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Precognition of a Quantum Process [1, 2]

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ABSTRACT: In two precognition experiments, the subjects were faced with four colored lamps which were lit in random sequence. Their objective was to guess which of the four lamps would light up next and to press the corresponding button. In the first experiment, there were three subjects, who carried out a total of 63,066 trials. Their combined results were highly significant ($p < 2 \times 10^{-9}$).

In the second experiment, two of the same subjects plus a third had their choice of trying to predict, as before, which lamp would light up next (to try for high score) or to choose one which would not light next (low score). In a total of 20,000 trials, the subjects were again successful in achieving their aim to a highly significant extent ($p < 10^{-10}$).

For providing the random target sequence, use was made of single quantum processes which may represent nature's most elementary source of randomness. A practical advantage of the device is that it works fast and that the randomness can be easily computer tested.

The author is a physicist who is particularly interested in statistical physics and the foundations of quantum theory. After teaching at universities in Germany, Canada, and the U.S. he has joined Boeing Scientific Research Laboratories. ---[Original]Ed.

I. INTRODUCTION

The main objective of the experiment was to test the existence of precognition[4] of quantum processes. The experiment was set up so as to provide what the author believed (as a result of a study of the literature) to be particularly favorable conditions for the occurrence of ESP, but no systematic study was made of the psychological conditions affecting performance.

The following are offered as the features of the equipment most likely to be conducive to the occurrence of ESP.

a. The equipment is transportable so that tests can be done in the subject's home.

b. The recording is done automatically. This not only excludes recording errors, but also relieves the experimenter from the role of watchdog. If desired, the subject can be left alone with the apparatus without the possibility of fraud.

c. The subject can proceed unrushed at his own rate.

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1 [Originally published in *JP, 1969, 33,* 99-108]

2 Presented on Dec. 30, 1967 at the Winter Review Meeting of the Institute for Parapsychology.

3 It is the writer's pleasure to thank J. E. Drummond for continuous criticism and encouragement, G. Marsaglia for help with statistical problems, and the test subjects for their cooperation.

4No attempt has been made in this experiment to distinguish between precognition and psychokinesis as an explanation of the results. The reader may substitute "precognition or psychokinesis" for the term "precognition," used for simplicity.

d. The subject sees immediately whether or not his guess (registered by pressing one of four buttons) is correct; if it is, the lamp next to the pressed button lights. Thus the subject is faced with the challenge of "beating the machine."

The psychologically important characteristics of the test procedure are:

a. The two experiments to be reported were done with teams of preselected subjects.

b. The total length of each experiment (number of trials to be made) was specified in advance.

c. Test sessions were held only when the subject felt in particularly good shape. The length of each particular session was not specified in advance; it was terminated whenever the subject felt he would perform poorly.

Some critics suggested that one should specify in advance the days on which test sessions should be held and how many trials each subject should make in each particular session. These critics felt, intuitively, that the high scoring rate obtained might be due to the subjects' freedom to stop whenever their scoring rate fell below average. However, it is easily seen that, provided the target sequence is random and the subjects have no advance information (no ESP) about the next target, the probability for obtaining *n* hits among the *N* trials is given by the binomial distribution independent of how many subjects participated and how often and where the subjects stopped in between.

$$PN(n, p) = \binom{N}{n} p^n q^{N-n}, \text{ with } p = 1 - q = 1/4, \binom{n}{}$$

A more rigidly predetermined experimental schedule is advantageous for studying some details of ESP performance, like a possible decline of the scoring rate towards the end of a session, or differences in the performance of different subjects. In favor of psychologically optimal conditions, however, I restricted the objective of the experiments to testing only the existence of precognition.

