Quantum Psychology of Nots †

by

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Abstract:

Quantum psychology was created in the mid-1970's in an attempt to reconcile controversy in the psychological literature about schizophrenia as a logical phenomenon. Its origin - as a reconciliation of the von Domarus/Arieti perspective on schizophrenia with that of double-bind theory - is presented. The resolution accommodates both: (1) the subjective logic of primary processes, which von Domarus and Arieti attributed to schizophrenics and claimed to be found in developmentally and evolutionarily early cognition; and (2) the conflicting metalogics found in double-bind communications and in such paradoxical interventions as "brief therapy."

Quantum psychology is proposed as an empirically meaningful formulation of the logic of experience; viz., the rules that characterize how individuals label, combine, transform, and select out their experiences. The model appears to have the same formal structure as von Neumann's "quantum logic" representation of quantum physics; thereby, the labeling "quantum psychology." As a model, it provides a more general representation than is found in classical (eg. computer-type) logics.

Simple illustrations of differences between quantum psychology and classical psychologies will be shown. An operational meaning for intrinsic, construct ambiguity and for complementarity will be given. The developmental transition from "kiddythink" into "operational thought" will be used to demonstrate the transfer of representational tools from physical to psychological modeling. The "classicalization" of experience will be discussed. The capacity to form negation will be proposed as a possible operational meaning for the conscious/unconscious distinction. The physical implications of negation will be described as an indication of how the quantum psychology approach might be empirically adapted into psychology.

INTRODUCTION

> "The general lesson of the role that mathematics has played through the ages in natural philosophy is the recognition that no relationship can be defined without a logical frame and that any apparent disharmony in the description of experiences can be eliminated only by an appropriate widening of the conceptual framework."
>
> *- N. Bohr, quoted in Jauch (1972, p. 137)*

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One aspect of the splendor of the 20th century must be the symbiotic growth between: (1) the symbolic models used for characterizing and interpreting experience; (2) the questions asked - and, thereby, the answers available - to improve our understandings; and (3) our capacities to influence our choices. The talk on "Quantum psychology and future directions" will describe some representational tools, which have been developed as part of a "quantum psychology" model (Q - ψ), and which proport to provide an improved representation of certain psychological phenomena. The present paper will overview the subjects which will be addressed in the talk.

In the 1930's, John von Neumann had attempted to discover the logical structure of quantum physics by examining the formal structure of experimental statements, as they are used by physicists in their descriptions of quantum theory. This resulted in a model of physics termed "quantum logic" (von Neumann, 1955/32; and Birkhoff & von Neumann, 1936). Although quantum psychology proposes a formal structure that is similar to von Neumann's quantum logic of propositions about physical experience, quantum psychology is not an application of quantum physics to psychology. To the contrary, it was constructed originally by piecing together variations upon certain formal models from artificial intelligence [1] and from neurophysiological modeling, [2] in an attempt to reconcile controversy in the psychological literature about schizophrenia as logical phenomena. The model was only later observed to have formal features such as those which characterize the differences between classical and quantum physics. [3]

As a scientific approach to psychology, quantum psychology attempts to formulate the empirical logic of psychological experience through a critical evaluation of the logical structure of psychological phenomena. As such, quantum psychology deals with empirical questions (Oshins & McGoveran, 1980, ft.nt. 10; Mackey, 1963, p. 64; Jauch & Piron, 1970; Jauch, 1968, Ch. 5, esp. pp. 72-4; von Weizsäcker, 1971, 1980, 1986/84) - ie. propositions about experience, which in principle have measurable consequences. Quantum psychology attempts to identify the rules by which propositions about such experiences are put together, taken apart, and transformed.

The quantum psychology process involves: (1) specifying a collection of questions that have empirically distinguishable answers; (2) specifying criteria by which observations pass and fail the test of the questions; and, then, (3) attempting to ask the questions of the relevant observation set. In quantum psychology, empirical truth is distinguished by whether or not the answers satisfy the agreed upon criteria. Because of this empirical validating scheme, the term "empirical logic" is sometimes used. As a formulation of empirical facts, it is subject to the same indeterminacies and uncertainties of any empirical facts.

