The Journal of Mind and Behavior
Spring and Summer 1997, Volume 18, Numbers 2 and 3
Pages 229 [127] – 246 [144]
ISSN 0271–0137
ISBN 0–930195–08–6

Quanta Within the Copenhagen Interpretation as Two-Neuro-Algorithm Referents

Larry Vandervert

American Nonlinear Systems

Neurological Positivism's (NP) single- and two-neuro-algorithmic referent (informational patterns in the brain) conceptions of subjective and objective experience respectively are discussed. NP's account of Bohr and Heisenberg's Copenhagen interpretation of quantum reality is then described in terms of nonlinear constructions of two-neuro-algorithmic referents that are proposed also to undergird William James's pragmatic conception of truth. In turn, qualia are depicted as nonlinear single-neuro-algorithmic referents in relation to the two-neuro-algorithmic quantum measurement procedure. Experientially, qualia are described as nonlinear "black twinkling" neuro-flux patterns (information) which in the context of overall brain organization in both phylogeny and ontogeny increase the brain's probability of survival. It is concluded that (1) ontological questions are really about the relationships between the two-neuro-algorithmic referent systems in the brain, and (2) the quantum theoretical measurement procedure is the best "test" of NP's two-neuro-algorithmic hypothesis and, as a test, greatly alters the traditional interpretation of Bell's theorem.

Neurological Positivism (NP)[1] is an ontology and epistemology which proposes that the preinferential data (that which is positive beyond all doubt) for human reality and knowledge is the neuro-algorithmic organization of the brain (Vandervert, 1988, 1996a). Neurological Positivism subsumes the traditional positivisms (the *social positivism* of Comte, the *experiential positivism*

Requests for reprints should be sent to Larry Vandervert, Ph.D., American Nonlinear Systems, W. 711 Waverly Place, Spokane, Washington 99205–3271.

[1]Neurological Positivism (NP) is a new kind of positivism that provides an ontological and epistemological basis for the scientific operationalization of self-organizing, *emergent* phenomena. NP represents an "emergent hypothetical realism" (Vandervert, 1993). That is, consciousness and mind are constantly constructed from hypothetical probability distributions of patterns of algorithmic activity from which workable patterns in relation to existing patterns are moment-by-moment selected. Consciousness evolves *both* in phylogeny and ontogeny. NP is not a solipsism. In NP the term "positivism" is retained to indicate that it is meant to replace the traditional purely reductionistic positivisms.

of Mach, and the *logical positivism* of Carnap, see, for example, Boring, 1950, pp. 633–634), replacing them with two-neuro-algorithm structures or referents (Vandervert, 1988, 1996b). These two-neuro-algorithm referents, are comprised of one neuro-algorithmic regime in perception–cognition (for example, the invariance algorithms that govern the perceptual constancies), and one in inseparably yoked descendent neuro-algorithmic regimes of cultural-level mental models (including mathematics, scientific operationalization, and language). The two neuro-algorithmic referents together comprise what have been referred to traditionally as *empirical referents*.

The latter neuro-algorithmic regimes associated with cultural-level mental models develop through learning, thinking, and discovery (Vandervert, 1996a). It is proposed in NP that these descendent neuro-algorithmic patterns are selectively driven into existence in accordance with maximum-power principle evolution (see Appendix) in an emergent, nonlinear fashion through both experience-dependent and experience-expectant (anticipatory) neural growth process during ontogeny (Vandervert, 1996b). [See Greenough and Black (1992); Edelman (1987) for descriptions of these neural growth processes.] Collectively, the descendent neuro-algorithms which underlie cultural-level mental models comprise "mind" in NP (Vandervert, 1991, 1995a).[2]

Purpose

The purpose of this paper is to propose a new epistemological explanation of the nature of empirical referents that helps clarify the meaning of observer-dependence or "brain-dependence" in quantum theory. In that process NP's neuro-algorithmic explanation of qualia (purely subjective experiences) will be described. In order to establish an integrated approach to both subjective and objective aspects of experience, NP's neuro-algorithmic account of the Copenhagen interpretation of quantum theory (Bohr, 1934, 1958; Heisenberg, 1958a), as Stapp (1972) connected it with William James's (1970) pragmatic conception of truth, will be proposed (Vandervert, 1996b). From this vantage point qualia will be (1) described within NP's neural-algorithmic account of the operational specifications of the Copenhagen scheme, and (2) differentiated from quanta. Before undertaking NP's neuro-algorithmic account of the operations involved in quantum theory, a brief digression to describe NP's account of the evolutionary origins of the operations of mind (see footnote 2) will be necessary.

[2]"Mind" in NP emerges from the neuro-algorithms of consciousness with the advent of the evolution of culture in the form of descendent neuro-algorithms of cultural-level mental models. See maximum-power principle in the Appendix.