II. THE ELECTRONIC TEST EQUIPMENT

During a test, the subject sits in front of a small panel with four pushbuttons and four corresponding colored lamps. Each of the pushbuttons simultaneously activates a recorder switch and a trigger switch. The recorder switch serves to register which of the buttons has been pressed. The four trigger switches are connected in parallel such that pressing any one of the buttons closes a circuit, in turn triggering the random lighting of one of the four lamps. The system is designed so that on repeated pressing of the buttons, the lamps light in random sequence, i.e., each lamp lights with the same average frequency, and there is no correlation between succesively lit lamps, or between the buttons pushed and the lamps lit. In part of the tests, the subjects had to guess repeatedly which lamp would light next and to register this guess by pushing the corresponding button. This triggered the random lighting of one lamp, and the subject could see immediately if the guess was correct, i.e., if the lamp next to the pressed button was lit. The objective here was to obtain a large number of hits, i.e., coincidences between the button pressed and the lamp lit. In the other part of the tests the subjects tried to obtain a small number of such coincidences by pressing a button next to any lamp which they expected would not light.

The Principle of Random Number Generation [5]

The random lighting of the lamps is provided by a quantum mechanical random number generator (Figure 1). Before a button is pressed, electrical pulses pass a gate and arrive at the rate of one million per second at an electronic four-position switch (modulo-4- counter), such that each arriving pulse advances the switch by one step, in the sequence 1,2,3,4,1,2,3,4,. . . . At this stage the lamps are unlit. After pressing a button, the gate is closed, so that the switch stops at random in one of its four possible positions, and the lamp corresponding to this position is lit.

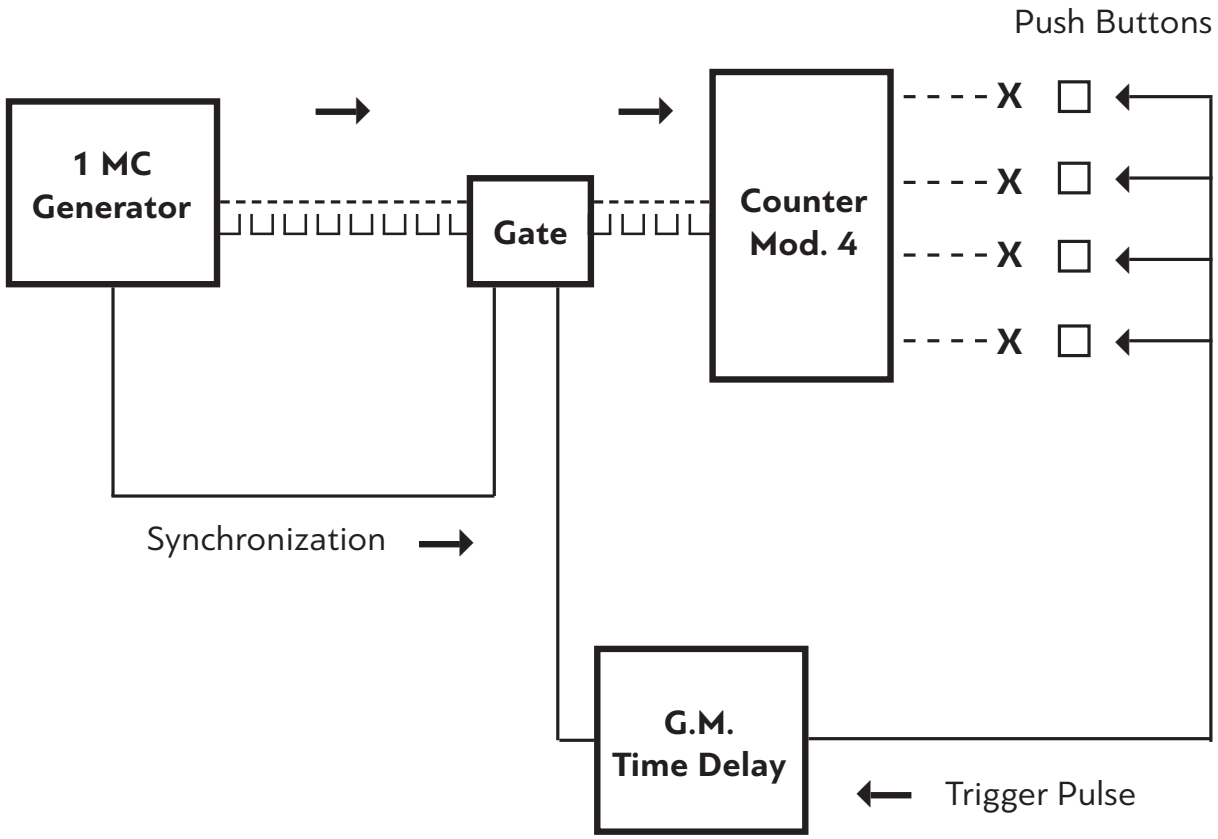

Fig. 1. The principle of random number generation.[6]