Oshins has proposed (Oshins & McGoveran, 1980; Oshins, 1984a,b) that (1) by exploiting the differentiating consequences between classical and quantum descriptions; (2) by posing appropriate empirical questions having separating alternatives with, in principle, decidable answers; and (3) by turning around von Neumann's identifications between physical phenomena and their associated logical (lattice) structures; one could find physical/neurological correlates of the underlying logic that "carries" the language of schizophrenics, and more general psychological processes.

The present talk shall review some of the controversy regarding schizophrenia as logical phenomena between members of the intrapsychic school who advocate a theory about defective syllogistic processes, known as von Domarus' principle of identification by predicates, and members of the communications school who advance a theory of metalogical disconfirmation, known as double binds. Quantum psychology will be proposed as an alternative characterization which embodies the essential features of the controversy within one coherent model. Quantum psychology will be seen to provide an operational meaning to ambiguity and to metalogical complementarity. Examples and simple characterizations will be given. Three advantages of the quantum psychology approach will be suggested:

> (1) As a critical theory. As a quantum parallel processing model, it is distinguishable from classical parallel processing models such as McCulloch-Pitts type classical neural nets (McCullochPitts, 1943), which in principle do not admit ambiguity (Oshins, 1984a, von Neumann, 1955/32); and from Pribram's hologram hypothesis (1971; Pribram, Nuwer, & Baron, 1974), which is a classical wave model of classical waves. [4] Quantum psychology provides explicit

criteria for discriminating between these models.

(2) As a theory allowing formal induction. It provides feasible understanding of the formal mechanism underlying the development of Piaget's stage of operational thought. We shall discuss how imposing a type of serialization upon the quantum logic structure forces it to become classical.

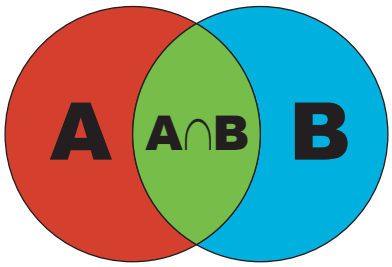
(3) As an empirical theory. Quantum psychology suggests possible experimental confirmation. [5] In particular, by exploiting the physical implications of negation, quantum psychology proposes an operational meaning to the unconscious/conscious boundary as a specific type of synchronization capacity.

We shall now outline of some of the particular concepts which will be addressed:

Schizophrenia as Logical Phenomena:

(1) The intrapsychic approach of Vitgotsky (1934), von Domarus (1944), Arieti (1948, 1950, 1960, 1964, 1967, 1974/55), and Boyd (1980):

- Example: Arieti (1967, pp 27-45; 1974/55, pp. 230-1): "I am a virgin. The Virgin Mary was a virgin; [therefore,] I am the Virgin Mary."
- The principle (von Domarus (1944, p. 111): "... whereas the logician accepts identity only upon the basis of identical subjects, the paralogician accepts identity based upon identical predicates."
- Venn diagram/set theoretic representation:



A means "I am a virgin." B means "The Virgin Mary was a virgin." "... the area of intersection of A and B symbolizes the common element" "virginity". This common element is termed by Arieti (1967, p. 110) "the identifying link or identifying predicate."

- The criticism (Bateson, et.al., 1956, p. 253): "... as we see it, Von Domarus' formulation is only a more precise ... way of saying that schizophrenic utterance is rich in metaphor. ... The peculiarity of the schizophrenic is not that he uses metaphors, but that he uses unlabeled metaphors. He has special difficulty in handling signals of the class whose members assign Logical Types to other signals."
- The response to criticism (Arieti, 1974/55, p. 370): "Whereas the poet is aware that he substitutes the abstract with the concrete, the patient is not. The metaphor is not a metaphor for the patient." As an example, consider Arieti's differentiation between a simile, a metaphor, and the corresponding schizophrenic identification. A simile might be "I am like a flower." The corresponding metaphor would be "I am a flower." The schizophrenic response would be, eg., "I have green petals and yellow flowers/buds."