The Mechanisms Which Construct Descendent Neuro-Algorithmic Operations of Objective Science From the Neuro-Algorithms of the Subjective Brain

Elsewhere, I have described the nonlinear, autocatalytic transition of the phylogenetic brain's neuro-algorithms into neuro-algorithms of cultural-level mental models (Vandervert, 1992, 1993, 1994, 1995a, 1996a, 1996b). Briefly, I have proposed that the phylogenetic neuro-algorithms of perception and consciousness are *transported* (see Appendix) through learning and thinking, into descendent nonlinearly "retooled" cultural-level neuro-algorithmic regimes, including those that undergird all discursive symbol systems. The objectifying neuro-algorithmic *"mechanisms"* which are transported into nonlinear retoolments are embedded in the operations of the system of the perceptual constancies, and the feedforward (a response in anticipation of a discrepancy between the actual state and the reference state in a system) body schema neuromatrix of consciousness (Vandervert, 1995a). That is, in accordance with maximum-power principle evolution, *the same algorithms that construct the perceived invariances and objectification of the perceptual constancies system and the body neuromatrix of consciousness, guide in an experience-expectant/experience-dependent fashion the construction or retoolment of neuro-algorithms into those that underlie the objectifying powers of discursive symbol systems, including the operations of science.* It is proposed that the development of descendent neuro-algorithmic regimes in this manner is orchestrated largely by the uniquely human neuro-algorithms of the neofrontocerebellar elaborations of the brain (see MacLean, 1991). Neofrontocerebellar neuro-algorithms are associated with feedforward planning and prediction, and related movement, and mathematics (although mathematics itself would be an *outcome* of the processes of retoolment as described above).

In this manner, the neuro-algorithms which undergird discursive symbol systems, including mathematics and scientific operationalization (operationism not implied), acquire their objectifying algorithmic properties from their parent, phylogenetic neuro-algorithms. *At the same time, by way of this process the neuro-algorithms of objective science and mathematics are of necessity deterministically mappable back onto those which generate subjective experience.* These two neuro-algorithmic regimes, one in the neuro-algorithms of perception and consciousness and one in descendent neuro-algorithms of discursive symbol systems, comprise systems of *absolutely inseparable* two-neuro-algorithm referents by which we come to know an "objective world." (All empirical referents and all operational specifications in science are two-neuro-algorithm referents.) If the two, inseparably yoked neuro-algorithmic referents were not completely inter-mappable, it would be impossible to validate the axioms of the sciences in terms of everyday experience. [See Vandervert

(1996a, "The Intuitive Leap to the Axioms of Science: The Einsteinian 'Feel' of the Algorithmic Transformation and Exteriorization of Mathematics and Science" p. 88).] This two-part, mind-created objective world is thus inherently observer-dependent, that is, it is dependent in the final analysis upon the operations of the neuro-algorithms of the perceptual constancies and consciousness.

The Composition of Two-Neuro-Algorithmic Dendritic Microprocessing

It will be helpful to illustrate the foregoing processes in a simplified pictorial manner. Figure 1 is a depiction of an idealized phylogenetic neuro-algorithmic "holoscape" for perceptual constancy objectification. In Pribram's (1991) holonomic brain theory, "The contours forming such a holoscape are embodied in the microprocess of polarizations occurring in dendritic networks, thus constituting a sub- and transneuronal manifold" (p. 29). [The depiction of consciousness would be similar, only involving holoscapes of more diverse circuitry, see Vandervert, 1995a.] When the network pattern is

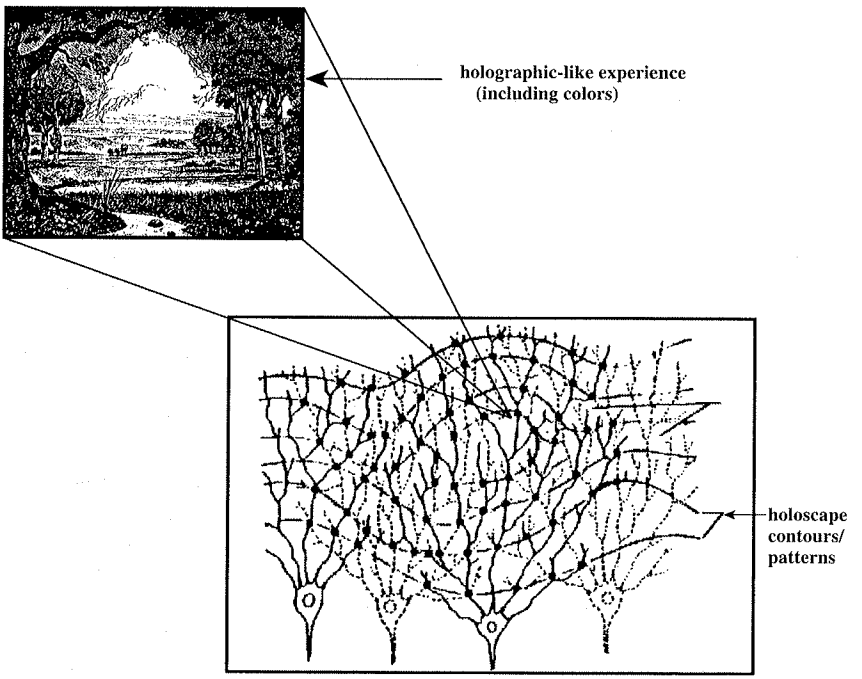

Figure 1: Holoscape algorithmic contour patterns, when activated, result in a holographic-like perceptual experience. Adapted with permission. From K.H. Pribram (1991), *Brain and Perception: Holonomy and Structure in Figural Processing*, p. 29. © Lawrence Erlbaum Associates, Inc., Hillsdale, New Jersey.

activated, it becomes palpable as an optical hologram-like experience.[3] Of course, the activated pattern arises from many correlated holoscapes and changes rapidly in everyday experience, thereby creating a unified, stream-like experience of perception and consciousness.