In order to exclude the (fairly remote) possibility that the subject might synchronize (within a millionth of a second) the pushing of a button with the high-frequency pulse generator and thus produce a nonrandom sequence, a time delay was introduced. After pressing the button, there is a waiting time of unpredictable length (average 1/10 sec.) before the gate is closed. This waiting time is determined by a single quantum process, the arrival and registration of an electron (from a radioactive strontium-90 source) as a Geiger-Müller tube. A further short-time delay guarantees that the gate is never closed while the modulo-4-counter is in the process of switching, which might impair the proper electronic operation.

5 Details on the circuitry and on the randomness tests are [were] available on request from the author.
6 [The graph in the original paper is better drawn than this scanned recreation.]

After the electron is registered and the switch has stopped, there is a locking time interval of approximately 1/2 sec. during which the mechanical counter for the number of trials advances by one step. The other counter, for the number of hits, advances by one step if the lamp corresponding to the pressed button has been lit. In addition, output channels receive voltage pulses which serve to register, on an external tape puncher, which button has been pressed and which random number has been generated. When the button is released and the locking time of 1/2 sec. has elapsed, the electronic switch continues advancing.

Recording and Safety Features

The RNG is designed to preclude fraud by the subject and to eliminate recording errors by the experimenter. In particular, simultaneous pressing of several buttons or extremely fast pressing of many buttons in succession does not impair proper operation of the machine. If one of the mechanical push-buttons is pressed, a corresponding electronic switch (flipflop) is flipped and, within less than one-millionth of a second, the other buttons are electronically blocked until the mahine has, after approximately 1/2 sec., completed the cycle described above and all the buttons have been released. Furthermore, if it should ever happen that two (or more) buttons were pressed simultaneously with an accuracy such that two (or more) of the electronic switches should flip, then the mechanical counters would become blocked and this event would not be registered.

The sequence of buttons pressed and lamps lit is recorded automatically on paper punch tape. In the research reported here, the two types of test (trying for a high or low number of hits) were recorded in different codes, such that the evaluating computer could distinguish between them. The numbers of trials made and hits obtained were displayed to the subject by electromechanical reset-counters. These numbers were also registered by nonreset counters, and the readings of all counters were regularly recorded by hand. This record agreed with the results obtained from the paper tape. The equipment was fraudproof, so that one could, in principle, let the subjects work alone. This was done, however, only in a small part of the tests with subject OC in the first experiment and did not increase the scores. In all other tests the writer was present in the same room with the subject.

III. RANDOMNESS OF THE TARGET SEQUENCE

For the interpretation of the experiments reported in this paper, it is most important to ascertain that the targets were sufficiently random, i.e., that their sequence did not have any pattern which the subject could detect and utilize for making correct predictions. Theoretically, the randomness should be guaranteed by the use of digital electronics in combination with a quantum device, provided no gross malfunction of the electronics occurred. But even though the electronic performance was checked repeatedly, explicit randomness tests of the generated numbers seemed desirable.

Analysis of the circuitry suggests that any breakdown should manifest itself in an increased generation rate in either one number or a pair of consecutive numbers. In randomness tests made on a sequence of five million generated and on paper tape recorded numbers, therefore, the frequency of the four possible numbers and of the 16 possible pairs of consecutive numbers was counted and evaluated. (Chi-square tests were applied to the whole sequence and to all 1,000 and 10,000 blocks in the

sequence.) No indication of non-randomness was found.[7] The five million numbers used for the randomness tests were recorded [8] on 100 different days, preferably directly after the experimental sessions. Thus the possibility that the electronics did work well in all randomness tests but might mal-function in most ESP tests is practically excluded. Consider also the other possibility, that there was some higher order pattern in the target sequence, a pattern which the subjects utilized, but which the randomness tests overlooked. Against such a pattern is the simplicity of the circuitry, for which all types of malfunction that could occur should affect the correlations tested. A further argument, which is stated only qualitatively, is that the majority of the subjects obtained their highest scoring rate in their first session of the preliminary tests, where they had a maximum of enthusiasm but a minimum of experience.

