Paper Presented to Symposium "Psychotherapy, Mind and Brain: Systemic Correlations," on 10 January 1980, at the Twenty-Fourth Annual North American Meeting of the Society for General Systems Research with the American Association for the Advancement of Science, San Francisco, California, USA, and Discussed at the Post-Sessions on 11-12 January 1980. Published in the Proceedings: Systems Science and Science, ed. Bela H. Banathy.

NLP—108

...THOUGHTS ABOUT LOGIC ABOUT THOUGHTS...: THE QUESTION "SCHIZOPHRENIA?"

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ABSTRACT

This paper attempts to provide increased representational power for specialists in order to clarify and lay-bare pertinent issues regarding the question "Schizophrenia?" A representation of the empirical logic observed in schizophrenic cognition is constructed. Pertinent qualitative aspects of the semi-classical logics of Fuzzy Set Theory and The Laws of Form are briefly reviewed. A synthesis into Quantum Logic is motivated and described with distinguishing features of the improved representation being developed and discussed at an intuitive and conceptual level. We show that the resulting model provides a unified characterization of the phenomenon of schizophrenia embodying several "competing" schools of thought (for example, the Von Domarus/Arieti Principle; the Bateson, et al, Double-Bind Theory; Matte-Blanco's Principle of Symmetry).

I. INTRODUCTION

> Body and soul are not two different things, but only two different ways of perceiving the same thing. Similarly, physics and psychology are only different attempts to link our experiences together by way of systematic thought.
>
> A. Einstein (1937)

Questions about schizophrenia have been the subject of considerable controversy (Arieti, 1960, 1967:277, 1974:97-101, 300; Bateson et al., 1956:5-6; Watzlawick, 1963:139; Williams, 1964). The numerous definitions of schizophrenic behavior and the many theories of schizophrenia are often taken as being inequivalent or as being mutually exclusive. It is even asserted by some that schizophrenia is mythology, and a labelling unrelated to any clearly distinguishable phenomenon. Here, we will look at theories of schizophrenia that treat it as a disorder in logic. It is, perhaps, unnecessary to attempt to decide who, amongst the definers and theorists, is right and who is wrong. Indeed, such decisions do not lie within the specific competence of the authors. However, by introducing a formal theory which spans (embodies) the explanations of schizophrenia that have been given, a unified integration of these concepts is possible. We shall present a preliminary attempt at such a logical characterization in this paper.

In the modeling of schizophrenia (Oshins, 1978, 1979) which follows, we use a well-defined methodology (McGoveran, 1979). Section II contains a review of standard models of schizophrenia with associated empirical support for each viewpoint. Formal representations, which we consider relevant to a more general and encompassing model of schizophrenic behavior, are discussed in Section III. These are the semi-classical logics of Fuzzy Set Theory and The Laws of Form, and Quantum Logic. In Section IV, Genuine Stupidity Logic (GSL)[1] is presented in a developmental context as a synthesis of Fuzzy Set Theory and The Laws of Form into Quantum Logic. We demonstrate pertinent conceptual notions of GSL, and show that the models of Section II are spanned by it, through the use of examples and illustrations. We conclude in Section V with a summary of the major points presented in the paper and suggestions toward empirical resolution of the question "Schizophrenia?"

We believe that we have uncovered an empirical criterion for distinguishing the question "Schizophrenia?", whether or not there is such a phenomenon, and a framework for exploring it in this paper. Thus, we hope it will provide motivation and representational tools, for those whose ideas and theories have been addressed, in order to facilitate their working together in a more coherent fashion, treating the process of modeling schizophrenia as a task in which each has a mutually contributing role and not a seemingly contradictory or opposing one.

SECTION II

What is schizophrenia? Some suggest that it is merely a label for many kinds of unrelated and abnormal behavior. Others go as far as to assert that such labeling is substantively no more than a socio-political act. While we appreciate the sentiments behind such points of view in this paper, we take the position that schizophrenia is a major mental disorder which can be and is routinely (although perhaps not always appropriately) diagnosed. Although one might well be more interested in the etiology of schizophrenia than in a coherent description of the disease symptomology, the latter must precede the former. We shall not emphasize here the question of the intensity of the symptoms nor attempt to define the point at which "deviant" behavior indicates a mental or perceptual disorder. However, an empirically verifiable criterion exploring these issues is offered in Section V. In this section we examine some descriptive representations (caricaturizations) of schizophrenia in the hope of finding a means of later encompassing all of them within GSL. An unbiased methodology will demand that the formal aspects of the representations addressed here be freed from the interpretations given to them. Before that goal is achieved we will briefly examine three major points of view, presenting some of the evidence for each of them.

