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INFORMATION IN LIFE, CONSCIOUSNESS, QUANTUM PHYSICS, AND PARANORMAL PHENOMENA

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ABSTRACT: Information consists of symbols, media for storing and transmitting the symbols, and an interpretational infrastructure that establishes the meaning of the symbols, can generate and decode the symbols, and can take actions based on the symbols. Information processing in livings systems includes genetics, perception, behavior, memory, learning, communication, imagination, creativity, and culture. For certain hypotheses in quantum physics and most hypotheses in parapsychology, the media and interpretational infrastructures for information processing are beyond current scientific understanding. After extensive research, the hypothesis that an observer can sometimes paranormally influence the outcome of quantum events does not have convincing empirical support. The current experimental results in parapsychology do not have the properties of a signal in noise and cannot be convincingly distinguished from methodological bias. Prospective registration of experimental protocols could greatly reduce the confounding problem of methodological bias; however, the experimental results will likely continue to be inconsistent with the positions of both proponents and skeptics of experimental parapsychology. The findings of parapsychology may be most consistent with a model that paranormal phenomena are the result of supernatural information processing agencies with relatively independent motivations that manifest as spirituality and influence the meaning and direction of an individual's life.

Keywords: information, paranormal, spiritual, quantum-to-classical transition, consciousness, origin of life

Concepts involving information play an increasing role in some of the most challenging problems in science. Two of the most profound mysteries in science are how life began and how quantum physics should be conceptualized. There are strong arguments that concepts of information will have a fundamental role in understanding these mysteries (Greenstein & Zajonc, 2006; Schlosshauer, 2007; Yockey, 2005).

However, the relevant literature reveals differing concepts, terminology, and assumptions in discussing information in different scientific contexts. These differences result in ambiguities and inconsistencies that hinder scientific understanding. For example, the different uses and implications of the term information in biology and physics are not widely appreciated.

The purpose of this article is to summarize and clarify the concepts pertaining to information as these concepts are emerging in scientific research. This discussion may provide a basis for interdisciplinary insights

about life, consciousness, creativity, quantum physics, and phenomena that would be considered paranormal with current scientific understanding. The article focuses on the current state of concepts about information processing and is not intended to be a thorough review of each topic. The references are primarily books and review articles. The scientists who had prominent roles in the development of the topics are generally not identified.

Information Concepts

Everyday Information

Dictionary definitions of information focus on knowledge, facts, and data. These definitions include several assumptions and implications that need to be recognized if concepts of information are to be productively applied in science. Information has three components.

One component of information is symbolic representation. The knowledge, facts, and data of information are represented in some type of symbolic form. For humans, words are the most common symbols for conveying information. The evolution of human culture has resulted in increasing layers of symbolic representation. For example, a video recording of a scientific lecture is a symbolic representation of the original lecture, which in turn provided symbolic representations of scientific findings that were published in journals and were based on measurements that were symbolic representations of the outcomes of certain experimental conditions.

A second component is media for storing and transmitting the symbols. Different media can be used, such as printed pages, electronic signals, living brains, and sound waves. The same information can be stored and transmitted in different media and a given medium can be used with different information. Media involve matter and energy, whereas the symbolic representation has meaning that is distinct from the media.

The third component of information is an interpretational infrastructure that establishes meaning, value, and usefulness for the symbols, and can generate and decode the symbols. Without consistent meaning of the symbols, there can be no stable knowledge, facts, or data. The meanings assigned to different symbols are typically arbitrary in the sense that different symbols could be used equally well for different meanings, as occurs with different languages. Language requires the interpretational infrastructure of the human mind in context of culture. The interpretational infrastructure also includes the ability to generate and to decode the symbols in the media, and to take actions based on the symbols. Thus, the interpretational infrastructure also contains other information processing steps. As will become apparent, information processing implies the existence and interaction of multiple information processing systems.

Unfortunately, the interpretational infrastructure is often overlooked in discussions of information. However, the symbols would

Update after publication: A significantly updated discussion of information in life and physics is available at http://science.jeksite.org/info1

have no meaning or usefulness without the interpretational infrastructure. Because the symbols and the interpretational infrastructure are both essential, they must develop or evolve together.

One of the primary properties of information is that a relatively small amount of mass and energy in the media and symbols can be used to guide much larger amounts of mass and energy through the interpretational infrastructure. At the time of conception, the amount of mass and energy in the DNA of an elephant embryo is small; however, that genetic information will ultimately guide the development of a large animal. Similarly, the amount of mass and energy in a stop sign is much smaller than for the vehicles that the sign controls. In general, information is an innately emergent property that can have strikingly disproportionate influences on the distribution and flow of mass and energy.

From an everyday perspective, the concept of information appears to have meaning only in context of living creatures. In particular, the interpretational infrastructure appears to be a function of living creatures.

Quantitative Information Theory

Quantitative information theory was developed to evaluate and design electronic communication systems. The theory focuses on quantifying and optimizing the information transmission rate in a communication channel and the reliability of transmission through a noisy channel (Cover & Thomas, 2006). The methods of information theory can be used to quantify information in many areas of investigation, including biology and psychology.

Virtually any probabilistic or statistical model can be expressed mathematically in terms of quantitative information. For example, statistical hypothesis testing and information theory are closely related (Cover & Thomas, 2006). The statistical results of a scientific experiment or an individual scientific measurement indicate information obtained about nature.

Quantitative information theory ignores interpretational infrastructure and focuses on probability rather than on information. The theory does not consider whether the probabilities are for symbols with meaning, purpose, usefulness to living creatures, or implications for the distribution and flow of mass and energy (Brillouin, 1962, pp. 9-10; Roederer, 2005, pp. 13, 32–33).

Information and Life

DNA and the Genetic Code

DNA and the genetic code are very consistent with the everyday view of information. The medium for storing information is DNA, which consists of long sequences of chemical compounds called nucleotides that

can be of four types: A, C, G, and U (Yockey, 2005). Each sequential group of three nucleotides is a symbol for an amino acid. This is essentially digital information similar to the sequence of binary electronic states used to store data in computers. Three nucleotides with four possible types for each can code 64 different items. However, there are only 20 amino acids to be coded and some are coded redundantly. For example, CGG, CGC, CGU, and CGA all code arginine, and only UGG codes for tryptophan (Yockey, 2005). Proteins constructed from amino acids in the sequences specified by DNA are the basis for life as we know it.

