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POINT OF VIEW

Environmental Sensitivity: A Neurobiological Phenomenon?

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Researchers often use the term “sensitivity” when theorizing that certain persons may be more readily affected by various influences than others. Through a review of the literature, it is argued that some individuals are disposed toward a range of sensitivities that, in novelty as well as intensity, distinguish them from the general population. The author cites evidence indicating that such persons exhibit greater susceptibility to a range of environmental factors including allergies, migraine headache, chronic pain, and chronic fatigue. Their immediate family members appear to be similarly affected. Additionally, these “sensitive” individuals report a high degree of anomalous perception. While no single factor in a person’s background is likely to distinguish him/her as sensitive, eight demographic or personality factors are found to be significant.

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Researchers often use the word “sensitivity” when theorizing that certain persons may be more readily affected by various influences than others. But what does it mean to be sensitive? The dictionary offers a four-part definition: (1) capable of perceiving with a sense or senses; (2) responsive to external conditions or stimulation; (3) susceptible to the attitudes, feelings, or circumstances of others; and (4) registering very slight differences or changes of condition.¹

Evidence points to a wide variability of sensitivity, both among individuals and within the different stages of a person’s life. The differences between individuals are well known. To begin with, women generally exhibit markedly greater sensitivity across all five senses.² The perception of pain varies considerably from person to person,³ as does acuity in taste, smell, and color perception.⁴ Changes within a given person’s lifespan are equally noteworthy, with sensitivity fluctuating due to the influence of hormones (eg, a woman during ovulation), personal circumstances (an injury sustained or a disease suffered), preprogrammed genetic conditions (the onset of nearsightedness, for instance), and age (the acuity of smell declines as both women and men get older).^{5,6} Additionally, it is well known that individuals who are disadvantaged in one sense often enjoy greater sensitivity in another.⁷

In recent years, researchers have begun to focus on the idea

that certain types of people are seemingly predisposed toward extraordinary sensitivity—and to try to explain why. This body of research regards sensitivity from two equally valid perspectives: as a responsiveness to changing conditions outside of the individual and as a reaction to minute changes in his/her internal state (J. Palmer, personal communication, March 11, 2003). Aron,⁸ for instance, has coined the term highly sensitive person (HSP), describing such individuals as prone to be easily overwhelmed by sensory stimuli, deeply reflective, and unusually empathetic. In her words, HSPs are

... born with a tendency to notice more in their environment and deeply reflect on everything before acting ... They are also more easily overwhelmed by “high volume” or large quantities of input arriving at once. ... Mainly, their brains process information more thoroughly. This processing is not just in the brain, however, since highly sensitive people, children or adults, have faster reflexes ... are more affected by pain, medications, and stimulants; and have more reactive immune systems and more allergies. In a sense, their entire body is designed to detect and understand more precisely whatever comes in.

She adds that HSPs are “unusually empathetic,” feeling their own emotions and paying heed to others’ more intensively than other people. They also tend to have rich inner lives (with complex, vivid dreams) and come across as highly per-

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ceptive, creative, and intuitive when able to surmount what often is a natural inclination toward shyness, fearfulness, stress, and withdrawal.

Heller⁹ proposes the term “sensory defensiveness” to describe individuals who demonstrate a notable inclination toward fearfulness, shyness, stress, and withdrawal.

She notes that sensitivity often originates in infancy and provides the following evidence for the condition at an early age:

- Tactile defensive newborns will resist snuggling by stiffening or pushing away. Highly reactive infants show a faster heart rate when stressed and even when asleep.
- Fearful or inhibited children show more activity on the right side of the brain, whereas more outgoing infants show more brain activity on the left side—a pattern that can extend into adulthood.
- Anecdotally, many sensory defensive adults recall having an especially acute sense of smell as children, along with pronounced allergies.