A: All men are mortal.

B: Socrates is a man.

Thus: Socrates is mortal.

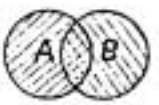
vs.

A: I (the paleologician) am a virgin.

B: Virgin Mary was a virgin.

Thus: I (the paleologician) am the Virgin Mary.

The major premise contains the minor.
Mode of Barbara



The intersection is the identified predicate virgin.
Schizophrenic (paleologic) Cognition

Figure 1: Illustration of "normal" logic vs. Von Domarus logic.

Silvano Arieti (1948, 1960, 1967, 1974) has extended and elaborated upon the basic hypothesis of Von Domarus (1944) that schizophrenic behavior is characterized by a specialized way of thinking. Under extreme stress, the schizophrenic regresses to a less advanced level of personality integration which entails the Von Domarus principle[2]. Von Domarus (1944: 111) or Arieti (1967:108-112, 274-277) might have drawn the following distinction between "normal thinking" and "schizophrenic thinking" thus: Whereas "normal thought processes" accept identity only on the basis of identical subjects or wholes, the "schizophrenic thought processes" are characterized by their acceptance of identity on the basis of an identical predicate or part in common. This "identification of predicates" leads to a failure to distinguish the class or aggregate from its parts. In the "normal mode" the notion of class and inclusion of classes is all important.

The Von Domarus principle is a particular kind of syllogism which is considered to be invalid.[3] As an example used by Arieti, consider a schizophrenic patient who concludes "She is the Virgin Mary" based upon thinking "The Virgin Mary was a virgin" and "She is a virgin." The argument may be compared to the usual syllogistic reasoning (Mode of Barbara)[4] which would claim "He is a man; All men are mortal; therefore, He is a mortal." Adapting Von Domarus' pictorial representation to our examples, one would have Figure 1.

Bateson, et al. (1956), among others, (Haley, 1963; Watzlawick, et al., 1967, 1974; Sluzki & Ransom, 1976), pioneered a "competing" school of thought on the nature of schizophrenia, which suggests that irresolvable sequences of experiences (referred to as "double-binds") are responsible for the inner conflicts of logical typing in schizophrenia. The double bind is essentially a "lose-lose" situation. There are punishments for both accurate and inaccurate discriminations of self-invalidating behavior which is incongruent between different levels of logical abstraction or aggregation. A "choice" is posed to the "victim" which is no choice and the victim must choose. The victim must be so dependent upon the person or situation posing the double bind that he can neither ignore nor fail to respond to the injunction. (This generally involves questions of power and the survival of physical or personal integrity.) Consider, as an example, the following interaction described by Laing (1965:205):

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 though for a moment you weren't ill, I would be furious with you.

To obey is to disobey---to disobey is to obey. No matter what the response, the child must lose in this paradoxical situation[5]. According to Bateson, et al., the schizophrenic comes to expect double binds and to see the world in terms of them as a means of coping. Feeling continually threatened, the schizophrenic comes, not to deny what he says, but to "deny it in such a way that his denial is denied" (Haley, 1963:92). He engages in "flip-flop" behaviors, choosing first one side of the paradox and then the other, thereby abdicating responsibility for either.

Matte Blanco (1959a, 1959b, 1975) postulates that schizophrenic behavior follows laws of a logic which are different from Aristotelian logic. There are two basic axioms to his characterization of the unconscious (system Ucs) of which, he asserts, that schizophrenic thinking is only an application: (1) the principle of generalization, and (2) the principle of symmetry. According to the principle of generalization, all things are members of classes and every class is a subclass of a still more general class. This results in a hierarchy of classes. The principle of symmetry implies that all relations are symmetrical; thus, the converse of an assymetric relation would be treated as equivalent to that relation. The notion of equivalence is derived from that of a symmetrical relation, as distinguished from that of equality which is derived from an assymetrical relation. Confused use of these terms through the principle of symmetry results in the inability to maintain consistent hierarchical ordering. In the words of Miller, et al. (1960), "A plan is any hierarchical process in the organism that can control the order in which a sequence of operations is to be performed." Thus, application of the principle of symmetry results in a diminished ability to plan and a corresponding loss of control.

