A LOGICALLY CONSISTENT MODEL OF A WORLD WITH PSI INTERACTION

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I. INTRODUCTION

With the accumulation of evidence for precognition, psi research became somewhat confusing for the experimenter and theorist alike. It appeared that the future could affect the present directly, in a manner quite inconsistent with our notions about the order of nature in terms of cause and effect. Thus, experimental parapsychology indicated the inadequacy of our concepts of world order, but it did not show which kind of new ordering principle should replace the old one.

The present paper is concerned with the search for such a new ordering principle. No attempt is made, however, to develop a complete theory of psi. The goal is rather a more modest one: to present a very simple model of a "world" with psi-like features, in the hope that the study of this and of similar models will lead to a better theoretical understanding of some aspects of psi and may be helpful for the formulation of some later theory.

The model contains "psi sources" which display essential features of successful test subjects. The properties of the psi sources are axiomatically specified in mathematical form and no attempt is made to reduce these properties to some underlying "mechanism." The guiding principle for formulating the axioms for the properties of psi sources and their interaction with the rest of the world was the requirement of mathematical simplicity, a requirement which has been proved very successful in physics as a guide into areas which are not accessible to our everyday common-sense experience.

II. THE CONVENTIONAL CONCEPT OF A STATISTICAL WORLD

Quantum theory suggests that nature is partly governed by pure chance in the sense that the present state of the world does not uniquely determine the future world history but that rather very many possible future histories are consistent with a given present state. Quantum theory gives specific prediction concerning the probability that a particular world history is realized. We will assume the general statistical viewpoint of quantum theory but, with the introduction of "psi sources" in the next chapter, we will slightly modify the prescription of quantum theory for calculating the statistical weight of a particular world history.

In the present chapter, we remain within the bounds of conventional physics. We will introduce some "devices" which are helpful for later discussions and we will give a few examples for worlds with different possible histories.

A. Random Generators

Consider a device with one trigger input and N signal outputs. Assume that, upon triggering, one of the outputs is randomly selected, the output i with the probability p_i, to emit an output signal (e.g., a short electrical pulse). Let the selection be based on some quantum process with N possible outcomes, so that the selection is indeterministic in the current understanding of quantum theory. Such a device, a (discrete) random generator, is used in many psi tests as a source of randomness, and the random processes occurring in nature can be described, at least in good approximation, in terms of assemblies of discrete random generators.

B. The Concept of a World Structure with Many Possible Histories

Let us apply the term world structure to a system whose interaction with the rest of the world can for the present purpose be neglected and for which some initial or boundary conditions are given. A world structure, for example, might be specified by an experimental setup and a prescription how to perform the experiment. Then, for a world structure, there may exist several possible world histories corresponding to the different possible outcomes of the experiment.

As a simple example for a world structure, take an isolated system which contains the mentioned random generator and a device which triggers the generator at some time T_0. This world structure has N possible histories which can occur with the probabilities $p_1,\ldots,p_N$. Figure 1 gives a graphical representation of this world structure with the N possible histories represented by different paths. The broken triangle represents the random generator, the line entering at the left symbolizes the arriving trigger signal (the time axis runs from left to right), and the outgoing lines at the right represent the N

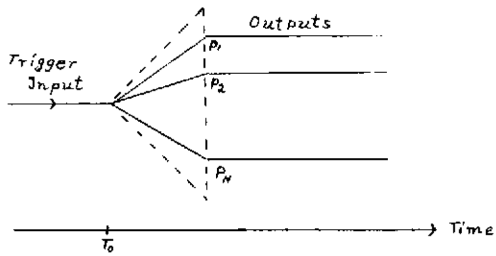

Figure 1. Representation of a random generator with N outputs. Upon a trigger signal at time T_0, one of the outputs emits a signal with an associated probability p_i. This is an example of a system with N possible histories.

possible outcomes of the random process. We may visualize these lines as wires carrying the trigger signal and the output pulses, respectively.

A slightly more complex world structure, with three binary random generators RG1, RG2, and RG3, is indicated by Fig. 2. RG1 is triggered at time T_1. Depending on the outcome of the random process, either RG2 or RG3 is triggered at a later time in the particular world history. This world structure has four possible histories with the probabilites p_1p_3, p_1q_3, q_1p_2, and q_1q_2, respectively. The heavy line in Fig. 2 represents the particular history with the probabilities p_1q_3, where RG1 decides for the upper channel (probability p_1) and the consecutively triggered RG3 decides for the lower channel (probability q_3).

Let us introduce in connection with this example some general terminology. A particular random generator may or may not

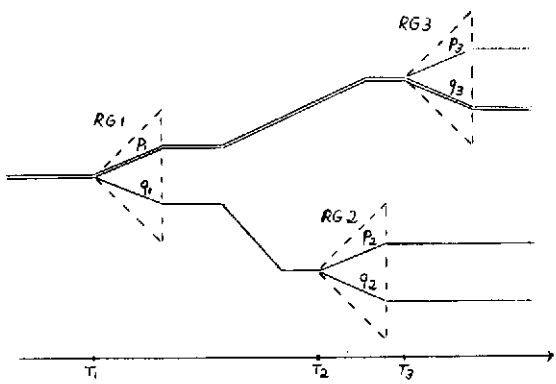

Figure 2. An example of a more complex world structure. A binary random generator RG1 is triggered at some time T_1 and depending on the outcome of the random process either RG2 or RG3 is triggered at some later time. The heavy line indicates a particular one of the four possible histories.

"participate" in a specific world history. If it participates it can do so in several "modes," corresponding to the different possible outcomes of the random process. Let us call the probability of a particular outcome the "weight" of the corresponding mode. Then the probability of a particular history to occur equals the product of the weights of the modes of the participating random generators.

