obtain a privileged position, gaining the power to represent the other images as image? This is precisely what the representationalist assume. The brain as part of the abstract, homogeneous space, now described by whatever abstract image one chooses – atoms, molecules, neurons – and of the same order as these images, is given the inexplicable power to create an image of the external material field, an image now necessarily qualitative, with colors and forms, with time-scale and time-extent, a qualitative image that now by definition must reside in some ever-mysterious realm outside the abstract, homogeneous space. This is a crass psychophysical parallelism (cf. Bergson's (1904/1920) critique), and the current debates on the subtleties of this inexplicable realm perpetuate it.

This was Bergson's solution: Noting that there is, and can be, no "photograph" of the external field developed in the brain, he stated his vision of the holographic nature of the material field (Bergson 1896/1912, p. 31, emphasis added) like this:

> But is it not obvious that the photograph, if photograph there be, *is already taken, already developed in the very heart of things and at all points in space.* No metaphysics, no physics can escape this conclusion. Build up the universe with atoms: Each of them is subject to the action, variable in quantity and quality according to the distance, exerted on it by all material atoms. Bring in Faraday's centers of force: The lines of force emitted in every direction from every center bring to bear upon each the influence of the whole material world. Call up the Leibnizian monads: Each is the mirror of the universe.

At variance with Pribram (1971), for Bergson the brain is not simply a "hologram". In the holographic process, several object waves, respectively reflected from an object can be recorded on a holographic plate, with the object wave interfering with a reference wave of some unique frequency ($f_1, f_2, ...$, cf. Figure 8). A reconstructive wave, successively modulated to one of the original reference frequencies and beamed or passed through the set of interference patterns now superimposed and recorded on the holographic plate, is successively *specific* to the original source of the object wave.

To place Bergson's view in modern terms (Robbins 2000, 2002, 2006, 2007, 2009, 2012a), the brain is the *modulated reconstructive wave* passing through the external, holographic matter-field. The dynamics of the brain must be viewed as supporting this very concrete wave, specific to a past source in the field – a past portion and extent of the field's motion at a particular time-scale. The image of perception, then, is neither generated

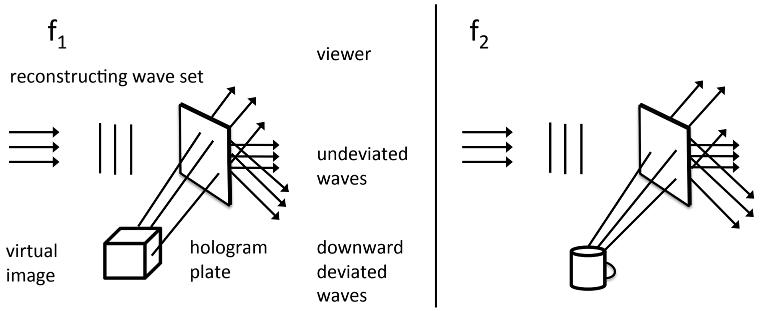

Figure 8: Holographic reconstruction. The reconstructive wave, modulated to frequency f_1, reconstructs the stored wave front (image) of a cube. The reconstructive wave, modulated to frequency f_2, now reconstructs the wave front of the cup.

by the brain nor is it represented or encoded in the brain. It is simply a *diminution of*, a selection from, the entire holographic field as a whole. The dynamic state of the brain is just specific to this subset of the field and its motion.[7]

As noted above, the specification always refers to the past of the field. The fly's wing-beats being specified have long gone into the past, but the undivided motion of the field with its intrinsic, primary memory supports this past-specification. The fly's motion with its wing-beats does not consist of a series of instants, each of which immediately enters the non-existence of the past as the present instant arrives. The image, too, is right where it says it is – in the field. It *is* the field – the (specified) past of the field – at a specific scale of time.

Similarly, even one second of the strobed, rotating cube is in reality a vast series of (interpenetrating) states within the external, ever-transforming holographic field. Each state in this series contains a slightly different orientation of the cube. Under the out-of-phase strobe, the optimal specification is to a superposition of this series (at a particular scale of time) wherein the rigid edges and vertices are lost and the image appears as a wobbly, plastic-like non-cube.