The interpretational infrastructure for the symbols in DNA consists of a complicated, integrated network of biochemical processes for storing and duplicating DNA, reading the sequences, constructing the proteins, and making error corrections. Each new generation must have the same interpretation of the symbols in the DNA. As Harold noted "… sequences are just strings of symbols without intrinsic significance. At the end of the day, the object of the genetic exercise is to specify the shape of a protein that performs a biological function" (Harold, 2001, p. 50). Error handling is particularly important. "The use of multiple, unrelated, and redundant regulatory devices is quite typical. . . . Control circuits … are more elaborate than the processes which are regulated" (Harold, 2001, p. 53). As expected, this interpretational infrastructure involves other layers of information processing, particularly with the regulatory processes.

All known living cells, from bacteria to the cells in humans, use the same genetic code for mapping DNA to amino acids. At the same time, this mapping appears to be arbitrary like the meanings assigned to symbols in other types of information (e.g., CGG could have been used equally well for tryptophan as for arginine). These findings are generally taken as evidence that all life on earth evolved from one ancestor. If life spontaneously originated at different times, different genetic codes for constructing proteins would be expected, much like the different spoken (and computer) languages that have emerged.

The origin of life remains a profound mystery because the DNA medium, the genetic code symbols, and the complex interpretational infrastructure all must have originated together. It is difficult to imagine how the complex interdependent information processing systems that are the foundation of life could have spontaneously appeared. The principles of evolution cannot account for the origin of life because genetics and evolution as currently understood cannot occur without all the information processing components functioning in an integrated manner. Evolution cannot explain the origin of evolution.

Perception

Perception of and response to environmental factors are basic information processing capabilities of living organisms. Single-cell bacteria

have the ability "to register cues from the outside world and to respond in a goal-oriented manner" (Harold, 2001, p. 87). The media for perception are receptors that respond to certain environmental factors. The output signals of the receptors are symbols for the environmental conditions. The interpretational infrastructure consists of biochemical processes that respond to the signals.

With evolution, the receptors have become more sophisticated and the processing of signals from receptors has become much more complex. In human vision, over a million individual receptors in the eye respond to specific details of edges, lines, angles, shapes, color, movement, and depth. The signals from these receptors are sent to several regions of the brain that perform specific integration functions, such as facial recognition or tracking movement of objects.

> As you look at someone, the visual information is sent to your brain as millions of neural impulses, then constructed into its component features, and finally, in some as yet mysterious way, composed into a meaningful perceived image, which is then compared with previously stored images and recognized. (Meyers, 2005, p. 152).

Extensive parallel processing and hierarchical integration are utilized in achieving this result. Again we find many layers of information processing with different media and symbols.

The senses of hearing, smell, taste, touch, and body position are similarly based on receptors that generate signals that are processed and integrated in the brain (Meyers, 2005).

Learning

Developing the capability to learn was a very important step in evolution. The behavior of a simple living organism is determined by genetic programming of automatic responses to environmental conditions. For these organisms, adaptation to environmental changes occurs at the species level through genetic mutations and diversity in the species. When environmental changes occur, many or most individuals may die whereas a few with favorable genetic mutations survive and reproduce. Of course if the environmental changes are outside the range of species diversity, the species will become extinct, as has happened for over 99 percent of the species that have existed on earth (Guttman, 2002). The ability to learn allows individual organisms to adapt to environmental changes during their lifetimes and thus to delay death.

An implied requirement for learning is that an organism can generate variability in responses or behavior. Behavior is not limited to genetically programmed automatic responses to certain environmental

stimuli. Neural mechanisms that provide variations in behavior have become increasingly sophisticated with evolution.

Another implied requirement for learning is that an organism can identify and remember correlations with and among the signals from receptors. Identifying these correlations creates information and requires an interpretational infrastructure that is dynamic as well as having memory. Similar to the processing of perceptions, learning can utilize groups or patterns of symbols to form higher level integrated symbols, such as recognizing an animal and anticipating its movements. Self-awareness results from receptor signals from internal processes rather than from environmental conditions.

The evolution of language in humans is a pinnacle of both information processing and learning (Deacon, 1997; Donald, 2001). Language allows people to share knowledge with others and across generations, as well as to negotiate and work cooperatively. In a communicating group, the effective memory and learning capacity can be much greater than for any individual. Language abilities required the evolution of special information processing capabilities in the brain, enhanced perceptual capabilities, and structures in the throat for speaking (Deacon, 1997).

For spoken words, the information medium is sound waves and the symbols are the words. The interpretational infrastructure for spoken words consists of many other layers of information processing, including the receptors for the sense of hearing as well as the subsequent processing and integration in the brain. Memory of the meaning of the words learned from culture is another important component of the interpretational infrastructure.

Imagination and Creativity

The evolutionary trend toward increased information processing has culminated in consciousness with imagination. The media, symbols, and interpretational infrastructure for imagination initially reside within a brain. The symbols are to a great extent self-generated.

Imagination of potential or possible futures goes beyond learning empirical associations and introduces the ability to create new conditions in the world. The ability to do planning based on hypothetical futures is one of the key abilities resulting from the evolution of the human mind (Donald, 2001). Imagination allows manipulation of symbols in a way that can result in creativity and greatly enhanced problem solving. The imagined potential futures can include individual or group activities or new technology ranging from primitive tools to the complex electronic systems of modern society.

Creativity such as developing new technology typically involves developing new symbols or new meaning for symbols. The new information must be learned and distributed, which are adaptations of the interpretational infrastructure and include culture.

Discussion of Information and Living Systems

Livings systems have layer upon layer of interacting information processing, including within and among genetics, perception, behavior, memory, learning, communication, imagination, creativity, and culture. The purposeful nature of living creatures is based on information processing. The interpretational infrastructure consists of other layers of information processing. The information processing is parallel as well as sequential, and often with hierarchical integration. Information processing is a defining property of life.

