Original Article

Extrasensory Perception and Quantum Models of Cognition

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Abstract

The possibility that information can be acquired at a distance without the use of the ordinary senses, that is by "extrasensory perception" (ESP), is not easily accommodated by conventional neuroscientific assumptions or by traditional theories underlying our understanding of perception and cognition. The lack of theoretical support has marginalized the study of ESP, but experiments investigating these phenomena have been conducted since the mid-19th century, and the empirical database has been slowly accumulating. Today, using modern experimental methods and meta-analytical techniques, a persuasive case can be made that, neuroscience assumptions notwithstanding, ESP does exist. We justify this conclusion through discussion of one class of homogeneous experiments reported in 108 publications and conducted from 1974 through 2008 by laboratories around the world. Subsets of these data have been subjected to six meta-analyses, and each shows significantly positive effects. The overall results now provide unambiguous evidence for an independently repeatable ESP effect. This indicates that traditional cognitive and neuroscience models, which are largely based on classical physical concepts, are incomplete. We speculate that more comprehensive models will require new principles based on a more comprehensive physics. The current candidate is quantum mechanics.

Key Words: extrasensory perception, non local perception, ganzfeld, meta-analysis, mental entanglement, quantum mechanics

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Introduction

Quantum mechanics made its advent at the turn of the 20th century through the work of Einstein, Bohr, Heisenberg, Schrödinger, Jordan, Pauli, and many others. Despite its unquestionable success, interpretations of quantum mechanics remain controversial. To avoid some of the conceptual difficulties, von Neumann (1955) postulated that there are two fundamentally different types of evolution in a quantum system: the causal evolution of the Schrödinger wavefunction, and a non-causal, irreversible change due to measurement. The latter, sudden change is postulated to occur "outside" the physical system under consideration; it was metaphorically called the "collapse of the wave function." This idea led Jordan, Pauli, Wigner and others to propose that one candidate for the something "outside" was human consciousness. This in turn suggested that some form of mind-matter interaction was contained in, and perhaps required for, the formalisms of quantum theory.

However, von Neumann's postulate - the idea that consciousness plays a role in the manifestation of the physical world - is still as controversial today as it was when first proposed. This is because many physicists are reluctant to include anything as ephemeral as consciousness into the study of the physical world (Rosenblum and Kuttner, 2008), but it is also resisted because

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of the success of the neurosciences, which have shown great progress in explaining perception, cognition, and awareness in purely classical terms. As a result, until very recently, there was little reason to question the paradigmatic assumptions or conclusions of neuroscience.

This situation is possibly poised to change because of recent mathematical developments. Conte (2010) modeled von Neumann's postulate mathematically to describe the process of wave function collapse. To do this, he linked his model of measurement to a cognitive act, rather than to the prevailing concept of measurement as an irreversible, mechanistic process. He then proposed that quantum mechanics may be fundamentally based on cognitive and conceptual entities rather than on physical factors.

Among the types of experimental evidence suggesting that some human cognitive abilities are better explained using quantum rather than classical formalisms, Conte *et al.*, (2009) investigated and confirmed the presence of quantum-like interference effects during perception of ambiguous figures, in the Stroop effect, and in cognitive anomalies such as the conjunction fallacy (Conte *et al.*, 2009; Franco, 2009). Briefly, the conjunction fallacy is a logical fallacy that occurs when it is assumed that specific conditions are more probable than a single general condition. A classic example is captured in the following problem: *Linda is 31 years old, single, outspoken, and very bright. She majored in philosophy. As a student, she was deeply concerned with issues of discrimination and social justice, and also participated in anti-nuclear demonstrations. Given this scenario, w*hich is more probable? (a) Linda is a bank teller; or (b) Linda is a bank teller and is active in the feminist movement? Most participants, usually around 80%, choose option (b). Conte *et al.*, (2009) and Franco (2009) demonstrated that the conjunction fallacy can be considered an interference effect predicted by a quantum formalism used to describe intuitive judgments and, in general, any bounded-rationality regime.