These principles are interspersed with normal manifestations, necessitating a sort of "double-bookkeeping" by the schizophrenic patient. Matte Blanco (1959b:93) concludes that for the schizophrenic, as a result of such thinking: (1) there is no succession and, thus, no time; (2) the part is identical to the whole; (3) the members of the class are identical; (4) there is no contiguity and no space, as we know it, due to lack of spacial ordering (in particular, Matte Blanco, 1975:13), "...the unconscious does not know 'inside' or 'outside' and does not know objects."); and (5) a statement is equal to its converse. For example (Matte Blanco, 1975: 39) consider the patient who employs the relation "the body is part of the arm as though identical to its converse relation "the arm is part of the body" in reaching conclusions.

There are numerous disagreements and discussions in the literature concerning which of these models is the correct representation of schizophrenic behavior. We suggest that each is essentially correct and can be viewed in terms of a single model.

SECTION III

In this section we will describe the essentials of three formalisms which are relevant to the development of a more encompassing model of schizophrenic behavior. Each of these formalisms are presented as a variant logic, although it should be noted that there are equivalent representations in lattice theory, group theory, algebra, and geometry. In general, a logical calculus consists of a set of symbols representing propositions, one or more operations, and the laws which the logic obeys. The usual symbolic logic consists of propositions; the operations of negation, conjunction, and disjunction; identity, idempotency, and the laws of associativity, commutivity, and distributivity. In addition to these laws, there is a truth valuation function, which assigns to any proposition the values 0 or 1, depending on whether that proposition is invalid or valid, respectively. We wish to emphasize that the usual symbolic logic is only one example of a logical calculus. We shall consider others.

Zadeh (1965) has introduced the concept of propositions which have a degree of truth instead of being either valid or invalid. Thus, the truth valuation function is usually given as a closed, real line interval with the endpoints labeled as 0 and 1, corresponding to the classical states of absolute invalidity (the absurd proposition) and of absolute validity (the trivial proposition). In the special case, where the truth valuation function is restricted to the endpoints of the interval, the fuzzy logic goes over to the usual Aristotelian logic. The operators of negation, conjunction, and disjunction, are also defined such that the corresponding Aristotelian limits result. In addition, it is necessary that these operations leave the structure or topology of the interval intact. Thus, they are

closed on the open interval (0,1). If the proposition "A and B" is formed from the propositions "A" and "B", the valuation of the compound proposition will be the smaller of the two valuations. Similarly, the disjunction proposition "A or B" is evaluated as the larger of the two. A negation is defined to complement any proposition "A" and denoted "A⊥" such that the sum of the lengths of the two valuations yields the identity valuation of absolute validity. There will exist a unique point, called the hindge or halfway point, such that: (1) the conjunctive valuation of a proposition and its corresponding negation will always be smaller than the hindge, or "not true-directed"; (2) the disjunctive valuation of a proposition or its corresponding negation will always be larger than the hindge, or "true-directed"; (3) if a proposition has a valuation on one side of the hindge, the corresponding negation is valuated at a point located symmetrically about the hindge; and (4) the valuation of the hindge and the valuation of its negation are both equal to 1/2, having their common length precisely mid-way between the 0 length of absolute invalidity and the unit length of absolute validity. In this sense, the upper (true-directed) and the lower (not true-directed) regions are qualitatively different and thus separable. A direction of meaning is thus posited, ordering the logic (Orlov,—).

Consider the statements "Tom likes Jane very much" and "Tom likes Jane very, very much." If the validity of the first statement is 7/10, that of the second might be 8/10. The corresponding negations would then have values of 3/10 and 2/10, respectively. The two statements are thus ordered with respect to each other, and the aggregation of truth values of all statements involving "like" thus form a linear ordered set (Stoll, 1961:49-50) with valuations as real numbers such that their truth valuations are always comparable, ordered lengths.