Conceptually distinguishing symbols, media, and interpretational infrastructure may clarify the dilemma that our self-aware consciousness feels like it is separate from matter, yet appears to emerge from and depend on the matter in the brain. This dilemma is the source of much debate and controversy in science and philosophy. The media for information is matter and energy, but the meaning of the symbols is independent of the media.

The physical brain serves as media for symbols, but the symbols have meaning beyond the media function of the physical brain. The basic nature and value of information is that it provides meaning beyond the physical properties of the media. A type of dualism between meaning and media is implied. This is true for information in general and for imagination in particular.

The ability to symbolically represent hypothetical possibilities as well as manifest reality is pivotal. Ultimately, most information of interest to living beings pertains to manifest reality, whether current or future conditions. However, the ability to think about abstract possibilities provides the power to cause or create the manifestation of a desired possibility. This ability emerges from many layers of information processing.

Information and Quantum Physics

Quantum Physics and Potential Outcomes

In quantum physics, equations have been developed that describe the outcomes of experiments with great accuracy; however, the interpretation of the terms in the equations has thus far defied scientific understanding (Greene, 2004; Greenstein & Zajonc, 2006; Schlosshauer, 2007). The primary equation of quantum physics is in the form of waves that include terms for every potential or possible outcome of an experiment or observation. However, there is intrinsic variability and uncertainty on the quantum level, and the waves indicate only the probability that a given outcome will occur. The equations do not deterministically specify which outcome will actually be found. The actual outcome that manifests appears to be random. The waves are often described as *probability waves* and the equation is called the *wave function*. There is no known medium or substance for the waves.

Taken at face value, the wave function indicates that the actual physical state of a particle or system prior to observation is a combination of all possible outcomes of the observation. Numerous experiments support this interpretation (Greenstein & Zajonc, 2006; Schlosshauer, 2007). The most well known is the double slit experiment which indicates that an unobserved individual particle sent toward two slits in a screen in some way responds to both slits as if it were a wave spread over space rather than a discrete particle. The experimental results display *interference patterns* that are exactly in accordance with the wave function. The simultaneous existence of different possible outcomes in a wave function is called a *superposition.*

One of the most perplexing features of quantum physics is that when particles interact with each other, they can become *entangled* in a way that is *nonlocal* (Greenstein & Zajonc, 2006; Schlosshauer, 2007). Two particles become entangled when the wave function has interaction terms that make the state of one particle dependent upon the state of the other particle. The two particles must be considered as a unitary system. A particle that is not entangled can be completely described with a wave function that does not include terms referring to another particle. The entanglement is nonlocal because the two particles (or precursors to particles) may become widely separated in space but somehow remain connected. When the state of one particle is subsequently measured, the state of the other is instantly defined. Nonlocal entanglement has been verified empirically. The specific outcome that is found with a measurement appears to be randomly selected from the potential outcomes, which means entanglement cannot be used to directly transmit useful information instantly between different locations. Entanglement can also occur between a particle and a larger system or the environment.

The terms in the quantum wave function symbolize potential outcomes similar to the human imagination of potential future events. Both involve symbols of potential conditions rather than symbols of existing reality. In both cases, the manifestation of one of the potential outcomes can be viewed as information creation.

Quantum Physics and Measurement

In quantum physics, a measurement not only obtains information about the state of a system, but also has an active role in forming the state that is found. The system can be in a superposition of possible outcomes prior to measurement. The act of measurement or observation transforms the state of the system from the superposition to a single outcome state consistent with classical physics.

The basic wave function of quantum physics offers no insight into how and when the superposition of probability waves gets transformed into the one outcome that becomes manifest (Greenstein & Zajonc, 2006). This is known as the *measurement problem* and is subsumed by the newer

term *quantum-to-classical transition*. The wave function predicts that when a particle interacts with a measurement apparatus, the particle and apparatus may become an entangled superposition, but not transformed into one outcome. At present, scientists understand neither how to conceptualize the probability waves nor how observed physical reality emerges from them. Several ideas have been proposed for addressing this measurement problem but none have convincing support. One of the oldest ideas is that the observation of a measurement outcome by a conscious observer causes the wave function to *collapse* from a superposition to a discrete outcome (Schlosshauer, 2007, pp. 359–365). As discussed in a later section, this hypothesis is often favored within parapsychology.

Which-Path Information and the Quantum-to-Classical Transition

Recent studies have investigated what constitutes a measurement that causes the quantum-to-classical transition. It has long been known that adding a detector to determine if the particle passed through one of the slits in a double slit experiment will eliminate the quantum superposition and result in classical individual particles. Experiments have investigated different methods for obtaining this *which-path information* or *which-way information*.

One of the most important findings is that the quantum-to-classical transition occurs when there is potential which-path information, whether or not someone observes the information and whether or not there is a specific detector for it (Greenstein & Zajonc, 2006; Mandel, 1999; Schlosshauer, 2007). A common expression is that the information is available "in principle." For example, if individual photons (light particles) are sent one at a time through a screen with two slits, an interference pattern will occur indicating a quantum superposition. If plates that alter light polarization are placed in front of the slits, the photons from the different slits will have different polarizations that could be detected by an appropriate device to indicate which slit a photon passed through. The presence of the polarizing plates eliminates the quantum interference pattern. This occurs even if there is no detector to measure the polarization to identify which slit a photon actually passed through, and thus no observation of the which-path information (Schneider & LaPuma, 2002; Walborn, Terra Cunha, Padua, & Monken, 2002, 2003).

Another important finding is that the quantum-to-classical transition can be partial and gradual rather than an instantaneous all or none collapse (Greenstein & Zajonc, 2006; Schlosshauer, 2007). When partial information is obtained about the path of a particle, the resulting interference patterns are weaker but still present. The interference patterns fade out and the results become classical as more information is obtained about the path of the particle.