Aerts (2009) also argued that quantum mechanical principles, such as superposition and interference, may be at the origin of effects in cognition related to context sensitivity, such as the *guppy effect*. This refers to the observation that free associations to the word "fish" or the word "pet" rarely elicit "guppy," but associations to the richer context of "pet fish" frequently include "guppy." Pothos and Busemeyer (2009) showed that quantum probability models provide better explanations than classical probability models for results obtained with the two-stage gambling game or the Prisoner's Dilemma game, two tasks commonly used to study human decision models. Busemeyer, Wang and Lambert-Mogiliansky (2009) demonstrated that quantum probability theory is superior to classical (*i.e.*, Markov) models in a categorization task. Bruza, Kitto, Nelson and McEvoy (2009) postulated quantum-like entanglement properties within the human lexicon. And Blutner and Hochnadel (2010) advanced a model of Jungian theory that included quantum entanglement-like features correlating psychological functions and attitudes. In the present issue of this journal, Conte (this issue) describes experimental results that further support the superiority of quantum vs. classical models in explaining a variety of cognitive tasks. In sum, these recent theoretical advancements suggest that quantum mechanical-inspired models may be useful for describing a wide variety of psychological processes that have been difficult to accommodate under traditional assumptions.

Quantum-like mental entanglement

One of the values of this new approach is that it helps to illuminate a body of anomalous experimental results collected over a century. These results are reminiscent of quantum entanglement-like cognitive processes *between* people isolated by shielding or distance. Quantum entanglement in the purely physical sense describes what happens when two or more elementary particles interact – a new property of the multi-particle system arises that can no longer be considered separate regardless of how far apart the original particles travel in space or time. This "spooky action at a distance" effect, as Einstein called it, was dubbed *entanglement* by Schrödinger. The principal characteristic is that isolated particles remain instantaneously connected through spacetime, and to date all experimental tests of these predictions have been confirmed (Gisin, 2009). This "nonlocal" connection that transcends the classical boundaries of space and time was initially thought to apply only to microscopic particles. But recent advances have shown that nonlocality is a general phenomenon that also occurs in macroscopic systems (Vedral, 2008), possibly including living systems at room temperature such as photosynthesis (Sarovar *et al.*, 2010) and DNA (Gutiérrez *et al.*, 2010).

If quantum-like models are valid ways of understanding certain forms of perception and cognition and nonlocal entanglement-like connections, are inherently contained within such models, then it seems reasonable to expect some aspects of those isolated systems we call "individuals" to be more connected than they appear to be. Gaining information without use of the conventional senses, or "extrasensory" perception (ESP), might be one way that those connections might manifest.

A detailed account of possible relationships between ESP and quantum theory is beyond the scope of this paper, but to illustrate how these two domains may be related, we briefly mention three points. The first is that like the quantum phenomenon of nuclear decay, ESP and synchronicity (a possibly related paranormal phenomenon) are, or would seem to be, determined with confidence only through analysis of statistical data. As explained by Storm (2008);

> Pauli did not accept that synchronistic phenomena can be measured in a statistical way as are quantum events. . . . He recognised that "statistical correspondence" is the kind of law that "acts as a mediator between the discontinuum of individual cases" (themselves non-reproducible) "and the continuum that can only be realized (approximately) in a large-scale statistical framework." [Meier, 2001, p. 56] The parallels between the single quantum event, individual cases of synchronicity, and spontaneous non-recurrent cases of Psi should be evident. And surely the solution devised by parapsychologists to surmount the problem of the individual case, just as physicists overcame a similar problem in quantum mechanics, can be seen as applicable to synchronicity (Storm, 2008, pp. 262-263).

The second point is the intriguing analogy between quantum entanglement and telepathy, as noted by Einstein and others. Beyond the analogy, neuronal activity may include sub-atomic processes that incorporate information or energy transfer at the requisite scale to provide genuine quantum connections (Hagan *et al.,* 2002). The third point refers to the quantum measurement problem's "collapse of the wave function," which appears to require an observer to transition quantum potentials into classical actualities (Radin, 2006; pp.258-259). If the observer includes humans, then mind-matter interactions such as ESP should be expected.

Beyond musing about such analogies and possibilities, one could conduct experiments to see whether such abilities actually exist, and indeed, experiments of this type have been performed for over a century. Here we concentrate on one type of telepathy experiment that has been repeatedly performed in many laboratories over the past 30 years.

All of these experiments share the requirement that the participants, who are isolated from each other by distance and/or shielding, cannot obtain information from one another by conventional means. Strict controls are imposed so that no cues can be provided about the telepathic "targets" by the experimenters or by the experimental protocols, and that chance identification of target information can be precisely assessed.

In these studies, the telepathic "receiver's" state of consciousness is altered through use of a procedure called "ganzfeld" stimulation. The term ganzfeld, derived from German *ganz*, meaning "whole" and *feld* or "field," was coined as a generic term for an unpatterned visual field. The ganzfeld environment is used to induce a hypnagogic-like state, similar to states that occur spontaneously at sleep onset. A recent review of the phenomenology and cerebral electrophysiology of the ganzfeld experience is available in Wackermann, Pütz and Allefeld (2008).