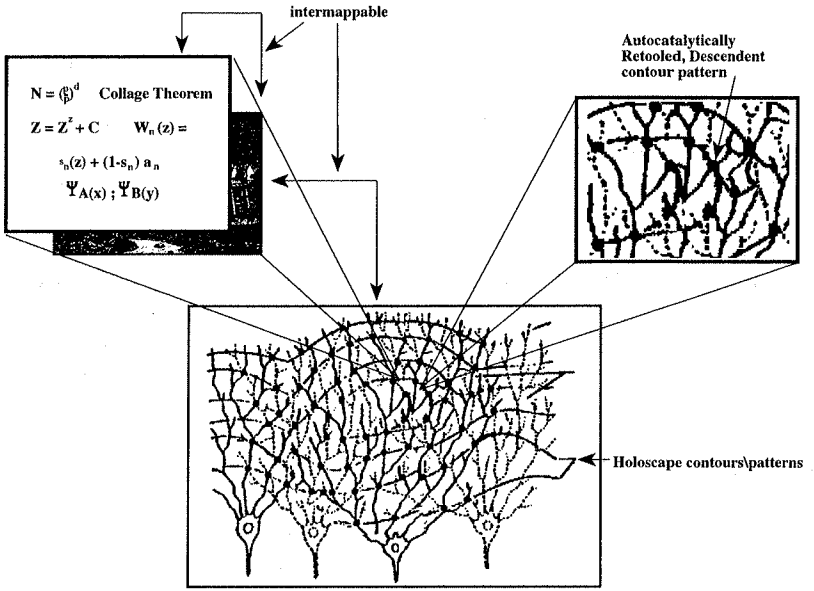

Figure 2: Experience-dependent and experience-expectant neural growth processes (nonlinear retoolments) result in descendent cultural-level discursive symbol systems. The symbol systems thus developed are mappable back onto perceptual–cognitive experience. Perception–cognition and symbol systems comprise nested two-neuro-algorithmic referents of objective science. Adapted with permission. From K.H. Pribram (1991), *Brain and Perception: Holonomy and Structure in Figural Processing*, p. 29. © Lawrence Erlbaum Associates, Inc., Hillsdale, New

Figure 2 represents the holoscape patterning of contours as it has been retooled through learning and thinking. As described earlier, this learning and thinking process consists of fed forward nonlinear rapid simulations operating in accordance with the maximum-power principle of evolution. The retooled pattern contains the old pattern from which it descended, but at the same time it has acquired new, self-similar micro-dendritic growth patterning which is mappable back onto the old pattern. In the retoolment

[3]One does not necessarily have to adopt the holonomic brain theory in order to appreciate the heuristic value it offers here. After all, some holographic-like process describes perceptual experience (including the phantom limb experience) quite well. In addition, other styles of simplified neuro-algorithmic depiction would have additional shortcomings. The maximum-power principle process associated with the proposed evolution of ontogenetic neuro-algorithms from those of phylogeny is not dependent upon holonomic brain theory.

process the neuro-algorithms of the objectifying perceptual constancy mechanisms have been transported into self-similarly descendent neuro-algorithms that undergird the objectifying powers of socially shared discursive symbol systems. The new two-part system of neuro-algorithms is transportable into substrates of the physical world because and only because it bestows advantage in accordance with the maximum-power principle — in short, because it works (more on this workability point in terms of quantum theory below).

When the brain learns or thinks, it is constantly retooling its own neuro-algorithmic structures in accordance with the demands associated with neofrontocerebellar fed forward simulations of future states of the environment. (These are mostly nonlinear simulations due to the maximal complexity of human physical and social environments.) In NP, according to these demands, neuro-algorithm fragments are "stitched together" in the experience-dependent and experience-expectant neural growth patterns described by Greenough and Black (1992). In cognitive terminology the transformation of perceptual processing into discursive symbol systems depicted in Figure 2 involves the perceptual analysis to image-schema to language sequence described by Mandler (1988, 1992, in press). I have proposed that the basic *patterns* of mathematics (the science of patterns) are direct abstractives of Mandler-type image-schemas (Vandervert, 1996b). In any case, both the neurological and cognitive models describing the transition of perceptual processes into discursive symbol systems are nested with the maximum-power principle of evolution.

Of course, as two-neuro-algorithm referents are composed during development in ontogeny and in culture, sudden saltatory jumps from perceptually based referents to those of symbol systems do not occur. Within the connective nonlinear pathways leading from perceptual algorithms to those of symbol systems are stages of maturation of the phylogenetic brain which serve as general "guideposts" for experience-expectant growth of neuropile. These stages manifest in transitional gradations of cultural-level mental model formations of mind, for example, from iconic to analogue to symbolic models (Ackoff, Gupta, and Minas, 1962, chapter 4; Vandervert, 1991). Such stagewise mental model transitions map generally to categories of information storage development described by Piaget (1980).

As the patterns in the nested two-neuro-algorithmic referents are composed in accordance with the maximum-power principle, they thereby achieve the capacity to be transported (see Appendix) into additional substrates wherein time, size, and energy-information scales are manipulable in absolutely any manner which bestows advantage. This means that the two-neuro-algorithm referents have the capacity to have their informational patterns selectively transported (or any energy/information-advantageous

portions thereof) into an unlimited number of contrivances or "machines" which can manipulate and/amplify all scales. (Again, it is suggested that this transport process is largely orchestrated by the neofrontocerebellar neuro-algorithms, and carried out by perceptual–motor neuro-algorithms.) These contrivances include everything from chalkboard and computer mathematical proofs to the quantum-theoretical procedural arrangement to be discussed in the next section.

In sum, these two patterns, one in the neuro-algorithmic regimes of perception, and one in the neuro-algorithmic regimes of discursive symbols, are the two nested referents by which everyday subjective experience and objective science are connected through methods (algorithms) of scientific validation. This point takes us directly to NP's neuro-algorithmic explanation of the Jamesian pragmatic nature of the Copenhagen interpretation of quantum theory.

