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Noise, Physics, and Psi: New Ideas for Research

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In parapsychology, there is still a primary emphasis on the psychological aspects of psi experiences, and much less on the physical characteristics. Recent exceptions are studies which show correlations between success in psi tasks and the local sidereal time (Spottiswoode, 1997), possible relationships between psi and electromagnetic sensitivity (Stevens, 1997), and the work of Henry Stapp into quantum theory (Stapp, 1993). While the psychology of the experience, and the characteristics of the experiencer are important, it seems unlikely that the field will advance any faster than it is advancing currently until we have some idea of the physical mechanisms underlying psi effects. At best, knowledge of these may enable us to construct shielding for psi-free control periods, or at least, to work out some plausible limits for psi. The purpose of this paper then, is to describe some ideas and techniques used in current physics which might also have relevance to psi research.

It is not generally recognized that the most commonly-used target systems in psi experiments tend to have some random element. For example, in micro-psychokinesis experiments, the target system is often based on solid-state semiconductors, the random element coming from electronic noise (Fraser, 1983). Other target systems have included the decay of radioactive elements (Schmidt, 1974) and the statistical distribution of macroscopic particles undergoing random displacements (Nelson, Dunne, & Jahn, 1988). In ESP and DMILS experiments, the target system is a living system. (Experiments which use the DMILS protocol — defined as "direct mental interaction with living systems"— seek interactions between living systems by examining such non-conscious measures as physiological measurements.) As the normal functioning of all biological cells involves a stochastic gating process (Hille, 1984), as

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well as other random fluctuations, these systems too have an inherent randomness. With this in mind, it may be useful to look at some of the developments concerning the physics of random, or stochastic, systems. One of the most promising of these involves a phenomenon called *stochastic resonance*.

Stochastic Resonance

Stochastic resonance (SR) is a phenomenon wherein a noisy system is driven by an external signal that would normally be considered too weak to affect it (Moss & Wiesenfeld, 1995; Gammaitoni, Hänggi, Jung, & Marchesoni, 1998). Some characteristics of the signal (amplitude, signal-to-noise ratio, coherence, etc.) are, counter to intuition, actually improved by the presence of the noise. Essentially, the noise randomly boosts the weak signal by sometimes giving it enough extra energy to become detectable. If the weak signal is periodic, this random boost can be enough for the receiving system to pick up on the periodicity. The simplest case is illustrated in Figure 1. Line A depicts a weak, periodic signal that is below the threshold of detection. Line B depicts a random

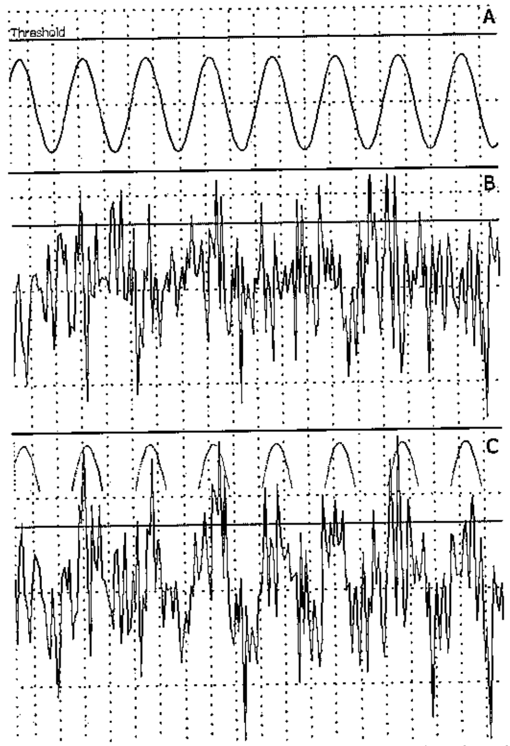

Figure 1. A weak, below-threshold signal (A) when combined with noise (B) becomes detectable (C).

noise signal that would be strong enough to be detected, but contains no useful information. However, when the two are experienced simultaneously, they add together to give a new signal that is detectable. Although not perfect, this new signal contains enough information for the periodicity of the original weak signal to be found (using techniques such as a Fourier transform to isolate the primary frequencies of the signal). The weak signal is thus given enough extra power from the noise to cause a receptive system to oscillate at the same frequency.