C. Experimenters and Other Devices

In order to obtain a well-defined and logically consistent world model, let us consider the human experimenters as "devices" with well-specified properties. Human experimenters are able to record and evaluate observations, to make subsequent logical decisions, and to execute the decisions by changing the course of an experiment. Thus, a model of an experimenter should include recording devices to register experimental results, computers to make logical decisions, and "program switches" which execute decisions by rearranging the experimental setup, flipping switches, etc.

Some decisions made by the experimenter intuitively rather than according to some rigid logic pattern may depend on chance factors. Thus, a realistic model of an experimenter should also include some random generators. In addition, we might want to include, later, "psi sources" into the experimenter model, since a "psychic" effect due to the experimenter cannot always be neglected.

D. Example of a Program Switch

Situations where the future of an experiment depends on previous test results or on other experimenter decisions can be discussed conveniently with the help of program switches. Let us discuss here the "basic switch" which will be used in later discussions. We represent the basic switch by a rectangle with two inputs at the left, two outputs at the right, and two trigger inputs marked 0 and 1 [Fig. 3(a)].

The basic switch has two possible positions, the "straight" position which is assumed initially and whenever the most recent trigger signal arrived at the trigger 0 input and the "crossed" position which occurs whenever the most recent trigger signal arrived at the 1 input. In the straight position, an input signal at *a* or *b* leads to an output signal at *a'* and *b'*, respectively, while in the crossed position an input signal at *a* emerges at *b'* and an input signal at *b* comes out at *a'*. Figures 3(b) and 3(c) indicate the internal connections for the two cases.

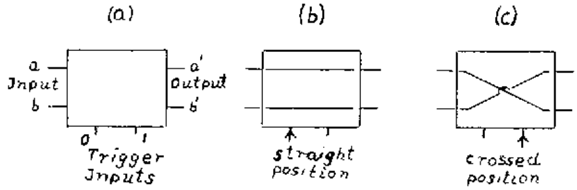

Figure 3. (a) The basic switch. (b) Internal connection in the "straight position" which is assumed after a trigger input at 0. (c) Connections in the "crossed position" assumed after a trigger input at 1.

III. PSI SOURCES

We assume for our world model the existence of "psi sources" which have the essential features of somewhat idealized successful PK subjects. We will specify the properties of the psi sources by the "psi axiom" in mathematical form and make no attempt to reduce these properties to some underlying "mechanism." The guiding principle for formulating the psi axiom will be the requirement of mathematical simplicity, which has been proved in physics very successful as a guide into areas outside our everyday experience.

Let us introduce the concept of a psi source in connection with a specific example. Consider a binary random number generator with two output channels (*a*) and (*b*) with the associated probabilities p and q. If the generator is triggered in the absence of a psi effect, a signal is emitted through (*a*) or (*b*) with the probabilities p and q respectively (Fig. 4).

Next let a PK subject, whom we will call the "psi source," be linked to the generator in such a manner that with every *a*-output signal from the random generator, the subject receives a rewarding input signal, whereas a *b*-output signal from the random generator has no effect on the subject. In the case of a human subject who is instructed to enforce a high rate of *a*-outputs this rewarding input signal could be simply a success indicator, and for an animal the input signal might consist in the administration of food, warmth, or some other reward.

Many experiments with human subjects have shown that under such conditions the relative frequency of *a*-outputs from the generator may be systematically increased so that the presence of the subject (the psi source) changes the output probabilities of the generator from p, q into p', q' with $p' > p$.

Then we can introduce a quantity θ, which we call the strength of the psi source, so that

$$p'/q' = \theta p/q \qquad (1)$$

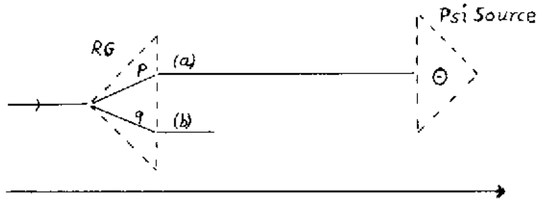

Figure 4. A typical PK experiment with a binary random generator. The psi source can be a human subject or an animal connected to some stimulator which is activated by an input signal.

which implies (because of $p + q = p' + q' = 1$)

$$p' = \frac{p\theta}{p\theta + q}, \qquad q' = \frac{q}{p\theta + q}. \tag{2}$$

In the case of a positive PK effect we have $\theta > 1$, and in the case of PK missing we would have $0 \leqslant \theta < 1$.

In the framework of the present model, we will assume that each psi source has an associated "strength" θ and that this strength is a constant, as the p_i values of a random generator are constants determined by the internal structure of a generator. We will, thus, for the present, disregard changes of the θ value as they may occur in human and other subjects as a result of fatigue, encouragement, etc.

In order to emphasize the mathematical simplicity of our model, let us introduce psi sources in an axiomatic manner. So far, we have defined one type of random device, random generators. We have seen that a random generator may participate in a history in one of several modes with an associated weight or it may not participate (depending on whether or not the device receives a trigger signal during the particular history).

Now we introduce "psi source of strength θ" as a random device with only one trigger input. Depending on whether the device is triggered during a history or not, it participates in the history or does not participate.

Next, let us define the statistical weight of a world history as the product of the weights of the modes of all the participating random devices, where a participating psi source of strength θ has an assigned weight θ. The two possible histories in the previous example (Fig. 4) assume then the weights $W_1 = p\theta$ and $W_2 = q$, respectively.

In the presence of psi sources the weights $W_1, \ldots, W_n$ of the different histories can no longer be interpreted as probabilities since ΣW_n may differ from 1. We can, however, still consider the weights as measures for the relative probabilities of the different world histories. This is the essence of the following psi axiom.

