Review Article

Extrasensory Perception and the Brain Hemispheres: Where Does the Issue Stand Now?

Bryan J. Williams

ABSTRACT

For over a century, evidence has been gathered to indicate that the two cerebral hemispheres of the human brain each tend to have their own behavioral specializations. An issue that has long been of interest to parapsychologists is whether the ostensibly anomalous behavioral phenomenon of "extrasensory perception" (ESP), in which a person seems to obtain veridical information about other people, objects, places, or events beyond the range of the body's sensory-motor system, may be a specialized function of either of the brain hemispheres. To address this issue, a review of parapsychological experiments designed to explore the potential relevance of cerebral lateralization to ESP performance was initially conducted by Broughton in 1983. He generally concluded that, although there was some possible indication of a contribution to ESP by the right hemisphere, the results were mixed and possibly confounded by issues of interpretation. In a more concise review conducted in 2002, Alexander found that a limited number of experiments continued to indicate a right hemispheric tendency, although certain others separately indicated left hemispheric involvement. Thus, the issue is still clearly unresolved. This paper seeks to build upon these two previous reviews by providing an updated and broader review of the various findings obtained in the experiments that have been conducted up to the present time. Although several experiments continue to offer modest support for a right hemispheric contribution, general interpretation of the current database remains hindered by a wide degree of variability in experimental methods and outcomes, potentially confounding factors, and the scarcity of additional clarifying data. Thus, while the issue remains unresolved, there appear to be at least some potential avenues for progress in future experiments.

Key Words: brain hemisphere, extrasensory perception (ESP), cerebral lateralization, hemispheric asymmetry, neuroscience

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Introduction

Ever since the pioneering efforts of Broca (1865), Wernicke (1874), and Hughlings Jackson (1915) in the late 19th and early 20th centuries, the cerebral lateralization of behavioral processes has been a fundamental concept of psychology and neuroscience. And indeed, for well over a century, a considerable amount of clinical and experimental evidence has been gathered to indicate that, although they look nearly identical on the surface, the two cerebral hemispheres of the human brain each tend to be specialized for certain behavioral functions (for a historical overview, see Harrington, 1995).

For instance, there is now a large amount of clinical and neuropsychological evidence to support the initial observations of Broca and Wernicke that the left hemisphere tends to be functionally specialized for speech and language processing (Bhatnagar, 2002, pp. 361 – 367; Geschwind, 1990; Kolb and Whishaw, 1990, Ch. 22; Pinel, 2006, pp. 411 – 423; Schneider and Tarshis, 1995, pp. 636 – 639).[2] This is not limited solely to spoken

Corresponding author: Bryan J. Williams
Address: Psychical Research Foundation, Albuquerque, New Mexico 87110, United States.
Phone: +(505) 292-8435
✉ bwilliams74@hotmail.com and bryanwilliams@psychicalresearchfoundation.com
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[2] For a small amount of people in the general population (roughly 30%) who are left handed or ambidextrous, speech and language are

language, but also apparently extends to non-verbal communication such as sign language (Corina *et al.,* 1992; MacSweeney *et al.,* 2008). In addition, the left hemisphere appears to have a role in memory for words (Funnell *et al.,* 2001), and in the visual identification and processing of printed words (McAuliffe and Knowlton, 2001). Generally, according to Springer and Deutsch (1993), the left hemisphere has been thought to represent the verbal, active, analytical, and rational side of the brain.

In contrast, on the basis of his observations of "split-brain" patients, Nobel laureate Roger Sperry (1982) wrote that the right hemisphere is adept at processing non-verbal, non-analytical, and non-sequential tasks such as "…the reading of faces, copying of designs…the discrimination and recall of nondescript factual and visual shapes, spatial transpositions and transformations…and perceiving whole forms from a collection of parts" (pp. 57 – 58). Another perspective, based in phenomenology, comes from neuroanatomist Jill Bolte Taylor (2009), who claims to have personally experienced the domain of the right hemisphere after suffering a severe stroke that affected the left temporal, frontal, and parietal regions of her brain. A partial account of the profound feeling of her experience is as follows:

> I remember that first day of the stroke with terrific bittersweetness. In the absence of the normal functioning of my left orientation association area [located within the left parietal lobe], my perception of my physical boundaries was no longer limited to where my skin met air. I felt like a genie liberated from its bottle. The energy of my spirit seemed to flow like a great whale gliding through a sea of silent euphoria. Finer than the finest of pleasures we can experience as physical beings, this absence of physical boundaries was one of glorious bliss. As my consciousness dwelled in a flow of sweet tranquility, it was obvious to me that I would never be able to squeeze the enormousness of my spirit back inside this tiny cellular matrix [of the human body] (p. 69).

The phenomenology of Taylor's (2009) experience seems to suggest the perception of a broader spatial expanse, which may perhaps reflect a contribution of her right hemisphere to compensate for the debilitation of her left hemisphere. The possibility that Taylor's experience was more reflective of a contribution from the right hemisphere rather than the left is indicated by the difference she perceived in her post-stroke subjective experience, which she described as a

> …dramatic silence that had taken up residency inside my head. It wasn't that I could not think anymore, I just didn't think in the same way. Communication with the external world was out. *Language with linear processing was out. But thinking in pictures was in. Gathering glimpses of information*, moment by moment, and then taking time to ponder the experience, was in (pp. 77 – 78, emphasis added).

Elsewhere in her personal account, Taylor again states that she "…stopped thinking in language and shifted to taking new pictures of what was going on in the present moment" (p. 71).

The absence of language and a description of "thinking in pictures" in Taylor's (2009) account both seem to suggest a prime *visual-spatial* component to her experience, a component that is commonly associated with the right hemisphere. And indeed, a large amount of neurological and neuropsychological evidence seems to support Hughlings Jackson's (1915) initial suggestion that the right hemisphere has a prime role in spatial perception and orientation. For instance, lesions to the right parietal lobe are more commonly found to induce spatial deficits in neurological patients than left parietal lesions (Heilman *et al.,* 1986, p. 698; Kolb and Whishaw, 1990, pp. 428–429). In addition, a meta-analysis of 4,728 published experiments relating to hemispheric dominance in spatial tasks by Vogel, Bowers, and Vogel (2003) found a highly significant overall result in favor of the right hemisphere (p = .00028).

There also appears to be growing evidence to indicate that the right hemisphere is involved in the mental tracking of time. For instance, Harrington et al. (1998) found that neurological patients with lesions in the right prefrontal and right inferior parietal cortices frequently exhibited deficits in their ability to time events. Similarly, Morin et al. (2005) found that patients with right hemispheric damage due to stroke made significant errors

processed either by the right hemisphere, or by both hemispheres (Kandel *et al.,* 1995, p. 358).

in estimating the current clock time. Lewis and Miall (2006) have found that the right dorsolateral prefrontal cortex is the brain region activated most frequently during the cognitively controlled timing of events. And Battelli et al. (2007; 2008) have found evidence that the area of the brain supporting the cognitive analysis of the temporal sequence of events is focused around the right parietal lobe, which hints at the possibility that this area may be a part of the "when" pathway in tracking event occurrence.

In addition, there is some indication that the right hemisphere may be specialized for object identification. In a study with a split-brain patient, Funnell et al. (2001) found a high amount of correct memory recall responses when pictures of objects and faces were presented to the left visual field (processed by the right hemisphere) as opposed to the right visual field (processed by the left hemisphere). McAuliffe and Knowlton (2001) also found that healthy participants identified pictures of common objects faster when they were shown in the left visual field as opposed to the right. Similarly, Laeng et al. (2007) found that their participants better recognized pictures of common objects shown to their left visual field as compared to the right when testing them for picture recognition one to six days after initially showing them the pictures.

In general, according to Springer and Deutsch (1993), the right hemisphere tends to be considered the non-verbal, spatial, non-analytical, holistic, and intuitive side of the brain (for additional reviews and discussion of brain hemisphere specialization, see *e.g.,* Ornstein, 1997; Pinel, 2006, Ch. 16; and Springer and Deutsch, 1993).

ESP and the Brain

One type of behavioral phenomenon that has reportedly been experienced by many people (see *e.g.,* Feather and Schmicker, 2005; Rhine, 1981; Stevenson, 1970), but the existence of which remains controversial within psychology and neuroscience, is "extrasensory perception" (ESP), in which a person seems to obtain veridical information or impressions about other people, objects, places, or events that apparently lie beyond the range of the body's sensory-motor system. Based on the assumption that the human brain lacks the capacity to acquire such information, many psychologists and neuroscientists remain unconvinced of the existence of ESP, despite the considerable amount of supporting experimental and anecdotal evidence that has been gathered for it over the past several decades within the field of parapsychology (for recent reviews and discussions, see *e.g.,* Jahn and Dunne, 2011; Krippner and Friedman, 2010b; Powell, 2009; Radin, 2006; Storm *et al.,* 2010; Tressoldi, 2011; and Tressoldi *et al.,* 2010). However, it might be reasonable to think that if ESP is similar in any way to ordinary behavioral phenomena such as cognition, volition, and sense perception, then perhaps it too could be associated in some way with the functions of the brain. And indeed, a number of parapsychological studies seem to offer various lines of evidence indicating that ESP can and does show at least some correlates with brain activity (for recent reviews, see *e.g.,* Alexander, 2002; Krippner and Friedman, 2010a; Williams, 2011; and Williams and Roll, 2008).