Heller⁹ points out that “any trauma that disrupts the nervous system at any age can generate sensory defensiveness,” including head injury and psychological abuse. “Severe or long-standing trauma,” she argues, can “alter brain chemistry and literally rewire the brain.” And sensory overload, however acquired, increases stress as well as vulnerability to illness.⁹

Over time, sensory defensiveness has a major effect on many bodily functions, according to Heller. The body’s flight-or-fight system is constantly in operation, as the overload of environmental stimuli conditions a chronic stress response: “Eventually the immune system is depleted and the body succumbs and breaks down.”⁹ At that point, the stage is set for a variety of ailments, including fatigue and depression, sleep difficulties, headaches, tense muscles, decline in sex drive, decreased memory and ability to concentrate, high blood pressure, migraine headaches, irritable bowel syndrome, ulcers and similar gastrointestinal problems, asthma, allergies, skin disorders, and chronic pain.

In recent years, a good deal of research has sought to illuminate the causes and markers of four poorly understood conditions: migraine headache, chronic and debilitating pain (clinically termed fibromyalgia), chronic fatigue, and depression. Many parallels have been noticed among them, including the following:

- Women are disproportionately affected. Fibromyalgia occurs seven times more often in women than in men, while migraine is three times more common in women.^{10,11}
- The sex hormones appear to play a role in both fibromyalgia and migraine. It is not uncommon, for example, for fibromyalgia to begin after menopause.¹⁰ In contrast, the overall incidence of migraine is *reduced* after menopause—and migraines generally stop during pregnancy.¹¹
- Ninety percent of persons with fibromyalgia experience moderate to severe fatigue.¹⁰

- People who have migraine headaches are two to three times as likely to become depressed. Individuals who suffer from depression are three times as likely to get migraines.¹¹
- Both fibromyalgia and migraine appear to run in families,¹⁰ suggesting that a genetic predisposition may be present.

Given these overlaps, researchers suspect that the above conditions have a similar neurobiological basis—relating to the way the central nervous system processes pain and other types of sensory stimuli. Hypersensitivity of various stripes may be the result.¹⁰

Hartmann¹² has attempted to explain a broad range of sensitivities through the organizing principle of “boundaries.” He proposes a spectrum of personality types from thick boundary to thin:

There are people who strike us as very solid and well organized; they keep everything in its place. They are well defended. They seem rigid, even armored; we sometimes speak of them as “thick-skinned.” Such people, in my view, have very thick boundaries. At the other extreme are people who are especially sensitive, open, or vulnerable. In their minds, things are relatively fluid . . . Such people have particularly thin boundaries. . . . I propose thick and thin boundaries as a broad way of looking at individual differences.

Characteristics evident among thin boundary persons¹² are:

- A less solid or definite sense of their skin as a body boundary;
- An enlarged sense of merging with another person when kissing or making love;
- Sensitivity to physical and emotional pain, in oneself as well as in others;
- Openness to new experience;
- A penchant for immersing themselves in something—whether a personal relationship, a memory, or a daydream;
- An enhanced ability to recall dreams;
- Dream content that is highly vivid and emotional; and
- A tendency to experience nightmares.

Such porous or flexible characteristics suggest to Hartmann that thin boundary people actually live their lives “more dreamily” than those at the thick end of the spectrum. The latter “function chiefly in a focused waking mode [and] have excellent and well-functioning connections *within* [brain] regions but do relatively little connecting between or across regions.” Thin boundary processing is more like dreaming, “less straightforward but more flexible,” with more connections between regions and thus the proclivity to “explore all

kinds of side connections.”¹³ The idea of normal conscious experience as a *continuum* including vivid imagery at one end has also been articulated by Slade and Bentall.¹⁴

Individuals who scored exceptionally thin on Hartmann’s Boundary Questionnaire also reported more symptoms of illness—which might reasonably be expected based on the process articulated by Heller. Indeed, Hartmann notes that many of his subjects’ symptoms “relate to anxiety and depression, so that one cannot distinguish purely physical from more psychological problems.”¹²