A. The Psi Axiom

This axiom specifies how devices with one trigger input, which we call psi sources, interact with the rest of the world.

In order to formulate this interaction, we define the weight W_n of a world history as the product of

(1) The weights of the modes of the participating random generators (as in conventional physics)
(2) The strength factors θ associated with the participating psi sources. (Here each psi source is understood to participate whenever it is triggered so that a particular source can participate repeatedly in a history, contributing each time a factor θ to the weight).

Now we postulate that the probabilities P_n for the occurrence of the individual histories are proportional to the associated weights W_n, i.e.,

$$P_n = W_n/W \qquad \text{with} \qquad W = \sum W_n. \tag{3}$$

In the following, we will explore the implications of the psi axiom, i.e., we will study systems which contain psi sources besides conventional components.

B. A Simple Example: Addition of PK Effects

Consider a world structure [Fig. 5(a)] where a number N of psi sources with strengths $\theta_1, \theta_2, ..., \theta_N$ are coupled to a binary random generator (p,q), so that all psi sources are triggered if and only if the random generator decides for the output a.

The weights of the two possible world histories are

$$\begin{aligned} W_a &= p\theta_1\theta_2\cdots\theta_N \\ W_b &= q \end{aligned} \tag{4}$$

and according to the psi axiom, the probability for a signal to appear at a rather than b becomes

$$P_a = \frac{p\theta_1\cdots\theta_N}{q + p\theta_1\cdots\theta_N}. \tag{5}$$

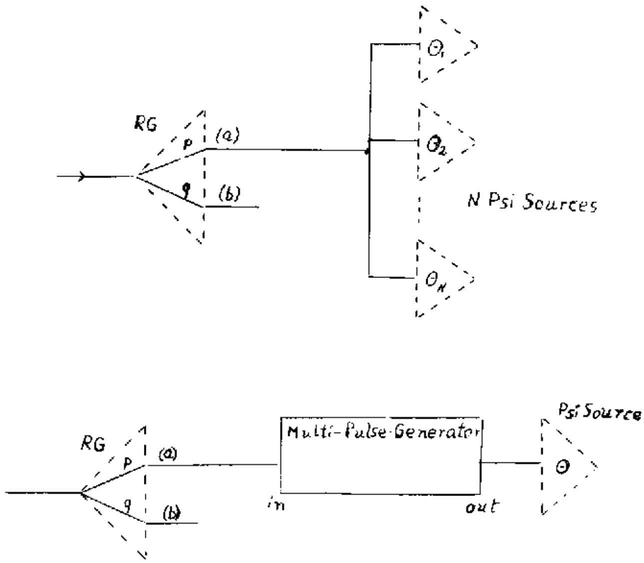

Figure 5. Increase of the PK effect by simultaneous triggering of many psi sources (a), or by repeated triggering of one psi source with the help of a multipulse generator which emits M output pulses for each input signal (b).

In the case of a weak psi source, we can write

$$\theta_i = 1 + 2\epsilon_i \qquad \text{with} \qquad |\epsilon_i| \ll 1. \tag{6}$$

If, furthermore

$$\sum_{i=1}^{N} |\epsilon_i| \ll 1, \tag{7}$$

we can approximate

$$\theta_1 \cdots \theta_N = (1 + 2\epsilon_1)(1 + 2\epsilon_2) \cdots (1 + 2\epsilon_N) \approx 1 + 2 \sum \epsilon_i. \tag{8}$$

From Eqs. (5), (7), (8) we obtain

$$P_a \approx p(1 + 2q \sum \epsilon_i) = p + pq \sum (\theta_i - 1), \tag{9}$$

which expresses the linear superposition of weak PK effects, whereas Eq. (5) gives the superposition in the general case.

In the framework of our formalism, an addition of PK effects can also be observed and utilized in connection with a single subject. In the setup of Fig. 5(b), each a-output of a binary generator (we assume $p = q = ½$ for convenience) triggers a multipulse generator to administer a sequence of M stimuli to the subject. Then each history with the signal emerging at a rather than b obtains an additional weight factor θ^M and the new output probability for side a of the generator becomes

$$\tilde{p} = \theta^M/(1 + \theta^M). \tag{10}$$

By this method of multiple stimulation, the efficiency of a PK test can be increased without an increase of the average number of stimuli administered to the subject. To demonstrate this consider, for say the case of a weak PK source ($\theta = 1 + 2\epsilon$ with $|\epsilon| \ll 1$), the following two situations:

(1) In a usual PK test indicated by Fig. 4, the generator (with $p = q = ½$) is triggered $N = MS$ times. Then for a weak source,

$$\theta = 1 + 2\epsilon \qquad \text{with} \qquad |\epsilon| \ll 1, \tag{11}$$

the probability for an a-output becomes

$$p' = \theta/(1 + \theta) = ½(1 + \epsilon), \tag{12}$$

and the expected average CR value which measures the statistical significance of the test in demonstrating the existence of PK is

$$CR_1 = N(p' - ½)/(¼N)^{1/2} = \epsilon N^{1/2}. \tag{13}$$

(2) In the test situation indicated in Fig. 5(b), let the generator be triggered S times, with

$$N = MS. \tag{14}$$

In this case, each output at a causes the administration of M successive stimuli to the subject, so that again the average number of administered stimuli is, in the absence of PK, $N/2$. For each of the S trials, the probability of an a-output is [Eq. (10)]

$$\tilde{p} = \theta^M/(1 + \theta^M) = ½(1 + \epsilon M) \qquad \text{for} \qquad |\epsilon M| \ll 1. \tag{15}$$