In other experiments, the decision as to whether or not to use a which-path device is made after the particle has presumably passed through

the slits. The quantum-to-classical results of these *delayed choice* experiments are the same whether the decision is made before or after the particle should have passed through the slit(s) (Greene, 2004, pp. 186–199; Greenstein & Zajonc, 2006, pp. 39–44). Such results are incomprehensible in terms of classical physics and traditional scientific determinism.

If the state of a particle is entangled with another particle, each particle does not have a quantum superposition or interference pattern when observed individually. If photon A has two possible paths and photon B has possible states that are entangled with the path of photon A, then the which-path information for photon A can be obtained by observing photon B. Once photon A becomes entangled with photon B in a way that depends on the path of photon A, photon A will not show superposition or interference patterns if it is examined alone. This is true even if photon B is not observed by a person. However, if the two photons are examined together with a coincidence detector, an interference pattern can be seen in the relationship between the particles that cannot be found with either particle individually. These results have been found in various experiments (e.g., Herzog, Kwiat, Weinfurter, & Zeilinger, 1995; Wang, Zou, & Mandel, 1991; Zou, Wang, & Mandel, 1991) and can be derived from the wave function. The fact that which-path entanglement causes quantum superpositions to disappear for the individual entangled systems has important implications and is the foundation of decoherence.

Quantum Physics and Decoherence

Outside of highly controlled laboratory conditions, quantum systems are in constant interaction with the environment. These countless interactions include air molecules, thermal radiation, and cosmic radiation (Greenstein & Zajonc, 2006; Schlosshauer, 2007; Zurek, 2003a, 2003b). The initial theoretical development of quantum physics focused on isolated systems and did not consider the implications of the interactions with the environment in open systems.

These countless interactions are actually the environment becoming entangled with which-path (or more appropriately which-state) information for a quantum system. Although the amount of which-path information in each individual interaction is tiny, the cumulative effect of all the interactions is decisive. Substantial theoretical and experimental research confirms this conclusion (Schlosshauer, 2007; Zurek, 2003a, 2003b). As noted in the previous section, which-path entanglement results in the loss of quantum superpositions and causes the quantum-to-classical transition.

These environmental interactions cause the absence of quantum effects in our everyday world (Schlosshauer, 2007; Zurek, 2003a, 2003b). The elimination of quantum superpositions by environmental interactions is called *decoherence*. For example, estimates of decoherence times for a dust grain are so fast that superpositions would be extremely difficult to

observe (Schlosshauer, 2007, p. 135; Zurek, 2003a). The decoherence times for larger objects are many orders of magnitude faster.

Decoherence is a dominant factor in the quantum-to-classical transition, but whether it fully resolves the measurement problem remains an open question (Greene, 2004; Greenstein & Zajonc, 2006; Schlosshauer, 2007). As yet it is not possible to empirically distinguish among different hypotheses. Given that key aspects of quantum physics remain beyond current scientific understanding, it is appropriate to remain cautious in drawing conclusions on this topic.

Discussion of Information and Quantum Physics

Because the human experience most analogous to quantum probability waves is the imagination of hypothetical futures, the attribution of mental properties to the quantum domain may be inevitable. Stapp (2009, p. 195) described the quantum domain as "idealike" rather than "matterlike." He pointed out that the basic properties of the quantum domain are represented by potentialities and probabilities, and the actual outcomes that are manifest appear to be selected in a way not controlled by any known mechanical law. The interconnectedness in the quantum domain that supports entanglement and delayed choice apparently has a means to incorporate all the relevant factors, conditions, and possibilities in a given situation, even though the factors and conditions may be spread over space and time, and the possibilities may be potential or hypothetical events. Because this interconnectedness does not involve any known energy, the closest analogy appears to be information. As might be expected, the term information is increasingly used in discussions of quantum physics (e.g., Bohm & Hiley, 1993; Greenstein & Zajonc, 2006; Schlosshauer, 2007; Zurek, 2003b).

However, as yet there has been virtually no consideration of media, symbols, or interpretational infrastructure for the quantum domain. Theoreticians such as Bohm (Bohm & Hiley, 1993) appear to be using the term *information* as a label for unknown and basically incomprehensible processes. Bohm's assumption that a particle has a "rich and complex inner structure which can respond to information" (Bohm & Hiley, 1993, p. 39) and that "a rudimentary mind-like quality is present even at the level of particle physics" (p. 386) is attributing to particles the information processing capabilities of life. The analogies he offers to help clarify his ideas about information on the quantum level all involve living systems (seeds, people, ships guided by people). However, the theory does not attempt to identify or describe the medium or interpretational infrastructure in the quantum domain that functions as if there was instantaneous transfer of nonlocal information.

Discussions of decoherence often include descriptions that imply that the environment serves as media for symbolic representation of the state

of a quantum system. These descriptions include, "encoding information in the environment," "transfer of information to the environment," "environmental monitoring," and "environment as witness" (Schlosshauer, 2007; Zurek, 2003b). However, there has been no description of an interpretational infrastructure that decodes the symbolic representations and takes corresponding actions for the quantum-to-classical transition.

On the other hand, there appears to be an emerging understanding that entanglement is the key factor for the quantum-to-classical transition, not whether the which-path state is actually measured or is symbolically represented in media (e.g., Ferrari & Braunecker, in press). The expression which-path information "in principle" implies that symbolic representation in media is not necessary. For example, which-path information has been based on the time of arrival of a particle even though the actual time differences were "millions of times shorter than the resolution of the detectors and electronics" (Mandel, 1999, p. S280).

On a more general level, Bell argued that the term *information* should be excluded from fundamental theories in physics because the term requires the specification of "whose information" and "information about what" (Bell, 2004, p. 215). Bell's point recognizes that established information processing is associated with life and has an interpretational infrastructure. If the term *information* is used in physics, the assumptions about media for the symbolic representations should be described, as well as whether the actions resulting from the information require an interpretational infrastructure that has properties of a living system.

One important question is whether some interactions cause quantum superpositions to collapse as historically assumed for measurement, or whether a more appropriate model is that superpositions endlessly shift to higher order interactions, with the classical world emerging behind this moving front of increasingly complex entanglement. The latter is more consistent with the wave function. Analysis of multiple interactions may provide insights about higher order entanglement and the measurement problem.