The relationship of brain and body in certain individuals is also the interest of Wickramasekera.¹⁵ He believes that a person’s highly charged psychological issues can be transmuted into physical symptoms, such as asthma and other forms of allergy, chronic pain and fatigue, sleep disorders, etc. Wickramasekera terms the process by which psychological distress engenders physical illness “somatization.” “Put simply,” he writes, “the [individual] is being . . . made sick by distressing secret perceptions, memories, or moods that [he/she] blocks from consciousness.” Despite the unconscious nature of somatization, the affected person can become manifestly hypersensitive and even (in a parallel to Hartmann’s concept of thin boundaries) absorbed in the problems of others to such an extent that somatic symptoms develop out of this “surplus empathy.”¹⁵

A need for deep connections with other people is one of five areas of extreme sensitivity identified by Kazimierz Dabrowski (1902-1980), a Polish psychiatrist interested in personality development. Dabrowski studied “gifted” individuals and noted these recurring traits, which he called over-excitabilities:¹⁶

- *Psychomotor*: surplus of energy, restlessness, curiosity.
- *Sensual*: strong reaction (either positive or negative) to sensory stimuli, aesthetic awareness.
- *Imaginational*: strong visual thinking, vivid fantasy life, remembers dreams, enjoys poetry or metaphorical speech.
- *Intellectual*: intense focus on particular topics, enjoys questioning and complex reasoning, problem solving.
- *Emotional*: heightened emotional reactions, need for strong attachments, empathetic, difficulty adjusting to change.

Dabrowski’s work merits attention because he captured the traits of “Highly Sensitive Persons,” the “Sensory Defensive” person, and similar terms used by authors and therapists today who are popularizing the notion of sensitivity.

Both Hartmann and Dabrowski have highlighted the penchant for sensitives to *immerse* themselves in something, be it sensory experience, an intellectual task, or fantasy. This ability, which can occasion the loss of one’s normal sense of time and space, is termed “absorption.” As first articulated by Tellegen and Atkinson,¹⁷ is “a disposition for having episodes of total attention . . . result[ing] in a heightened sense of reality of the attentional object, imperviousness to distracting events, and an altered sense of reality in general.” Some statements conveying this capacity are the following:

- The sound of a voice can be so fascinating . . . that I can just go on listening to it.
- While acting in a play, I have sometimes really felt the emotions of the character and have “become” him or her . . . forgetting, as it were, both myself and the audience.
- I can sometimes recollect certain past experiences in my life with such clarity and vividness that it is like living them again.
- If I wish, I can imagine (or daydream) some things so vividly that they hold my attention in the way a good movie or story does.

Absorption is closely related to both hypnotic susceptibility and dissociation (a lack of identification with one’s body and immediate feelings). Lines between what is manifestly real and what is imaginary become blurred as the person becomes immersed in some reverie or experience, to the point he/she can become dissociated from actual bodily feelings during those periods. Such deep experiences are sometimes perceived as mystical or transcendent.¹⁷

Along parallel lines, Wilson and Barber¹⁸ explored the phenomenon of fantasy proneness, sounding out individuals who, from an early age, immersed themselves in such vivid fantasy that the products of their imagination are experienced as “real as real.” In their seminal paper, “The Fantasy-Prone Personality,”¹⁸ the researchers described a group of 52 female subjects who “fantasize a large part of the time, who typically ‘see,’ ‘hear,’ ‘smell,’ ‘touch,’ and fully experience what they fantasize.” For these people, vivid fantasy was operative throughout childhood. Imaginary companions and imaginary worlds were experienced as immediately real while awareness of actual surroundings tended to recede. Even as adults, these individuals continue to lose themselves in reverie. Such experiences resemble full-fledged hallucinations since:

*Imagined aromas are sensed, imagined sounds are heard, and imagined tactile sensations are felt as convincingly as those produced by actual stimuli . . . When they recall an event, they are able to see, hear, and feel it again in much the same way as they did originally . . . they sometimes feel that their fantasy world is real and that the actual world is a fantasy.*¹⁸