Therefore, the expected CR value in this experiment is

$$CR_2 = S(\tilde{p} - ½)/(¼S)^{1/2} = \epsilon MS^{1/2} = M^{1/2}\epsilon N^{1/2}, \tag{16}$$

i.e., CR_2 is by a factor $M^{1/2}$ larger than CR_1 which means that the second experiment is M times more efficient than the first one.[1]

C. A Further Example: Branching Ratios

Consider the case (Fig. 6) where a ball rolls down a chute, hits a divider, and is deflected to the left or to the right with the probability p_1 and q_1, respectively. Let there be another divider in the left branch so that an arriving ball takes the left or the right path with the probability p_2 and q_2, respectively. Then, the ball can follow three different histories with the weights

$$
\begin{aligned}
W(A) &= p_1 p_2, \\
W(B) &= p_1 q_2, \qquad (17) \\
W(C) &= q_1.
\end{aligned}
$$

Assume next that a PK subject tries to force the ball into path A and that the subject learns only whether he succeeded or not (but not whether, in a case of a miss, B or C was chosen). Then the presence of the PK source (the subject) may change the weight of a hit-history or a miss-history by some factor θ_+ or θ_-, respectively, so that the new weights are

$$
\begin{aligned}
W'(A) &= p_1 p_2 \theta_+, \\
W'(B) &= p_1 q_2 \theta_-, \qquad (18) \\
W'(C) &= q_1 \theta_-.
\end{aligned}
$$

This gives for the probabilities of the three histories

$$
\begin{aligned}
P'(A) &= p_1 p_2 \theta / W, \\
P'(B) &= p_1 q_2 / W, \qquad (19) \\
P'(C) &= q_1 / W,
\end{aligned}
$$

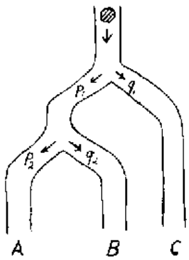

Figure 6. Test for PK effect on branching ratios. At each fork a random process determines whether the down rolling ball goes to the left or the right.

with

$$\begin{aligned} W &= p_1 p_2 \theta + p_1 q_2 + q_1, \\ \theta &= \theta_+/\theta_-. \end{aligned} \tag{20}$$

It is seen in particular that in this situation, where the subject cannot tell the difference between the two histories B and C, the ratio $P'(B){:}P'(C)$ is unchanged by the PK effort.

A change in this ratio might, however, occur through an experimenter PK effect, even if, during the test, the experimenter is kept as blind as the subject and only in the later analysis learns how often the individual paths B and C were chosen.

One could easily give a large number of interesting branching experiments where the branching ratios could be measured and compared with the prediction of our model.

D. The Divergence Problem

The space-time independent formulation of the psi axiom leads to a typical difficulty: The outcome of a PK test does not only depend on the overt PK subject but also on all the observers who look, no matter how much later, at the results, provided these observers can exert some PK effect. At first, one might hope that the effects of these later observers might cancel out if there are PK hitters and PK missers among them. A quantitative study within our formalism shows, however, that this is not the case: If there is a sufficiently large number of later observers who act as PK sources, then, even though their first-order PK effects may cancel out, there is a nonnegligible psi background noise left which can wipe out all efforts of even an exceptionally high scoring subject.

For the present discussion of our model, we will circumvent this difficulty by considering world histories during finite time intervals and by assuming that at the end of these intervals the psi sources are "turned off" so that PK influences by later observers vanish.

The divergence problem may suggest that the assumption of complete space-time independence of psi is an oversimplification but a quantitative comparison between the predictions of our model and experimental observation may give more specific information on the limits of the model.

To demonstrate the divergence problem explicitly, consider an experiment where a coin is flipped ($p = q = ½$) and a PK subject S (with $\theta > 1$) tries to obtain a head (side a of coin). Let there be a number $(N - 1)$ of observers, $S_2, \ldots, S_N$, which act as PK sources of strengths $\theta_2, \ldots, \theta_N$ [Fig. 5(a)]. Then we can use Eqs. (4) and (5) to calculate P_a/P_b, where P_a and P_b are the probabilities for a head or a tail, respectively:

$$P_a/P_b = \theta_1\theta_2\cdots\theta_N = \theta_1 e^S, \tag{21}$$

where we have introduced

$$S = \ln\theta_2 + \cdots + \ln\theta_N. \tag{22}$$

Then we can write Eq. (5) as

$$P_a = \frac{\theta_1 e^S}{1 + \theta_1 e^S}. \tag{23}$$

If the average PK effects from $S_2, \ldots, S_N$ do not favor one side, the statistical distributions of $\theta_2, \ldots, \theta_N$ and of $1/\theta_2, \ldots, 1/\theta_N$ are equal, i.e., the values $\ln\theta_i$ are statistically distributed symmetrically to the origin and for $i > 1$, $\langle \ln\theta_i \rangle_{av} = 0$. (Note that two sources, S_2 and S_3 with $\theta_3 = 1/\theta_2$, i.e., with $\ln\theta_2 = -\ln\theta_3$, correspond to PK effects of equal magnitude on side a and b, respectively.)