In initially considering this line of reasoning, Broughton (1975) raised two additional points for consideration, which he stated in the following manner:

1. If we assume that some paranormal information, an extrasensory percept, somehow gets into the nervous system of a human being, then for it to come out in any of the familiar ways this signal will have to pass through the cerebral cortex at some point, if it isn't already there from the start.
2. If this hypothetical ESP signal is processed by the cerebral cortex, might it not be subject to the same sort of laterality effects as normal cognition? (pp. 139 – 140)

Thus, a related issue of interest to parapsychologists is whether ESP could be associated with the functions of either of the two brain hemispheres. As Broughton (1975) has pointed out, this is not a recently raised issue; in fact, it is nearly as old as the concept of cerebral lateralization itself (see also Harrington, 1995, p. 15). As early as the late 19th century, the psychical researcher F. W. H. Myers (1885) noticed in his studies of trance mediumship that the scrawled messages produced by the mediums through automatic writing (i.e., ostensible ESP mediated through manual motor automatism) had a tendency to resemble the written attempts at

communication made by neurological patients suffering from aphasia (impaired language ability due to left hemispheric damage; Bhatnagar, 2002, pp. 362 – 365). From his observations, Myers suggested that perhaps in the same way that patients with aphasia seem to be utilizing the compensating processes of the right hemisphere to communicate, the mediums may be using their right hemispheres to facilitate their automatic writing.

Nearly a century after Myers' initial observation, Ehrenwald (1975, 1977) made a similar one when he compared the response drawings made by participants in a telepathy[3] test to those drawn by patients suffering from agnosia (an inability to recognize whole objects and attach meaning to sensory impressions, resulting from damage to the left parietal and occipital lobes; Kolb and Whishaw, 1990, pp. 247 – 248). Similar to the patients' drawings, the drawn responses of the test participants had a tendency to reflect only certain aspects of the target object (such as the general shape of its components), which at times appeared in a slightly disorganized or distorted manner. On this basis, Ehrenwald (1975, p. 395) suggested that, like the perceptions of patients with agnosia, the test participants were apparently able to perceive the individual components of the target object, but unable to grasp the object as a whole. As he wrote:

> ...the telepathic subject, like the patient suffering from agnosia, uses his *right*, rather than the dominant *left*, hemisphere for the central processing and organization of his impressions. The brain-injured patient has to fall back on the groping attempts of the "other side" of his brain to make up for the existing deficit on the left side. In turn, the telepathic percipient's productions carry all the hallmarks of the same difficulty in the organization and comprehension of his target material. That is, his responses likewise point to the part played in their origin by the right hemisphere (Ehrenwald, 1977, p. 725, italics in original).

From his observations and those of Myers, Ehrenwald (1984) later suggested: "It appears that whether the right hemisphere is the site of the hypothetical 'psi receptors' or is only instrumental in the *central processing* of psi functions, it does so despite the blocking effect of the left hemisphere" (p. 33, italics in original).

Broughton (1975) pointed to a few other examples in the early psychical research literature that were suggestive of considerations of laterality, such as a reference made by Nandor Fodor (1933) in the volume *The Encyclopaedia* [sic] *of Psychic Science*. As Broughton states, Fodor

> ...mentions that some of the investigators of the famous medium, Eusapia Palladino, noted that in her trances the normally right handed medium became left handed. This was interpreted to signify increased participation of the right lobe in mediumistic states (p. 140).

Close examination of the verbal accounts given by individuals adept in the use of remote viewing (a technique used to gather ESP impressions about concealed target objects or distant geographical locations; Puthoff and Targ, 1976; Targ, 2004; Targ and Puthoff, 1977/2005; Schwartz, 2007) seems to indicate that analytical mentation (which is usually associated with the left hemisphere; Springer and Deutsch, 1993) has a negative effect on ESP performance. For instance, Targ (1994, 2004, pp. 53 – 55) noticed that whenever remote viewers tried to directly analyze or draw conclusions about the target, there was a tendency for the quality of their viewing to decrease. Schwartz (2007, pp. 337 – 338) made a similar observation in his examinations of the mentation techniques employed by two participants in his applied remote viewing studies: the late fiction author Michael Crichton and intuitive psychiatrist Judith Orloff. Schwartz noticed that Crichton and Orloff both had a tendency to use the free-flowing, non-analytical mentation associated with the right hemisphere while gathering their remote viewing impressions. After gathering them, Crichton and Orloff both seemed to enter an analytical frame of mind to interpret their impressions.

On the surface, these anecdotal examples seemed to suggest a contribution by

[3] In the traditional conceptualization of telepathy, it is thought that a "receiver" somehow receives impressions about an ESP target from the mind of a "sender." However, in such a situation, it is also important to acknowledge the alternate possibility of *clairvoyance*, in which the receiver may be able to receive impressions by perceiving the target directly, without the aid of the sender. Because of the inherent difficulty of distinguishing between telepathy and clairvoyance, references made to telepathy in this paper should be taken only as convenient labels, and not as decisive indicators of the type of ESP modality involved.

the right hemisphere to ESP, with a possible interference effect by the left hemisphere. But to be more certain of this possibility, experimental verification would be required. Since the 1970s, several parapsychologists have conducted experiments designed to explore the potential relevance of cerebral lateralization to ESP test performance. Broughton (1983) later conducted a review of the earliest experiments, which mostly involved forced-choice ESP tests designed around cognitive tasks thought to be associated with a certain hemisphere. In general, Broughton concluded that although some of the experimental results did indicate a possible contribution to ESP by the right hemisphere, most of the results were mixed and potentially confounded in their interpretation by various factors. For instance, although they were thought to engage one particular hemisphere, some of the cognitive tasks utilized in the studies may have contained aspects that engaged the other hemisphere, as well (discussed further in the next section). Broughton (1983) pointed out that:

> Brain hemisphere research bears many similarities to parapsychology. Many cognitive lateralization effects seem unstable and subject to all sorts of unexpected influences and many simply prove to be artifacts of the test procedure. Not surprisingly, a fair bit of reported hemisphere differences suffer from repeatability problems. In merging parapsychology and brain hemisphere research we are giving ourselves a difficult job (p. 381).

In a more concise review of the literature relating to ESP and the brain hemispheres reported nearly two decades later, Alexander (2002) found that some experimental results continued to indicate a right hemispheric tendency, while others indicated separate involvement of the left hemisphere, as well. Because the number of experimental studies was still quite limited, she suggested that additional research should be conducted using advanced electroencephalographic (EEG) monitoring, normative EEG reference databases, and functional neuroimaging techniques such as positron emission tomography (PET), functional magnetic resonance imaging (fMRI), and single-photon emission computerized tomography (SPECT). Generally, these two reviews indicate that the issue of whether ESP is associated with either of the brain hemispheres is still clearly unresolved.

In order to see where the issue stands at the present time (2012), this paper seeks to build upon these two previous reviews by presenting an updated and broader review of the various experimental findings related to ESP and cerebral lateralization. Included in the review for completeness are the older studies involving hemispheric cognitive tasks, as well as more recent studies employing EEG and neuroimaging techniques. Because of their overt methodological differences, each type of study shall be examined in a separate section. It is important to keep in mind that, unless indicated, the studies described in the following two sections were all conducted with volunteer participants recruited from the general population (who are simply referred to hereafter as *participants*). Few (if any) of these participants reported an extensive personal history of experiencing ESP, or claimed to possess developed ESP abilities. Because *psychic claimants* (i.e., those individuals who do report having extensive personal histories of ESP, and/or who claim to possess developed ESP abilities) seem to constitute a special case in terms of their personal histories and their claimed abilities, studies with these individuals shall be examined in a separate section.

Hemispheric Cognitive Tasks and ESP Performance

In the same way that psychologists have attributed different cognitive characteristics to the left and right hemispheres (such as those outlined by Springer and Deutsch, 1993), Braud (1975) hypothesized that the two hemispheres may differ in their representation of ESP. Partly guided by subjective accounts from psychic claimants of their mental states during ESP, Braud hypothesized that the spatial, holistic, and non-analytical mentation of the right hemisphere may be more in line with an ESP facilitative state, whereas the analytical, rational, and active state of the left hemisphere may be more ESP inhibitive.

To test this, Braud and Braud (1975) conducted a free-response ESP experiment in which they separately tested two groups of ten right-handed participants. Each test trial began with members of both groups listening

to a progressive relaxation tape to help ensure that, initially, they were all roughly in the same relaxed state of mind. Then, members of one group (referred to here as the "left hemispheric" group) listened to an audiotape that contained a cluster of exercises emphasizing left hemispheric mentation, such as letter counting, arithmetic and logical problems, and reading excerpts on philosophy, law, physics, and vocabulary. Members of the other group (the "right hemispheric" group) listened to a different audiotape that contained pieces meant to encourage right hemispheric mentation, such as classical music, natural environmental sounds (*e.g.,* thunderstorms, animal sounds), and synthesized sounds evocative of depth and imagery (*e.g.,* low frequency bells and gongs). After listening to their respective tapes, the members of each group attempted to gain ESP impressions about a randomly-selected target picture being viewed by another person (acting as a telepathic sender) in a separate room. A comparison of the ESP performance of the two groups indicated a marginally significant difference ($p < .05$), with the left hemispheric group scoring significantly below chance ($p = .011$). Contrary to prediction, the right hemispheric group scored at chance.