In a typical ganzfeld telepathy experiment, a "receiver" is left in a room relaxing in a comfortable chair with halved ping-pong balls over the eyes, and with a red light shining on them. The receiver is asked to keep his/her eyes open, and to wear headphones through which white or pink noise is played. The receiver is exposed to this state of mild sensory homogenization for about a half hour. During this time a distant "sender" observes a randomly chosen target, usually a photograph or a short videoclip randomly drawn from a set of four possible targets (each as different from one another as possible), and he or she tries to mentally send this information to the receiver. During the ganzfeld stimulation period, the receiver verbally describes any impressions that come to mind. These "mentations" are recorded by the experimenter (who is also blind to the target) via an audio recording or by taking notes, or both. After the ganzfeld period ends, the receiver is taken out of the ganzfeld state and is presented with four photos or video clips, one of which was the target along with three decoys. The receiver is asked to choose which target best resembles the image sent by the distant sender.

The evaluation of a trial is based on (a) selection of one image by the receiver, based on his/her assessment of the similarity between his/her subjective impressions and the various target possibilities, possibly enhanced by listening to his/her mentation recorded during the session, or (b) an independent judge's assessment of similarity between the various targets and the participant's mentation recorded during the session. The results are then collected in the form of 'hit rates" over many trials, (i.e., the proportion of trials in which the target was correctly identified). Because four possible targets are typically used in these studies, the chance hit rate is normally 25%. After many repeated trials, hit rates that significantly exceed chance expectation are taken as evidence for nonlocal information transfer. Most of these experiments are now fully automated, eliminating the possibility of data recording errors.

Since 1974, six meta-analyses have been performed on ganzfeld experiments (all references may be obtained upon request from the first author): (1) Honorton (1985), N = 28 studies; period of analysis: 1974 to 1981; (2) Bem and Honorton (1994), N = 10; period of analysis: 1983 to 1989; (3) Milton and Wiseman (1999), N = 30; period of analysis: 1989 to 1997; (4) Storm and Ertel (2001), N = 11; period of analysis: 1982 to 1989; (5) Bem et al. (2001), N = 9 (only new studies, after elimination of one outlier), period of analysis: 1997 to 1999, and (6) Storm, Tressoldi & Di Risio (2010), N = 20; period of analysis: 1997 to 2008.

In all of these meta-analyses, the primary measure was percentage of correct hits, and inferential statistics were calculated via exact binomial probabilities, which in turn were transformed into standard normal deviates (z scores). Effect size was expressed as $ES = z/\sqrt{n}$, where n was the number of test sessions. There is some dispute about the optimal statistics to use to best characterize these effects (Timm, 2000), but to simplify interpretation of the mean effect size across meta-analyses, we use the statistic π (Rosenthal and Rubin, 1989), which conveniently recasts mean chance expectation into π = .50. Results expressed in terms of π are shown in Table 1.

Table 1. Mean effect size π and 95% confidence interval, obtained in the six meta-analysis

Meta Analysis	Mean and 95% CI	z	p
Honorton (1985)	.62 (.60 to .66)	7.72	1.2×10^{-12}
Bem & Honorton (1994)	.59 (.53 to .64)	3.7	.0002
Milton & Wiseman (1999)	.53 (.50 to .56)	2.04	.041
Storm & Ertel (1999)	.58 (.53 to .63)	3.11	.002
Bem et al. (2001)	.64 (.59 to .68)	6.05	1.4×10^{-7}
Storm et al. (2010)	.59 (.56 to .62)	5.65	8.00×10^{-7}

Considering all reported trials, after the elimination of 6 outliers (see Storm et al. 2010 p. 477), the hit rate was 1323 hits in 4196 trial = 31.5 %, as compared to chance expectation of 25%. This corresponds to an ES of 0.135 (95% confidence interval from 0.10 to 0.17). In terms of the π statistic, π = 0.58, (95% CI from .56 to .60, Z = 9.9, $p = 1.0 \times 10^{-11}$. The possibility that these effects are due to inflation from selective reporting has been considered in detail (e.g., Storm et al. 2010), and it is generally agreed, including by skeptical reviewers, that the "filedrawer effect" (referring to unpublished papers will null results that languish in investigators' file drawers) cannot account for the observed results.