(2) The metalogic approach of Bateson, et.al. (1956; Watzlawick, Weakland & Fisch, 1974; Weakland, et.al., 1974).

- Example (Laing, 1956/76, p. 205): [6]

> Mother: "I don't blame you for talking that way. I know you don't really mean it."
>
> Daughter: "But I do mean it."
>
> Mother: "Now, dear, I know you don't. You can't help yourself."
>
> Daughter: "I can help myself."
>
> Mother: "No, dear, I know you can't because you're ill. If I thought for a moment you weren't ill, I would be furious with you."

• The principle: schizophrenia develops from repeated exposure to errors in logical typing in individuals raised in environments:

(1) which negate in a "paradoxical way" at both level and metalevel;

(2) which forbid commenting upon this; and

(3) in which one's "choice" is experienced as being survival related.

• Metalogic representation: The mother is not telling the daughter that she [mom] disagrees with what the daughter is saying, eg. she [mom] does not say "I disagree with what you [daughter] say (or mean)." Instead she [mom] effectively says "You [daughter] do not mean what you [daughter] say (or think) you [daughter] mean." The mother is not commenting on what is being said by the daughter but making a metacomment on the truth value of what the daughter is saying, i.e., that the construct frame which the daughter is asserting is wrong (not-true), not that whichever answer may be chosen within a particular construct frame is wrong (not-true).

• The criticism (Arieti, 1960, pp. 710; cf. also, 1974/55, pp. 97-100): "... Double-bind situations represent not necessarily pathology but reflect the complexity of human existence ... or, if we want to use the traditional terminology, to conflictful situations ... But for the child who is to become schizophrenic, the double-bind is not only a double-bind;

it is also one of the many carriers of hostility and anxiety from the general environmental situation. Being exposed to an atmosphere of excessive anxiety or hostility and not to an atmosphere of basic trust, he is ill equipped to handle many situations, including double-bind situations. It is this general atmosphere to which he is exposed that is the primal source of his difficulties. ... In other words it is not the double-bind mechanism per se which is pathogenetic but the use of it in a pathogenetic environment."

• The response to criticism (Foudraine, 1961, pp. 93-5; cf. also Watzlawick. 1963, p. 139): "I doubt whether Arieti does justice to the double-bind theory. The specific and pathogenic element in this communicational situation ... is not that the child is exposed to two mutually contradictory messages which he has to obey (as in the situation of divided loyalty), but the fact that this contradiction takes place on a metacommunicative level. [Emphasis in the original.]"

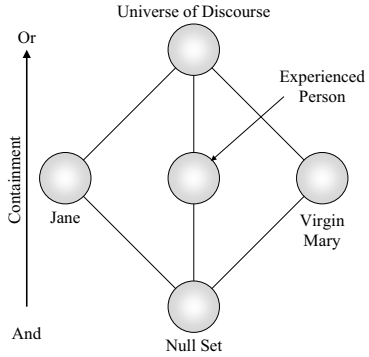
(3) Quantum psychology of schizophrenia (Oshins & McGoveran, 1980; Oshins,1983/82; Oshins & Carlton, 1984):

• An operational notion to ambiguity. As an alternative to psychoanalytic related efforts at interpreting the "schizophrenic syllogism" through classical set theory, Oshins proposed a realization in terms (which physicists would use) of a Dirac linear superposition of rays within a nondistributive lattice (or generalized logic) of noncommuting, "intertwining" observables. In a quantum lattice, the distributive law of classical logic is replaced by the fundamental law of coherence of rays which provides a:

• Principle of operational ambiguity: "If one does not (operationally) distinguish between two (atomic) predicates A & B, there will always exist a third possible contrary (atomic) predicate C such that (A or B) = (B or C) = (C or A)," ie. they are equivalent perspectives - there is no way to operationally distinguish between A, B, & C.