Although the results seem to lend at least partial support to the hypotheses made by Braud (1975), an observation made by Broughton (1983) raises some degree of ambiguity in their interpretation. As Broughton stated:

> …one of the facts which has emerged from this and other lines of research is that the relative balance between the activation of the specialized processing facilities of the hemispheres is a dynamic, ever changing one which responds on a moment by moment basis to the demands of the perceptual input. The assumption that the hemisphere activation presumed to be accomplished by the tapes continued for any length of time after the tapes ended is a serious weakness of this study which could have contributed to the marginality of the results (p. 375).

To explore possible hemispheric differences in ESP performance, Broughton (1976) designed three forced-choice experiments in which right-handed participants were asked to make separate ESP responses with their left or right hand while continuously performing a task that would presumably engage the cognitive ability of one specific hemisphere (the left).[4] The reasoning underlying this design, according to Broughton (1976), was that

> …if a task which primarily occupied only one hemisphere were to be combined with an ESP task that was non-verbal and at least to a certain degree could be controlled by either hemisphere in turn, then the fact that one hemisphere had to contend with a competing task would be reflected by differences between the hemispheres in ESP scores (pp. 385 – 386).

This was partly inspired by the early examples Broughton (1975) had uncovered in the psychical research literature that suggested the right hemisphere may be involved in ESP, as well as the idea that "…the addition of a competing task on one of the hemispheres might be expected to affect differentially ESP ability either by inhibiting ESP ability itself or by disrupting a process which normally serves to inhibit ESP" (Broughton, 1976, p. 386).

This design led to four separate test conditions that were examined in each of the three experiments:

1. ESP responses made with the left hand (controlled by the right hemisphere) while the left hemisphere was separately engaged in a competing task
2. ESP responses made with the right hand (controlled by the left hemisphere) while the left hemisphere was simultaneously engaged in a competing task
3. ESP responses made with the left hand without the left hemisphere being engaged in a competing task
4. ESP responses made with the right hand without the left hemisphere being engaged in a competing task

The latter two were comparison conditions meant to explore any effects (whether facilitative or inhibitory) that the left hemisphere may have when it is presumably operating at its full normal cognitive capacity, and is not distracted by the competing task.

[4] Initially, Broughton also intended to include a task that would presumably engage the right hemisphere. However, he was unable to find a task that could be overtly monitored to ensure that participants were continually engaged in it, and that did not involve the left hemisphere as well. For these reasons, this aspect of his experimental design was left unbalanced.

The first of Broughton's (1976) three experiments involved a telepathy test in which 20 right-handed participants attempted to call the random sequence of ESP card symbols (circle, square, star, cross, and waves) being flashed to a partner (acting as a telepathic sender) by an automated test machine in a separate room. To make their calls without speaking, the participants were asked to lift one of five wooden geometric shapes (sphere, cube, cone, cylinder, and pyramid) with their hand, with each shape corresponding to a certain ESP symbol. To examine test conditions 1 & 2, half of the participants' calls were made with the left hand, while the other half were made with the right hand. While making their calls, the participants continually engaged in the competing task of counting back from one thousand by threes, fours, or a combination of both. To examine conditions 3 & 4, the participants simply sat quietly while making their calls with their left or right hand. Although most of the ESP scores were near chance in all of the conditions, a closer *post hoc* examination of the data revealed a slight tendency for greater deviations from chance when responses were made with the left hand (controlled by the right hemisphere) while the left hemisphere was presumably distracted with the counting task.

In an attempt to further explore this tendency, the methodology for Broughton's (1976) second experiment was kept nearly the same as the first, with the only modifications being that the test was now conducted in a clairvoyance situation, and that the competing task now involved the 20 right-handed participants reading aloud from legal reports (which would presumably engage the language ability of the left hemisphere). Chance results were again obtained across all of the conditions, although a closer examination of the data seemed to indicate that other factors may have been involved (discussed later in the "Potential Factors" section).

To see if clearer results could be obtained, Broughton (1976) reverted back to a telepathy test situation in his third experiment, and kept reading aloud from legal reports as the competing task. All other aspects of the methodology were kept the same as the first experiment in order to duplicate it as closely as possible. In line with the outcome from the first experiment, the ESP scores obtained by the 20 right-handed participants were significantly above chance (p = .025) for responses made with the left hand while the left hemisphere was presumably distracted with reading. Scoring for the other three conditions was at chance.

A similar kind of finding was obtained by Broughton (1977) in one of two other experiments he later conducted. These two experiments were partly modeled after cognitive experiments designed to explore hemispheric lateralization effects on a person's reaction time to a certain stimulus, such that when the stimulus is presented unilaterally to each side of the body, the brain hemisphere that is thought to be more specialized at processing the stimulus seems to react faster than the other hemisphere (as inferred from measurements of the reaction times of the limbs controlled by each hemisphere on the contralateral side of the body).

Broughton's (1977) ESP adaptation of these reaction experiments involved a telepathy test situation in which 40 right-handed participants were asked to press a button as quickly as possible in response to the (bilateral) auditory presentation of a 1 kHz tone. Half of the time, the participants used their left hand to press the button, while in the other half, they used their right hand. During some of the trials, the tone was also presented to a friend of the participant (located in another room) 250 milliseconds before it was presented to the participant. It was thought that, in his or her role as the telepathic sender, the friend might be able to relay extrasensory "warnings" about the impending presentation of the tone to the participant, which would presumably result in faster reaction responses by the participant. On the basis of such a possibility, it was predicted that the participant's reaction times during these randomly-determined trials (referred to here as "warning trials") would be shorter than during other trials in which the tone was not presented to the participant's friend ("no-warning trials").

Each of Broughton's two experiments focused on a separate test condition: In the first experiment, the participants simply sat quietly while they made their reaction responses. In the second experiment, the competing task of continuously reading aloud from legal reports was introduced so as to presumably distract the left hemisphere during the participants' responses. While the

results of the first experiment indicated no significant difference in reaction time, the results of the second experiment indicated a shorter reaction time during warning trials as compared to no-warning trials when the participant's responses were made with the left hand. For responses made with the right hand, the reaction time was longer, resulting in a significant difference ($p < .025$) between the warning and no-warning trials that involved the right hand.

Taken together, Broughton's (1976; 1977) experiments seem to indicate a slight advantage for ESP responses made with the left hand (controlled by the right hemisphere) while the left hemisphere is presumably occupied with a competing cognitive task. In addition, one of them (the reaction time experiment) hinted at a slight disadvantage for right hand responses. However, because of the unbalanced nature of his experimental design (see Note 3), proper interpretation of these results becomes rather difficult. In addition, interpretation may be confounded by an issue raised by Maher and Schmeidler (1977; 1978) regarding the method chosen by Broughton (1976) in his first three experiments to allow participants to make their ESP responses without speaking. Although the method of having the participants lift wooden geometric shapes would seem to lessen the likelihood of left hemispheric involvement, there is some uncertainty as to whether the method could clearly be considered neutral with regard to hemispheric involvement. Maher and Schmeidler (1977; 1978) argued that tactile contact with these shapes may have engaged the specialized ability for "tactile-spatial processing" that tends to be associated with the right hemisphere. The possibility that the right hemisphere could have been engaged through the use of this method may further be raised in light of the more recent findings (mentioned in the Introduction) that indicate the right hemisphere may be specialized for object identification.

To further explore and conceptually replicate Broughton's findings, Maher and Schmeidler (1977) devised a more balanced experimental design to examine the possible effects of hemisphere specialization on ESP performance. To examine the effects of the left hemisphere, 24 right-handed participants were asked to reach with their right hand into an opaque bag filled with 25 clear plastic cubes that had been randomized by shaking. To presumably draw upon the language abilities of the left hemisphere, five of the cubes contained slips of paper with the word "clover" written on them (the targets), and 20 cubes contained slips written with the word "wrong" (the decoys). The goal for the participants was to successfully pull one of the target cubes out of the bag, while avoiding the decoy cubes. To ensure that the participants were not making their selections based on tactile sensory cues (such as those stemming from subtle cracks in the surface of the cubes), control tests were made in which individuals attempted to identify and select a certain target cube within the bag on the basis of its surface texture. None were successful.

As they made their selections from the bag, the participants were asked to perform the competing task of finding and tracing with their left hand a design pattern hidden within an optical image, which would presumably engage the visual-spatial abilities of the right hemisphere and distract it from the selections being made from the bag by the right hand.

To examine the effects of the right hemisphere, the participants were again asked to try and successfully select the five target cubes from the bag, but now the left hand was used, and the cubes were now filled with material intended to draw upon the object identification abilities of the right hemisphere. The five target cubes contained actual four-leaf clovers, and the decoy cubes contained bits of clear plastic that were approximately the same weight as the clovers. As they made their selections, the participants performed the competing task of solving logical syllogisms read from a card in their right hand to presumably engage and distract the left hemisphere through its analytical abilities.

To fully balance the design, participant performance in these two conditions was examined along with performance in conditions where participants made their selections while not performing the corresponding competing tasks, and in conditions where participants made their selections using the hand controlled by a specific hemisphere at the same time that that hemisphere was presumably being engaged and distracted by a competing task. ESP scores were at chance in all but one of the conditions. In that one exception, a significant amount ($p = .007$) of target cube selections were made

when the cubes were selected with the right hand (controlled by the left hemisphere) while the right hemisphere was presumably engaged and distracted with the competing pattern tracing task. This result is the mirror opposite of the one found in Broughton's experiments.