Fantasy-prone persons also tend to see themselves as psychically sensitive, reporting such perceptions as telepathy, precognition, being out-of-body, and seeing or hearing apparitions. Another anomalous “talent” reported is the sense of having a powerful influence on electrical appliances. Such perceptions would strike most people as highly dubious. Wilson and Barber conclude, however, that the fantasy-prone personality is *not* pathological: “[most] work, love, and socialize within the broad average range of adjustment.”¹⁸ Later researchers agree with this assessment.¹⁹

Thalbourne’s²⁰ concept of “transliminality” relies implicitly on sensitivity. Building upon late 19th and early 20th century speculations on subliminal consciousness (principally F.W.H. Myers and William James), Thalbourne defines transliminality as a “tendency for psychological material to

cross thresholds in or out of consciousness.” Thus, “persons who manifest a medium to high degree of transliminality might . . . be expected to have erupt into consciousness, from the preconscious, experiences that we variously know . . . as psychic, mystical, and creative . . . Conversely, persons low in transliminality would be expected to be of the sort who rarely if ever report experiences of such eruptions.” Studies by Thalbourne demonstrate correlations among nine factors now considered components of transliminality²⁰:

- paranormal belief and experiences
- creative personality
- mystical or religious experience
- magical thinking
- manic-like experience
- absorption
- fantasy-proneness
- an interest in dream interpretation
- a heightened sensitivity to environmental stimulation.

One aspect of “environmental stimulation”—though not one specifically investigated by Thalbourne or his colleagues—is the phenomenon of alleged electrical sensitivity. Shallis²¹ conducted an intriguing investigation into this matter. His major results were the following:

- 80% of Shallis’ survey population of “electrical sensitives” were women.
- 23% said they had been struck at least once by lightning.
- 70% reported that they were affected by allergies. The more severe their electrical sensitivity, the more severe the allergies were said to be.
- 69% claimed to have had at least one psychic experience.
- 70% said they were susceptible to loud sounds and bright lights.
- 60% claimed to be affected by advancing thunderstorms (including all of the allergy sufferers).

Feeling poorly in advance of a thunderstorm is not an entirely rare phenomenon.²² The buildup of positive ions in the air is believed to raise the bloodstream level of serotonin (a neurotransmitter) in affected individuals, bringing on such feelings as irritability, depression, and nausea as well as blurred vision and headache—including migraine.

Indeed, studies of migraine suggest that some people possess a strong and often uncomfortable level of neurobiological reactivity to environmental changes.^{22,23}

Any number of outside factors can trigger a headache: noise, glare, certain odors or foods, even the weather—particularly changes in humidity and barometric pressure.²⁴ Many migraine sufferers become acutely aware of smells, sounds, and lights and seek refuge (at least temporarily) in quiet, dark hideaways. “It is probable that [their] nervous system is overreactive . . . and responds rapidly to any intense bombardment of the brain by sensory impulses.”²⁴

Similarly, perhaps, some people, when viewing the aurora borealis, report hearing a “hissing, swishing or crackling sound” comparable to “rustlings in a field of corn.”²⁵ It is possible that these persons are particularly sensitive to elec-

tromagnetic activity. Persinger²⁶ has attempted an explanation, theorizing that extremely low-frequency, naturally occurring electromagnetic fields interact with the temporal lobe of the human brain. Electrical stimulation of that lobe applied in the laboratory, he notes, has produced in certain people a range of anomalous perceptions, including apparitions, voices, and a feeling of being out of one’s body. Persons whose temporal lobes are subject to frequent bursts of electrical activity, he asserts, are more prone to anomalous experience. It should be noted that the evidence is far from clear-cut that persons who claim to be electrically sensitive actually *are*.²⁷