Stochastic Resonance (SR) has been found in a variety of sensory and physiological systems, including tactile sensation (Richardson, Imhoff, Grigg, & Collins, 1998), visual perception (Srebro & Malladi, 1999), central nervous system signaling (Traynelis & Jaramillo, 1998), and in the detection of weak electromagnetic fields by human cells (Galvanovskis & Sandblom, 1997). It also appears in many physical systems — the phenomenon was originally found in the periodic recurrences of Earth's ice ages (Wiesenfield & Moss, 1995). The Richardson et al. (1998) study is of particular interest as it demonstrated cross-modal SR in human sensory perception. That is, the ability of percipients to detect a weak signal using one sense was improved by adding a random noise signal through a different sense. In this case, perception of the presence of a subthreshold tactile stimulus was improved by adding a noisy electrical current to the percipient's skin. This finding implies that the resonance effect acts at some more fundamental level than that of the primary sense organs. Other research confirms this, finding the resonance taking place at the neuronal level (Longtin, 1993).

So how is this relevant to psi research? In a typical psi experimental set-up in which the characteristics of both the receiving system and the weak signal are unknown, we can gain information about either the system or the signal only by observing the system's output as a time series of events. We then assume that this output relates to the psi mechanism plus the noise sources and we look for any consistent patterns or characteristics by eliminating as much of the noise as possible. In SR, a system actually becomes a more sensitive detector as more noise is added, at least up to a point: it is optimally sensitive at some non-zero level of input noise. This could suggest an alternative way of conceptualizing psi studies. Rather than trying to remove sources of noise (always a difficult proposition when we don't know the nature of the signal), we might, instead, vary the amount and type of noise and then record the output characteristics. Comparing the system output for different amounts or types of noise might give us more information about a possible psi signal. For example, plotting the distribution of frequencies contained within the output signal (the power spectrum) should demonstrate peaks corresponding to the dominant frequencies of any psi signal. Such characteristics could enable us to locate the site of the psi source, as well as help us to identify possible noise sources. Alternatively, plotting the output of an analog system for different levels of input noise should, at least, show the characteristic SR signature (see Figure 2), indicating whether this approach is a useful one to pursue.

To further understand how SR might help us understand some aspects of psi, let us consider a variety of typical experimental protocols in turn.

Extrasensory Perception (ESP)

The most common ESP experiment is that using the "ganzfeld," a mild form of sensory deprivation which promotes a homogenous field in the major sense organs. For the receiver, awareness of tactile and kinesthetic stimuli is reduced by a combination of a physically-relaxed state and a comfortable, reclined chair. A random but uniform distribution of audio frequencies (white noise) is played over headphones to reduce patterned audio stimulation. Translucent, acetate hemispheres (the infamous halved ping-pong balls) are placed over the eyes and a low-intensity ambient red light used, giving a uniform, unpatterned visual field.

The ganzfeld technique was originally introduced into psi research

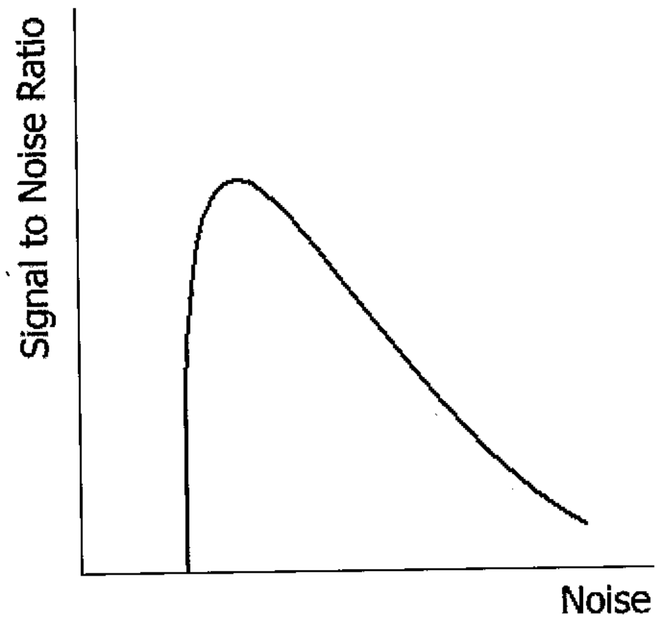

Figure 2. A sharp increase followed by a more gradual decrease with increasing noise, the characteristic shape of stochastic resonance.