IV. THE TWO EXPERIMENTS

Prior to the experiments, preliminary tests were done with approximately 100 persons. Some of these were chosen because they reported having occasional "psychic experiences." These preliminary tests suggested that a few of the 100 persons could predict the lamp to be lit next fairly consistently, with slightly more than the expected 25% accuracy. For each of the two experiments, a team was selected from among these high-scoring people, and the total number of trials to be made was specified.

Whenever a subject from the team was available, eager to perform, and not too preoccupied with other matters, a test session was held. The number of trials to be made in a session was not set in advance, but the session was terminated when the subject lost interest or felt he would perform poorly. The whole experiment was terminated after the preset total number of trials was completed.

The tests were carried out in the persons' homes and great care was taken to have the subject work only under what seemed to be psychologically favorable conditions. During the tests, the paper tape recorder was connected to the RNG and the electromechanical reset and nonreset counters for the numbers of hits and trials were switched on. Between tests, the subjects were allowed to play with the machine in order to determine their momentary efficiency in predicting. During these play periods, the paper tape puncher and the nonreset counters were disconnected. It was decided in advance to evaluate all the events and only the events recorded on tape.

The First Experiment

From among the people who showed promise in the preliminary tests, three were selected for the first main experiment. Two of these (JB and KR) were professional mediums, while the third (OC) was an amateur psychic. The two mediums were chosen because of their being accustomed to "psychic" work over long periods of time. OC was selected because he had to stay at home with a broken foot and could thus fully concentrate on the tests.

The results are summarized in Table 1. It is seen that OC and KR obtained significantly high scores, while JB's score is only slightly above the expectation value. The total result is highly significant.

7 For example, it can be concluded with confidence 1017:1 that none of the numbers is generated systematically with a relative frequency above 0.252.

8 For this purpose, one of the pushbuttons was activated automatically at an average rate of one per second.

Table 1
RESULTS OF THE FIRST EXPERIMENT (FEB.—MAY, 1967)

Subject	No. Sessions	Prespecified No. Trials	No. Trials	Dev.	CR	*p*
OC	11	15,000 < *N* < 20,000	22,569	285.75	4.39	< 1 : 27,000
JB	5	20,000 < *N* < 25,000	16,250	90.5	1.64	< 1 : 6.5
KR	2	20,000 < *N* < 25,000	23,247	315.25	4.68	< 1 : 94,000
Total	18	55,000 < *N* < 70,000	63,066	691.5	6.36	< 2 X 10-9

In calculating *p* it was taken into account that the number (*N*) of trials to be made was prespecified only within certain limits. The *p* column gives the probablity for obtaining, by chance alone, the actual or a higher value of CR, anywhere in this *N*-interval.

The probability is less than 2 X 10-9 that chance would give a value this high or higher for the critical ratio (anywhere within the pre- specified *N*-interval).[9]

After the tests with the first subject, OC, were completed, the following control test was made: From the paper tape the whole sequence of the numbers predicted by OC (i.e., the sequence in which he pressed the buttons) is on record. In the control test the buttons of the machine were activated automatically in the same sequence in which OC had pressed them, with different input speeds. Ten such control runs were made. The numbers of hits above average obtained here (+5, +4, -53, +13, +54, +28, +73, +5, -20, -36) are not significantly high (OC's value +285, $\sigma = 65$).