Even illusions – the great redoubt for the ubiquitous conception that the brain must somehow generate the image – are but optimal specifications of events in the field. Even the lack of processing during a saccade, argued by indirect realists (Smythies 2002) to prove that the brain must generate an image to maintain the illusion of a continuous world, can be countered by noting that the reconstructive wave supported by the brain need not cease during a saccade.

As argued before, the brain dynamics supporting the specification determines the specified scale of time, and the chemical velocities underlying that dynamics are responsible for this. Increase these velocities (or, equivalently, the energy state of the body/brain), and the fly transitions from a buzzing fly to a fly barely flapping its wings like a heron, to a motionless being, to a vibrating, crystalline structure. Again, scale implies quality. Specification of a qualitative field always occurs at a scale of time. In this view, what we have construed as abstract computations processing in the brain (and responding to the invariance structure of external events) are in fact integral to a very concrete, dynamical device supporting a very concrete wave form.

[7]In other words, as Bergson noted, this field with its holgraphic properties, is perception – *pure perception*, as he called it. The problem is not how perception arises, it is how it is *limited*.

8. The Image as Virtual Action

The continuous modulation of the brain (as a wave) is driven by the invariance structure of the transforming external events, e.g., the velocity flows defined over the sides of the cube as it is rotating conjoined with its symmetry period.[8] Due to the continuous motion of the field, this information is always inherently uncertain – there is always an *optimal specification* of the past motion of the field. As we have seen, a reconstructive wave, passing through a hologram and successively modulated to different frequencies, successively *selects* information from the multiple, superimposed wave fronts originally recorded on the hologram, and successively *specifies* each source. If modulated to a non-coherent (non-unique or composite) frequency, it specifies a fuzzed superposition of the sources. There is no "veridical" selection. So too, the brain, as a reconstructive wave, selects information from the ever transforming, holographic matter-field, where the principle of selection is based on information (invariants) relatable to the body's action systems.

Bergson visualized this holographic field as a vast field of "real actions". Any given "object" acts upon all other objects in the field, and is in turn acted upon by all other objects. It is in fact obliged (Bergson 1896/1912, p. 28)

> to transmit the whole of what it receives, to oppose every action with an equal and contrary reaction, to be, in short, merely the road by which pass, in every direction the modifications, or what can be termed real actions propagated throughout the immensity of the entire universe.

In his succinct phrase, *perception is virtual action*, i.e., perception is the display (or selection) of possible action in the field relative to the body. Following hard on the passage describing the "photograph developed in the very heart of things and at all points in space", Bergson (1896/1912, pp. 31f, emphasis added) noted:

> Only if when we consider any other given place in the universe we can regard the action of all matter as passing through it without resistance and without loss, and the photograph of the whole as translucent: Here there is wanting behind the plate the black screen on which the image could be shown. Our "zones of indetermination" [organisms] play in some sort the part of that screen. They add nothing to what is there; they effect merely this: *That the real action passes through, the virtual action remains.*

[8] Elsewhere (Robbins 2006, 2007, 2008, 2009, 2012a, 2012b) I developed the notion of invariance structures in more detail. An invariance structure can be defined *as the transformations and invariants determining an event and rendering it a virtual action.* This issue is particularly important to the theory of memory and cognition.

This, it can be argued, is significant for the intimate feedback to and from the brain's motor areas to the visual areas, i.e., the modulation of the visual areas by the motor areas (Churchland 1994). It is consonant with the finding that perceptions reflect the body's biolological action capabilities (Viviani and Stucchi 1992, Viviani and Mounoud 1990, Glenberg 1997). It is also significant for the fact, noted by Weiskrantz (1997), that upon severing the tracks from the motor areas to the visual areas, monkeys undergoing the procedure went blind (Nakamura and Mishkin 1980, 1982). With no connection to action, there is no selection, no virtual action, and no vision.

There is yet a deeper, ultimately testable implication that derives from the principle of virtual action: The heron-like fly slowly flapping its wings is also a specification of the action possible to the body at this particular scale of time. This reflects the ability to move the hand leisurely to catch the fly by the wing.