In addition, Maher and Schmeidler (1977) claimed that since their experimental procedure offered "…parallel opportunities for ESP facilitation based on the specialized features of each hemisphere" (p. 267), they also performed a *post hoc* analysis in which they combined the scores from the condition in which cubes containing words were selected with the right hand while the right hemisphere was occupied with pattern tracing (i.e., the condition which presumably offers optimal facilitation of ESP processing by the left hemisphere), with the scores from the condition in which cubes containing objects were selected with the left hand while the left hemisphere was occupied with solving syllogisms (i.e., the condition which presumably offers optimal facilitation of ESP processing by the right hemisphere). The combined scores were significantly above chance ($p < .04$), which led Maher and Schmeidler to suggest that both hemispheres may be involved in ESP, such that "…each hemisphere is better at processing the kind of ESP input and output which corresponds to the sensory input and output it normally processes better" (p. 270).

Maher, Peratsakis, and Schmeidler (1979) attempted to replicate these findings in a follow-up experiment conducted with 24 additional participants who were right hand dominant. The design of this follow-up experiment remained virtually identical to the initial experiment by Maher and Schmeidler (1977), with only two exceptions. First, all of the participants were male (the reason for this shall be addressed later in the "Potential Factors" section). Second, since many participants in the initial experiment had expressed a disliking of the syllogism solving task used to presumably distract the left hemisphere, it was replaced by a task in which participants were asked to look up certain words in the dictionary and read their definitions aloud. The results were at chance in all of the conditions, and the significant finding from the initial experiment of right-hand cube selections made during the pattern tracing task was unable to be replicated.

Like Broughton's, interpretation of Maher et al.'s (1977; 1979) findings may be confounded by an issue regarding the task they chose to presumably engage and distract the right hemisphere. As Broughton (1978) pointed out, although the task of finding and tracing a pattern design within an optical image may have engaged the specialized *visual-spatial* ability of the right hemisphere, there is some question as to whether the fine motor skills needed for tracing the pattern with the hands may have also engaged the left hemisphere as well, based on evidence from lesion studies that suggests the left hemisphere has a role in bilateral motor control of the body (Kolb and Whishaw, 1990, pp. 314 – 315).

The most recent effort to explore hemispheric differences in ESP performance using a cognitive approach was made by Alexander (1999; Alexander and Broughton, 2001), in which 50 participants (41 right-handed) were asked to take part in two separate experimental sessions. In the first session, the participants completed a battery of eight neuropsychological tests designed to assess individual performance on cognitive tasks thought to be associated with the specialized abilities of a specific hemisphere: Four of the tests involved tasks to assess the *visual-spatial* abilities of the right hemisphere, and the other four tests involved tasks to assess the verbal/sequential abilities of the left hemisphere. The participants were classified as being either more right hemisphere dominant or more left hemisphere dominant on the basis of whether they obtained better scores on the *visual-spatial* tasks or the verbal/sequential tasks, respectively.

In the second session, participants assumed the role of the receiver in an automated test for telepathy involving a sensory reduction technique known as ganzfeld (for a convenient summary of ESP studies using the ganzfeld, see Tressoldi *et al.,* 2010, pp. S83 – S85). Alexander found that participants classified as being right hemisphere dominant had scored fewer correct responses (or "hits") than left hemisphere dominant participants (30.8% vs. 41.7% hit rate, respectively; 25% is expected by chance), although the difference in scoring was not statistically significant. This offered slight evidence against the idea that the right hemisphere is involved in ESP.

A general criticism that can be raised against experiments employing a cognitive-based approach is that the association between certain cognitive abilities and the functions of the cerebral hemispheres is only indirect and made by inference, and for that reason, measures of these abilities may not be optimal indicators of hemispheric involvement in ESP. In order to more directly assess hemispheric involvement, monitoring of hemispheric activity during ESP tasks using electroencephalography and functional neuroimaging may be useful.

EEG Monitoring and Functional Neuroimaging of Hemispheric Activity During ESP

Generally, there are five known types of brain waves that can be detected during the monitoring of a person's EEG: delta, theta, alpha, beta, and gamma (Carlson, 1992, pp. 242 – 243; Kolb and Whishaw, 1990, pp. 53 – 56; Schneider and Tarshis, 1995, pp. 412 – 413). Four of these have prime relevance in the present review: Theta waves (4 – 7 Hz) are often detected during sleep, most often during bouts of drowsiness and the onset of light sleep. Alpha waves (8 – 12 Hz) are typically associated with a state of relaxed awareness and reduced cognitive processing, while beta waves (13 – 30 Hz) are often associated with a state of active cognitive processing. Gamma waves (30 – 80 Hz) are thought to be associated with the complex integration and processing of sensory stimuli, among other behaviors related to perception and awareness, memory, problem solving, and motor skills (Herrmann, Fründ, and Lenz, 2010; Reider *et al.,* 2011).[5]

The cognitive processing interpretation of alpha and beta waves partly has its basis in an EEG study by Galin and Ornstein (1972), who found evidence to suggest that a greater amount of alpha activity present in one hemisphere (as compared to the other) during a cognitive task was negatively correlated with that hemisphere's level of active engagement in the task (i.e., more alpha, less active engagement of the hemisphere). An inference commonly drawn from this negative correlation is that the abundance of alpha activity in one hemisphere is indicative of a lack of beta activity in that hemisphere, which would suggest a reduction in active cognitive processing by that particular hemisphere.

The inference drawn from this negative correlation helped form the basis for the predictions made in one of the earliest experiments designed to explore EEG differences in hemispheric activity during an ESP test. Conducted by Kobayashi, Terry, and Thompson (1979), this experiment involved 50 participants (45 right-handed) who were assigned to either a "psi" group or a "non-psi" group on the basis of their individual performance in an ESP card test. Participants who scored significantly above chance were assigned to the psi group, whereas participants who scored close to chance were assigned to the non-psi group. The researchers predicted that EEG data collected from these two groups during the ESP test would indicate a notable difference between the groups in the level of active engagement of the right hemisphere, as inferred from the amount of alpha activity present in that hemisphere. Specifically, on the hypothesis that the right hemisphere is more actively engaged in ESP, they predicted that the psi group would exhibit less alpha in the right hemisphere than the non-psi group. They also hypothesized that participants in the psi group would exhibit less alpha in the right hemisphere during the ESP test period than during a pre-test relaxation period.

At the start of the test sessions, participants were placed into a state of sensory reduction using the ganzfeld technique, which was followed by the pre-test relaxation period. An experimenter then conducted the ESP test, which involved participants calling 50 ESP cards individually sealed in envelopes, which the experimenter placed one at a time on the back of the participant's right hand. Throughout the sessions, the participants' EEGs were recorded bilaterally from the occipital (electrode sites O1 & O2) and temporal (electrode sites T3 & T4) lobes.[6] The resulting EEG data did not support the researchers' first prediction, although the participants in the psi group did exhibit significantly less alpha in the right hemisphere ($p < .01$) during the test period than during the

[5] In some of the older EEG experiments conducted in the 1980s, the gamma frequency band was considered to be two or more separate subsets of the beta band, and thus gamma is referred to in some older reports as the "beta II" (~ 25 to 34 Hz), "40 Hz" (~ 35 to 45 Hz), and "beta III" bands (~ 46 to 62 Hz).

[6] All references made in the text to electrode sites refer to the sites associated with the International 10-20 electrode placement system layout (Jasper, 1958).

relaxation period, a finding consistent with the second prediction. In addition, participants in the non-psi group exhibited significantly less alpha ($p < .01$) in both hemispheres during the test period than during the relaxation period. The researchers interpreted these findings as indications that participants in the psi group were able to "quiet" both hemispheres during the relaxation period and then activate the right hemisphere for the ESP test, whereas participants in the non-psi group were not.

The inference drawn from the negative correlation between alpha activity and hemispheric engagement also helped form the basis for the predictions made in an EEG experiment conducted by Maher (1986). Guided in part by the findings from the cognitive-based experiments by Maher et al. (1977; 1979) that suggested either hemisphere may be involved in ESP, Maher's (1986) experiment was an effort to examine how the hemispheres processed emotional stimuli received through ordinary visual perception and through ESP. To do this, Maher used two films of differing emotional content as target stimuli. One film (referred to as the "love" film) was comprised of filmed interviews with people who shared their personal views on the topic of love, and the intimate and empathic content of the film was expected to elicit strong emotion in the viewer. The other film (referred to as the "city" film) contained architectural views and time-elapsed sequences of daily city life, and its more neutral content was expected to elicit little or no emotion in the viewer.

On the basis of findings in the cognitive literature that suggested the right hemisphere may have a role in the processing of emotional stimuli (*e.g.,* Borod *et al.,* 1998), as well as indications in the parapsychological literature that emotion is a common characteristic of spontaneous ESP experiences (*e.g.,* Feather and Schmicker, 2005; Rhine, 1981; Stevenson, 1970), Maher (1986) predicted that EEG indicators of hemispheric asymmetry would be present during ESP and ordinary visual perception of the two films. Specifically, she predicted that greater active engagement (as inferred from a reduction in alpha activity) would be seen in the right hemisphere during ESP and ordinary visual processing of the love film as compared to the city film.

To test the prediction, 20 right-handed participants (comprised of ten males and ten females) were asked to take part in two consecutive experimental sessions that were meant to separately engage two modes of perception: ordinary visual perception, and ESP. In the first session (the ESP session), participants were asked to try and gain clairvoyant impressions relating to the two target films, which were being played in random order on a television in a separate, empty room. Then in the second session (the visual perception session), the participants were asked to directly view the two films. During both sessions, EEG data were continuously recorded from the temporal and parietal lobes, at points midway between electrode sites T3 and P3, and T4 and P4.