A variety of neuroimaging data, however, do support the proposition that persons who are sensitive in one form or another—or at least have a distinctive neural condition—display a unique pattern of neural activity. Individuals with irritable bowel syndrome, for instance, demonstrate greater activation of a particular region of their brain than control subjects.²⁸ Elsewhere, positron emission tomography (PET) performed on highly hypnotizable subjects has traced a more extensive pattern of blood flow in the brain after being given a hypnotic suggestion versus when these same subjects were not hypnotized.²⁹ The same has been demonstrated with schizophrenics who have auditory hallucinations: when they hear voices, parts of their temporal lobes light up, just as they would if listening to an actual conversation.³⁰ Phantom tastes and smells are likewise revealed by functional magnetic resonance imaging (fMRI). When persons who complain of such phantom sensations are treated effectively, their characteristic brain activation diminishes.³¹ In addition, researchers have found that people who are depressed or fearful according to standardized psychological tests evidence greater activity on the right (behavior inhibiting) side of the brain than more cheerful, outgoing individuals.³²

Even synesthesia—the blending of senses, which in most people, are separate and distinct—is also demonstrable through neuroimaging. For persons who routinely “hear” words in color, for example, both fMRI and PET scans reveal activity in the language and visual areas of the brain concurrently; whereas activity registers solely in the brain’s language area for “normal” individuals.³³ This is fascinating since synesthetes are known to harbor their unique sensory associations (eg, the “sweet” sound of a trumpet, or the redness of the number four) from earliest childhood.³⁴ Like hallucinations, synesthetic perceptions are also regarded as manifestly real, not just something conjured up in the mind’s eye. And synesthesia seems to bear a close relationship with environmental sensitivity, as many synesthetes suffer from sensory overload.^{34,35} In this regard, it is perhaps not surprising that people who have synesthesia seem more prone than the general population to anomalous experiences.³⁶ The flip side is that persons who are fantasy prone and those with perceived electrical sensitivity may also, at least occasionally, experience synesthesia.^{18,21}

Taken together, the evidence points to sensitivity as a bona fide neurobiological phenomenon. It seems quite possible that certain individuals are, from birth onward, disposed to a number of conditions, illnesses, and perceptions that, in nov-

elty as well as intensity, distinguish them from the general population. Sensitivity thus goes to the very heart of the dictionary definition: “capable of registering very slight differences or changes of condition.”¹

My hypothesis is that *some* especially sensitive individuals, based upon their distinctive neurobiological makeup, will react to *some* external influences under *some* conditions. Furthermore, the degree to which a person draws upon unconscious material (a form of internal sensitivity or, one might say, thin boundaries) will inevitably color his/her perceptions. So, to the extent that any anomalous influences exist in the external environment, certain individuals will register these more clearly versus others who see, hear, feel, and smell through a denser “veil” of internal imagery. None of this obviates the possibility that, in any given circumstance, individuals who are suggestible, who are anxious or fearful, who believe a priori in the paranormal, or who are simply uncomfortable with ambiguity, will misinterpret normal stimuli.³⁷⁻⁴⁰

Elsewhere,⁴¹ the author reports the findings of his own survey of individuals who describe themselves as sensitive, contrasted with a control group made up of individuals who do not consider themselves sensitive. Both groups responded to a range of items pertaining to demographic, personality, and environmental factors. The survey results support the hypothesis that certain people do appear to be much more susceptible to allergies, illness, depression, migraine headaches, nightmares, etc. than the general population. The same is evidently true of their immediate families.

The findings also support the contention that hypersensitivity may encompass an anomalous aspect, as the respondents are much more likely than the controls to have had one or more apparitional experiences. That this link should appear is not surprising in view of the fact that, to gain participation, the survey was presented as examining both environmental *and* psi sensitivity. Additional investigation is needed to determine more precisely what demarcation may be found between persons who consider themselves to have (or better yet, are actually *diagnosed* as having) some form of environmental illness versus those who consider themselves psychically sensitive.

While no single factor in a person’s background is likely to distinguish him/her as “sensitive,” the author found eight demographic or personality factors to be significant:

1. Being female;
2. Being a first-born or only child;
3. Being single;
4. Being ambidextrous;
5. Appraising oneself as an imaginative thinker;
6. Appraising oneself as introverted;
7. Recalling a plainly traumatic event—or series of events—in childhood;
8. Asserting that one’s presence causes televisions, lights, computers, etc to malfunction.