9. Subject and Object in the Temporal Metaphysics

The holographic properties of the field entail that the state of each event reflects the mass of influences from the whole and therefore represents a state of very elemental "awareness" of the whole. This awareness is a field property. It is not elementary constituents with *ad hoc* intrinsic and extrinsic properties that must be composed. The brain's specification, then, is simultaneous to a time-scale specific form of the vast, taut web of awareness defined throughout the field.

At the null scale of time, there is no difference between subject and object. There is one continuous field, a field with undivided *extension.* It is not infinitely divisible, it does not consist of external elements. Running the scaling transformation in reverse, the fly transitions from waves in the field undifferentiated from the perceiving subject to a crystalline, vibrating being, then to the motionless fly, then the heron-like fly slowly flapping its wings, and finally to the buzzing fly of normal scale. Subject differentiates itself from object. This is the meaning of Bergson's (1896/1912, p. 77) statement: "*Questions relating to subject and object, to their distinction and their union, must be put in terms of time rather than of space.*"

The body-brain is a modulated reconstructive wave passing through a holographic universal field, specific to a subset, to a time-scaled image of the past motion of the field's undivided motion, and reflective of possible action. This is the beautifully elegant solution of the universe to the problem of specifying an image of the external world for its living organisms. Nearly fifty years before Gabor, the father of holography, this was Bergson's remarkable insight.

10. Color and Form

Color has been a star exhibit in the debates on qualia. Color is quality. And form is quality, too. Both are optimal specifications of the past motion of the material field at a certain scale of time. The brain is confronted with a standard environment of ever-changing illumination and shadow. No color remains the same for a moment in this changing ambience. It is the same story as with form: The brain is presented, constantly, with a field of dynamic flux. Zeki (1993) hypothesized that the brain isolates invariants of spectral reflectance from this flux, where the spectral reflectance profile of an object is given by the percentage of incident light reflected by that object.

There are multiple apparent problems, all supporting the view that there are no straightforward properties, such as reflectances, that specify color. Metamers, for example, are stimuli with different spectral reflectance distributions that produce the same experienced color. There is also the complex web of similarity relations among colors. Purple is more similar to blue than green, red is more similar to other shades of red. In this complex, there is a structure of opposition: Red is opposed to green in the sense that no reddish shade is greenish, and the same holds for yellow and blue. There are unique hues (red, yellow, green, blue) and binary hues (purple, orange, olive, turquoise), perceptual mixtures of the unique hues. All of this appears as a problem for a qualitative field supporting color. The consensus is that there is no mapping from such physical properties to the subjective color experience.

The same thing is true of form. There is no simple mapping to the wobbly cube of Shaw and McIntyre. There is no mapping to the nonrigid ellipse. In each case, the brain performs its best to isolate invariance and to create an optimal specification of some aspect of the past motion of the external material field, be it form, sound or color. In this respect, Byrne and Hilbert (2003) argued that visual experience represents objects as having *proportions of hue-magnitudes.* Using their example, we can specify the size of a rectangle by the product of two properties, height h and width w. We can say that rectangle A has a height that is 25% of its width, or B has a height that is 20% of its width. In this way, we express A and B by proportions of magnitudes of h and w.

Similarly, focusing only on hue, we need the four hue-magnitudes R (red), Y (yellow), G (green), and B (blue), the sum of which will be the object's total hue. A purple object is, say, 0.55(R) and 0.45(B), a blue object is perhaps 0.99(B) with very small proportions of R, Y and G. When we look at a tomato, the representational content (as per Byrne and Hilbert 2003) is not simply red, but rather the tomato is 0.80(R) and 0.20(Y). If we take L-intensity, M-intensity and S-intensity as the degree to which light stimulates L, M and S cones, respectively,[9] then an object is uniquely red, in terms of hue-magnitudes, if it reflects light with a greater L-intensity than M-intensity; the greater the difference, the greater the value of R.