Maher (1986) found that when the male participants directly viewed the love film, they exhibited greater active engagement (as inferred from alpha reductions) in their right hemispheres, as predicted. However, she also found that females exhibited greater active engagement in the right hemisphere when they viewed the city film rather than the love film, which seems to be an unexpected reversal of the right hemisphere-emotional processing correlation. Although she was unable to readily provide a way to account for the finding, Maher speculated that it may reflect the possibility that "…females, as a group, may be more analytical than males when evaluating or responding to emotional disclosures made by others" (p. 246).

In analyzing the EEG data from the ESP session, Maher (1986) found that the same sex-specific patterns of hemispheric asymmetry were exhibited in the participants' right hemispheres. That is, males again exhibited greater active engagement in the right hemisphere while trying to gain clairvoyant impressions about the love film, whereas females exhibited greater right hemispheric engagement when trying to gain clairvoyant impressions about the city film. These parallel indicators of hemispheric asymmetry across ESP and ordinary visual perception suggest that sensory and "extrasensory" stimuli were both being processed by the right hemisphere in a similar way. In addition, they suggest a possible difference in the way that males and female brains process such stimuli (the issue of sex differences shall be discussed further in the next section).

A confounding issue relevant to Maher's (1986) findings is that although several studies do suggest that the right hemisphere has a role in emotional processing (*e.g.,* Borod *et al.,* 1998; 2001; Heller *et al.,* 1998), not all studies have consistently pointed in this direction. For instance, a meta-analysis of 106 neuroimaging studies of emotion by Murphy, Nimmo-Smith, and Lawrence (2003) did not find any clear tendency toward right hemispheric involvement. This meta-analysis did not consider any possible effects of sex differences, however. Thus, it currently remains unclear as to whether or not the right hemisphere is specialized for emotional processing.

McDonough, Don, and Warren (1994) used quantitative EEG to examine the brain wave activity of 20 participants acting as the receiver in a telepathy experiment using the ganzfeld technique. While in a state of mild sensory reduction induced through the technique, the participants attempted to gain impressions about a video clip being viewed by another person (acting as the sender) in a separate room on another floor of the laboratory building. Throughout the experiment, EEG data in the delta, theta, alpha, beta, and gamma frequency bands were collected from 19 individual electrode sites positioned across the scalp. Spectral analysis revealed that participants who "hit" the target (*i.e.,* gave correct responses) showed more EEG power in the alpha and beta bands than participants who "missed" the target (*i.e.,* gave incorrect responses). There was a suggestive difference in alpha power across all electrode sites ($p < .10$), which seemed to favor electrode sites along the right hemisphere, particularly at the right frontal (electrode site F4), temporal (electrode sites T4 & T6), and occipital (electrode site O2) regions. In contrast, participants who missed the target showed significantly more EEG power in the delta and theta bands than participants who were correct ($p < .04$). In this case, there was tendency toward left hemispheric electrode sites at the fronto-polar (Fp1), parietal (P3) and temporal (T3 & T5) regions. These results seemed to suggest that the right hemisphere may be associated with ESP "hits," whereas the left hemisphere may be associated with "misses."

Quantitative EEG was also used by McDonough, Don, and Warren (1996) to examine the brain wave data collected from McDonough in two of seven experiments in which he completed 100 trials of a computerized forced-choice ESP test called ESPerciser™, developed by Honorton (1987). Because it will be mentioned in relation to other studies reviewed in this paper, and familiarity with the operation of its program will be useful in understanding the procedures of those studies, a brief description of ESPerciser™ is given here:

In an ESPerciser™ test trial, four different cartoon-like images of everyday objects (*e.g.,* a dog, a flag, a coffee cup, and a car) are shown together on a computer screen, and the participant is asked to select the one that he or she thinks was randomly chosen by the computer to be the ESP target (the other three images are decoys). After selecting an image, the participant is shown the actual target as feedback, and then the process repeats for the next trial. ESPerciser™ is able to test either for clairvoyance or for precognition: In the clairvoyance test mode, the computer chooses the target *before* the participant selects an image. In the precognitive test mode, the computer chooses the target only *after* the participant has selected an image.

Across all seven experiments, McDonough scored 199 hits out of 700 total trials (28.4% hit rate, where 25% is expected by chance; $p = .021$). Spectral analysis of the EEG data collected bilaterally from the anterior temporal (T3 & T4) and posterior temporal (T5 & T6) electrode sites revealed significantly greater alpha power at the posterior sites ($p < .05$), and significantly less alpha power at the anterior sites ($p < .03$), for hits as compared to misses. As McDonough et al. (1996) noted, general interpretation of these opposite alpha power patterns is not clear, although greater alpha power at posterior sites could be related to the closer proximity of the posterior sites to the occipital lobes, from which alpha is often recorded. Alternatively, the researchers suggested that the patterns could be related to the meditation-like technique used by McDonough to induce a relaxed state "…characterized by low arousal and a marked reduction of higher cognitive processes" (p. 15). Also for the posterior sites, alpha was significantly greater within the left hemisphere as compared to the right ($p = .02$), which according to the

researchers, was consistent with McDonough's "self-reported reduction of verbal thought processes" (p. 15) as he tried to gain impressions about the ESP target.

In two other experiments (Don, McDonough, and Warren, 1998; McDonough, Don, and Warren, 2002), the three researchers explored the possibility that changes in neuroelectric voltage appearing on a person's EEG in response to sensory stimulation, known as event-related potentials (ERPs), could serve as unconscious indicators of precognition. To do this, the researchers ran ESPerciser™ in its precognitive test mode and slightly modified its appearance so that it overtly resembled a card game, replacing the four cartoon-like images with pictures of the four playing card suits (spade, club, heart, and diamond). They then recruited 45 participants from the general population who regularly engaged in gambling and asked them to play ESPerciser™ (which they were led to believe was just a standard gambling task, and not an ESP test) while their EEGs were continuously monitored.

In addition to its appearance, the beginning of an ESPerciser™ test trial was slightly modified so that each of the four images was presented to the participant in sequence by flashing them one at a time on the computer screen. The flash of each image was meant to act as the equivalent of flashing a light in the participant's eyes, allowing a separate ERP to be recorded for each image.

Although the participants scored at chance in each of the two experiments, analysis of their EEG data revealed significant differences in voltage between ERPs recorded when the participants were viewing the images later chosen as targets, and ERPs recorded when they were viewing images that were decoys (i.e., images not selected as targets). Compared to the decoy-related ERPs, the target-related ERPs had a much stronger negative voltage. This suggested that although the participants were not able to correctly select the ESP targets on a conscious level, there were EEG indications that their brains were able to unconsciously distinguish between the targets and the decoys *before* learning which were which.

In one of the experiments (Don *et al.,* 1998), the significant differences were observed in EEG data collected from five electrode sites lateralized along the left hemisphere (frontal: F3, central: C3, temporal: T3 & T5, and occipital: O1). A *post hoc* analysis of the EEG data collected from the analogous sites along the right hemisphere indicated that although the voltage changes in the latter hemisphere were of comparable magnitude and direction, they did not reach statistical significance. In the other experiment, however, the changes occurred primarily over six electrode sites in the right hemisphere (frontal: F4 & F8, central: C4, parietal: P4, and temporal: T4 & T6) (McDonough *et al.,* 2002). The researchers suggested that this topographic variability may perhaps be partly due to differences among the studies in using physical- vs. digital-linked EEG reference, or to event-related changes that may occur in association with the motor responses required for participants to manually enter their selections into the computer. (For a convenient summary of the experiments by McDonough, Don, and Warren, see Don, 2010.)

Kokubo, Yamamoto, and Watanabe (2005) used functional near-infrared spectroscopy (fNIRS) to monitor changes in cerebral blood flow in 14 participants as they took part in a computer-based forced-choice clairvoyance test. For each test trial, a computer randomly chose a target image from a pool of five distinct images and displayed it on a monitor screen covered over with a thick paper shield. The participants then tried to gain clairvoyant impressions about the target image behind the shield, using a switch box to electronically register their guess of which of the five images it was. Overall, participant scoring was slightly below chance and non-significant, with ten hits scored out of 69 trials (14.5% hit rate, where 20% is expected by chance).

Monitoring of blood flow in the right temporal lobe revealed spontaneous changes in the amount of hemoglobin in ten test trials, and these changes were significantly associated with strong visual impressions of the target images ($p < .001$).[7] It was noted that the changes were observed in three of the ten hit-scoring trials, a suggestive result ($p = .06$). Kokubo et al. (2005) estimated that these spontaneous changes occurred once in every seven to eight trials, and considered them to

[7] Although the direction of the hemoglobin changes was not specifically stated by Kokubo et al. (2005), an example shown in their Figure 1 suggests that these changes were mostly increases.

be "…a physiological event which corresponds to the so-called flash, intuition or inspiration encountered in daily life" (p. 308).

One potential problem with the Kokubo et al. (2005) study is that few specific details were given about the position of the participant in relation to the computer monitor displaying the target images. Although a thick paper shield can help to block out sensory cuing, this alone may not be sufficient to ensure that the participants did not receive subtle cues about the targets.

In a second fNIRS experiment, Kokubo et al. (2006) further explored their findings using two types of free-response clairvoyance test. In the first type of test, participants attempted to clairvoyantly determine which areas of a medical patient's body were diagnosed as unhealthy. In the second type of test, participants attempted to gain clairvoyant impressions about a small target object placed in a dark box.