Let us assume that the sources $S_2, \ldots, S_N$ are weak, i.e.,

$$\begin{aligned} &\theta_i = 1 + 2\epsilon_i \quad \text{with} \quad |\epsilon_i| \ll 1 \quad \text{for} \quad i = 2, \ldots, N, \\ &\ln\theta_i \approx 2\epsilon_i. \end{aligned} \tag{24}$$

Then, for large N, the random variable S is normally distributed with

$$\begin{aligned} \langle S \rangle_{av} &= 0, \\ \langle S^2 \rangle_{av} &= 4(N-1)\langle \epsilon_i^2 \rangle_{av}. \end{aligned} \tag{25}$$

This gives for the distribution density function $P(S)$

$$P(S) = \frac{1}{(2\pi)^{\frac{1}{2}}\sigma} e^{-S^2/2\sigma^2} \quad \text{with} \quad \sigma^2 = 4(N-1)\langle \epsilon_i^2 \rangle_{av}. \tag{26}$$

From Eqs. (23) and (26) we obtain the average frequency for heads

$$\langle P_a \rangle_{av} = \int_{-\infty}^{\infty} dS \frac{1}{(2\pi)^{\frac{1}{2}}\sigma} e^{-S^2/2\sigma^2} \frac{\theta_1 e^S}{1 + \theta_1 e^S}. \tag{27}$$

If there is no PK contribution from the observers, $\sigma = 0$, then we again have

$$\langle P_a \rangle_{av} \rightarrow \theta_1/(1 + \theta_1) \quad \text{for} \quad \sigma \rightarrow 0, \tag{28}$$

but in the other extreme case that σ is very large, Eq. (27) gives

$$\langle P_a \rangle_{av} \rightarrow 1/2 \quad \text{for} \quad \sigma \gg |\ln\theta_1|. \tag{29}$$

Thus, in the second case, the randomly distributed PK effects of a very large number of observers who are present during the test or study the test result later, can cancel out any PK success the subject would have in the absence of such observers.

IV. GENERAL IMPLICATIONS OF THE PSI AXIOM

A. Irrelevance of the Complexity of the Random Generators

In our formalism, the physical structure of a random generator determines the numbers p_i, the output signal probabilities in the absence of psi sources. Thus, the p_i's are constants for each generator. In a similar way, a constant θ, the strength factor, is assigned to each psi source.

If we couple random generators and psi sources, then, according to the psi axiom, the probabilities for the different world histories to occur are determined completely by the p_i and θ values of the participating devices. Thus, apart from the p_i values, the internal structure of a generator is irrelevant for the effect of the psi sources.

The following experiment was made to check this implication:[2] Two binary random number generators of different degrees of complexity were used to activate a light display which the subject tried to influence mentally. In part of the trials the simpler generator and in the other the more complex one were connected to the display panel and neither subject nor experimenter knew which of the generators was momentarily in action. This precaution served to avoid the formation of a psychological bias in favor of one generator. The scoring rates on the two generators were sufficiently similar to be consistent with complexity-independent scoring.

Whereas the original psi axiom considers the strength θ of a psi source as constant, it is in many cases like the previous one more realistic to allow for some dependence of θ on the physical and psychological test conditions. We can generalize our model easily in this respect: We assume that θ is uniquely determined by the physical and psychological conditions but the model makes no prediction about this dependence.

B. PK and Other Forms of Psi

By applying the psi axiom to different world structures, i.e., to different assemblies of psi sources and other more conventional devices, we can study a large variety of seemingly different phenomena which parapsychologists might term PK, precognition, clairvoyance, etc.

We have seen already how a psi source can display essential features of a successful PK subject. Let us show next how with the help of a psi source we can build a device which has the properties of a successful ESP subject.

Figure 7 shows a "circuit diagram" of such a device, which we will call the "paragnost," with two inputs (A, B), two corresponding outputs (A', B'), and a trigger input. The internal components of the paragnost are, apart from signal lines, a binary random generator with $p = q = \frac{1}{2}$, a basic switch (described in II.D), and a psi source.

Let us first discuss the function of the paragnost in the setting of Fig. 7, where the outputs of a binary random generator (with output probabilities p, q) lead to the paragnost inputs, and where the output signals of the paragnost are automatically recorded. We will assume a test situation where at some time $T = 0$, the paragnost trigger input is activated and at some later time $T > 0$, the external random generator is activated to send a signal into the paragnost input A or B.

The triggering of the paragnost at $T = 0$ produces an immediate output signal at A' or B', whereas the input signal at A or B arrives at some later time T.

The world structure of this test situation has four possible histories corresponding to the two possible output signals (A' or B') and the two possible input signals (A or B).

From the psi axiom, we obtain for the weights of the corresponding histories

$$W(A,A') = \tfrac{1}{2}p\theta, \qquad W(A,B') = \tfrac{1}{2}p,$$
$$W(B,B') = \tfrac{1}{2}q\theta, \qquad W(B,A') = \tfrac{1}{2}q \tag{30}$$

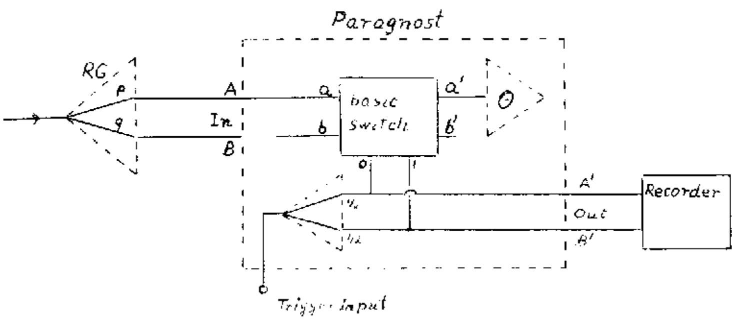

Figure 7. Three components, a binary random generator, a basic switch, and a psi source form the "paragnost" (inside the broken rectangle) with inputs A, B, corresponding outputs A', B', and a trigger input. The paragnost is connected to a random generator whose outputs are to be predicted and to a recorder which registers the prediction.

which gives for the probabilities of the four histories

$$P(A,A') = p\theta/(1 + \theta), \qquad P(A,B') = p/(1 + \theta),$$
$$P(B,B') = q\theta/(1 + \theta), \qquad P(B,A') = q/(1 + \theta). \tag{31}$$

We see that for $\theta > 1$, the location of the output signal (A' or B') is positively correlated to the location of the later arriving input signal (at A or B).