as a tool to reduce external sensory impressions, thereby inducing the receiver to focus inwards, where, it was hoped, they would be better able to detect subtle psi impressions. However, with the idea of SR in mind, this raises an intriguing point: Could the application of external audio noise, and the promotion of internal noise also be important in promoting psi functioning? As was mentioned earlier, SR in human sensing appears to work cross-modally. Thus, noise added to the system in any form is incorporated by the relevant processing systems and need not be in the same modality as the amplified signal. We might then benefit from experimentally manipulating the types of noise used with participants. For example, studies in other areas have found differing results depending on the specific type of noise applied. Different colored noise (that is, noise with different frequency distributions) can produce effects which differ from those produced by white noise. Nozaki, Mar, Grigg, and Collins (1999) found evidence of differing effects in sensory neuron responses for different colors of noise. Collins, Chow, and Imhoff (1995) provide an experimental analysis of the effects of adding general noise to a multi-unit system which leads them to state that:

> [C]onstant levels of internal or external noise in a sensory system could optimally enhance the overall response of the system to a range of sub-threshold signals … additive noise could be incorporated into the design of a multi-component signal-detection system. (p. 237)

This also suggests that, as well as adding external noise, more attention should be paid to internal noise. That is, sources of noise within the receiver could also have relevance to ESP task success. The ganzfeld state itself, as with many relaxed, sensorially-restricted states (e.g., hypnogogia), promotes an increase in somatic noise (Sakata, Shinohara, Hori, & Sugimoto, 1995). Being able to classify how "inherently noisy" the receiver will be in the ganzfeld state might then enable better selection of participants for future studies. Such noise might relate to the lability of the receiver's physiological activity (more on this in the next section), or to some of the psychological constructs that have already been used in psi research. For example, extroversion and field dependence both seem to relate to levels of baseline physiological variability (Eysenck, 1967; Histmyer & Karnes, 1964), and may also relate to success in psi tasks (Sargent, 1981; Stevens, 1998). Creative participants also appear to be more successful (Dalton, 1997), creativity possibly being linked to random neural activity (Reinsel, Antrobus, & Wollman, 1992).

Direct Mental Interaction with Living Systems (DMILS)

The typical DMILS protocol involves two participants: the "receiver" whose physiological activity is monitored, and the "influencer" who observes a display of this activity and attempts to bring about a change. This change depends upon a randomized schedule of periods during which the intention is to arouse, or to calm, the receiver, with rest periods interspersed.

The assumptions here are that: (a) the sender can bring about a change in the receiver corresponding to their intention; and (b) all sender-receiver pairs will react in a consistent way to an "arouse" intention, and to a "calm" intention. Are these reasonable assumptions? Without knowing the mechanism involved, this is hard to say. The strategies of different senders will be very different: some will try to be active during arouse periods and relaxed during calm periods, while others will be passive in all periods, relying instead on mental visualization. Unless psi is unlike all other biological phenomena, we might expect that the state of the influencer would be related to the information that is presumably transferred in the DMILS attempt. That is, when the influencer is attempting to bring about a change, this will be qualitatively different from times when they are simply resting. We might then be better, if there is a psi signal, to look for a difference between any of the intention periods and the rest periods. The difference between calm and arouse periods would not necessarily be consistent as both involve an intention and associated heightened mental/physiological activity. This was indeed the case in a recent study (Delanoy & Morris, 1998) in which one set of sessions found greater electrodermal activity in arouse than in calm intention periods, while the other showed a reversed effect.