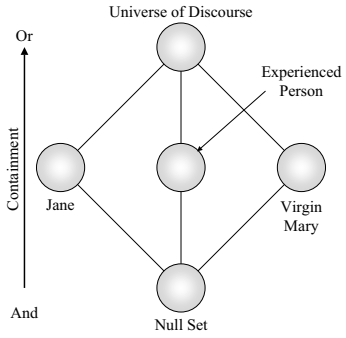
This fundamental or irreducible, quantum ambiguity is claimed to underlie the developmentally and evolutionarily earlier "primary process" thought mechanisms. Reformulating the von Domarus/Arieti principle of "identification by predicates" results in a "lattice perspectivity" (as in projective geometry), such as is found in quantum logic. A type of mathematical degeneracy, equivocation, or linear dependence results, which can be expressed: "'I ≡ Virgin Mary' (modulo 'virginity')."

This type of fundamental, irreducible, representational ambiguity, which is realized through this operational, equivocation process, does not exist in classical representations, such as in computers. From the perspective of Oshins' "picture logic" representation, this relation would be illustrated thus:



where we are considering "I" to be, say, "Jane".

Comparing this with the classical realization of a lattice with 3 atoms or unit propositions, which is represented thus:



where it should be clear from the illustrations that these two structures, quantal and classical, are different. The reader who is familiar with using a lattice "Hasse diagram" should be convinced that the first picture violates the distributive law while it holds for the latter picture.

An operational notion to metalogical complementarity. Bohr (1961/1929b, p. 96) proposed that quantum experience "forces us to adopt a new mode of description designated as complementary in the sense that any given application of classical concepts precludes the simultaneous use of other classical concepts which in a different connection are equally necessary for the elucidation of the phenomena." As such, complementary constructs provide competing, alternative frames of reference. Bohr (1987a/1954, p. 81) gave the example of the competition between "Love" and "Justice" as complementary constructs. Heisenberg (1958, p. 179) gave the example of enjoying music vs. evaluating music as complementary constructs.

The construct ambiguity between complementary constructs provides a metalogic for the constructs. In order to represent the multilevel, metalogical structure which underlies the disconfirmations attributed to double-binds, and the strategic and ofttimes paradoxical interventions of the Mental Research Institute's brief therapy (Watzlawick, et.al., 1974), quantum psychology uses the same type of metalogic found in quantum logic: using a Boolean (distributive) lattice, it follows from ["'statement-A' is 'true'" is "'false'"] that ["'statement-A' is 'false'"]. This conclusion is not valid in quantum logic [7]

The rule of thumb for interpreting when the law of coherence of quantum logic applies is that it will apply if (for atomic propositions) "A or not-A is true" does not require that "A is true" nor that "not-A is true". Such an example is when the atomic proposition "B is true" is the case. Oshins has proposed adapting this type of metalogic structure to psychological framings.

As an example of quantum psychology's reinterpretation of logical paradox, Oshins (1987, pp. 15, 24; 1980; also, Orlov, 1982) has reinterpreted the paradox of "This statement is false" as "This statement is 'true or false'" does not necessitate that "This statement is 'true'" nor that "This statement is 'false'." It is irreducible to either alternative, and the truth valuation induces a transition in the truth value.

Quantum Parallel Processing (Oshins, 1984a):

