Noise, physics and psi: new ideas for research

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Abstract

Although not generally recognised, 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 affect it. In a typical psi experiment, information can only be gained by observing the target system's 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 conceptualising psi studies: rather than trying to remove it, the noise becomes a variable that actively contributes to the output characteristics.

Introduction

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 the studies showing 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 currently until we have some idea of the physical mechanisms underlying psi effects. At best, knowledge of these might enable us to construct shielding for psi-free control periods; 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.

Now, it is not generally recognised 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 et al, 1988). In ESP and DMILS experiments, the target system is a living system. As the normal functioning of all biological cells involves a stochastic gating process (Hille, 1984), as 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 be normally be considered too weak to affect it (Moss & Wiesenfeld, 1995; Gammaitoni et al, 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. (A) shows a weak, periodic signal that is below the threshold of detection (the grey line). A random noise signal (B) 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.

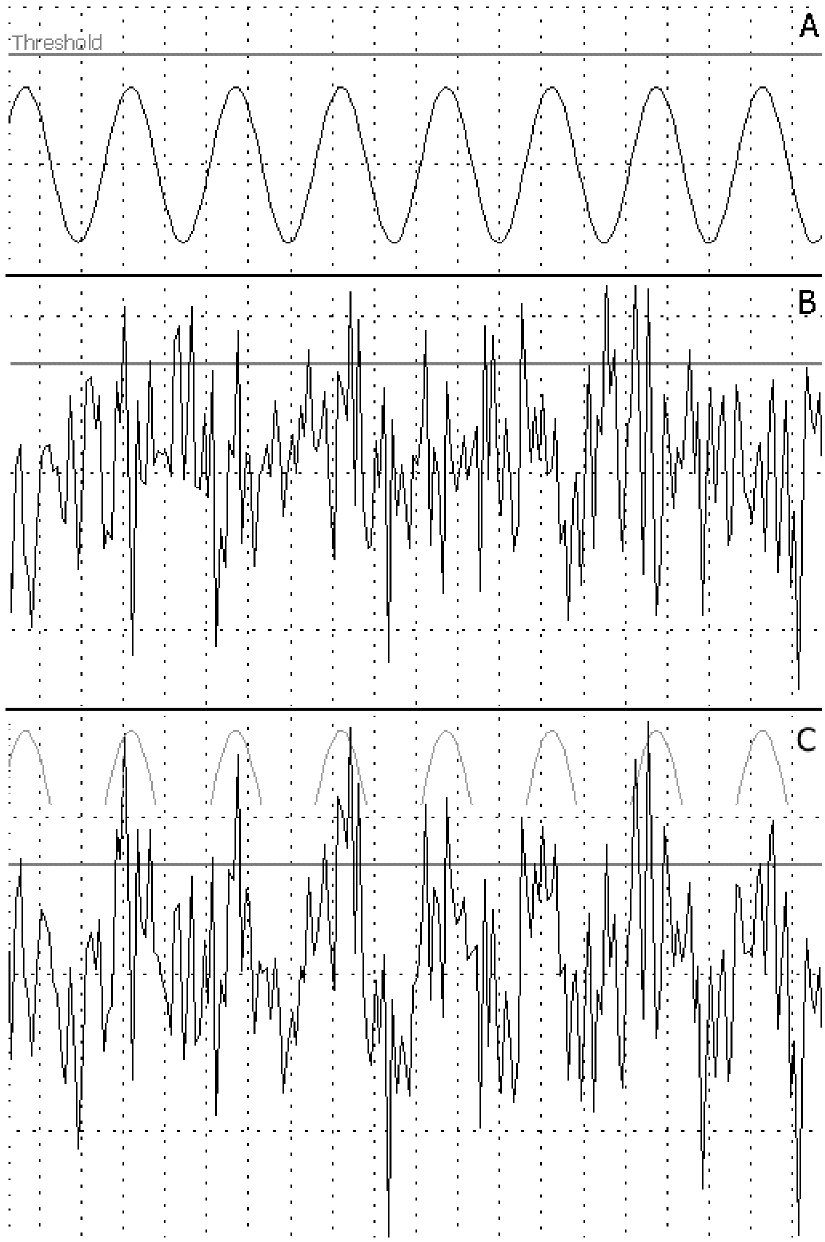

FIGURE 1: A weak, below-threshold signal (A) when combined with noise (B) becomes detectable (C).

SR has been found in a variety of sensory and physiology systems, including tactile sensation (Richardson et al, 1998), visual perception (Srebro and Malladi, 1999), central nervous system signalling (Traynelis and Jaramillo, 1998) and in the detection of weak electromagnetic fields by human cells (Galvanovskis and Sandblom, 1997). It also appears in many physical systems - the phenomenon was originally found in the periodic recurrences of Earth's ice ages (Wiesenfield and Moss, 1995). The Richardson et al study (1998) is of particular interest as it demonstrated cross-modality 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), implying 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, where the characteristics of both the receiving system and the weak signal are unknown, we can gain information about either 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 noise sources and look for any consistent patterns or characteristics by eliminating as much of the noise as possible. Now, 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 conceptualising 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 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 helping to identify possibly noise sources. Alternatively, plotting the output of an analogue system for different levels of input noise should at least show the characteristic SR signature (see figure 2), showing if this approach is a useful one to pursue.