The quantum domain may fluctuate among possible outcomes, with the outcome that becomes manifest determined by the state of the fluctuations when an outcome inducing interaction occurs.[1] Entanglement implies that the components fluctuate in a correlated or connected manner that is not constrained by the space and time of classical physics. Thus, the fluctuations would appear to be among the virtual outcomes as units,

[1] This model for the selection of the quantum outcome that becomes manifest is analogous to the operation of certain electronic random number generators (RNGs) used in parapsychological experiments. These devices internally oscillate rapidly between possible outcome states. When an outcome decision is initiated, a random time delay is implemented using radioactive decay or a noise diode. The state of the oscillator at the end of the delay is the selected outcome. Similarly, the quantum level could rapidly fluctuate among potential outcomes and the manifest outcome be determined by the state when an outcome inducing interaction occurs.

including nonlocal correlations for an outcome. This model may be an alternative to information processing on the quantum level.

Information and Paranormal Phenomena

Unique Creation Events

Can a functioning information processing system with symbols, media, and interpretational infrastructure develop spontaneously from interactions of inanimate matter and energy? This is a fundamental question for the origin of life. Investigation of this question is dominated by basic principles of scientific methodology.

The most convincing scientific evidence for a hypothesis comes from repeatable controlled experiments, preferably randomized and double blind. Studies based on nonexperimental observations can only report descriptions and correlations, and are inevitably controversial if people have differing motivations about the results. Any conclusions from these nonexperimental studies are dominated by the traditional warning in science that correlation does not prove causation. Alternative explanations can virtually always be proposed by opponents.

Most allegedly "scientific" claims about the origin of life or the origin of the universe are actually speculations with no hope of even minimally convincing empirical evidence for the indefinite future. The origin of the universe and origin of life are extremely difficult to investigate meaningfully because directly relevant observations are not possible. Claims for empirical evidence must be based on speculations about residual artifacts from unique events in the remote past, long before there was any possibility of human observation. These are extreme cases of controversial nonexperimental research.

A creation event that may have occurred only once in the history of the universe cannot be empirically distinguished from a miracle and is outside the domain of convincing scientific explication. The most convincing evidence would be if other occurrences were somehow found. Even events created in laboratory experiments would be controversial because that would only demonstrate that intelligent beings can create the event, not that the event can occur spontaneously in nature.

At present, opinions about these unique creation events are matters of faith in a personal philosophy and/or cultural fads rather than scientific evidence. A person's basic personality can be a determining factor for beliefs about such matters (Kennedy, 2005). For example, some people have personalities that are by nature drawn to transcendence and mysticism, whereas others have personalities that are materialistic and distrusting of abstract ideas. The plausibility of different philosophies can be expected to differ among people with these different personality factors.

Conscious Observers

For those who propose that conscious observation has a significant role in the quantum-to-classical transition, it is a relatively small step to propose that the observer can influence the outcome of the transition. In fact, a priori, if a conscious observer causes the quantum-to-classical transition, it would be more surprising if the observer could not influence the specific outcome than if the observer could influence it. However, such an influence would currently be considered paranormal because all prominent interpretations of quantum physics assume that the actual outcomes are completely random. Of course, this hypothesis must ultimately be addressed empirically. Walker (1975, 2000) has done the most work to develop the theory that conscious observers can influence the outcome of quantum events.

Walker developed a quantitative model of quantum effects at synapses in the brain and described the "will" as the information rate in human consciousness that could influence the outcome of quantum events. According to his estimates, the information rate of the will is about .001 smaller than the total information rate in the conscious stream, which indicates a very poor signal-to-noise ratio (Walker, 2000, p. 264–265). This could explain the unreliable effects in parapsychological experiments. He also retrospectively calculated the expected variation in the results of efforts to paranormally influence dice made of different materials and reported good agreement with a set of experimental data (Walker, 1975). He proposed that this model could explain the psi effects reported in parapsychological experiments.

The hypothesis that a conscious observer causes the quantum-to-classical transition is less plausible now given the evidence that the transition requires neither a detector nor observation. Also, the hypothesis of a conscious observer has long been recognized to be problematic when applied to cosmology because it would appear to require a conscious observer that is outside of the recognized universe (e.g., Bohm & Hiley, 1993, p. 24). However, as noted above, these matters of interpretation are not yet fully resolved.

More importantly, Walker's work has not found significant empirical support. His work has not produced more reliable experimental results in parapsychology.

The experimental results in parapsychology do not have the properties of a signal in noise as assumed by Walker's model and as assumed for statistical analysis of experiments. For a phenomenon with a poor signal-to-noise ratio, redundancy can be used to increase the reliability of results. This is the standard assumption for signal enhancement in quantitative information theory and for doing power analyses to determine the sample size for designing experiments. However, the results of efforts to apply signal enhancement methods in parapsychology have consistently deviated

from the expected results (Kennedy, 1979, 1995). Similarly, meta-analyses and other summaries of parapsychological research have consistently found that a larger sample size in an experiment does not increase the likelihood of obtaining a significant result (Kennedy, 2004a, 2006).

These findings are contrary to the basic assumptions for statistical analysis and indicate that the standard procedures for statistical analyses, experimental design, power analysis, and meta-analysis are not applicable for parapsychological experiments. Such patterns are normally interpreted as symptoms of methodological problems in a meta-analysis (e.g., Egger, Smith, Schneider, & Minder, 1997).

The current experimental findings in parapsychology cannot be convincingly distinguished from a database dominated by methodological biases (Bosch, Steinkamp, & Boller, 2006a, 2006b; Kennedy, 2004a). After much research effort, there is not convincing empirical evidence for the hypotheses that an observer can sometimes influence quantum outcomes. The bottom line remains that if the primary challenge for parapsychological research was a poor signal-to-noise ratio, standard research methods should have produced reliable results long ago.