The subject KR had in preliminary tests used two different approaches for obtaining high scores. In some tests he waited for an intuition concerning the next light and then pressed the corresponding button. In other tests, however, he concentrated on the red lamp (the colors were blue, green, orange, red), operated only the button corresponding to this lamp, and tried to enforce the lighting of this lamp with increased frequency by PK. KR used this latter approach throughout the reported test runs and succeeded in having the red lamp lit with significantly above expectation frequency. The experimental setup, however, does not permit a distinction between precognition and psychokinesis. KR might have obtained the high score also by pressing the button only at times when he felt, precognitively, a good chance for the red lamp to light; and conversely, the high scores of the subject OC might also be the result of PK.

9 The mathematical formulae necessary for the derivation of the probability (taking into acount the prespecified *N*-interval) may be obtained on request.

The Second Experiment

One of the subjects from the previous test (KR) had become unavailable and was replaced by SC (16-year-old daughter of OC). In this experiment, the subjects had the option of either to predict which lamp would light next and to press the corresponding button (try for high score) or to try to select one lamp which would not light and press that button (try for a low score). At the beginning of each session it was decided whether to try for a high or a low score. The two modes of operation were recorded on tape in different codes such that the evaluating computer could separate the two types of test. The results are summarized in Table 2. The subjects were so successful [10] that the probability for obtaining this or a better score by chance is less than $10^{-10.}$

V. DISCUSSION

The highly significant results which were obtained indicate that the subjects in this experiment were able to predict randomly selected events to a degree far exceeding what would be expected by chance.

Explanations of the high scores as the result of recording errors, chance, or nonrandomness in the target sequence can be ruled out with reasonable confidence, due to the precautions taken.

The experiments done so far do not permit a distinction (if such a distinction is at all meaningful) between the three possibilities:

Table 2

RESULTS OF THE SECOND EXPERIMENT (SEPT.—NOV., 1967)

Subject	No. Sessions	Goal	No. Trials	Hits Above Chance	CR
OC	4	High Score	5,000	+ 66	2.15
JB	high+low:	High Score	5,672	+123	3.77
JB	11	Low Score	4,328	- 126	4.42
KR	6	Low Score	5,000	- 86	2.81
Total	21		20,000	401	6.55
					$p < 10\text{-}10$ b

Note.—The subjects had the option to try for a high or for a low score. The number of trials to be made was prespecified to be either exactly 20,000 or exactly 40,000. Actually, 20,000 trials were made.

*Evaluated is the sum of the deviations (of the number of hits) from chance in the desired direction.

[b]The *p* is the probability for obtaining for the corresponding CR the actual or a higher value by pure chance.

10 Comparison of Experiment 1 and Experiment 2 raises an interesting question: Why did JB score so differently in these two experiments? JB thinks the improvement was due to some learning process. Another contributing factor might have been this: shortly before the second experiment, the writer gave JB the opportunity to demonstrate abilities in "psychometry" (a term meaning free association tests of ESP with the use of token objects) which might be, as judged from a few tests only, quite outstanding. This certainly did raise JB's self-confidence, remove some of the writer's prejudices against professional mediums, and thus create psychologically more favorable working conditions.

1. Precognition within the mind of the subject: the mind can pre-see a signal, which it will receive approximately 1/10 sec. later.
2. Precognitive coupling between the random number generator and the mind. The mind can pre-see directly the future state of the random number generator. (This mechanism should, contrary to the previous one, lead to high scores even if the subject is not, after the trial, informed by a lamp of the target aimed for.)
3. Psychokinetic coupling between the mind and the number generator.

But the available equipment can easily be adapted to more specific experiments.

Précognition d'un Processus Quantique

RESUME : Dans deux expérimentations de précognition, les sujets faisaient face à quatre lampes colorées qui étaient allumées selon une séquence aléatoire. Leur objectif était de deviner laquelle des quatre lampes allait ensuite s'allumer et de presser le bouton correspondant. Dans la première expérience, trois sujets ont réalisé un total de 63.006 essais. Leurs résultats combinés étaient hautement significatifs ($p < 2 \times 10\text{-}9$).