> (1) Synaptic summation (McCullochPitts, 1943) as basis for neural nets and for man as "Turing automata": "Because of the 'all-or-none' character of nervous activity, neural events and the relations among them can be treated by means of propositional logic. It is found that the behavior of every net can be described in these terms ... and that for any logical expression satisfying certain conditions, one can find a net behaving in the fashion it describes. ... in conclusion ... every net ... can compute only such numbers as can a Turing machine; second, that each of the latter numbers can be computed by such a net. ... This is of interest as affording a psychological justification of the Turing definition of computability and its equivalents ... If any number can be computed by an organism, it is computable by these definitions, and conversely."
>
> - von Neumann (1951/48), who also played a seminal role in the development of computers and neural networks, and who vigorously admonished people not to identify them with actual animal nervous systems, pointed out: "... The McCulloch-Pitts result ... proves that anything that can be completely and unambiguously put into words, is ipso facto realizable by a suitable finite neural network. ... there is no difference between the possibility of describing a real or imagined mode of behavior completely and unambiguously in words, and the possibility of realizing it by a finite formal neural network. The two concepts are coextensive." [Emphasis added]
> - Oshins (1984a) has proposed a quantum "synaptic 'spanning'" model, which embodies irreducible ambiguity as a fundamental principle, as an alternative to the McCulloch-Pitts model. The term synaptic spanning comes from the identification between the law of coherence (above) and Dirac's fundamental principle of linear superposition of rays or directions in a type of vector space called a (projective) Hilbert space. If one identifies a pair of rays with "filters" upon them, the set theoretic interpretation of logical-or, which represents aggregation, would be the set theoretic union of the two filters. On the other hand, the quantal interpretation of logical-or would be the space generated by the pair of rays, or spanned by them, resulting in a plane. The quantum interpretation is that if one does not distinguish between a pair of bases vectors in the plane, there exist alternative pairs of bases vectors that fully, equivalently realize the situation. Oshins (1987, p. 15) has suggested that in this sense, black/white and male/female are equivalent representations of person, if that is the only information available, eg. "A person came into the room."
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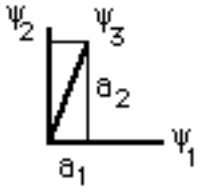
> (2) Synaptic superposition (Pribram, 1971, p. 142) as basis for the hologram hypothesis: "The holographic hypothesis on brain function ... takes the form of superposition ... [of] wave front[s] of light." Since the early 1980's, Pribram (1980) has been suggesting that hologram models are

relevant to a quantum psychology. This claim is apparently (Pribram & Carlton, 1986; Pribram 1988) due to confusing the classical Hilbert (vector) space of classical fields, such as can be used for holograms, with the quantum Hilbert space (modulo the complex field) of rays.

The Hilbert space that is relevant to the principle of linear superposition of quantum states (Dirac, 1969, pp. 36, Oshins, 1987, pp. 77-8) uses rays, or directions, not vectors such as physical fields. This distinction is of fundamental importance. For a vector, the components themselves are important; but for a ray, only the ratio of components is relevant. As a consequence, one can multiply a ray by any number and obtain the same ray, viz. the identical state of information encodement. In such a projective (or ray) representation space, the projection of one direction upon another provides a measure of the probability that a state of experience represented by the former will lead to a state of experience represented by the latter. Let Ψ = ray encodement of all measurable or observable properties of the system. Representing Ψ_1, Ψ_2, Ψ_3 as unit rays such that none line up and only two are independent, if you add two permissible rays (unit states) you get a third unit ray,

$$\Psi_3 = a_1\Psi_1 + a_2\Psi_2,$$

which is a coherent, linear superposition of rays Ψ_1 and Ψ_2:



Notice that: (1) any two vectors that don't line up, determine a plane (ie. the span which contains any state that can be made up with the other two and which represents the logical "or") & (2) that if we do not distinguish axes then there will always be a third possible axis that lies in the plane and could replace one of the other two in determining the same plane. This is the geometric realization of what we referred to above as the logical principle of complementarity. We can think of a_1 and a_2 as the components of Ψ_3 in Ψ_1 and Ψ_2, respectively. One computes probabilities of information in one state being evaluated in another state by computing the magnitudes of the projections.