The Two-Neuro-Algorithmic Referent Basis of the Pragmatism of the Copenhagen Interpretation of Quantum Theory

The ontological essence of the Copenhagen interpretation of quantum theory is that "the complete description of nature at the atomic level [is] given by probability functions that referred not to underlying microscopic space–time realities but rather to the macroscopic objects of sense experience" (Stapp, 1972, p. 1098; page 25 this issue). That is, there are no little objects "down there" at the atomic level which form the basis of reality. Forming atomic reality, instead, are abstract symbolic devices [wave functions: $\Psi_A(x)$, $\Psi_B(x)$] created by the human mind, which are *inseparably* tied through operational specifications to the entire quantum measurement arrangement which includes the observer's perceptual–cognitive operations at the macroscopic level. Thus, within NP, quantal atomic reality in the Copenhagen scheme consists of two-neuro-algorithm referents as described above and as depicted in Figure 2.

Figure 2 also illustrates precisely how at the neuro-algorithmic level the Copenhagen view of reality is observer-dependent. (It must be noted however that, as described earlier, objects in classical physics are also dependent upon perceptual invariance mechanisms of the observer.[4]) The validity

[4]Lorenz (1959/1962) was the first to articulate the idea that the mechanisms of the perceptual constancies might underlie the operations of scientific activity; although in his day he did not have at his disposal a specific process by which to connect them:

> Without the perceptual apparatus, above all without the literally *objectifying* achievement of the so-called constancy mechanisms, we could know nothing about the existence of those natural units of varying duration which we call *objects* . . . . If one assumes a real external world at all, one has to concede that the way in which the simplest forms of space orientation and perception transmit to us, by analogy, knowledge of extra-subjective actuality; is basically equivalent to the way in which the highest forms of reason [science, in this context] do the same (differing only in degree of analogy reached). (pp. 37–38)

requirement of the inter-mappable development of the neuro-algorithms of perception into descendent neuro-algorithms of discursive symbol systems clarifies in terms of brain operations the absolutely fundamental condition of quantum theory that Bohr (1958), the father (along with Heisenberg) of quantum theory, repeatedly emphasized:

> It is imperative to realize that in every account of physical experience one must describe both experimental conditions and observations by the same means of communication as one used in classical physics. In the analysis of single atomic particles . . . the experimental conditions can be varied in may ways, but the point is that in each case we must be able to communicate to others what we have done and what we have learned, and that therefore the function of the measuring instruments must be described with the framework of classical physical ideas. (pp. 88–89)

Figure 2 illustrates precisely Bohr's point in that if the abstract symbolic devices of quantum theory are not mappable back onto language associated with neuro-algorithms of perceptual–cognitive processes which instantiate classical objects/instrumentation, they aren't (can't be) about anything.

Additional corroborative support for NP's two-neuro-algorithm referent basis for the Copenhagen view is provided by critical elements in Stapp's (1972) analysis of the Jamesian pragmatics of the view. Stapp prepares his readers for the Copenhagen interpretation's unconventional conceptions of reality by describing point-by-point parallels between Bohr's ideas and James's (1970) pragmatic philosophy which describes how humans construct the truth of ideas. He summarizes James's conception of what is involved in the formulation of how we know what is true about reality, as follows:

> The contention that underlies James's whole position is, I believe, that a relationship between an idea and something else can be comprehended only if that something else is also an idea. Ideas are eternally confined to the realm of ideas. They can "know" or "agree" only with other ideas. There is no way for a finite mind to comprehend or explain an agreement between an idea and something that lies outside the realm of experience.
>
> So if we want to know what it means for an idea to agree with reality we must first accept that this reality lies in the realm of experience. (Stapp, 1972, p. 1004; page 34 this issue)

In other words, for an idea to be true it must be *workable* within a scheme of other ideas — in this sense, "An idea is true if it works" (Stapp, 1972, p. 1003; page 34 this issue). The key parallel with the foregoing that appears often in Bohr's writings on the Copenhagen interpretation of quantum theory is, I think, the following theme: "In our description of nature the purpose is not to disclose the real essence of phenomena but only to track down as far as possible relations between the multifold aspects of our experience" (Bohr, 1934, p. 18).

It must be pointed out that the ideas James and Bohr talk about cannot all be of the same level of abstraction. As described earlier in relation to

Figure 2, in NP ideas emerge at the simple iconic model level of cognition in ontogeny and culture (Halverson, 1992), while other analogue, and symbolic-level models such as those of mathematics, emerge deterministically in a nonlinear fashion. In thought processes, especially those related to discovery and the contrivance of experiments and the communication of results (see Bohr, 1958), there is a necessary co-mingling of the various abstractive levels of models. This is a rather important clarification of James on truth in that it offers developmental–evolutionary insight as to how (via the nature of the brain-algorithmic pathway) quantum-theoretical operational procedures are created and are then "reverse engineered" into statements in classical physics and "icons" of everyday experience.