Parapsychology has not been able to successfully shift from an exploratory methodology to a convincing confirmatory methodology. Meta-analysis is a type of post hoc analysis that is useful for exploration, but as normally applied is methodologically incapable of providing convincing confirmatory evidence in controversial settings (Kennedy, 2004a, 2006). The strongest experimental evidence comes from developing a protocol that describes the planned experiment and planned analysis, and then carrying out the experiment in accordance with the protocol. The protocol should include a power analysis that specifies a sample size with at least 80% probability of obtaining significant results, and the results should be consistent with this expectation (Kennedy, 2004a). Unfortunately, the experience to date indicates that this research strategy does not work with parapsychological experiments.

The evidence that allegedly paranormal phenomena do not conform to the usual assumptions for experimental research does not mean that paranormal phenomena never occur. Different research paradigms, strategies, and methods may be needed (e.g., Kelly, Kelly, Crabtree, Gauld, Grosso, & Greyson, 2007; Kennedy, 2004b; White, 1997a, 1997b). This evidence does, however, rule out the simple experimental methods and models that have dominated parapsychology thus far. These methods were an appropriate starting point for research, and the experience with them is scientific progress.

Here too, a person's attitude will depend on personal philosophy, worldview, and personality. For example, those who are materialistic by temperament will probably interpret the current state of research as additional compelling evidence that paranormal phenomena do not exist. Alternatively, those who are more mystical by temperament will likely

believe that it was naive to hope that these phenomena could be reliably controlled using relatively simple experimental methods. If that were true, the paranormal would be normal, which has been an implicit assumption of the research program. From this perspective, the current state of research is a natural evolution toward more appropriate models and methods. An obvious alternative research strategy is to investigate spontaneous cases to better understand the process and purposes of psi.

Spontaneous Cases

Surveys typically find that about half the general population report that they have had a paranormal experience (Stokes, 1997). These experiences have been a strong motivation for investigating paranormal phenomena. However, closer examination of the cases indicates that only about 10% to 15% of the population has had experiences that could be actual psi, which means that at least 70% to 80% of the people reporting psychic experiences appear to be misinterpreting the experiences (Kennedy, 2005). A previous article reviewed personality and motivations to believe, misbelieve, and disbelieve in paranormal phenomena (Kennedy, 2005).

The most commonly reported psychic experiences manifest in an uncontrolled manner through the imagination as dreams, hallucinations, or intuitions (Stokes, 1997). Belief in and reports of psychic experiences are associated with personality factors such as absorption that indicate higher degrees of imagination (Kennedy, 2005).

In terms of information processing, receptors would be expected that somehow respond to something like other dimensions of space or time. However, in the absence of predictable occurrences of the phenomena, there is little hope of identifying a receptor. In fact, it is unlikely that such receptors exist.

The absence of reliable, useful applications of psi virtually precludes the hypothesis that psi is a human ability, and precludes any associated information processing model for psi. Abilities of clairvoyance and/or precognition would obviously have great survival value and would be expected to be enhanced through evolution as has occurred with other useful perceptual abilities. However, the alleged psi abilities have not been reliably demonstrated to a degree that is convincing to most scientists and are not noticeably useful in the many situations when such abilities would be of great value. Psi apparently is not susceptible to evolutionary forces, and therefore is not consistent with a human ability.

The fact that psi is apparently not a human ability does not mean that paranormal phenomena do not exist. It does mean that the source is better conceptualized as external to living people. People describe these events as happening to them rather than as something that they initiated or could control. The association of psi experiences with imagination may

reflect a tendency to misinterpret the experiences, or it could indicate that more imaginative people are susceptible to external paranormal influences.

Supernatural

The term supernatural generally implies a being or agency that is different from life as we know it and that has its own motivations and intentions. Even scientists who entertain the possibility of parapsychological phenomena often tend to balk at hypotheses involving the supernatural. Parapsychological models usually involve some type of perceptual or instrumental ability of living beings and assume that these abilities are directed by motivations, intentions, or needs of the living being. However, contrary to the assumptions of experimental parapsychology, the research findings suggest that paranormal phenomena may result from motivations or intentions that are not associated with identifiable living beings.

The seemingly capricious, evasive results of paranormal phenomena are often described in terms that indicate an active agency with motivations different from the people involved. These descriptions of psi include "actively evasive" (Beloff, 1994), "self-obscuring" (Braud, 1985), "trickster" (Hansen, 2001), "seems to avoid those positions in space and time when we are actively looking for it" (Batcheldor, 1994, p. 93), "can act capriciously, as if . . . to resist complete verification" (McClenon, 1994, p. 75), and "intended . . . to remain *baffling*" (James, 1909/1960, p. 310). Hansen (2001) devoted an entire book to the applicability of the trickster concept to paranormal phenomena. The trickster has a long history in shamanism as a spirit whose role was "to show how egocentric, selfish behavior resulted in humiliation and bad outcomes, or how the spirit world could play unpredictable tricks on people and thus prevent them from becoming too self-confident or haughty" (Hayden, 2003, p. 119).

Ideas like the trickster appear consistent with the experimental findings that defy the assumptions for standard statistical methods. Researchers tend to propose these concepts only after decades of futile efforts to obtain reasonably consistent empirical results. Jahn and Dunne (2001) well summarized the situation as: "At the end of the day, we are confronted with an archive of irregular, irrational, yet indismissable data that testifies, almost impishly, to our enduring lack of comprehension of the basic nature of these phenomena" (p. 300). The failure to develop practical applications of psi after numerous efforts is strong evidence that these phenomena defy human intention and motivation (Kennedy, 2003).

Spontaneous cases of psychic phenomena are often most consistent with some type of supernatural explanation. These cases are typically unexpected, do not have any material benefit to the person, and are frequently transformative and interpreted as evidence that the person's life is guided or watched over by a higher power (Kennedy, 2000; 2004b; Kennedy

& Kanthamani, 1995; White, 1997a, 1997b). Similarly, paranormal events were claimed in the history of most religious and/or spiritual traditions and are interpreted as evidence for the existence and intervention of a supernatural transcendent power or being (Kennedy, 2004b; McClenon, 1994; Woodward, 2000).