Dans la seconde expérimentation, deux des mêmes sujets et un troisième pouvaient choisir soit d'essayer de prédire la prochaine lampe qui devrait s'allumer (celle qui obtiendrait un score élevé), comme dans le test précédent, ou bien de choisir quelle lampe n'allait pas s'allumer (score faible). Dans un total de 20.000 essais, les sujets étaient à nouveau en réussite selon le but choisi avec un score très significatif ($p < 10\text{-}10$).

La source de la séquence aléatoire provenait de processus quantiques uniques qui pourraient représenter la source la plus élémentaire d'aléatoire dans la nature. Un avantage pratique de ce dispositif est qu'il fonctionne rapidement et que l'aléatoire peut être facilement testé par un ordinateur.

L'auteur est un physicien qui est particulièrement intéressé par les statistiques physiques et les fondements de la théorie quantique. Après avoir enseigné dans des universités en Allemagne, au Canada et aux Etats-Unis d'Amérique avant de rejoindre les laboratoires de recherche scientifique de Boeing. —Ed.

Präkognition Eines Quantenprozesses

ZUSAMMENFASSUNG: In zwei Präkognitionsexperimenten wurden den Versuchspersonen vier farbige Lämpchen gezeigt, die in zufälliger Abfolge aufleuchteten. Ihre Aufgabe bestand darin, zu erraten, welches der vier Lämpchen als nächstes aufleuchten würde und die entsprechende Taste zu drücken.

Im ersten Experiment gab es drei Versuchspersonen, die insgesamt 63.006 Einzelversuche absolvierten. Zusammengefasst waren die Ergebnisse hochsignifikant ($p < 2 \times 10\text{-}9$). Im zweiten Experiment hatten zwei dieser Versuchspersonen zusammen mit einer Dritten die Wahl, wie bisher vorherzusagen, welches Lämpchen als nächstes aufleuchten würde (um eine hohe Punktzahl zu erreichen), oder ein Lämpchen zu wählen, das als nächstes nicht aufleuchten würde (niedrige Punktzahl). In insgesamt

20.000 Einzelversuchen konnten die Versuchspersonen ihr Ziel erneut in einem hoch signifikanten Ausmaß erreichen ($p < 10\text{-}10$).

Zur Herstellung der zufälligen Zielfolge wurden Quantenprozesse verwendet, die die elementarste Zufallsquelle der Natur darstellen. Ein praktischer Vorteil des Gerätes besteht darin, dass es schnell arbeitet und die Zufälligkeit leicht am Computer getestet werden kann.

Der Autor ist ein Physiker, der sich besonders für statistische Physik und die Grundlagen der Quantentheorie interessiert. Nach Lehrtätigkeiten an Universitäten in Deutschland, Kanada und den USA ist er Mitarbeiter bei den Boeing Scientific Research Laboratories. -Hrsg.

Precognición de un Proceso Cuántico

RESUMEN: En dos experimentos de precognición, los sujetos observaron cuatro lámparas de colores que se encendían en una secuencia aleatoria. Su objetivo era adivinar cuál de las cuatro lámparas se iluminaría a continuación y pulsar el botón correspondiente. En el primer experimento, tres sujetos llevaron a cabo un total de 63,066 ensayos. Sus resultados combinados fueron altamente significativos ($p < 2 \times 10\text{-}9$).

En el segundo experimento, dos de los mismos sujetos más un tercero tuvieron la opción de intentar predecir, como antes, qué lámpara se encendería a continuación (para intentar obtener la puntuación más alta) o elegir una que no se encendería (puntuación baja) . En un total de 20,000 ensayos, los sujetos nuevamente tuvieron éxito en lograr su objetivo en un grado altamente significativo ($p < 10\text{-}10$).

Para proporcionar la secuencia objetivo aleatoria, se hizo uso de procesos cuánticos específicos que pueden ser la fuente más elemental de aleatoriedad de la naturaleza. Una ventaja práctica del dispositivo es que funciona rápidamente y que la aleatoriedad se puede evaluar fácilmente por computadora.

El autor es un físico particularmente interesado en la física estadística y los fundamentos de la teoría cuántica. Después de enseñar en Universidades de Alemania, Canadá y los Estados Unidos se ha unido a Boeing Scientific Research Laboratories. -Ed.