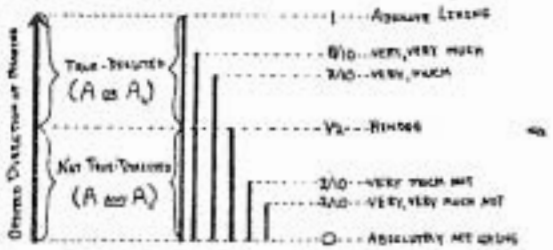


Figure 2: Length of valuation of different fuzzy hedges or qualifiers of the proposition "Tom likes Jane."

Brown (1972) chose to extend the usual truth valuation in a different way. Dealing with paradoxical propositions (Brown, 1972:x-xi), such as "This statement is false", he likens it to the following equation:

$$X = \frac{-1}{X}$$

where the values 1 and -1 represent true and false, respectively. In this equation the choice of either 1 or -1 for X on one side of the equation leads to the opposite value on the other side of the equation—thus the perceived truth valuation oscillates in time. If this equation were solved mathematically, the solution would be

$$X = \pm\sqrt{-1} = \pm i,$$

where "i" represents an "imaginary" unit number (Walker, 1963:29-33). Brown's formalism is characterized by a single definition of distinction and two axioms or laws.

Birkoff and von Neumann (1936) introduced another variation of the standard logic. Unlike the preceding two logics, the quantum logic, which was formulated to expose the logical foundations of the (then) new quantum theory, brought about a denial of the validity of the distributive law (cf. Appendix).

Without entertaining too much of the details of the quantum logic (Finkelstein, 1963, 1968a, 1968b; Jauch, 1968; Putnam, 1968; Von Neumann, 1955:247-254), we will point out some of the essential consequences of this logic. The logic does not treat all concepts, all propositions as compatible. Thus the order of concepts in a proposition is important. This means that the concepts are coupled in some way. Consider, for example, the propositions "Do you like me?" and "Do you love me?" The order in which one asks these questions and experiences the situational frame will often change the answers one gets, since one response can restrict the availability of possible answers to the other. Each imparts a certain psychological set to the individual being questioned. "Love" and "like" are incompatible in this sense. William James noted this complementarity of psychological concepts as early as 1890 (Holton, 1973:140-142). Although quantum logic was introduced to account for the logic of empirical quantum mechanics, it is applicable in some form to many empirical systems.

SECTION IV

In this section we present a representation or formalism which encompasses the essential aspects of the formalisms reviewed in the previous section. Although our application and results may be new, this is essentially not a new formalism, and we attempt to draw upon historical use of the formalism for clarity. The formalism is then partially interpreted to yield a model of some aspects of schizophrenia, with the hope that a complete model is inherent within the GSL formalism.

In particular, we interpret GSL insofar as it is relevant to a synthesis of the models presented in Section II.

Consider the incomplete progression of classical (Aristotelian) logic through the deviant logics of fuzzy set theory, laws of form, and quantum logic. Classical logic starts with a two-valued truth set which fuzzy logic extends to a line-interval with the two values of classical logic as end points. The laws of form incorporates paradoxical statements by allowing a four-valued truth set and quantum logic treats the two-valued truth set via different laws of aggregation (See Figure 3).

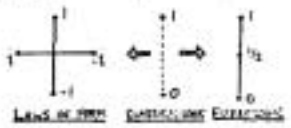


Figure 3: Classical and semi-classical logics.

We seek a coherent unification of this progression. First consider the equation of paradox introduced by Brown (which led to the introduction of i as an additional truth value) in the light of fuzzy logic. Let us perform a one-to-one substitution by using the real line interval (-1, 1) instead of the usual (0,1). In this way, the endpoints correspond to the two real truth values given by Brown. The point zero on this new interval corresponds to the fuzzy logic hindge (1/2). We then treat the equation of paradox as though it were a matrix equation.[6]

$$\mathbb{X}^2 = -\mathbb{1}$$

In this way the solutions of the equation become so-called "eigenvalues" or characteristic values and represent the observable quantities of the system. According to Brown these values are 1, -1, and i.[7] However, it is easy to show that the existence of an eigenvalue i implies the existence of an eigenvalue -i (Goldstein, 1950: 123). In this way we are led to a more comprehensive interpretation of the paradox. This formalism is also consistent with quantum logic. Order dependence is a well-known property of matrix operations. Empirically this implies an incompatibility of the observables which the non-commuting matrices represent.