So, if evidence of SR is to be looked for, then we might better find it if the intention periods as a whole are treated as those which might contain a signal, whereas the rest periods are treated as those which, presumably, relate to the intrinsic, background noise of the system. So how could the noise be quantified? This might relate to the lability of the receiver's physiology — the more labile the physiology, the more noise there is inherent in the system (noise being defined as the "unwanted signals"). If we make the approximation that all receivers will respond to a psi signal in a similar way, and that differences are due only to the amount of physiological noise in the system, then we can treat all the participants' data as though they were multiple measurements on the same system but with the level of noise varied each time. If some measure of the lability (e.g., the variance of resting physiology measurements) were plotted on the x-axis and the signal-to-noise ratio plotted on the y-axis, then it should be apparent if SR has a role in DMILS.

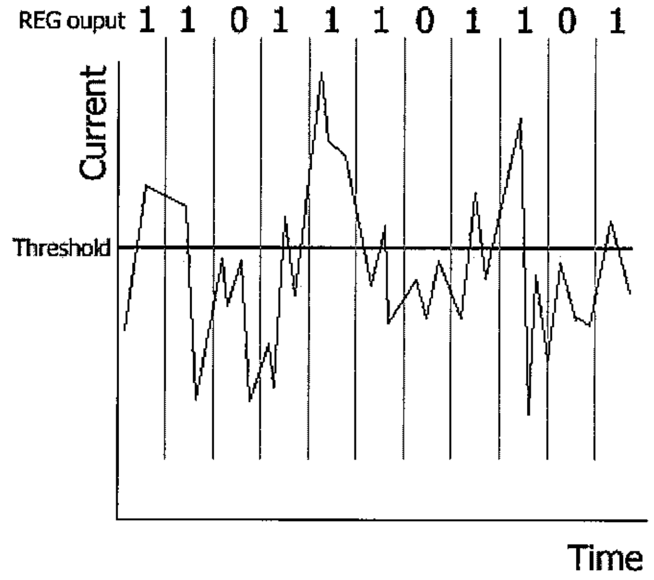

Figure 3. Threshold conversion of analogue current to binary REG output.

Psychokinesis (PK)

The most common laboratory PK[1] experiment involves a supposed influencer (the PK agent) and a source of randomness. This source is usually a device utilizing the properties of electronic noise to generate a stream of random events. Essentially, the random event generator (REG) has within it, at any given time, a randomly-varying current. The electronics within the REG are such that they are triggered to generate an output pulse if this current is greater than a preset threshold (see Figure 3). At regular intervals of time (typically many thousands of times a second), the state of the REG is checked: if a pulse has been generated, an event, or 1, is returned; otherwise a 0 is returned. In an experimental situation, the number and variability of ones and zeros is compared between the influence and control periods.

1. For now, when I use the term PK, I mean microscopic PK only (i.e., the effects are detectable only by some form of statistical analysis). I do not rule out the possibility of macro-PK but do acknowledge that there is insufficient reliable or controlled data to be able to consider it in any detail.

Now, if there is an actual psi signal affecting the REG, we might expect that the characteristics of the varying current within the REG would be related to that signal. Ignoring any other possible external signals, we could consider the uninfluenced (control) functioning of the REG to be a source of noise and the PK agent to be the source of a weak signal (possibly related to some aspect of the agent's physiological functioning). If SR was involved, then we might expect to find evidence of agent-related periodicities within the REG output.