Differences with other altered states of consciousness

Using the Storm *et al.*, (2010) database which includes other types of ESP experiments, it was possible to compare the outcome of 29 studies using ganzfeld stimulation with 16 studies using different types of altered states of consciousness (ASC), including hypnosis, meditation and dreaming. The mean ES and confidence intervals for ganzfeld were π = .60 (95% CI .58 to .62; Z = 7.97; $p = 2.00 \times 10^{-13}$) and for other ASCs, π = .57 (95% CI .54 to .61; Z = 4.08; $p = 4.00 \times 10^{-3}$. This suggests that there may not be anything especially unusual about the use of the ganzfeld procedure, and that there may be many ASC approaches to enhance ESP. This outcome is supported by a previous meta-analysis by Stanford & Stein (1994) related to use of hypnosis to enhance ESP and of Child (1985) and Sherwood & Roe (2003) related to ESP in dreams. By comparison, as reported in Storm et al. (2010), in analysis of 14 experiments where participants were not in a ganzfeld or ASC (after elimination of outliers), the results was at chance (ES π = .49 [95% CI .46 to .52], z = -.69; p = .49).

Variations in the effect

One may observe the overall hit rate of 32% in the ganzfeld experiments (vs. chance expectation of 25%), and, despite acknowledging the clear statistical outcome, remain unimpressed because after all, the yield in this type of experiment is only 7% above chance. If telepathy were really true, then one might wonder why hit rates are not much higher. One reason is that this 32% hit rate was obtained primarily with unselected volunteers claiming no special abilities, thus the 7% effect is a general population effect. When special populations are examined, such as creative artists, substantially higher hit rates are obtained (e.g., 47% reported in Holt, 2007). A second reason is that ESP, like many perceptual and behavioral phenomena (e.g., visual acuity varies with light intensity; domestic violence increases during geomagnetic storms), may be influenced by a host of psychological and environmental factors, and we haven't yet found a way to eliminate the effect of these noisy variables.

Theoretical considerations

Despite substantial empirical evidence, the concept of ESP has eluded scientific acceptance for two primary reasons. The first is a belief held within the academic mainstream that there is no empirical evidence in support of this claimed phenomenon, or that if there is some evidence, it is not repeatable and therefore not amenable to scientific inquiry. The meta-analyses reported here, as well as a dozen other meta-analyses investigating various other classes of ESP experiments, unambiguously demonstrate that this commonly held belief is simply mistaken.

The second reason is a lack of well accepted theoretical models. The present paper suggests that in the second decade of the 21st century quantum-inspired models are beginning to become acceptable in conventional psychology because they offer solutions to problems that classical models cannot easily accommodate. However, quantum-inspired models in psychology are not new. A half-century ago, researchers studying ESP effects were already proposing models based on quantum concepts (Walker, 1979; Dunne and Jahne, 1987; Houtkooper, 2002; Lucadou *et al.,* 2007; Roll and Williams, 2008). Supporting those models is a growing body of experimental data which show "spooky" correlations in, for example, electrical brain activity between people isolated at a distance (see Supplementary Information A). While the concept that ESP may be explainable via some form of entanglement between living brains is still frankly speculative (Radin, 2006), recent developments in quantum biology suggest that entanglement *may* play a role in explaining the stability of the DNA double helix (Rieper, Anders and Vedral, 2010). That line of research may eventually lead to testable models for entangled brains at the neuronal level, and then to entangled subjective experience, and thus ESP.

Final comments and a note of optimism

It is often said that extraordinary claims require extraordinary evidence. The empirical results presented here for the ganzfeld telepathy experiment seem to satisfy this requirement. More than 50 authors have reported successful replications from laboratories across the USA, UK, Sweden, Argentina, Australia, and Italy, and the reported effects have been reliably repeatable for over 30 years. In addition, a team of avowedly skeptical researchers led by Delgado-Romero and Howard (2005) successfully repeated the ganzfeld experiment, and they obtained the same 32% hit rate estimated by the meta-analyses. With the available data at hand, the nature of the debate is shifting from earlier arguments that ESP is impossible because it violates certain unspecified but presumably sacrosanct laws of nature, to quibbles over increasingly minor technical details (Hyman 2010; Storm *et al.,* 2010b).

Widely accepted theoretical explanations for ESP have continued to lag behind the collection of empirical data, but the explanatory playing field is rapidly advancing. For example, a recent book by Khrennikov (2010) summarizes the state of art of quantum-like models in cognitive science, psychology, genetics, economics, finance, game theory, and biology (Arndt *et al.,* 2009). Likewise, the Conte (2010) mathematical model, which proposes that quantum mechanics describes not only the behaviour of matter and energy, but also cognition, suggests a new vision of the human mind where the "classical" functioning of human cognitive abilities must be expanded with "quantum-like" features. Such models invite fascinating new perspectives on the study of cognition and perception, and on natural human capacities once thought to be impossible.

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Supplementary Information A.
Studies related to brain activity correlation at distance

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