Byrne and Hilbert (2003) talk about "representational content", but they have no theory of the origin of the external image, colored or not. This means that they do not really know what "representational content" is. Once the ambient light from the external environment is transduced to the neural-chemical code of the brain, representationalism has no resources to solve the coding problem – it cannot explain how the coded "representation" is unpacked as the external image. We may, however, equally construe the representation as specification. The dynamical apparatus supporting this specification, with its L, M, and S cones, selects information from the matter-field relative to action, just as a reconstructive wave selects information from the holographic plate.

Again, unless the matter-field is already qualitative, the generation by the brain of colored representations remains as miraculous as the generation of form. Color and form must then be assumed in some space outside of the abstract, homogeneous continuum of the classic metaphysics. But, in truth, the very concept that the process of perception begins with a matter-field without quality is the misconception of the classic, spatial metaphysics.

11. Conclusion

What has been described in this article is a theory of direct perception or direct realism. In its principle of optimal specification it is far from a naive realism. Gibson's (1966, 1979) ecological theory is its natural complement. For Gibson an invariant defined only over time, e.g., over a flow field, cannot exist in an instant. It is not a bit that travels along the nerves. This is why Gibson gravitated toward the notion of the *resonating* brain, where invariants or complex structures of invariants are supported over the resonant feedback of the brain, i.e. over a continuous, undivided flow.

According to Gibson this resonating brain is specific to the external environment. But (to Gibson) there are no representations, there is no image arising within this resonating brain, no more than there can be an image in a computer and its bit patterns. But yet, here is an image of the environment – what my resonating brain is specific to – my desktop surface with its computer and its lamp and its miniature John Deere farm tractor. Unless one is going to dismiss this as a delusion of introspection,

[9] L, M, S stand for long, medium, short wavelength sensitivity of the cells of the retina, called cones. Their values range between -1 and +1.

the origin of this image of the external world must be explained. This is why I have argued that Gibson must be placed in Bergson's holographic framework (Robbins 2000). His "specific to" must be taken in the same way as a reconstructive wave – passing through a hologram which holds a myriad of recorded wave fronts – is "specific to" one selected source. Bergson's temporal metaphysics and his holographic insight is required to make Gibson's theory of direct perception coherent.

As a general framework for a model of the brain in perception, this has certainly been a very high-level "specification". The concept of a holographic field has at least a decent status in physics (Bekenstein 2003, Bohm 1980), but conceptualizing the brain and its operations due to a holographic field has received no attention. My major suggestion is that the model of the brain with its processes as comprising a reconstructive wave must incorporate the fact that the brain responds to ecological invariance laws. Brain models must include how the wave incorporates these laws for the specification of events.

Could such a device be artificially constructed? Yes, if what is required to create the requisite real concrete dynamics can be built in artificial, as opposed to biological, materials. One does not build the real dynamics required for an AC motor out of rubber bands and toothpicks. Nor can its operative dynamics be described, or more precisely, be built, constructed or function in the abstract space and time of the classic metaphysics.

Nor can its operative dynamics be described in the abstract space and time of the classic metaphysics.

The abstract space and abstract time of the classic metaphysics is just as meaningless to the operations of Gibson's resonating brain or Bergson's modulated wave as it is to the growth processes of trees. The brain does not actually operate in the point-continuum of this metaphysics. As a physical device, the brain knows nothing about the continuum; it does not exist to the brain. The continuum is a conceptual derivative, a resultant from processes of the brain that a conscious being applies conceptually to external reality and its events, including the brain and its operations. But, according to Bergson, the brain works in an entirely different metaphysical structure. Thus, when a theorist drives the critical question down to the need to implement the biology of the brain (e.g., Searle 2000), we do in fact enter the question of the proper metaphysics.

The hard problem of consciousness with its core, the origin of qualia, is a child of the abstract space of the classic metaphysics. This great abstraction has become a projection frame for much theoretical work. It is a projection frame that has forced out all deeper consideration of the nature of time and its relationship to mind. Its facile treatment of time and motion has blinded theorists to the fundamental question of the memory that supports our perception of rotating cubes, twisting leaves and buzzing flies, to the point of obscuring the very possibility that these dynamic forms themselves are qualities that must be explained. Finally, and most remarkably, it has even managed to subvert all understanding of the hard problem of consciousness: the explanation of the origin of our image, in perception, of the external world.

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