Nine participants from the general population and two psychic claimants took part in these tests (the results with the claimants will be discussed in a later section). As they made their attempts at clairvoyance, five of the participants exhibited cerebral blood flow changes in their right temporal lobes. However, it is difficult to determine whether or not these changes were really ESP-related because Kokubo et al. (2006) do not present any evaluations of the participants' performance to determine whether they were successful or not in their attempts, nor do they give complete details about the test procedures and the methods used to guard against sensory cuing.

Potential Factors Affecting Interpretation

The experiments reviewed in the two preceding sections show a wide degree of variability in their outcomes, which makes general interpretation in terms of possible lateralization effects difficult. Some of the experiments seem to offer modest support to the anecdotal accounts suggesting right hemispheric involvement in ESP, while others do not. As indicated in the text, the hand preferences of the participants were considered and examined in many of the experiments to increase the certainty that the variability in the outcomes could not have been due to lateralization differences associated with handedness (see Note 1). However, it is possible that the variability could be attributed to several other factors. First, the experiments tended to differ greatly in the ESP test designs that were used, and in the methods of data collection that were employed. Second, as mentioned in the case of the cognitive-based experiments, the association between certain cognitive abilities and hemispheric functioning is only indirect and inferential, and may therefore only be indirect indicators of hemispheric involvement. This is further confounded by the possibility that some of the cognitive tasks meant to engage a specific hemisphere could have inherently contained certain perceptual or motor aspects that engaged the other hemisphere, as well. EEG and neuroimaging techniques seem to offer a more direct way to monitor hemispheric involvement, although there may be some potential factors to consider with these approaches, as well.

As mentioned earlier, the EEG findings obtained by Maher (1986) point to one potential factor: a possible confounding effect stemming from differences between male and female brains. Sex differences have long been an issue not only in cognitive-based research, but in neuroscience, as well (for reviews, see Cahill, 2006; and Hines, 2004). This includes possible sex-related differences in hemispheric asymmetry. For instance, in their meta-analysis of 4,728 experiments on hemispheric dominance in spatial tasks, Vogel, Bowers, and Vogel (2003) found that males showed a marked right hemispheric advantage (p = .002), whereas females showed no such advantage. Within the neuroimaging domain, Cahill (2006) noted that a handful of PET and fMRI experiments examining the functional activity of the amygdala in relation to the processing of emotion-related stimuli had found lateral differences between males and females. In general, functional activity within the amygdala tends to be focused more toward the right side for males, whereas in females, the activity tends to be focused more towards the left side. Cahill (2006) argued that consideration of sex differences can help explain contradictory findings, such as those that may arise when hemispheric lateralization data from both males and females are aggregated.

It can be argued that if ESP is similar to ordinary behavioral phenomena such as

cognition and perception, then perhaps it too may be influenced by sex differences. Maher's (1986) EEG findings indicating differences in hemispheric asymmetry between males and females in the processing of sensory and "extrasensory" stimuli would certainly seem to suggest this possibility, as would some of the other experiments reviewed here. Upon learning of the study findings relating to sex differences that were already starting to accumulate at that time, Broughton (1976) conducted a *post hoc* re-evaluation of the data from his three forced-choice ESP experiments using the geometric shapes. Starting with the third experiment because of its closer balance in the number of male and female participants, he found that presumably engaging and distracting the left hemisphere with reading was effective only for the male participants (p = .003). The same finding appeared in Broughton's second experiment; although this was based on the data from only five male participants (the other 15 participants were all female). No clear sex differences were found in the overall data from his first experiment. Further examining the data from his reaction time experiments, Broughton (1977) again found the left hemisphere interference effect only with the male participants (p = .047). However, Broughton (1983) later noted that when he tried to replicate these effects in both the shape and the reaction time experiments with equal numbers of male and female participants, the results were entirely at chance.

Maher and Schmeidler (1977) also examined the data from their first cube selection experiment for possible sex differences and found that the number of correct selections made with the right hand while the right hemisphere was presumably occupied with the competing pattern tracing task was significant higher for male participants (p < .006). In addition, when the male data from this condition was combined with the male data from the condition in which left hand selections were made while the left hemisphere was presumably occupied with the competing syllogism solving task, the total number of correct choices was again significantly high (p < .007). This suggested that the two conditions thought to produce "optimal facilitation of ESP processing" by each hemisphere were most effective with male participants. To try and replicate this effect, Maher et al. (1979) conducted their follow-up experiment with all male participants. But as mentioned previously, the results of this follow-up experiment were at chance.

While not being an effect that is consistently observable across all the experiments, there seems to be some indication here that sex differences may be a factor to consider in brain-related ESP studies that involve both male and female participants. Additional data are needed to determine whether such differences are indeed a factor, and if so, to what degree.

A second potential factor may have to do with the inference drawn from the negative correlation between the amount of alpha activity in one hemisphere and the relative engagement of that hemisphere in a cognitive task. If it is assumed that this inference is indeed valid for both cognitive tasks and for ESP-related tasks, then it would seem difficult to reconcile with various findings from other brain-related ESP studies that suggest alpha activity tends to be positively correlated with successful ESP performance (for reviews, see *e.g.,* Alexander, 2002; Krippner and Friedman, 2010; Williams, 2011; and Williams and Roll, 2008). On the basis of this alpha-ESP correlation, it could be alternatively argued that the hemisphere which exhibits a greater amount of alpha activity (as compared to the other hemisphere) may be the one more engaged in the ESP task. However, seemingly in line with the inference, there are also a few EEG studies of ESP that suggest higher brain wave frequencies in the beta and gamma range may correlate with certain types of ESP, such as remote viewing and precognition (*e.g.,* Alexander, 2000a, 2000b; Don, 2010). Because the amount of available ESP-related EEG data is still relatively limited, additional data are needed for further clarification of this potential factor.

As mentioned previously, all of the studies reviewed in the previous two sections were conducted with volunteer participants recruited from the general population. Since few, if any, of these volunteer participants claimed to have an extensive history of ESP experiences or claimed to possess any developed ESP ability, examining hemispheric contributions to ESP with these participants is likely to have been rather challenging because any hemispheric patterns may have been too subtle to detect. This important factor may

perhaps be overcome by examining the brain hemispheres of selected psychic claimants.

Hemispheric-Related Studies with Psychic Claimants

In a cognitive-based study, Fenwick et al. (1985) conducted individual neuropsychological assessments and clinical interviews with 17 people enrolled in psychic development courses at the College of Psychic Studies in London. Compared to a control group matched in age, sex, and social class, the 17 psychic claimants reported significantly more episodes of serious illness (p = .02), serious head injury (p = .01), and blackouts (p = .04). In addition, eleven of the claimants (65%) showed signs of impairment to the right hemisphere, particularly to the right temporal lobe. In contrast, none of the claimants showed any signs of left hemispheric impairment.

Don, Warren, McDonough, and Collura (1988, 1989) collected two separate sets of event-related potential (ERP) data from a psychic claimant, Olof Jonsson, in an extended effort to determine whether there might be distinct ERP-related signatures between correct and incorrect ESP responses, and between three separate altered states of consciousness experienced by Jonsson as being ESP-conducive (for brevity, only the ESP response data shall be considered here).

To collect each set of ESP response data, Jonsson was asked to sit in a fixed position with an experimenter standing behind and to the left of him. A clairvoyance design was used, in which Jonsson was asked to call 120 ESP cards that were placed face down, one at a time, on top of his left hand by the experimenter. To prevent sensory cuing, the symbols on the faces of the cards were covered over with two layers of adhesive tape that could not be removed without tearing the cards, and the experimenter was kept unaware of the randomized symbol sequence.[8]

As Jonsson called each of the cards, ERP data were recorded over three midline electrode sites (Fz, Pz, & Oz), as well as the left central (C3) and right central (C4) electrode sites. Analysis of the two sets of collected data indicated that hit-scoring trials were associated with higher voltage over the right central (C4) site across a broad range of brain wave frequencies, with most being in the beta and gamma ranges (*i.e.,* greater than 13 Hz).

Don, McDonough, and Warren (1996) later collected quantitative EEG data from Jonsson as he made forced-choice ESP calls using the ESPerciser™. Jonsson's overall scoring was at chance, but additional *post hoc* analyses revealed that on his first test run, Jonsson scored significantly above chance, scoring 12 hits in 24 trials (50% hit rate, where 25% is expected by chance; $p < .007$). In his fifth run, Jonsson scored significantly below chance, scoring only 2 hits in 24 trials (8.3% hit rate; equivalent to $p < .04$).

Topographic brain maps produced from EEG data recorded from 19 different electrode sites across Jonsson's scalp revealed different patterns for each of the two runs. For the above-chance run, a clear left-to-right gradient in EEG power was observable, with a gradually increasing shift from low power at the left lateral electrode sites to higher power at right lateral sites. Minimum power was localized in the left anterior temporal region (electrode site F3), while maximum power was localized in the right lateral frontal (electrode site F8) and right anterior temporal regions (electrode site T4). This power gradient occurred within the theta, alpha, beta, and gamma bands.

In contrast, the below-chance run showed a reversed pattern, with higher power in the theta band being localized to a roughly triangular-shaped region over the left frontal lobe and the left anterior temporal lobe, a region covering electrode sites Fp1, F7, and T3. Maximum power occurred at the left posterior temporal region (electrode site T5) and along the central and parietal midline regions (electrode sites Cz & Pz). Decreases in power occurred along the right hemisphere, with minimum power localized in the right anterior temporal region (electrode site T4).