Let us call the cases where inputs and outputs appear on corresponding channels a success situation (hit) and the other cases a miss situation. Then the probabilities for a hit or a miss are

$$\text{Prob(Hit)} = P(A,A') + P(B,B') = \theta/(1 + \theta),$$
$$\text{Prob(Miss)} = P(A,B') + P(B,A') = 1/(1 + \theta). \tag{32}$$

Thus, for $\theta > 1$, the paragnost gives advance notice about the outcome of a later random event, just like a successful subject in a "precognition test" with an electronic random number generator.[7] In our model, as in the experimental test situation,[3] it is not reasonable to distinguish whether the subject did "really" use precognition to guess the outcome of the random event or used PK to make the outcome conform to the prediction.

Human test subjects have been known to score successfully not only under the mentioned condition where the targets are provided by a random generator which is subject to PK effects but also in cases where the targets are prerecorded from random number tables so that PK is excluded, whereas clairvoyance as alternative to precognition enters. Experiments with human subjects did not show significantly different scoring rates under the two conditions[3,4] although more extensive comparison tests might still be desirable.

Let us see how our paragnost scores under this new condition. Assume that the external random generator in Fig. 7 is replaced by some deterministic device which activates the inputs A and B, according to some prerecorded binary sequence.

Consider first the case where the next signal is bound to come through A. For this situation, we have two possible histories with the (easily calculated) probabilities for a hit or a miss, respectively,

$$P(A'|A) = W(A,A')/[W(A,A') + W(A,B')] = \theta/(1 + \theta),$$
$$P(B'|A) = W(A,B')/[W(A,A') + W(A,B')] = 1/(1 + \theta). \tag{33}$$

This gives the same value for the hit probability as before and the same holds true for the case that the signal enters through B.

Thus, we see that the paragnost operates with the same scoring rate (hit probability) no matter whether the targets are generated during the experiment by a random generator or whether the targets are taken from prerecorded random number tables or from any other deterministic generator.

As a last example, let us show how we can make the paragnost perform a PK task. Figure 8 gives the experimental setup. The basic switch in front of the paragnost provides that the paragnost can succeed (i.e., input corresponds to output) if the external random generator emits a signal through a. Then the paragnost always succeeds since an output through A' or B' sets the basic switch into the straight or the crossed position, respectively, and the input signal reaches the paragnost at A or B, respectively. Similarly, the paragnost always scores a miss when the generator activated a b output. Thus, qualitatively speaking, the paragnost's tendency to succeed can be realized only by an increased output of a signals.

Using the psi axiom, we find for the total weights of the two hit histories and the two miss histories

$$\begin{aligned} W(\text{Hit}) &= \tfrac{1}{2}[W(A,A') + W(B,B')] = \tfrac{1}{4}\theta, \\ W(\text{Miss}) &= \tfrac{1}{2}[W(A,B') + W(B,A')] = \tfrac{1}{4}, \end{aligned} \tag{34}$$

which gives for the hit probability, i.e., for the appearance of a signal at a

$$\text{Prob(Hit)} = \theta/(1 + \theta), \tag{35}$$

i.e., we have the same scoring rate as in the situation of Fig. 7.

This raises the question whether, again, human subjects seem to behave like the paragnost and score equally under the two conditions. A look at Figs. 7 and 8 shows that we can make the two tasks appear identical to the subject so that a psychologically unbiased comparison is possible. In a typical test, the subject would be faced by a panel with two pushbuttons (to give the output signals A' and B') and two corresponding lamps to display the (later) inputs to the subject. The subject would be asked in either case to predict (and to register the prediction by the pressing of a button) the lamp to be lit next.

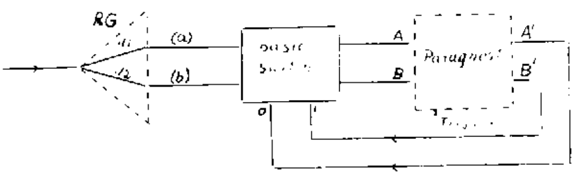

Figure 8. Paragnost in a PK test arrangement.

Such a comparison test has been reported previously.[5] The only difference was that a four-choice random generator (with a correspondingly modified basic switch) was used. The statistically highly significant results did not suggest any scoring difference between the two conditions, i.e., the human subjects did indeed seem to behave like the paragnost.

From the last example where the paragnost performed a PK task, we can conclude that the paragnost and the psi source are equivalent: Even though primarily the functions of the psi source and the paragnost seem to resemble more the functions of a PK or ESP subject, respectively, the paragnost, in connection with other conventional components, can form a psi source just as the psi source together with other conventional components could form the paragnost.

C. Space-Time Independence of Psi and PK Effects on Past Random Events

The psi axiom makes no reference to either the spatial separation between random generator and psi source or the time lag between the random event and the arrival of the corresponding signal at the psi source. In this sense, our model provides a space-time independent description of psi. In view of the divergence problem mentioned earlier, it seems particularly important to study this space-time independence experimentally.

A simple example of such an experiment is provided by a modification of the basic PK experiment of Fig. 4. Instead of sending the output signal from the random generator directly to the PK source, we can store the signals, say, on an ordinary tape recorder and then we can at some later time (and, if desired, at some distant location) play the signals from the *a* output back, to trigger the stimulator for the subject. Experiments with human subjects have shown that PK effects do occur under such conditions.[6]

This possibility of PK action with time displacement, where the subject's effort or the transmission of the stimulus to the subject occurs after the random process has happened, opens many new possibilities which are yet to be explored experimentally.

V. CONCLUSION

The discussion was based on the working hypothesis that the fundamental laws of nature are mathematically simple and that in particular the often complex appearance of psi results from an interplay between a simple psi principle and the complex brain.