Although Pribram (Pribram, Nuwer, & Baron, 1974, pp. 419-20) correctly states that for a hologram "the film stores the intensity (the square of the amplitude) of the light," he is incorrect (Pribram, 1988) that brain networks, holograms, and quantum states "obey the same rules ... the same mathematics." Adding a physical field, such as the light field of a hologram, to itself results in twice the field and 4 times the intensity. On the other hand, as mentioned above, adding a quantum state as a ray to itself yields the identical state and thus the same intensity. [8]

From Kiddy-Think to Operational Thought (Oshins, 1987):

- Piaget[9] (Cowan, 1978, pp. 16-17) focuses on the fact that pre-operational children form improper logical groupements. Oshins (1987, p. 16) has suggested that when a child says, "That's a dog," about 3 animals, one of which goes "bow-wow," the next goes "meow," and the next goes "moo," then the child is effectively perceiving (or, expressing the information of), say, "4-legged animal," ie. "'dog ≡ cat ≡ cow' (modulo '4-legged animal')". Oshins has termed this "kiddy-think".
- Piaget (1957, pp. 6-7) points out that for young children "Transitivity is ... absent." He gives as an example, "From 8 to 9, for example, the child will state that a brass bar A weighs the

same as another bar B, and that as the latter weighs the same as a lead ball C, A = B and B = C. But he rejects the conclusion that A = C since from past experience he expects the relation $A < C$, and says 'B certainly weights as much as the ball C, but with A it will be different!'"

• Jauch & Piron (1970) have presented a theorem that, as distinguished from ordinary "logic," a quantum logic (lattice) does not have a rule of deduction; thus, inferences are impossible. This is because it does not admit a conditional in the Philonian sense, whereby a proposition is false only if it begins with a truth and ends with a falsehood. (This appears to be the underpinning of the logical peculiarity that false implies true!) In a quantum lattice, the inclusion relation, which in a classical lattice realizes the logical conditional, is not an element of the lattice but a relation between elements of the lattice. It is not possible to express the conditional in terms of other logical connectives in a quantum logic.

• Fáy's Theorem: Fáy (1967) has shown that by imposing a transitive relation to the lattice element "not-A or B" forces the lattice to become distributive and Boolean (classical). Oshins (1987, p. 16) has proposed that this seriation underlies the development of operational thought and the use of the INRC group of the truth tables (Piaget, op.cit., pp. 32-37).

Physical Implications of Negation [10] (Oshins, 1987):

• To Freud (1963/25; Brandt, 1981, Oshins, 1984b,c), the fundamental attribute of the System Unc. [sic., the unconscious] is that there is an absence of negation. Negation plays three significant roles: (1) necessary for conscious, (2) necessary for mature judgement, and (3) necessary to form boundary between self and other. In a related context, Freud (1938/13, pp. 345-6) states: "The attitude of dreams to the category of antithesis and contradiction is very striking. This category is simply ignored; the word 'No' does not seem to exist for a dream. Dreams are particularly fond of reducing antitheses to uniformity, or representing them as one and the same thing." Oshins has proposed an operational meaning to the conscious/unconscious distinction as the capacity to form negatives.

• From the quantum psychology point of view, the capacity to form negatives follows naturally. Specifically, Finkelstein (1972, pp. 2220-4; 1977, pp. 426-29; Oshins, 1984b, p. 73; 1987, pp. 26-7, 80) has proposed a "relativistic quantum logic" which does not have a negative function, nor a metric structure, nor a clock (time function), as does ordinary quantum logic.

• Finkelstein's theorem (op. cit.): In order to have a negative coded in the information content of physical signals requires a synchronization (or a co-channel acting like a clock) between the preparation of a state of information and its determination or measurement of its information content. This is to say that inquiring question-A of proposition-B requires a synchronization between their information contents in order to code a negative in the information content.

• Oshins (op.cit.) has proposed that S.Q.U.I.D. (superconducting quantum interference device) technology might be capable of determining phase synchronization effects in the firing patterns of the brain which would correlate with the capacity to form negatives, and thereby determining the capacity to have consciousness. There would be significant scientific and social consequences to such demonstration.