In further contrast to the above and below chance runs, examination of topographic maps created from quantitative EEG data collected during chance scoring runs

[8] It should be noted that in informal ESP testing situations, Cox (1974) has reportedly found Jonsson engaging in simple trickery. Cox stated of this: "I am not of the personal opinion that Jonsson actually has more than a very casual knowledge of basic conjuring sleights, even though upon occasion I have caught him employing such sleights, or their equivalent, during loosely controlled demonstrations" (p.13). Although the test conditions employed by Don et al. appear to be more strictly controlled, caution in accepting and interpreting these and other ESP test results with Jonsson should be taken.

revealed no clear power gradients. When taken together, these topographic mapping results suggest that ESP "hits" are associated with greater EEG power along the right hemisphere, whereas ESP "misses" are associated with greater power along the left hemisphere. No clear hemispheric tendencies are seen in test trials for which there is no clear evidence of ESP.

Additional EEG studies were conducted by Don, McDonough, and Warren with three other psychic claimants: Susan (Cottrell) Goebel, Mel Doerr, and Malcolm Bessent. Goebel was known for receiving some media attention in the 1980s for demonstrations in which she claimed to be able to locate specific cards within a standard deck of playing cards. Initial testing with Goebel by McDonough, Don, and Warren (1989) proceeded in much the same manner as their clairvoyance testing with Jonsson using ESP cards:[9]

Goebel was asked to sit in a fixed position while she called 100 ESP cards, which were placed one at a time on the top of her left hand. To prevent sensory cuing, the symbols on the faces of the cards were again covered over with two layers of adhesive tape, which could not be removed without tearing the cards. Overall, Goebel scored 26 hits out of 100, which was above chance to a modestly suggestive degree (26% hit rate, where 20% is expected by chance; $p < .087$).

As she called the cards, EEG data were recorded from three midline electrode sites (Fz, Pz, & Oz), as well as the left central (C3) and right central (C4) electrode sites. Spectral analysis indicated higher power in the theta ($p < .01$) and "40 Hz" gamma bands ($p < .05$) for hits as compared to misses. Both of these higher power values were localized in the right hemisphere, at the central electrode site (C4).

In a second study, McDonough, Warren, and Don (1989) monitored Goebel's EEG while she was tested for telepathy and clairvoyance using a task modeled after her demonstrations for locating specific cards within a standard playing card deck. In each test trial, an experimenter randomly selected a target card in the deck using a random number table. Guided by the equally-paced numerical increments of an LED counter (which counted from 1 to 52, representing the number of cards in the deck), the experimenter slowly flipped through the cards in the deck one at a time. In the telepathy condition, the experimenter flipped through the cards face up, whereas they were face down in the clairvoyance condition. At the same time, Goebel sat in a separate test room with another experimenter and watched the increments of the LED counter on a separate display. When she felt that the first experimenter in the other room had reached the target card, she pressed a button which activated a buzzer in both rooms and stopped the LED counter. The number on which the counter had stopped represented her guess of the ordinal position of the target card in the deck.

Although Goebel's overall scoring was at chance, there was one block of 20 test trials (comprised of trials in both the telepathy and clairvoyance conditions) in which there appeared to be some statistical evidence for ESP ($p = .013$). Analysis of the EEG data collected bilaterally from the central (C3 & C4), temporal (T3 & T4), and occipital (O3 & O4) electrode sites during this block revealed higher delta and theta power in all three bilateral pairs of electrode sites for hits as compared to misses, as well as higher beta power in the right temporal region (T4) for hits. In addition, alpha power was found to be higher in the left central region (C3) than in the right central region (C4) for misses. These results suggested that although there was low-frequency brain wave activity in both hemispheres, hits tended to be associated with fast beta activity in the right hemisphere. In contrast, misses tended to be associated with alpha activity in the left hemisphere.

Don, McDonough, and Warren (1990) conducted two forced-choice experiments with Doerr, a claimant who served as a full-time "psychic counselor," and was known for performing psychometry.[10] The procedure for the two experiments was essentially the same:

[9] It should be noted that, like Jonsson, Goebel has reportedly been caught engaging in simple trickery under informal ESP testing conditions, which has been the focus of some debate (see *e.g.,* Eisenbud, 1980a, 1980b, 1981; Randi, 1979, 1980a, 1980b, 1981). The apparent trickery has involved manipulation of the ordinal sequence in a deck of playing cards using sleight of hand. Although the conditions employed by McDonough et al. (1989) did not allow Goebel to handle and manipulate the cards directly, caution should be taken in accepting and interpreting the results produced in ESP testing with her.

[10] Also known as *object association* or *token object reading*, psychometry is a form of ESP practiced by many psychic claimants in which ESP impressions about a particular person or event are gathered by the claimant while holding a token object associated with that person or event.

To serve as token objects, new ballpoint pens were distributed to staff members who were not directly involved in the experiments. The staff members carried the pens for one week, and were asked to sign their names with them once a day. At the end of the week, the pens were collected, washed with alcohol to remove any identifying fingerprints and scents, and assigned unique code numbers to identify the carriers. During each test trial, one of the pens was placed in Doerr's right hand, and while holding it, he attempted to gain an impression of the carrier's sex. To make sure they provided no sensory cues to him, the experimenters who handed the pens to Doerr were kept unaware of the carriers' identities. Doerr's overall scores were non-significantly above chance (81 hits in 148 trials, 54.7% hit rate, where 50% is expected by chance) in the first experiment, and significantly below chance in the second experiment (35 hits in 96 trials, 36.5% hit rate; $p < .04$).

While Doerr was giving his responses, EEG data were collected bilaterally from the central (C3 & C4) and temporal (T3 & T4) electrode sites. Analysis of the EEG data from the first experiment indicated significantly higher power across all the measured frequency bands (delta, theta, alpha, beta, and gamma) in the right hemispheric electrodes (C4 & T4) than in the left ($p < .002$) for hits as compared to misses.

In the EEG data from the second experiment, higher power in the gamma range was indicated only in the right temporal region (T4) for misses as compared to hits. In addition, higher power was found across the delta, theta, and gamma bands in the left hemispheric electrodes (C3 & T3) than in the right for misses, an apparent reversal of the effect found in the data from the first experiment. Don et al. (1990) viewed the results of these two experiments as being consistent with the idea that ESP "hits" are associated with the right hemisphere, and that "ESP" misses are associated with the left hemisphere.

Warren, McDonough, and Don (1992, 1996) also conducted two forced-choice experiments with Bessent, a psychic claimant who had previously shown significant above-chance performance in tests using the ESPerciser™ that were conducted by Honorton (1987). Because of his previous success, Warren et al. decided to test Bessent again on the ESPerciser™ for both clairvoyance and precognition while bilaterally recording event-related potentials from the frontal (F3 & F4), anterior temporal (T3 & T4), posterior temporal (T5 & T6), central (C3 & C4), parietal (P3 & P4), and occipital (O1 & O2) electrode sites. Like the gambling participants in the other ERP studies conducted by these same researchers (Don *et al.,* 1998; McDonough *et al.,* 2002), Bessent's overall scoring was at chance in both studies, although his ERP data showed significant differences between ERPs recorded when Bessent was viewing images later selected as targets, and the ERPs recorded when he was viewing decoy (*i.e.,* non-target) images. In particular, the target-related ERPs showed a greater negative voltage than the decoy-related ERPs. Consistent with those obtained with the gambling participants, these results suggested that Bessent's brain was unconsciously distinguishing between targets and non-targets *before* he learned which were which. In the first study with Bessent (Warren *et al.,* 1992), these differential ERP effects were localized primarily to the electrode sites in the right hemisphere. In the second study, however, the effects were slightly greater along the left hemisphere (Warren *et al.,* 1996).

During the 1970s, the *Psychical Research Foundation* conducted an extensive series of ESP tests with Sean Lalsingh Harribance, a psychic claimant who had become known on his native island of Trinidad for his psychic readings (Morris *et al.,* 1972; Roll and Klein, 1972; Stump, Roll, and Roll, 1970). EEG data collected bilaterally from Harribance's occipital lobes during two of the test series indicated that Harribance showed significantly more alpha activity ($p < .03$) during high-scoring ESP test runs than during chance-scoring runs (Morris *et al.,* 1972).

In a separate study, Kelly and Lenz (1976) were able to collect bilateral EEG data from the central electrode sites (C3 & C4) while Harribance worked with a mechanical two-choice clairvoyance testing device controlled by a random event generator. Although Harribance's overall scoring was slightly below chance and non-significant (48 hits in 106 trials, 45.3% hit rate, where 50% is expected by chance), spectral analysis revealed indications that the EEG activity recorded in the two seconds prior to a response was able to significantly distinguish between hit and miss

outcomes. In particular, excessive EEG power was found for the miss trials, which was focused primarily in the 12 to 13 Hz (alpha to beta) band. Although this power effect was found at both electrode sites, it seemed more prominent along the right central (C4) site. A similar effect was found in a follow-up study with Harribance by Kelly, Hartwell, and Artley (1978) using the same clairvoyance testing device. Excess EEG power was again found for miss trials in the 6 to 10 Hz (theta to alpha) and 12 to 14 Hz (alpha to beta) bands. Although the effect appeared bilaterally, it was again most prominent along the right central (C4) electrode site.