Operational Truth as an Outcome of Maximum-Power Principle-Composed Systems of Two-Neuro-Algorithmic Referents

Both James's pragmatic conception of truth and Bohr's Copenhagen pragmatism agree completely with NP's two-neuro-algorithm conception of reality construction. NP's position, however, describes operationalizeable *mechanisms* of truthful connectivity among the manifold aspects of experience. It provides a two-part answer to the question, What are the operationalizeable *dynamics* of truth? First, the notion that "an idea is true if it works," is simply a shorthand, nonmechanistic way of describing the maximum-power principle evolution of the neuro-algorithms that underlie abstract symbols from those of perception-cognition (see Appendix, and Figure 2).[5] Put simply, an animal, or a brain algorithm is selected if it "works." Second, the notion that ideas can *only* be comprehended in relation to other ideas, or, more to the point of Bohr's view of quantum theory, *only* to track down the relations among the manifold aspects of our experience, is precisely the nonlinear, self-referential neuro-algorithmic situation depicted in Figure 2. Thus NP provides an *operational* version of the Copenhagen interpretation, and of James's pragmatics of truth, bringing them into the operational realm of quantum theory itself. This overarching operational vantage point can now be extended to include a neuro-algorithmic *explanation* of qualia.

[5]The discursive symbol systems depicted in Figure 2 are the equivalent of James's "sense objects" or publicly objective experiences. In NP, Jerison's (1988) evolutionary description of language in the evolution of shared realities is adopted to explain how James's sense objects came into being among humans.

A Neuro-Algorithmic Explanation of Qualia Within the Context of Quantum Theory

Traditionally, "qualia" are described as subjective experiences for which parallel empirical referents cannot be determined. For example, while we may be able to explain how the brain formulates color impressions, we are not able to determine any particular objective substrate, or material "stuff," for, say, the subjective color sensation of green. In other words there seems to be no "green" anywhere in the universe except in subjective experience. From this traditional perspective on the idea of qualia, there are countless other examples of these purely subjective phenomena. For example, there seems to be no objective bases for the sensation of an itch, a pain, or even for "believing" in quanta (or qualia) for that matter. This apparent lack of substrate or empirical referencing for qualia has traditionally presented a philosophical and scientific conundrum. If qualia have no objective substrates, just what is the nature of their existence in our experience?

The following approach to the problem of the nature of qualia is derived directly from the neuro-algorithmic perspective so far outlined. I believe that most philosophers, psychologists, and neuroscientists who tackle the problem of the nature of qualia become bogged down in the above conundrum, because in asking what qualia *are* and how the brain produces qualia, they ignore what I feel is the more preliminary and critical question concerning how brain produces any reality at all. That is, they take the classical physics view for granted in assuming the reality of an objective scientific world "out there," and then question the possibility of observer phenomena that don't seem to fit that reality. But the fuller picture of human operational reality as shown in Figure 2, and the discussion of the two-neuro-algorithm basis of quantum theory indicates the classical view is not only limited, but is essentially backwards. That is, the situation depicted in Figure 2 which shows the two-neuro-algorithmic referent nature of the objective operational specification of science, depends *absolutely* on the preliminary evolution of the objectifying mechanisms (operations) depicted in Figure 1 (see also footnote 4).

Qualia Are Single-Neuro-Algorithmic Referents From Which All Two-Neuro-Algorithmic Referents Descend, Including Quanta

The Copenhagen interpretation of quantum theory informs us that there is no underlying deep physical reality — "[only] relations between the multifold aspects of our experience" (Bohr, 1934, p. 18). It suggests further that, as Stapp (1972) pointed out, classical space, and time "like color, lie in the

mind of the beholder" (p. 1108; page 41 this issue). From an ontological standpoint what are we to make of this overall point? Does it really mean that the deepest reality is wrapped up in the beholder? In NP it means precisely this, and, further, the only *workable* (in Bohr's and James's sense) way to understand its truthfulness is in the *relationship* between single- and two-neuro-algorithmic referents. Therefore, I propose that qualia *are* the parent "single neuro-*algorithmic* referents" as depicted in Figure 1. Qualia are the subjective neuro-algorithmic parents of all objective science.

This position leads to two tradition-breaking explanations of phenomena in general. First, it is not surprising that empirical referents, physical measurables, or "stuff" cannot be determined for the sensation of, for example, the color green. Green is not this or that substrate, it is *algorithmic* — no material stuff for the sensation of green will ever be "found." Human experience floats not on a world of material substrates, but on a world of neuro-algorithmic flux — of adaptive informational patterns (Vandervert, 1996b). And, all of these problem solving informational patterns (including those that give rise to the sensation of green) can potentially be transported into a variety of material substrates just as long as the adaptive pattern(s) could be duplicated precisely — we are only at the beginning of this process with computing systems which are maximum-power nonlinear descendents of brain algorithms (Vandervert, 1993).

Qualia Are Single-Neuro-Algorithmic Flux Patterns

How are these neuro-algorithmic fluxes (either single- or two-neuro-algorithmic) related to everyday conscious experience? The most apt two-neuro-algorithmic model is the nonlinear neural model proposed by Kelso (1995) and his multidisciplinary team of scientists at the Center for Complex Systems at Florida Atlantic University:

> The thesis here [of his book] is that the human brain is *fundamentally* a pattern-forming, self-organized system governed by nonlinear dynamical laws. Rather than compute, our brain "dwells" (at least for short times) in metastable states: it is poised on the brink of instability where it can switch flexibly and quickly. By living near criticality, the brain is able to anticipate the future, not simply react to the present. (p. 26)
>
> It is, I like to say, a "twinkling" system, creating and annihilating patterns according to the demands placed on it. [In NP, this "twinkling" system unfolds in accordance with the maximum-power principle.] (p. xvii)

In NP, conscious experience "is" the world of such nonlinear "twinkling" flux patterns of information — albeit a world of "black twinklings" inside

the skull.[6] How consciousness can "know" or "be" a world of light, sounds, and movements is explained by the evolutionary transport of physical world substrate algorithms into parallel "twinkling experiences" in neural substrates inside the skull (see Appendix, Transport of Algorithms). Briefly, patterns of environmental dynamics are selectively transported from external physical world substrates into internal neuro-algorithmic substrates (Vandervert, 1996a). The experience of light (including that of greenness), for example, is a dynamic algorithmic pattern and therefore can be "run" in a "black substrate" that bestows advantage to the system. Such patterns are unique in the universe to the neuro-algorithmic organization of the phylogenetic brain (see, for example, Freeman, 1995; Freeman and Barrie, 1994). However, they are "workable" in precisely the Jamesian–Copenhagenian sense in *relation* to all other neuro-algorithmic pattern regimes and to impinging environmental dynamics.