However, currently the situation is unfortunately more complex due to the nature of the REGs used. First of all, the conversion of the original electronic noise current to a digital, binary signal would remove much of the information contained within the REG output. Any periodicity of the current that occurred completely above or below the digital conversion threshold would be obscured. To make matters worse, most current REGs further distort the output by sampling two discrete random sources simultaneously, ignoring coincident events (e.g., the Orion[2] REG compares the activity of two Zener diodes by using a logical operation known as a NAND-gate wherein the output is high only if one or both of the inputs is low). This was implemented to avoid the possibility of extraneous events biasing the REG output (such as fluctuations in the main lines of electricity into the building), but it would also effectively distort any psi signal. A return to REGs from which we can sample the original noise current directly might yield more useful results. There may be some extraneous signals within such output, but these should be consistent if artificial (e.g., main lines of electrical power operate on an identifiable fixed frequency and transient surges would be as likely to occur in control as in influence periods if a suitable methodology was used). An attempt to construct and make use of such an analog REG is currently underway at the Koestler Parapsychology Unit. Alternatively, it may be possible to model the effects of digitization and filtering upon an SR-based PK signal to make some more predictions (a priori and post hoc) for PK studies. Whichever approach is used, a study of PK data with SR techniques in mind may allow us to build more sensitive "psi detectors" by fine-tuning the noise characteristics used in detection devices to better match those found in biological systems. Such a study would also represent a welcome move towards looking at the physical processes of PK rather than merely attempting to produce incontrovertible evidence.

One last interesting point concerns the way in which data is collected from the random source and stored. As mentioned above, a common technique is to take an analog random signal and convert it to a digital one. Many standard analog-to-digital converters make use of a process termed "dithering" which helps minimize signal distortion. This process involves adding a noise signal to the original signal before it is converted — a technique which was arrived at primarily by experimental trials. This process has since been shown to be a case of SR (Gammaitoni et al., 1998). This then begs the question as to where PK is actually taking place? Could the conversion process be the site where PK is being observed and not the presumed target system? Two possibilities come to mind: (1) a weak PK signal could be amplified by the dithering process; or (2) a PK signal could itself act as an additional noise source, amplifying other weak signals from the environment. If PK could act at the site of conversion, this could help explain some of the findings (Schmidt & Pantas, 1980; Lucadou, 1991) which imply that PK acts irrespective of the nature of the presumed target system. A similar suggestion, although arrived at by different means, has also been made by Ibison and Jeffers (1998).

2. This is one of the most commonly-used types of commercial REG. For details see http://rng.interact.nl/

Geomagnetic Correlations

One last area of psi research which seems the most likely to benefit from research into SR is the often-reported relationship between activity in the Earth's (geo-)magnetic field (GMF) and psi phenomena (e.g., Dalton & Stevens, 1996; Gissurarson, 1992; Persinger & Krippner, 1989). For the real-time correlation, a linear relationship is usually assumed. However, perhaps this is an example of SR, the geomagnetic activity acting as a source of noise and aiding or interfering with the psi signal. If this were the case, then the correlation found would depend on the range of noise that occurred during the experimental period. If this range covered the lower end, then any correlation found would be either a steep, positive one or no correlation at all; if it covered the higher end, then a shallower, negative correlation would be found. This could explain the fact that, although many studies do find the expected negative correlation, some have reported finding no correlation or sometimes a positive one. Only if a complete range of GMF activity was achieved (e.g., by combining a much wider range of results from different studies) would any evidence of SR be seen.

Until such an analysis is done, we cannot be sure that SR is involved. However, there have been studies in other fields which make it seem likely that such an analysis may be useful. Uzdensky and Kutko (1998) investigated neuronal response to very weak, extremely-low frequency electromagnetic fields (in the range 0.001–100 Hz, of intensity 1–400 micro-T). They found an unexplained variance, with the neurons sometimes responding, sometimes not. This was explained by taking into account geomagnetic variations, a nonlinear relationship being found with the geomagnetic indices a_p and K_p, also the most common measures of GMF change used in psi studies. The recent discovery (Spottiswoode, 1997) of an apparent association between success in free-response psi tasks and the local sidereal time might also relate. Could the key point of local sidereal time indicate the location, or alignment, of an amplifying noise source?

Conclusion

Whether the specific phenomenon of stochastic resonance (SR) is involved in psi remains to be seen. The ideas and techniques presented in this paper are intended, in best brainstorming manner, to provoke thought and lead to new analyses and experiments. The techniques described will not tell us what psi is, but they might help us to understand the way it interacts with receptive systems. Likewise, if evidence of SR is found, it only tells us that a signal has been received — what happens to that signal still depends on the individual who may interpret, ignore, or otherwise distort it. If we are ever to understand psi, physics and psychology (and a whole host of other disciplines!) must work hand-in-hand.