In the late 1990s, Alexander (2000a; Alexander *et al.,* 1998) was able to collect quantitative EEG data from Harribance during a brief visit he made to the Institute for Parapsychology in North Carolina. While he performed five separate ESP tasks (consisting of two psychic readings from photos, two ESP card test runs, and one remote viewing session), EEG data were continuously collected from 19 different electrode sites across Harribance's scalp. Topographic brain maps produced from the resulting data indicated alpha activity present bilaterally in Harribance's paraoccipital region during these tasks, with maximum alpha power being present in his right posterior parietal lobe (electrode site P4). In addition, beta activity was detected in his left frontal lobe (electrode site F7).

Images of Harribance's brain created using single-photon emission computerized tomography (SPECT) later revealed increases in neurometabolic activity in two areas of his right posterior parietal lobe (the paracentral and superior parietal lobules) during the time he was giving a 45-minute photo-based psychic reading to a volunteer (Alexander *et al.,* 1998; Roll *et al.,* 2002). In addition, the results of a neuropsychological assessment and a comparison of Harribance's resting quantitative EEG data with a normative EEG reference database both indicated signs of decreased neural functioning bilaterally in Harribance's frontal, temporal, and occipital regions (Alexander *et al.,* 1998; Roll and Persinger, 1998; Roll *et al.,* 2002). One of the regions showing decreased functioning was the right occipito-parietal region, which was also found to be a region of interest in an MRI examination conducted with another psychic claimant (see below).

Later on, Alexander (2000b) was able to collect quantitative EEG data from BSJ, a female claimant who reported an extensive history of ESP-related experiences. The procedure was similar to that used with Harribance: While BSJ attempted to remote view target images being shown on a computer in another room, EEG data were recorded from 19 electrode sites across her scalp. BSJ's remote viewing responses were found to correspond with the target images to a marginally significant degree (p = .056), and analysis indicated that, compared to the EEG data collected during control periods, BSJ showed significantly higher wave magnitude and peak amplitude values in the alpha and beta range during the remote viewing test periods. These higher values were localized bilaterally to the frontal (F1, F2, & F7) and temporal (T3 & T4) lobes. It is interesting to note that, like Harribance, BSJ exhibited beta activity in the left frontal lobe (electrode site F7) during the test periods.

EEG examinations of the reported remote viewing ability of another psychic claimant, Ingo Swann, were made by Persinger et al. (2002). Swann had become particularly well-known for his success in remote viewing studies conducted in the 1970s (Puthoff and Targ, 1976; Targ and Puthoff, 1977/2005), and in two test sessions, he was asked to remote view concealed photographs located in another room, or distant geographic locations being visited by two experimenters. EEG data obtained during both sessions displayed an unusual pattern of 7 Hz (theta) "spikes" in Swann's occipital lobes, which was not seen in data collected during resting control periods. This pattern positively correlated (p < .05) with Swann's rated accuracy in describing the targets. Although the pattern was generally bilateral, there were reportedly indications on the EEG record that it first appeared in Swann's right hemisphere. MRI scans made of Swann's brain while he was resting showed no clear indications of trauma or damage, although four anomalous signals were noted in his right hemisphere, just below the parieto-occipital sulcus. This is within roughly the same region found in Harribance's right hemisphere to show mildly decreased functioning.

As mentioned previously, Kokubo et al. (2006) had used functional near-infrared spectroscopy (fNIRS) to examine the cerebral blood flow activity of two psychic claimants while they attempted to gain clairvoyant impressions about certain targets. One female claimant claimed the ability to clairvoyantly determine which areas of a medical patient's body were diagnosed as unhealthy, and fNIRS scans made during her attempts to use her ability indicated blood flow changes in the area proximal to the right dorso-lateral prefrontal cortex. The other claimant, also female, attempted to gain impressions of an object hidden in a dark box, and unlike the other claimant, her fNIRS scans indicated blood flow changes in her left lateral frontal lobe. However, as Kokubo et al. note, because the claimant was occasionally giving her impressions verbally, this change could be associated with talking. And as mentioned, it is difficult to determine whether or not these changes were really ESP-related because Kokubo et al. (2006) do not give any results to indicate whether the claimants were successful or not in their attempts at clairvoyance, nor do they give complete details about the test procedures and the methods used to guard against sensory cuing.

In one of the most recent studies, Venkatasubramanian et al. (2008) used blood oxygenation level dependent (BOLD) fMRI to examine the brain activity of a psychic claimant, Gerard Senehi, during a free-response telepathy test.[11] While he lay in the fMRI scanner, Senehi attempted to gain impressions about a picture being drawn by another person who acted as the telepathic agent. Following the scan, Senehi drew a sketch of the image that came to his mind. Compared to the impressions sketched by a control participant, Senehi's sketch seemed to bear closer resemblance to the drawing made by the agent. The resulting fMRI scan revealed significant BOLD activation in the right parahippocampal gyrus, a curved sub-cortical structure adjacent to the hippocampus (the prime brain structure involved in memory).

There are three issues, however, which make interpretation of this finding difficult. First, the finding is based solely on one test trial, which could have been successful by chance. Venkatasubramanian et al. (2008) recognize this limitation, and state that they did pursue further trials because Senehi reported some discomfort following the fMRI scan. Second, unlike in most ESP studies, the targets for Senehi and the control participant were not randomly selected from a fixed pool of targets. Instead, the targets were roughly the same in both cases, and simply came from the agent's imagination. This makes the process susceptible to choice and response biases. Third, the details that Venkatasubramanian et al. (2008) give in their report on the controls they employed in the experiment are vague and incomplete, which makes it difficult to determine whether sensory cues and other conventional factors were sufficiently eliminated.

Summary and Outlook

The main purpose of the present review was to determine where the issue of ESP in relation to cerebral lateralization stands at the present time. It should be clear, from the complex nature of the various experimental findings that have been gathered to date, that much about the issue still remains open and unresolved. A prime challenge in trying to resolve the issue lies in the difficulty in interpreting the findings, when they show a wide degree of variability and when some may be burdened with potential confounds. As Broughton (1983) initially pointed out, many hemispheric lateralization effects tend to vary across studies and can be subject to various influences of mood and noise artifacts, which can make them difficult to replicate. This is as much the case for EEG and neuroimaging experiments as it is for cognitive-based experiments. In addition, it is important to recognize that many of the ESP experiments reviewed here (particularly those involving volunteer participants from the general population) may not have had sufficient statistical power, being limited only to a few hundred test trials at most. Recent estimates indicate that several thousand trials may be needed to produce more discernible effects (*e.g.,* Tressoldi, 2012); this is likely to be a matter relevant not only to proof-oriented research, but also to process-oriented research, as well. Moreover, it should be recognized that although a fair number of experiments on ESP and cerebral lateralization

[11] In their report, Venkatasubramanian et al. (2008) use the term *mentalist* to refer to Senehi. Although the Western usage of that term is associated with stage magic, the researchers make it clear that their usage of it is meant to be a synonym for *psychic claimant* by stating that Senehi is "…an expert with telepathic ability (mentalist)" (p. 66).

have been conducted since the 1970s, the amount of available data is still quite minuscule when compared to the amount of data that has been gathered in conventional neuroscience on cerebral lateralization effects of ordinary behavioral phenomena such as sense perception and various forms of cognition. In line with the view initially expressed by Broughton (1983), all of these factors have not made research on ESP and cerebral lateralization very easy.

There may be some potential avenues for progress, however. As suggested previously, cerebral lateralization effects on ESP performance may be more discernible in studies conducted with selected psychic claimants. In spite of their own potential confounds, the experiments reviewed here would seem to indicate that this approach may be promising. Based on a simple vote-counting approach, the results of 16 lateralization experiments conducted with psychic claimants seem to be in line with the suggestions from early anecdotal reports that the right hemisphere may be associated with ESP. When the experiments possibly confounded by methodological issues and concerns about claimant deception (see Notes 7 & 8) are removed from consideration, the results of at least seven experiments (Alexander *et al.,* 1998; Don *et al.,* 1990, Exp. 1; Fenwick *et al.,* 1985; Kelly *et al.,* 1978; Kelly and Lenz, 1976; Persinger *et al.,* 2002; Roll *et al.,* 2002) continue to indicate a possible right hemispheric contribution. The most consistent findings seem to come from experiments with Sean Lalsingh Harribance (Alexander *et al.,* 1998; Kelly *et al.,* 1978; Kelly and Lenz, 1976; Roll *et al.,* 2002).

The results of six lateralization experiments seem to also indicate a left hemispheric contribution to ESP, particular to ESP "misses." When the experiments possibly confounded by methodological issues and concerns about claimant deception are removed, one still indicates a possible contribution to ESP misses (Don *et al.,* 1990, Exp. 2), while two others suggest that the left frontal region may be involved in remote viewing (Alexander, 2000a, 2000b), assuming that this is not an artifact of talking. Possible patterns that may be worth further exploration in other psychic claimants are the functional anomalies seen in the right occipital-parietal region of the brains of Sean Lalsingh Harribance (Roll *et al.,* 2002) and Ingo Swann (Persinger *et al.,* 2002), and the beta activity seen in the left frontal lobes (at electrode site F7) in the quantitative EEG data collected from Harribance and BSJ during remote viewing (Alexander, 2000a; 2000b). As suggested by Alexander (2002), future experiments should be conducted using quantitative EEG, normative reference databases, and functional neuroimaging techniques.

Some preliminary evidence suggests that, as in conventional neuroscience (Cahill, 2006), it may be important to take sex differences into account in future lateralization studies of ESP. Further data relating to sex differences can help determine the degree of relevance that this factor may have in clarifying hemispheric effects on ESP performance.

Although still much remains to be resolved, it is hoped that the avenues outlined here will pave the way to progress.

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