Conclusions and Implications

There are at least two significant conclusions and implications that derive from NP's description of qualia within the framework of its two-neuro-algorithmic referent interpretation of quantum theory.

The Nature of the Fundamental Ontological Problem

In my view the two worlds, real and ideal, that philosophers of ontology have been grappling with for centuries have actually been appearances of two tiers of the neuro-algorithmic growth processes going on inside the brain (see

---

[6]Within NP, Kelso's "twinkling Systems" are created and annihilated in accordance with maximum-power principle evolution as a natural part of the metastability of the larger earthly negentropic solar flux:

> Man's use [including that of brain operations] of energy on the earth's surface actually constitutes internal transactions with energy fluxes that are thermodynamically available, that is usable before the energy is thermally degraded to the average surface temperature or chemically degraded by diffusion to the environment. Taking commonly accepted average values for the temperatures of the sun and the earth, the 1.6×10^{15} megawatt-hours of energy radiated to outer space carries with it the capability for an entropy decrease, or "negentropy flux," of 3.2×10^{22} joules per degree K. per year, or 10^{38} bits per second . . . . A great deal of this information is "used" in meteorological processes (cloud formation, thunderstorms, the establishment of high-altitude lakes and watersheds and so on). A large additional amount is "used" for the life processes of plants and animals. A comparatively small quantity is under the control of man, yet this quantity is responsible for man's technological reshaping of his environment [see neuro-algorithmic basis for this reshaping in Figure 2]. (Tribus and McIrvine, 1971, p. 183)

This contexting of "twinkling systems" in the maximum-power principle should be compared with NP's conception of the *transport of algorithms* which appears in the Appendix. The larger context of earthly negentropic energy flux constitutes the environment from which the neuro-algorithmic fluxes of consciousness and mind descend.

Figure 2). Plato's world of ideal forms is immanent in the neural growth process that construct the neuro-algorithms of abstract symbol systems from those of perception and cognition. That is, "chairness" does not reside outside the skull in some abstract realm, it exists in the relationship between the neuro-algorithms of invariance (constancies) that construct perceived particular chairs, and the invariant chair of the neuro-algorithms of the chair as a Jamesian "sense object" that is commutable among different observers (see footnote 5). Thus, according to NP, Plato was not describing a reality of relationships "out there," but rather "in there." [See also, "Science's Erroneous Placement of the World Outside the Skull" (Vandervert, 1990, pp. 9–10).]

An Experimental "Test" of NP's Two-Neuro-Algorithmic Referent Quantum World

In the introductory section of this paper it was proposed that the neuro-algorithmic organization of the brain consists of physical world dynamics that became encapsulated in the neural substrate through selective processes (see also "Transport of Algorithms" in the Appendix). Then, in the section titled, "The Two-Neuro-Algorithmic Referent Basis of the Pragmatism of the Copenhagen Interpretation of Quantum Theory," the theoretical position of NP's two-neuro-algorithm referents (two-part "empirical referents") was described. Finally, in the section that followed on qualia, qualia were described as single-neuro-algorithmic referents (one-part "subjective referents"). Since this overall position incorporates descriptions and mechanisms for literally all of the human activity involved in the entire conceptions of classical physics and quantum theory, as well as the Copenhagen interpretation of quantum reality, I propose that a better preliminary test of the two-neuro-algorithm hypothesis could not be developed than the quantum theoretical measurement procedure *itself* (an algorithm devised by neuro-algorithms) [see Stapp, 1972, pp. 1099–1100; pages 27–29 this issue].

An important advantage of the above experimental "test" of the two-neuro-algorithmic approach is that if the two-neural-algorithm referent hypothesis had come first, it would permit us to interpret the significance and meaning of Bell's critical theorem (Bell, 1964) in an entirely different manner (see also Stapp, 1972, pp. 1109–1110). Bell's theorem and the Copenhagen interpretation are inseparably linked, but it is a Bohr–Kantian linkage as described. One must keep in mind that the Copenhagen interpretation suggests that it is the two-tiered neuro-algorithmic framework behind human thought, and not some eternally unspecifiable external framework, that will *always* be the source of any operational specifications of human reality. Bell's theorem could therefore only prove that any separation between the two neuro-algorithmic referents is impossible. The neuro-algorithms which

underlie descendent discursive symbol systems (including Bell's theorem) cannot be independent of their parent perceptual–cognitive neuro-algorithms. And, since according to the pragmatic Copenhagen interpretation à la James, *all* experiments can only be about relationships between ideas or two-neuro-algorithm referents, those that support for example a nonlocality conception, are actually about conditions or limitations imposed by the nature of relationships among algorithmic patterns of information *as they are modeled in such ideas or two-neuro-algorithmic systems*. Heisenberg (1958b) stated this idea clearly, but in my estimation did not take his own words seriously enough:

> we are finally led to believe that the laws of nature that we formulate mathematically in quantum theory deal no longer with the particles themselves but with our knowledge of the elementary particles . . . . The conception of the objective reality of the particles has thus evaporated in a curious way, not into a fog of some new, obscure, or not yet understood reality concept, but into the transparent clarity of a mathematics that represents no longer the behavior of the elementary particles but rather our knowledge of this behavior. (pp. 99–100)

In NP the transparent clarity of mathematics Heisenberg alludes to represents the two-neuro-algorithmic human reality, and it applies equally to Bell's theorem and to elementary particles. That is, we can recast the observer-created quantum situation in terms of all of the implications of Bell's theorem by simply recognizing the observer that is "hidden" within (nonlinearly enfolded within) mathematics (see Vandervert, 1993). Thus the first lesson of quantum theory is in how its operational specifications, because they must irrevocably be referenced back to classical physics, reveal the two-neuro-algorithmic referent system of the human brain that produces it. Quantum theory, whatever else its founders may have thought it represented, is a milestone in the modeling of the evolution of perceptual–cognitive processes.

References

Ackoff, R., Gupta, S., and Minas, J. (1962). *Scientific method: Optimizing applied research and decisions*. New York: John Wiley and Sons.

Bell, J. (1964). On the Einstein–Podolsky–Rosen paradox. *Physics, 1*, 195.

Bohr, N. (1934). *Atomic theory and the description of nature*. Cambridge, England: Cambridge University Press.

Bohr, N. (1958). *Atomic physics and human knowledge*. New York: John Wiley and Sons.

Boring, E. (1950). *A history of experimental psychology*. New York: Appleton–Century–Crofts.

Dennett, D. (1995). *Darwin's dangerous idea*. New York: Simon & Schuster.

Edelman, G.M. (1987). *Neural Darwinism: The theory of neuronal group selection*. New York: Basic.

Fox, R. (1988). *Energy and the evolution of life*. New York: W.H. Freeman and Company.

Freeman, W. (1995). *Societies of brains*. Hillsdale, New Jersey: Lawrence Erlbaum.

Freeman, W., and Barrie, J. (1994). Chaotic oscillations and the genesis of meaning in cerebral cortex. In G. Buzsaki, R. Linas, W. Singer, A. Bethoz, and Y. Christan (Eds.), *Temporal coding in the brain* (pp. 13–37). Berlin: Springer.

Greenough, W., and Black, J. (1992). Induction of brain structure by experience: Substrates for cognitive development. In M. Gunnar and C. Nelson (Eds.), *Developmental behavioral neuroscience: Volume 24, Minnesota Symposia on Child Psychology* (pp. 155–200). Hillside, New Jersey: Lawrence Erlbaum.

Halverson, J. (1992). Paleolithic art and cognition. *The Journal of Psychology, 126*, 221–236.

Heisenberg, W. (1958a). *Physics and philosophy*. New York: Harper Row.

Heisenberg, W. (1958b). The representation of reality in contemporary physics. *Daedalus, 87(3)*, 95–108.

James, W. (1970). *The meaning of truth*. Ann Arbor, Michigan: University of Michigan Press.

Jerison, H.J. (1988). Evolutionary neurology and the origin of language as a cognitive adaptation. In M.E. Landsberg (Ed.), *The genesis of language* (pp. 3–9). Berlin: Mouton deGruyter.

Kauffman, S. (1993). *The origins of order: Self-organization and selection in evolution*. New York: Oxford University Press.

Kelso, S. (1995). *Dynamic patterns: The self-organization of brain and behavior*. Cambridge, Massachusetts: The MIT Press.

Lotka, A.J. (1922). A contribution to the energetics of evolution. *Proceedings of the National Academy of Science 8*, 140–155.

Lotka, A.J. (1945). The law of evolution as a maximal principle. *Human Biology 17*, 167–194.

Lorenz, K. (1962). Gestalt perception as fundamental to scientific knowledge [C. Ghurye, Trans.]. *General systems: The yearbook of the society for general systems research* (Volume VII, pp. 37–56). Ann Arbor, Michigan: University of Michigan Press. (Original work published 1959)

Lorenz, K. (1977). *Behind the mirror: A search for a natural history of human knowledge* [R. Taylor, Trans.]. New York: Harcourt Brace Jovanovich. (Original work published 1973)

MacLean, P. (1991). Neofrontocerebellar evolution in regard to computation and prediction: Some fractal aspects of microgenesis. In R. Hanlon (Ed.), *Cognitive microgenesis* (pp. 3–31). New York: Springer–Verlag.

Mandler, J.M. (1988). How to build a baby: On the development of an accessible representational system. *Cognitive Development, 3*, 113–136.

Mandler, J.M. (1992). How to build a baby: II. Conceptual primitives. *Psychological Review, 99*, 587–604.

Mandler, J.M. (in press). Preverbal representation and language. In P. Bloom, M. Peterson, L. Nadel, and M. Garrett (Eds.), *Language and space*. Cambridge, Massachusetts: MIT Press.

Odum, H.T. (1983). *Systems ecology: An introduction*. New York: John Wiley and Sons.

Odum, H. (1988). Self-organization, transformity, and information. *Science, 242*, 1132–1139.

Odum, H.T., and Odum, E.C. (1981). *Energy basis for man and nature*. New York: McGraw–Hill.

Piaget, J. (1980). *Adaptation and intelligence: Organic selection and phenocopy* [S.S. Eames, Trans.]. Chicago: University of Chicago Press.

Pribram, K. (1991). *Brain and perception: Holonomy and structure in figural processing*. Hillsdale, New Jersey: Lawrence Erlbaum.

Stapp, H. (1972). The Copenhagen interpretation. *American Journal of Physics, 40*, 1098–1116.