The study of SR in general is still a relatively new area within physics but has already been found in a wide variety of systems. This work is continuing on to ever smaller levels, with evidence appearing that SR even plays an important role on the quantum level. If this is indeed the case, then maybe advances in physics will offer explanations for psi — perhaps even the very weak electromagnetic signals emitted from the bodies of all organisms can have a significant effect when amplified by the noise of fundamental quantum fluctuations. Whatever the future brings, if this paper manages to help us to understand better even part of the complex field that is psi research, it will have been worthwhile.

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Abstract

Although not generally recognized, most target systems in psi experiments have some random element (e.g., electronic noise or biological cell-gating). With this in mind, this paper describes ideas and techniques concerning the phenomenon of stochastic resonance, wherein a noisy system is driven by an external signal that should be too weak to effect it. In a typical psi experiment, information can only be gained by observing the target systems output as a time series of events. This output is assumed to relate to a psi mechanism plus noise sources, so analysis looks for patterns that are hidden by the noise. However, with stochastic resonance, a system becomes a more sensitive detector as noise increases, up to an optimal, non-zero level. This could suggest an alternative way of conceptualizing psi studies: rather than trying to remove it, the noise becomes a variable that actively contributes to the output characteristics.

Résumé

Bien que généralement non reconnus, la plupart des systèmes cibles dans les expérimentations Psi possèdent des éléments aléatoires (bruits électroniques ou «cell-gating» biologique par exemple). Cette étude expose des idées et des techniques relatives au phénomène de résonance stochastique, dans lequel un système de bruits est soumis à un signal externe qui devrait normalement être trop faible pour l'affecter. Dans une expérimentation psi typique, l'information peut seulement être acquise par l'observation des données en sortie des systèmes-cibles, données envisagées comme une série temporelle d'événements. Cette série est supposée être en lien avec un mécanisme psi mêlé aux sources de bruit et c'est pourquoi l'analyse recherche des «patterns» occultés par le bruit. Quoi qu'il en soit, avec la résonance stochastique, un système devient de plus en plus sensible au fur et à mesure que le bruit augmente, jusqu'à un niveau optimal et non nul. Ceci pourrait suggérer une voie alternative de conceptualisation des études psi : plutôt que de tenter de supprimer le bruit, celui-ci deviendrait une variable qui contribuerait éritablement aux caractéristiques des résultats.

Zusammenfassung

Wenn auch nicht allgemein zugegeben, so beinhalten doch die meisten Zielsysteme in Psi-Experimenten irgendein Zufallselement (z. B. elektronisches Rauschen oder bio-logischen Zelltakt). In diesem Sinne beschreibt dieser Aufsatz Ideen und Methoden bezgl. des Phänomens der stochastischen Resonanz, wobei ein Rauschsystem von einem externen Signal gesteuert wird, welches aber zu schwach sein sollte, um einen Effekt darauf auszuüben. In einem typischen Psi-Experiment kann Information nur durch das Beobachten der Ausgabe des Zielsystems als Serie von Ereignissen in der Zeit gewonnen werden. Von dieser Ausgabe nimmt man an, daß sie sich auf einen Psi-Mechanismus plus Ursachen für Rauschen bezieht, daher sucht die Ana-lyse Muster, die im Rauschen versteckt sind. Mit stochastischer Resonanz wird ein System jedoch ein umso empfindlicherer Anzeiger, je mehr das Rauschen zunimmt, bis zu einem optimalen, von Null verschiedenen Pegel. Das könnte einen alter-nativen Weg für die Konzeption von Psi-Untersuchungen nahelegen: statt zu ver-su-chen, das Rauschen wegzunehmen, wird es zu einer Variablen, die aktiv zu den Cha-rak-te-ri-sti-ka der Ausgabe beiträgt.