The main objective was to develop some model within which psi-like phenomena could be discussed in a logically consistent manner. Such a model could be derived from a mathematically extremely simple psi axiom. This axiom was formulated in terms of psi sources, i.e., structures with axiomatically defined properties. A close analogy to these simple psi sources seems to be given by primitive animals performing in an animal PK experiment.

At the present stage, the model could not be expected to give an accurate description of psi, but only to serve as a basis for further theoretical and experimental studies. Yet, the model displays a large number of features of the observed psi effects and it is not yet clear where the model disagrees with experimental evidence. Among the experimentally testable implications which might serve as a sensitive test for the model are an addition theorem for PK effects and a large group of phenomena associated with PK effects under time displacement, where the random effect occurs before the subject comes into play. Whereas the existence of such an effect has been recently confirmed, its finer details and possible applications still have to be explored.

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DISCUSSION

BEAUREGARD: I think this is an extremely interesting contribution, which goes in the direction of establishing the underlying identity between precognition and psychokinesis in this sort of phenomena. But I want to note that what you are calling a psi source acts in fact on what happens before. Therefore, it seems to me that it is much more a sink than a source.

SCHMIDT: That is a terminological point. Perhaps I could not find a neutral name.

BEAUREGARD: It seems to be a significant point, particularly because it looks very much as if you were using advanced waves.

TARG: There is feedback around that psi source. The output of the psi source should be connected to the input of the generator. The way I viewed and designed such an apparatus, I made that as a feedback loop.

BEAUREGARD: But it may work even if you do not have any feedback at the source, because the source will know about it later on through direct personal contact. In such a case, the psi source really acts as a sink.

SCHMIDT: Your viewpoint of my psi source acting as a psi sink may be very helpful, but I am somewhat hesitant to introduce at this stage any intuitively suggestive terms.

BEAUREGARD: Another point, which I have already made, is that you weigh the natural probabilities, and this means is essence that you are using Bayes's conditional probability formula.

SCHMIDT: That is correct. The important element is *how* I weigh the probabilities.

BASTIN: May I just ask you what is a world history? Is it an observer-centered motion? I mean does your scheme have an observer who assesses what the history really is? Could it be the same as another person's world history?

SCHMIDT: I can discuss the logical consistency and the experimental implications of the model without going into the question of whether there exists one objective reality and what role the experimenter plays. The model gives, like current quantum theory, predictions about the outcome of experiments. In order to define reality, I place macroscopic recording devices throughout the world and can define their readings as the objective reality.

BASTIN: Could you? I thought you were in fact saying, one person could have a world history in which William the Conqueror came in 1066. Another one would say, "No, sorry, old boy, that's not part of my world history." So you would not have an automatic objective background.

SCHMIDT: The model is logically consistent with the concept of one objectively real world, but it is equally consistent with Everett's picture of many equally real parallel worlds.

BASTIN: I was not particularly concerned with the logic of the situation. If you are going to discuss the precognitive relations between events, then you are up against the problem of whether all histories agree. Because they might just flatly disagree, as seems to me a normal situation in the world of precognition.

SCHMIDT: The model shows the logical possibility of a single objectively real world with precognition. Whether this logical possibility is realized in nature is certainly another question. You do not have to introduce the concept of many possible and equally real worlds in order to get a consistent model. Did you imply that one would need this kind of plurality in a world where precognition occurs?

BASTIN: Yes, I think that one would need some such counter-intuitive assumption, and that is the difficulty about precognition.

TARG: Helmut, I would like to propose to you two feedback loops, and see if this scheme meets with your general description of the experiments. According to your theory, the random number generator is obviously behaving in some way different because of the presence of the psi source. So I feel fairly confident that there should be at least one tentative input into your random number generator. There is probably even an additional output from the psi source, and that is, into the source himself, as he gets a direct awareness of his behavior. That is, the psi source is stimulated by the output of the random number generator. That is very clear, as it is a stimulus response. He gets the input of the light when it is on. He then emits some kind of response, because it is in fact his response that we are talking about. Now, he has first of all some putative self-awareness of his response, which you mentioned as when the additional theta cells in his brain begin to work together. In addition, the more overt evidence that he is making a response is the fact that the output of the generator changes.

Does this model correspond at all to the way you have pictured it?

SCHMIDT: Yes, I think we agree. You go just a little bit further by bringing in some self-feedback of the psi source. This may be important if we want to study the psi source more in detail. We would certainly want to know whether the axiomatically introduced psi sources are more than a logical construct, i.e., whether we can localize the psi sources and analyze their internal structure.

WALKER: In your experiments with various subjects, considered as theta sources, did you mention that you have used them in conjunction?

SCHMIDT: So far we have not. But that would be an interesting experiment, if we keep each subject blind to the presence of the other subjects.

WALKER: When you used several subjects in conjunction, or a pair of subjects, your model showed that there would be a product relation, theta one times theta two, and so on. I am not sure without calculating whether your results, treated as information sources, will be different from the prediction. I think that it should be as an information source, and I think one should then take the logarithms of the probabilities and add them. This is a prediction that I would make. However, as long as you are treating epsilon as a small number, you may not be able to notice the difference.

SCHMIDT: The model implies a mathematically very simple addition theorem which might well be identical to the one you mention. One aspect of the addition theorem, the linear superposition of small PK effects, would be most easily testable, whereas the study of the nonlinear region would require stronger sources, which might be found in a few outstanding subjects, or the use of a very large number of weak sources, which would be somewhat difficult to handle.