One possible explanation for this pattern of findings is that the primary function of paranormal experiences is to draw attention to spiritual matters. "The instances of striking psi draw attention away from the material world, and the capricious, actively evasive characteristics of psi thwart efforts to use psi for material self-interests" (Kennedy, 2004b, p. 1). White (1997a, 1997b) collected extensive documentation of the transformative after effects of psychic and other exceptional human experiences. These experiences can be subjectively very compelling for a person and have major effects on the person's worldview and values.

If paranormal effects could be reliably controlled, they would likely be used predominantly for material gain and dominance in business and war, as are other human abilities. Consistent with this view, the most extensive, well funded investigation of psi has been the 24-year Star Gate project for military applications (May, 1996). The capricious, evasive properties of psi have consistently prevented successful development of such applications, even with extensive effort (Kennedy, 2003). The inability to develop practical applications for self-serving purposes is a key factor for paranormal phenomena being associated with spirituality and personal transformation.

If paranormal effects actually occur, the overall pattern of evidence is most consistent with the hypothesis that the effects are produced by beings or an agency separate from the people involved. Based on well over a century of efforts to investigate and control paranormal phenomena, the properties of the phenomena make other explanations very unlikely.

Discussion of Information and Paranormal Phenomena

Psi is usually described as a form of information transfer that does not involve any known physical media. The unexplained nonlocal aspects of quantum physics and the increasing scientific recognition that additional dimensions of space and/or time may be needed to explain the properties of the universe (e.g., Greene, 2004) enhance the possibility of interactions outside the space and time of classical physics. Such interactions could be considered paranormal or supernatural given our current level of understanding. However, such speculations must ultimately be supported by empirical evidence. As yet, parapsychology has not produced empirical findings convincing to most scientists.

Some people have had experiences that they believe are paranormal and that influence the direction of their lives (White, 1997a, 1997b). I am one of those people (Kennedy, 2000). These spontaneous cases do not

provide convincing scientific evidence for cautious scientists; however, the subjective impact is compelling and is undaunted by the arguments of skeptics.

Just as quantum entanglement apparently cannot be used to instantaneously transmit useful information, perhaps paranormal phenomena cannot be reliably used for personal material gain or for military or business applications. These may be constraints built into nature. Parapsychological researchers have tended to rely on post hoc psychological speculations to explain the capricious, evasive results (e.g., Eisenbud, 1992; Radin, 2006; Tart, 1984). However, the persistent pattern of results appears more consistent with a fundamental property of nature (Kennedy, 2004b)

Given the research findings to date, the range of possible explanations for paranormal phenomena has narrowed considerably. A tentative model consistent with available data would be that there are other dimensions of space and/or time that humans are not aware of, and agencies in those dimensions can affect the physical world that we experience. However, those agencies intervene in the physical world only rarely and for very limited purposes related to meaning in life and spiritual growth for an individual person. The occurrence of such interventions varies greatly among people and can vary over the course of a person's life. With this model, paranormal phenomena are not human abilities and cannot be developed for reliable applications.

The spiritual aspects of paranormal phenomena may be a starting point for research. Kelly et al. (2007) proposed that a dualistic "psyche" associated with a person is the best explanation for paranormal and mystical experiences. This proposal came from an update and extension of the writings of William James and Frederick Myers. Kelly et al. described the associated psyche as an aspect of consciousness that is a fundamental, causal property of nature and probably is related to the interconnectedness of the quantum domain. With this model, a person's brain and associated psyche interact, with the brain generally serving as a filter or barrier for awareness of the associated psyche. The associated psyche apparently processes information in one or more dimensions that humans do not perceive directly. Kelly et al. note that the associated psyche may have autonomous aspects that are related to concepts of life after death. However, they do not specifically address the possibility that the associated psyche may have motivations, intentions, and values that are different than the biologically based motivations, intentions, and values of the physical body and brain.

The hypothesis that the associated psyche may introduce spiritual values is a minor clarification that has important implications and is consistent with the overall empirical data relating to paranormal phenomena and mystical experiences. If the primary purpose of paranormal experiences is to influence a person's sense of meaning in life and spirituality, then paranormal phenomena may tend to be conspicuous rather than unobtrusive. This is consistent with my experiences (Kennedy,

2000) and can be investigated by evaluating the effects of the experiences and alternative ways the effects could have been produced.

Unfortunately, parapsychologists have tended to avoid the religious or spiritual aspects of psi because they feared it would detract from their scientific standing. This was particularly true in the 1970s when I worked at J.B. Rhine's Institute for Parapsychology. Similarly, those recently investigating scientific perspectives on *divine action* do not mention parapsychology (Russell, Murphy, & Stoeger, 2008). These interdisciplinary discussions among scientists, theologians, and philosophers have focused on "noninterventionist" approaches that conceptualize divine actions as operating unobtrusively through points of indeterminism in natural processes rather than as miraculous interventions in natural processes. This strategy was specifically chosen to try to minimize discord with the worldview of the natural sciences. However, the spiritual aspects of paranormal experiences have central relevance for both parapsychology and the investigation of divine action.

Conclusions

Life consists of many layers of information processing, including genetics, perceptions, behavior, memory, learning, communication, imagination, creativity, and culture. Once the basic information processing to support evolution was in place, the evolution of enhanced information processing abilities could be expected, and creativity and culture may have been inevitable. However, the origin of the information processing needed to support life and evolution remains a profound mystery.

Recognizing the components of information as symbols, media, and interpretational infrastructure clarifies the relationship between information and matter. These three components must function as an integrated unit for information to occur. The symbols and interpretational infrastructure of information provide meaning, value, and effects that are far beyond the physical properties of the media. For example, spoken words often have results that are vastly greater than the direct physical force of the vibration of air molecules. This leap from matter to information via symbols and interpretational infrastructures creates a basic dualism.

The meaning of symbols has a different nature and properties than the physical media that hold the symbols. The subjective impression that our thoughts are more than the matter in the brain is correct. At the same time, if the media are damaged, information processing is also damaged. The controversies about human consciousness (see e.g., Donald, 2001) may result from differing emphasis on physical media versus symbolic functioning. Those drawn to deterministic materialism may focus more on the properties of the brain functioning as media, whereas others may focus more on the virtually unlimited degrees of freedom and creativity of the symbols and interacting layers of interpretational infrastructures.