Sommario

Sebbene ci se ne renda conto raramente, la maggior parte dei sistemi-bersaglio utilizzati negli esperimenti parapsicologici possiede una componente casuale (ad esempio un "rumore" elettronico o valori-soglia rapidamente variabili, come avviene nelle cellule biologiche). In riferimento a ciò, il presente lavoro discute alcune idee e tecniche relative al fenomeno della "risonanza stocastica," secondo il quale un sistema turbolento viene condizionato da un segnale esterno in apparenza troppo debole per influenzarlo. In un tipico esperimento parapsicologico, si possono acquisire informazioni semplicemente osservando lo stato finale di un sistema-bersaglio quale ad esempio una sequenza temporale di eventi. Si assume che questo stato finale (risultato) dipenda tanto da un meccanismo psi quanto dalle fonti di rumore, per cui l'analisi dei dati cerca di individuare andamenti significativi che rimangono oscurati dal rumore di fondo. Con la risonanza stocastica, invece, il sistema diventa un indicatore tanto più sensibile quanto più il rumore aumenta, fino a un livello ottimale diverso da zero. Ciò potrebbe ispirare un diverso modo di progettare gli studi parapsicologici: perché invece di essere un elemento da rimuovere, il rumore diventa una variabile che contribuisce attivamente a determinare il risultato finale.

抄　録

広く認められているわけではないが、サイ実験の多くのターゲット系は、ある種の無作為的要素（たとえば、電子的雑音や生物学的な細胞通門）を持っている。本稿では、この点を念頭に置きながら、確率論的共鳴現象に関する着想や技法について述べる。この現象においては、雑音系が、それに影響を受けるはずがないほど微弱な外部信号によって駆動される。典型的なサイ実験では、情報は、ターゲット系の出力を事象群の時系列として観測することによってのみ得られる。この出力は、雑音源が加わったサイ過程に関係していると仮定され、そのため、分析を通じて、その雑音によって隠されたパターンを見つけ出そうとするのである。しかしながら、確率論的共鳴の場合には、系は、雑音が（最適な非ゼロ水準にまで）増加するに従って、より感度の高い検出装置となる。このことから、サイ研究を、これまでとは異なる形で概念化する方法が示唆されよう。すなわち、雑音は、排除の対象となるよりむしろ、出力特性に積極的に寄与する一変数となるかもしれないのである。

Resumo

Embora geralmente não se reconheça, a maior parte dos sistemas de alvos nos experimentos psi tem algum elemento aleatório (ex. ruído eletrônico ou célula biológica). Partindo desse princípio, este artigo apresenta idéias e técnicas relacionadas ao fenômeno de ressonância estocástica, no qual um sistema de ruído é conduzido por um sinal externo que deveria ser muito fraco para influenciá-lo. Em um típico experimento psi, a informação só pode ser adquirida através do output dos sistemas de alvos como uma seqüência temporal de eventos. Assume-se que esse output esteja relacionado tanto ao mecanismo psi quanto à fonte de ruído, de modo que a análise tenta encontrar padrões ocultos pelo ruído. No entanto, com a ressonância estocástica, um sistema se torna um detector mais sensível à medida que o ruído aumenta, até um nível mais satisfatório diferente de zero. Isto poderia sugerir um modo alternativo de conceitualizar os estudos de psi: ao invés de tentar remover o ruído, ele se tornaria uma variável que contribuiria ativamente para as características do output.

Resumen

Aunque no se ha aceptado de forma general, la mayor parte de los objetivos en experimentos psi tienen un elemento aleatorio (e.g., ruido electrónico o actividad celular). Considerando esto, este artículo describe ideas y técnicas sobre el feómeno de resonancia estocástica, en el cual un sistema con ruido es activado por una señal externa que es demasiado débil como para poder afectar al sistema. En un experimento psi típico solo se puede obtener información observando a los objetivos como una serie de acontecimientos temporales. Se asume que esto está relacionado con un

mecanismo psi y con fuentes de ruido, por lo cual los análisis buscan patrones que no son visibles debido al ruido. Sin embargo, con la resonancia estocástica, un sistema puede volverse un detector más sensitivo cuando el ruido aumenta, hasta llegar a un nivel óptimo no-cero. Esto podría sugerir una alternativa para conceptualizar a los estudios psi: en vez de tratar de eliminar el ruido, éste se vuelve una variable que contribuye actívamente al proceso.