Conclusion:

This paper has attempted to survey some representational tools which have been developed in quantum psychology in order to improve our understanding of the logic of experience. We have examined controversy over schizophrenia as logical phenomena and found that the quantum psychology approach is capable of realizing the essential features of both sides of the controversy within one unified and coherent model.

This has led us to explore the representational differences between classical and quantum models in psychology, and to propose operational notions of ambiguity and of metalogical complementarity in terms of empirically distinguishable alternatives. We have suggested how quantum psychology can be viewed as presenting an alternative parallel processing model (termed synaptic spanning) which is distinguishable from the classical models of McCulloch-Pitts and of Pribram.

Finally, we have seen how quantum psychology's formal, representational power provides a new understanding of how imposing transitivity upon the quantum lattice (or generalized logic) brings about a transition from the equivocation process found in preoperational "kiddy-think" into the stage of classical logic. Through proposing an operational meaning for the conscious/unconscious distinction, as the capacity to form negation, we have suggested an empirically meaningful need for a synchronization between the preparation of a state of physically realized information, and the measurement or determination of its information content as an indication of future directions for empirical inquiry into the quantum psychology of experience.

Notes

1 Specifically, as an formal alternative to G.S. Brown's (1972) "laws of form" logic (Oshins, & McGoveran, 1980) and L. Zadeh's (1965) "fuzzy logic" (Oshins, & McGoveran, op.cit.; Oshins, Adelson, & McGoveran, 1984).

2 Specifically, in part, as an alternative to the McCulloch-Pitts (1943) neural nets, which, in principle, do not admit ambiguity; and to the Pribram (1971) "hologram hypothesis," which is only a classical wave theory of classical waves, despite contention to the contrary (eg., Pribram & Carlton, 1986; Pribram, 1988; Oshins 1984a, b, & c). Later in this paper, we shall overview the McCulloch-Pitts model and the Pribram hologram model. In a future publication, I will explain more fully how to apply the Schwinger quantization scheme (Oshins, Adelson, & McGoveran, 1984; Schwinger, 1970) and will elaborate further upon the differences between classical wave theories, such as holograms, and quantum theories.

3 The reader who is familiar with quantum physics might reasonably ask about the role of "Planck's constant" in quantum psychology. It enters the formalism through imposing (Galilean or Einsteinian) inertial invariance and appears as an absolute mass scale and as a minimal unit of energy transfer. I have suggested elsewhere that Planck's constant might act as a "contraction" parameter allowing for the classicalization of psychological experience, as it does for physical experience. (Oshins, 1984c, footnote 9, p. 767; Bargmann, 1954; Jauch, 1964, 1968; Mackey, 1968)

4 See note 2, above.

5 For example, Oshins (1984b, 1987, pp. 23, 26-31.).

6 This example was suggested by Paul Watzlawick during my 1978 talk at the department of psychology at Stanford University. I would like to express my appreciation to him, John Weakland, and Lynn Segal for their assistance in my understanding of their "brief therapy" approach.

7 In Oshins & McGoveran (1980, appendix), we demonstrate that the distributive law of classical logic fails for the Stern-Gerlach experiment. In particular, that it is false, for it to be true, that the spin degree of freedom points up, can mean that it is true that spin is pointing toward the right, instead of it being true that the spin is pointing down.

8 In a related context, Piaget (1957, p. 37, see also, p. 27; Cowan, 1978, pp. 1967) has differentiated between logical classes and numbers. "In arithmetic a unit added to itself gives a new number 1 + 1 = 2, but repeating a logical element only gives a tautology A + A = A." Oshins has suggested that aggregation into abstract constructs forms a such logical classification, 1 Boy + 1 Girl = 1 Person, not two people as in the enumerative grouping.

9 This example was first drawn to my attention by Gordon Bower, circa 1980. Chris Boyd, Sue Britson,

and Stephen Fleck have also been helpful in focusing my attention on Piaget.

10 Some of this material involves ongoing work with Lou Kauffman and Peter Gaposhkin. I have also benefited from comments by Larry Biedenharn and Niklas Damirus.

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