Stapp, H. (1993). *Mind, matter, and quantum mechanics*. New York: Springer–Verlag.

Tribus, M., and McIrvine, E.C. (1971). Energy and information. *Scientific American, 225*, 179–188.

Vandervert, L.R. (1988). Systems thinking and a proposal for a neurological positivism. *Systems Research, 5*, 313–321.

Vandervert, L. (1990). Systems thinking and neurological positivism: Further elucidations and implications. *Systems Research, 7*, 1–17.

Vandervert, L. (1991). A measurable and testable brain-based emergent interactionism: An alternative to Sperry's mentalist emergent interactionism. *The Journal of Mind and Behavior, 12*, 201–209.

Vandervert, L. (1992). The emergence of brain and mind amid chaos through maximum-power evolution. *World Futures: The Journal of General Evolution, 33*, 253–273.

Vandervert, L. (1993). Neurological positivism's evolution of mathematics. *The Journal of Mind and Behavior, 14,* 277–288.
Vandervert, L. (1994). How the brain gives rise to mathematics in ontogeny and in culture. *The Journal of Mind and Behavior, 15,* 342–349.
Vandervert, L. (1995a). Chaos theory and the evolution of consciousness and mind: A thermodynamic–holographic resolution. *New Ideas in Psychology, 13,* 107–127.
Vandervert, L. (1995b). Chaos theory and neurological positivism — clarifications: A reply to Newman, Bickhard, Alexander and Globus. *New Ideas in Psychology, 13,* 143–148.
Vandervert, L. (1996a). From idiots savants to Albert Einstein: An evolutionary brain algorithmic explanation of savant and everyday performance. *New Ideas in Psychology, 14,* 81–92.
Vandervert, L. (1996b, August). The algorithmic evolution of consciousness, creativity, and culture: A nonlinear dynamical model. In L. Vandervert (Chair), *Dynamical systems theory (including chaos) in psychology.* Invited symposium conducted at the XXVI International Congress of Psychology, Montreal.

Appendix

Maximum-power principle. The maximum-power self-organization principle may be stated as follows: *those systems that survive in the competition among alternative choices are those that develop more power inflow and use it to meet the needs of survival.* They do this by: (1) developing storages of high-quality energy; (2) feeding back (constitutes feeding forward, that is, responses in anticipation of discrepancies between the actual state and the reference state of the system) works from the storages to increase inflows (self-referentially); (3) recycling materials as needed; (4) organizing control mechanisms that keep the system adapted and stable; (5) setting up exchanges with other systems to supply special energy needs; and (6) contributing useful work to the surrounding environmental system that helps maintain favorable conditions (Odum and Odum 1981, pp. 32–33). Lotka (1922, 1945) formulated the maximum-power principle, suggesting that systems prevail that develop designs that maximize the flow of useful energy through feedback. These feedback designs are sometimes called *autocatalytic* (self-releasing, or feeding upon self) [Odum 1983, p. 6]. Overall, the autocatalytic relationship between brain and mind is one of fed forward *positive-feedback,* whereby energy dissipation is progressively accelerated.

The maximum-power principle is a macro principle of self-organization (Odum, 1988; Vandervert, 1991) that *itself* becomes encapsulated in the algorithmic organization of the human brain. Neuro-algorithms are thus energy-information patterns in neural substrates which link problems, input data, and solutions in accordance with the above six-point principle (see also, footnote 4). The maximum-power brain's neuro-algorithmic organization is essentially nonlinear due the fact that as Fox (1988) pointed out: "The dynamics of organism movements and their interactions with the dynamics of other organisms [both socially cooperative and competitive] and with the environment [are maximally complex and so] are usually nonlinear

phenomena" (pp. 158–159). Within its own maximum-power organization, then, the human brain with its highly elaborated neofrontocerebellar circuitry (a maximum-power outcome) contains the potentiality of the evolution of culture. It is manifest, for example, in the self-organization of the perceptual constancies as they are patterned in the autocatalytic emergence of descendent cultural-level mental models via experience-expectant and experience-dependent neural growth processes (Greenough and Black, 1992; Vandervert, 1991, 1993, 1996a, 1996b).

Transport of algorithms. Algorithm transport is based upon the *substrate neutrality* property of algorithms (informational patterns) as described in Vandervert (1996a). Essentially, algorithms are not dependent upon any particular substrate and move freely among substrates in accordance with maximum-power principle bestowed advantage. During the course of evolution physical world algorithms have been transported from distributions of neuroalgorithms associated with physical world dynamics into extant neural substrates by the selection algorithm. Konrad Lorenz (1973/1977), in his epistemological writings, expressed this algorithmic transport concept of evolution in a memorable and easy to understand manner:

> The scientist sees man as a creature who owes his qualities and functions, including his highly developed powers of cognition, to evolution, that age-long process of genesis in the course of which all organisms have come to terms with external reality and, as we say, "adapt" to it . . . . Similarly, anatomical development, morphogeny, produces in the organic system actual "images" [quotes added] of the outside world. The fish's motion and the shape of its fins reflect the hydrodynamic properties of water . . . . (p. 6)

Of course, such algorithmic transport applies in a completely complementary manner to the neural control apparatuses (their algorithms) of the fish's perceptual–motor systems.

In sum, all of the physical world dynamics associated with the two-neuro-algorithmic operations of classical physics have been transported into the neural substrate of the human phylogenetic brain. In qualia and in consciousness these are the dynamics that "run," feedforward (are "intended"), and are felt and experienced (Vandervert, 1995b).