The matrix formulation is extremely useful in exploring the various properties of this representation. The truth tables for the logic operations of conjunction and disjunction, etc., may be treated as 2 x 2 matrices. Solving Brown's ansatz by means of 2 x 2 matrices leads to three possible solutions, each of which is empirically interesting. The first solution is just the identity multiplied by +i. The second solution is more interesting. This is just Hamilton's quaternions. Pure quaternions are effectively three dimensional rotations with the properties of i; that is, they generate a rotation resulting in a final state which is orthogonal to the initial state (Walker, 1963; Misner, et al., 1970;1135-1141)[8] Pauli introduced something akin to the quaternions in matrix form. In this form they are referred to as spin matrices or bi-spinors. Bi-spinors can be thought of as operators on a space or state expressed as a spinor. Spinors are unobservable but necessary parts of the formalism of quantum mechanics. (They underlie the Pauli Exclusion Principle which gives rise to matter's chemical structure). This formalism allows us to represent an observation as a real magnitude and its negation as an imaginary magnitude, each at right angles to the other (i.e. orthogonal).

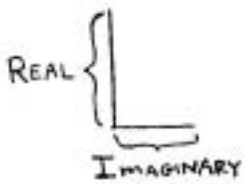


Figure 4: Real and imaginary truth.

The third solution is the so-called Time-Reversal Operator (Wigner, 1959). The Time-Reversal Operator is a special reflection which includes complex conjugation (i.e. it is antilinear). By time we mean that which parameterizes and defines an ordering of the causal structure. The formalism presented so far is thus rich and allows full interpretation in terms of a variation of the usual Aristotelian logic.

Consider as a partial interpretation of the formalism its correspondence to the notion of concepts. Following Brown we treat the process of distinctions as fundamental to concept formation. That is, a concept is formed in distinction to those things which it is not. The concept of "like", for example, may be used only by distinguishing things "liked" from things "not liked." For each such instance, the degree to which the thing is distinguished as "liked" is represented by a length which is a portion of the line segment with endpoints 1 and 0. (This can be obtained from Brown by returning the hindge (cf. fuzzy sets) to 1/2 and normalization). The total length of the segment must be conserved. We say that the portion not distinguished represents the complement -- that which is "not liked." This portion of the segment becomes orthogonal and thus bent by 90 degrees with respect to the distinguished part. Specific examples may be ordered with respect to each other. (Figure 5a):

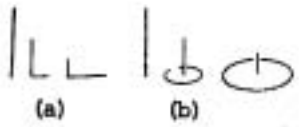


Figure 5: Ordered aggregation: (a) without phase; (b) with phase, as in Figure 6.

The aggregate of all things liked in this sense forms what we mean by the concept of "like." The process of non-distinguished or non-discriminated aggregation introduces a random relative phase between the specific distinguished members of the aggregate. The direction of the phase encodes the direction of meaning. This means that the parts not distinguished are unobservable in the aggregate. Thus each member of the aggregate is equivalent to a spinor. We postulate that concepts behave as spinors (Figure 6):

Figure 6: Alternative phase directions.

The time-reversal operator, as we stated earlier, implies the relative order reversal of the logical implication. This notion has direct consequences with regard to the Von Domarus principle. Consider a so-called Hasse diagram (Lieber & Lieber, 1959) of the propositions "I am a virgin" and The Virgin Mary is a virgin." (Figure 7):

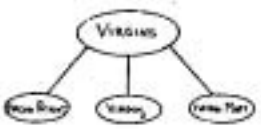


Figure 7: Hasse diagram.

The structure of the diagram is interpreted by saying that elements below and connected imply everything above. Thus the existence of "I" and of "Virgin Mary" imply the existence of "Virgins." The time reversal operator indicates that the direction of implication will be flipped. (Figure 8):

Figure 8: Implication reversal.