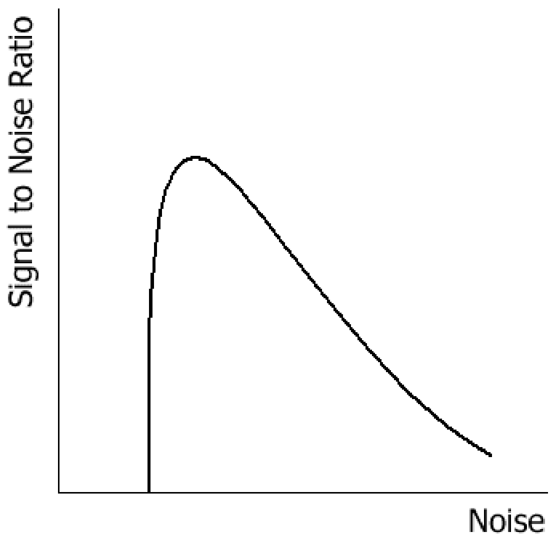

FIGURE 2: A sharp increase followed by a more gradual decrease with increasing noise – the characteristic shape of stochastic resonance

To further understand how SR might help us to 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 kinaesthetic 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 as a tool to reduce external sensory impressions, inducing the receiver to focus inwards where they would hopefully 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, and the promotion of internal, noise also be an important factor in promoting psi functioning? As was mentioned earlier, SR in human sensing appear 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 signal which is amplified. 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 coloured (i.e. different frequency distributions) noise can give different effects from white noise. Nozaki et al (1999) give evidence of differing effects in sensory neuron responses for different colours of noise. Collins et al (1995) provide an experimental analysis of the effects of adding general noise to a multi-unit system which leads them to state that:

> "…constant 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."

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 et al, 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, extraversion and field dependence both seem to relate to levels of baseline physiological variability (Eysenck, 1967; Histmyer and Karnes, 1964) and may relate to success in psi tasks (Sargent, 1981; Stevens, 1998); creative participants appear to be more successful (Dalton, 1997), creativity possibly being linked to random neural activity (Reinsel et al, 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 randomised schedule of periods where 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 their intention and (b) all sender-receiver pairs will react in a consistent way to an arouse intention, and to a calm intention. Is this a reasonable assumption? 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 visualisation. 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 and Morris, 1998) where 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 will 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 thought 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.

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 utilising 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.

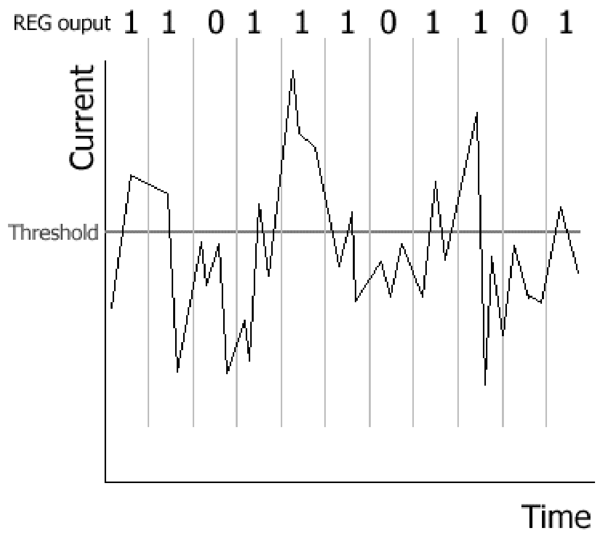

FIGURE 3: Threshold conversion of analogue current to binary REG output

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 and ignoring coincident events (e.g. the Orion[2] REG uses two NAND gated Zener diodes as a source). This was implemented to avoid the possibility of extraneous events (e.g. mains fluctuations) biasing the REG output but 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. mains power operates 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 analogue REG is currently underway at the Koestler

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.

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

Parapsychology Unit. Alternatively, it may be possible to model the effects of digitisation 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 the PK data with SR techniques in mind could let us build more sensitive 'psi detectors' by fine tuning the noise characteristics used in detection devices to better match those found in biological systems. It would also represent a welcome move towards looking at the physical processes of PK rather than attempting merely 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 analogue random signal and convert it to a digital one. Many standard analogue-to-digital converters make use of a process termed 'dithering' which helps minimise signal distortion. This process involves adding a noise signal to the 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 and Pantos, 1980; Lucadou, 1991) implying that PK acts irrespective of the nature of the presumed target system. A similar suggestion, though arrived at by different means, has also been made by Ibison and Jeffers (1998).

Geomagnetic Correlations

One last area of psi research which seems the most likely to benefit from research into SR is the oft reported relationship between activity in the Earth's (*geo-*) magnetic field (GMF) and psi phenomena (e.g. Persinger and Krippner, 1983; Dalton and Stevens, 1996; Gissurarson, 1992). 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 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 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 better understand even part of the complex field that is psi research, it will have been worthwhile.

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