All currently known information processing systems are a function of life. I find it impossible at present to conceive of symbolic information processing that is not ultimately a function of living systems. Therefore, hypotheses in quantum physics or parapsychology about information that is not a function of life as we know it imply dimensions of life that are beyond current scientific understanding. For example, the physical universe and/or life as we know it could serve as media for information from a higher level of interpretational infrastructure.

Quantitative information theory as utilized in physics and engineering uses the term *information* narrowly for certain mathematical probability models that generally do not consider the interpretational infrastructure or the meaning of symbols. This terminology tends to be ambiguous and to promote the dubious implication that any situation where uncertainty or probability is involved has information processing capabilities similar to living systems.

The concepts of information used in both quantum physics and parapsychology assume information transfer without known physical media. A dimension of reality that is currently not recognized would presumably function as media for the symbolic information. Such hypotheses require empirical evidence.

The current experimental evidence for parapsychological phenomena cannot be convincingly distinguished from methodological bias. This is due to the post hoc nature of meta-analysis and the fact that experimental results in parapsychology do not become more reliable with larger samples sizes as assumed for statistical research. This pattern could be a property of paranormal phenomena or a result of methodological bias. This ambiguity could be greatly reduced by registering protocols for experiments prior to conducting them. The protocol would specify the planned hypotheses and analyses. A meta-analysis of the registered studies conducted in accordance with the protocols should be free of most methodological problems that currently confound meta-analyses.

However, I expect that the results of the registered studies will be similar to current findings and therefore will be inconsistent with the positions of both skeptics and proponents of experimental parapsychology. Of course, this expectation needs to be verified empirically. The current parapsychological findings do not have the properties assumed for statistical research and therefore will not provide convincing evidence in the absence of an explanation for this anomaly. If these anomalous properties are not due to methodological problems, then new research strategies and models are needed for parapsychological research. Three properties of the research findings make scientific research in parapsychology particularly difficult.

First, for well over a century the most conspicuous property of parapsychological research has been the capricious and seemingly actively evasive outcomes. This property prevents the reliable demonstration and

useful application of psi effects. I see no hope for progress in parapsychology until this dominant characteristic is confronted. This property, combined with the evidence that paranormal phenomena often inspire meaning in life and spiritual transformations, suggests that investigation of the spiritual implications of paranormal phenomena may be productive. The overall properties of paranormal effects are more consistent with a model of a supernatural source rather than with a model of a human ability. The motivations and values of the supernatural source appear to be more consistent with spiritual values than with the materialistic self-interests that are assumed to underlie biological evolution (Kennedy, 2004b).

Second, as noted by Eisenbud (1992), parapsychological experiments are carried out with the curious assumption that everyone has psi ability except the experimenters. If psi is a human ability directed by motivation as assumed in experimental parapsychology, then the experimenters can paranormally influence the outcomes of their experiments to obtain whatever results they want. An experimental outcome is a random event and therefore would be susceptible to paranormal influence. Within the larger context of evasive results, consistent differences among experimenters have long been a prominent characteristic of parapsychological research. More successful experimenters have tended to be more successful subjects in psi experiments (Kennedy & Taddonio, 1976; Palmer, 1997; White, 1976a; 1976b). These findings imply that the experimental outcomes are usually related more to the experimenter than to the subjects. This property also undermines the interpretation and value of experiments.

A third property that undermines psi experiments is that psi appears to be goal-oriented (Kennedy, 1995; Schmidt, 1974; Stanford, 1977). This means that a psi effect is independent of the complexity of a random process. For example, with goal-oriented psi, an experiment can be viewed as the outcome of one complex random event with a probability of success of .05 (the alpha level of the experimental analysis). Alternatively, the experiment can be viewed as a series of subevents (i.e., each subject or each response) with a uniform effect applying to each subevent. The latter is the assumption for statistical analysis and results in higher statistical significance with larger sample sizes (more subevents) and effect sizes that are unrelated to sample size. However, if the experimental outcome is influenced as one random event, then the significance level will be unrelated to sample size and the effect size will be inversely related to sample size, which are exactly the characteristics typically found in meta-analyses of psi experiments (Kennedy, 2004a, 2006). Unfortunately, methodological bias such as selective publication also can produce this same pattern. However, this pattern has been found in at least one meta-analysis where publication bias was unlikely (Bem & Honorton, 1994). The proposed registration of psi experiments, combined with appropriate adaptations to the methodology and expectations for meta-analysis, should minimize this issue. In the absence of prospective registration of

experiments, methodological bias will continue to be the most common scientific interpretation for the findings.

If the results of psi experiments are not entirely due to methodological bias, the model that appears most consistent with the research findings is that psi effects are goal-oriented and operate on the overall experimental outcome as a unit within context of an active evasiveness that prevents reliable demonstrations or useful applications of psi. Also, the occurrence of paranormal experiences varies greatly among people, including experimenters. Research progress in this situation has been and will be very challenging. This model will strike many people as absurd. Of course that does not mean that it is incorrect, only that it is outside their current worldview.

There are sufficient anomalous effects to maintain the interest and sometimes inspire those who are attracted to mysticism or exceptional powers of the mind, and that appears to be a basic property (or intent) of the phenomena. However, the effects are too unreliable to convince cautious scientists and are not remotely convincing to skeptics. For the foreseeable future, neither skeptics nor proponents can provide convincing scientific evidence for their positions. Under these conditions, a person's attitude toward the paranormal will be subjective, with temperament and personality likely being significant factors (Kennedy, 2005).

The overall status of paranormal research has changed little over the past 100 years. In 1909, William James (1960) summarized the state of paranormal research by describing the phenomena as "… incoherent … fitful … with no law apparent but to interrupt, and no purpose but to baffle" (p. 319). He also concluded that "one cannot get demonstrated proof here. One has to follow one's personal sense … of the dramatic probabilities of nature. Our critics here obey their sense of dramatic probability as much as we do" (p. 320).

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