Thus, under the operation of the time-reversal operator, both "I" and "Virgin Mary" imply "Virgin" at the class membership level of abstraction. This solution to the paradox can only occur if the non-distinguished aggregate (the span[9] which is a higher level of abstraction) is formed inappropriately, namely, if the span is formed from members of classes and from classes without regard for the difference. Normally, the difference between a class and its member is a strong injunction against such an inappropriate span. Two concepts are at the same level of hierarchical distinction only if either, but not both, could answer a question. In short, the assymmetric implication is treated as a symmetric relation and the causal direction is not discriminated. (Figure 9):

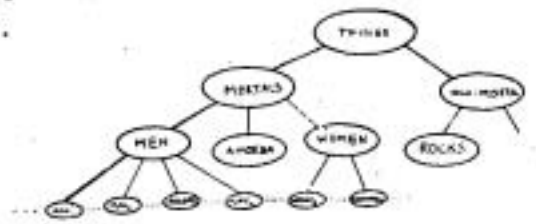


Figure 9: Hierarchical aggregation.

If we consider this interpretation from an experiential point of view, we are led to a description of the double bind. The paradox matrix equation has two states in a complex space as solutions. These solutions are conjugates or complex complements of each other, (e.g. z and $z_\perp$). (Figure 10):

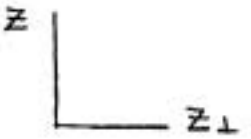


Figure 10: Conjugate solutions.

Paradoxical states result in concepts being treated as real instead of complex. But this is inappropriate since the correct solution to the paradox is in complex space. A non-distinguished state such as "Virgin" is forcibly selected, reducing the class to an unspecified member. Being forced to choose between z and $z_\perp$ and yet being in a state which is neither, z and $z_\perp$ are chosen with equal probability. (Figure 11):

Figure 11: Reducing the class to the member. (This corresponds to equating a plane with a line.)

The true actual experience is a third state, which must exist if no distinction is drawn between z and $z_\perp$, having a component in either but lying along neither. There is a feeling of being torn between two choices neither of which is compatible. In this flip-flop condition, there is no net causal ordering, an effect noted by Matte-Blanco.

V. CONCLUSIONS

The model presented in the previous section contains the essential aspects of the theories of schizophrenic logic presented by Von Domarus/Arieti, Bateson et al., and Matte-Blanco. The reversal of the implication relation is capable of yielding the identification of predicates in the Von Domarus principle as well as the loss of both spatial and temporal ordering. GSL connects the occurrence of the behavior observed by both Von Domarus and Matte-Blanco with the occurrence of a paradox or Double Bind. Thus the theories of Section II are seen not as competing schools of thought but as different views of the same process.

The formalism is not completely interpreted. There is, for instance, reason to believe that the difficulty reported by schizophrenics is directly attributable to a neural disorder--possibly a sensory or perceptual problem. Such might occur through an inappropriately functioning mechanism for encoding, decoding, or filtering neural phase ordering information. This could be responsible for the inability to form a hierarchical plan. Further interpretation will come with a more complete representation and with the interest of those familiar with the intricate behavior of schizophrenics. In this endeavor, we suspect that the phenomenologically distinguishable characteristics of antilinearity (Wigner, 1960) will eventually offer important empirical clarification and understanding of the question "Schizophrenia?"

Acknowledgements: Many people have helped to make Genuine Stupidity Logic possible. A partial list of the people who have made extensive contributions includes: Marvin Adelson, Claude Anderson, Hewitt Crane, Sidney Drell, David Finkelstein, Pierre Noyes, Karl Pribram, Lynn Segal, Richard Steiger, John Weakland, Michael Williams.

FOOTNOTES

1. GSL is proposed as an empirical logic of natural mind.

2. Arieti (1974: 234) states, "The whole field of Freudian symbolism from a formal point of view is based on Von Domarus' principle."

3. We note that the syllogism is considered to be associated with early developmental thought processes both phylogenically and in young children, and as a relatively common unconscious error in "normal" thinking.

4. It was pointed out to one of the authors by Marvin Adelson that the Mode of Barbara probably derives from the following mneumonic: "B/are/bar/A" = "Bar/B/are/A", where "bar", sic. "-", traditionally represents negation. We, thereby, have an encodement of our notion of logical disjointedness which provides an attractive means for expressing the related and relevant notions of compatibility and the distributive law of logic. This is discussed in Jauch (1968: 28).

5. The double bind is closely related to hypnosis except in the latter we can conceive of it as a "win-win" situation. The hypnotist might suggest something like: "Would you like to go into a trance now by raising your left hand, or later when you stand up." Indeed, the double bind hypothesis is an outgrowth of attempting to understand and represent the hypnotic and therapeutic strategies of Milton Erickson (Haley, 1973, 1963).