WALKER: Feedback has come up a number of times, and I think this suggests a fundamental experiment that could be done. It might even be more interesting to do a series of experiments in which the information that goes back to the subject and/or the experimenter is varied. I would suspect that if you measure the information channel back to the subject, this will place a very definite limit on the magnitude of the positive result that is achieved in the experiment. If you run a long series of experiments with a computer, used as a pseudo-random number generator, and you tell the individual, "Yes, it's significant," or "No, it's not significant," when you are through, he never knows anything else. And for that matter, the experimenter does not really know any more than that, because the computer can handle the tally. The level of significance will probably be very small. Whereas if the individual gets information back on each call, especially if he receives it as it happens, you can get very large levels.

[*Note added in proof*: More recent calculations based on my theory suggest the opposite result can occur in certain cases. Results to be expected depend critically on the details of the experimental procedure and protocol.]

SCHMIDT: Yes, there is also the additional problem that if you give immediate feedback as I do in all my tests, it is much more psychologically stimulating. So in this model, it yields a higher theta value.

WALKER: You can then explain it as being motivated, which makes difficulty for the theoretician. On the other hand, you may also discover that after three or four times, good subjects still do not produce extraordinary results on that particular kind of setup, despite considerable motivation.

SCHMIDT: I agree that would be a very interesting experiment.

KOESTLER: This is a short question for Dr. Schmidt. Could you be a little more explicit about the possible implications of this micro-model for macro-scale phenomena, such as poltergeist or Geller-type phenomena?

SCHMIDT: One might speculate that weak psi sources exist at the cellular or molecular level in the brain and that the outstanding psychics can stimulate many of these sources simultaneously, so that, due to the addition theorem, strong PK effects result.

The model describes PK as a statistical phenomenon, which violates the Second Law of thermodynamics, but does not violate the conservation laws for energy, etc.

The violation of only the Second Law might well lead to spectacular effects like the ones ascribed to Geller.

BLOESS: My question has been covered by Dr. Walker, but there is one small remark still open. In your theory of the addition, you can get, if you have enough subjects, more than certainty.

SCHMIDT: No, there is a saturation effect. Adding two sources means multiplication of the two θ values. Thus the total θ value could become very large, and in the limit of infinite θ, the hit probability reaches 100%.

VON LUCADOU: To apply your axioms to a situation that requires the principles of quantum mechanics for a theoretical explanation, let us assume that there is a machine, one part of which is not only a random generator, but is at the same time the experimenter who is conducting this experiment. Then you have the situation that the thing you want to investigate is the same entity as the instruments that you use to investigate. Probably only a theory that would have a structure similar to that of quantum theory could make this clear. I have shown this from another point of view in a theoretical paper that will appear next week, and I am very grateful to see a possibility to make this view more concrete.

SCHMIDT: I really do not get into all the difficulties of quantum mechanics, although the role of the experimenter does come in. As I described in my paper, if you want to include the experimenter, you can consider him consistently as a computer plus randomizing device. The experimenter can make random, that is to say, partly intuitive decisions.

FIRSOFF: We encounter this kind of problem even under gravitational interaction if we have two bodies moving relatively to each other. There are effects of higher orders. Dr. Schmidt has consistently limited himself to considering the first order. But there may be effects of higher orders. However, we have to stop at a certain limit, because the mathematical theory becomes so complicated that it is unworkable in practice. We have higher harmonics and still higher harmonics.

SCHMIDT: In order to live with this problem, I have considered finite systems in which the psi source is switched on only for a limited time interval. In the general case the complete space-time independence of psi leads to divergencies which I have not yet been able to resolve.

MATTUCK: I am very much fascinated by what looks like retro-PK, where the time delay is put in the circuit. Now, you say you used a tape recorder to introduce the time delay. What if you made a copy of that tape recording, and then looked to see whether the retro-PK was not really retro-PK, but present PK on the tape recording itself? In other words, one could compare the two tape recordings, the one which the subject looked at, and one which was kept in another room or another building. Have you tried that?

SCHMIDT: Yes. The answer is that we always made two recordings, one recording on the tape recorder, another on punch tape in digital form, and these two records agreed. The term "retro-PK" somehow implies an interpretation already. So I do not like it.

FEINBERG: Could you say roughly the order of magnitude of theta in the experiments that you have done?

SCHMIDT: Typical scoring rates are 52% where 50% is chance expectancy. The correspondence θ value is 1.08.

FEINBERG: On the order of about 1%? That is useful information. If I have understood your model of precognition, it seems to require a rather elaborate interaction between the psi source and the thing that it is precognizing. However, it is not clear to me how applicable that kind of model would be to a situation where one does not imagine any obvious coupling between the psi source and the precognition. For example, if a person is trying to precognize what will happen a month from now, and he will not be in any particular proximity or obvious relationship to the thing a month later, I do not immediately see how that kind of situation would be covered by your model. Could you say something about it?

SCHMIDT: In the framework of the model a person can predict a future event only if he (or some other person who acts as psi source) gets later feedback on the accuracy of the prediction. Thus the subject predicts now what he will see or hear later. Thus the feedback to the psi source, the stimulation of the source is a vital link in the precognition process.

BEAUREGARD: In answer to Dr. Targ, I am afraid that by falling back on retroaction, you are willing to fall back on the *de facto* time asymmetry we are living in, that is, away from the *de jure* time symmetry I have been discussing. So I am afraid you are spoiling the specificity of our phenomenon.

TARG: I did not particularly mean this as a retroactive phenomenon. I did say that the subject does in fact respond to his own output, in just the way you said. If the subject makes a correct response, he is aware that he made a correct response, and his next response is a reinforcement. Basically, there is feedback around the subject. I think that is absolutely clear, since he is aware of his own awareness. He did something, a response occurred, and he is happy he did the right thing. I was not saying anything more than that.

WALKER: You had two recording devices. From your comment, I take it that they agreed within one another and so agreed on a single world history, as it were.

SCHMIDT: Yes. That is correct.