6. In Heisenberg's formulation of Quantum Mechanics he "just" took observables and transitions and recast them into matrices. As expressed by Born (van der Waerden, 1967: 37) "... And one morning... I suddenly saw light: Heisenberg's symbolic multiplication was nothing but the matrix calculus, well known to me since my student days.... I recognized at once its formal significance. It meant that the two matrix products pq and qp are not identical... that matrix multiplication is not commutative..." From which one grasps the fundamental significance of the indeterminacy principle.

7. Actually, Brown does observe that there are two imaginary roots, but does not fully exploit this differentiation. Empirically, the sign of i specifies the temporal ordering and i posits a temporal superselection rule, which appears to be violated in the formulations of schizophrenia.

8. The work of Cooper and Shepard (1978) and Shepard (1979) indicates that internal representations are mentally rotated in order to form comparisons. In our formulation, although we are using a complex or Hilbert Space and rotations are called unitary transformations. The complex formulation allows us to use the more fundamental, simply connected, covering group SU(2,C) instead of the traditional orthogonal rotation group O(3,R).

9. In quantum mechanics one treats distinguished observations logically dif-

ferently than non-distinguished ones (Feynman, 1963:Ch. I; Putnam, 1968; Finkelstein, 1963, 1968a, 1968b).

10. What we mean by empirical truth is quite specific: (1) we agree upon a collection of questions; (2) we agree upon criteria by which observations pass the test of the questions; and (3) we ask the questions of the observation set. Empirical truth is distinguished by whether or not the answers satisfy the agree upon criteria.

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APPENDIX

The Stern-Gerlach Experiment and the Fracture of Classical Logic

In the early part of the century, an experiment was performed by Stern and Gerlach in which a beam of sliver atoms carrying the spin of a single electron is passed through an inhomogeneous magnetic field with gradient. This experiment is sufficient to derive the transformation properties of 1/2-integral spin matter, such as electrons and nucleons (Feynman, 1962; Feynman et al., 1963:Ch.1-5). The beam is split into precisely two separate beams which are either in the direction of the gradient of the magnetic field or opposed to it. (This is not a statistical effect and can be done one atom at a time.)

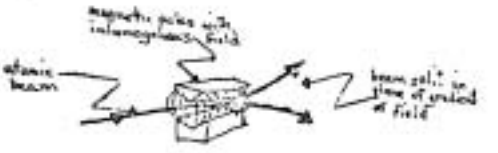
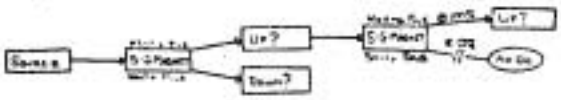


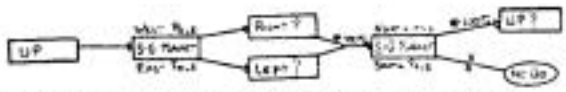
Figure 12: Stern Gerlach Magnet separating the beam into two beams.

If the initial beam was alined, say, vertically, we could call the beams Up and Down. If we should select out Up and subject this known beam to a second Stern-Gerlach apparatus which has its gradient alined horizontally, thereby allowing only

a Right or Left determination, it is empirical truth[10] (always the observed case) that:

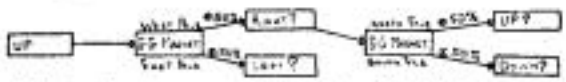


(1) Up is true, and Up is true.



(2) Up is true, and (Right or Left) is true.

It is empirically false that:



(3) Up is true and Right is true.

(4) Up is true and Left is true.

The distributive law of classical logic asserts that it is always true that

A and (B or C) = (A and B) or (A and C).

Upon substituting the empirical data we find (with obvious abbreviations)

U and (R or L) $\stackrel{?}{=}$ (U and R) or (U and L)

T and T $\stackrel{?}{=}$ F or F

True $\neq$ False

False

We are forced to conclude from the "non-classical two-valuedness" that the distributive law of classical logic is empirically violated. It is replaced by the principle of complementarity: If two constructs are not-distinguished, there will always be a third within the span such that non-distinguished aggregates of any pair will be equal to the span (Finkelstein, 1963, 1968a, 1968b).

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