Factors 1, 4, 7, and 8 strike the author as being especially noteworthy—and deserving of explication. It seems possible, for a start, that being sensitive, female, and ambidextrous have the same root. Consider that the posterior portion of the corpus callosum—an elongated bundle of nerve fibers that carries information between the brain’s two halves—is wider in women than in men. The difference exists not just in adulthood; it has been found in utero.⁴² This indicates that, throughout their lives, females have greater communication between the hemispheres. Quantitative evidence is provided by the finding that women’s rate of rate of interhemispheric blood flow is generally about 15% higher than men’s.² Women may thus harbor an inherent sensitivity due to their differently organized brains.

It may be no coincidence that ambidexterity (the ability to use either hand) was found to occur more often among persons who consider themselves sensitive. This result was particularly interesting given that left-handedness, in and of itself, was not found to be a “marker” of sensitivity. It seems reasonable to infer that, in ambidextrous individuals, a higher degree of interchange exists between the brain hemispheres that control the body’s two sides.

Differences between sensitives and controls were also pronounced when it came to self-reports of a traumatic event or events in childhood, as well as a family history of alcoholism, depression, etc. Sensitivity, then, appears to correlate with (though not necessarily be caused by) trauma. Several researchers have sought to establish that anomalous experiences are indeed *conditioned by* trauma, especially chronic childhood abuse.^{43,44} Irwin,^{45,46} for example, posits that psi experience is fundamentally dissociative. He has proposed a model under which personality traits such as fantasy proneness, absorption, and belief in the paranormal all develop in childhood “as a defense mechanism . . . an escape from stressful awareness of an aversive environment.” Terr,⁴⁷ an expert on trauma, has likewise identified absorption and dissociation as coping mechanisms that certain children resort to in order to mentally “escape” from intolerable situations.

Equally, one might consider that children who are *born* sensitive may be prone toward these same personality characteristics. In a fascinating paper published a half-century ago, Bergman and Escalona⁴⁸ described children (age 3 months to 7 years) who reacted intensively or aversely to odors, sounds, colors, textures, or temperatures. If the stimulus was pleasing, these children would delve into it (absorption); if it was noxious, they would seek an escape route. In a poignant evocation of some of these early defense mechanisms, the investigators describe children rhythmically rocking themselves by covering their eyes and ears from the unwelcome stimuli. The “private world” these children entered into could, I suggest, be construed as a crucible for introspection, fantasy proneness, and dissociation.

With regard to factor 8 (self-reported electrical sensitivity), this article has already offered the possibility that the neurobiological makeup of certain persons disposes them to be far more sensitive to electromagnetic activity than is the norm. A more prosaic explanation, of course, would be that such persons are mistaken and that they exert *no* peculiar influence on the oper-

ation of electrical appliances and vice versa. This alternate view, as we have seen, argues that such illusions are the expression of a subconscious mechanism whereby the person seeks to “rise above” deeply traumatic experience.

At least one study infers that this coping mechanism is operative in the case of people who believe they are electrically sensitive.⁴⁹ My own suggestion is that, for certain innately sensitive individuals, the significant effects of trauma are more a *reflection* of their neurobiology and less a cause of their misattributing everyday occurrences as electrical anomalies.

If additional surveys, carried out by other researchers, were to document similar results, the concept of sensitivity might be documented as having a genuine neurobiological basis. It might follow that individuals having a certain degree or configuration of sensitivity could register (either consciously or unconsciously) anomalous influences in the environment that bypass most other people.

References

- Morris W (ed): American Heritage Dictionary of the English Language. Boston, MA, Houghton Mifflin Company, 1981
- Velle W: Sex Differences in Sensory Functions. *Perspect Biol Med* 30: 490-522, 1987
- Coghlan A: How sensitivity to pain is really all in the mind. *New Scientist* June 28, 2003, p 17
- Hollingham R: In the realm of your senses. *New Scientist* January 31, 2004, pp 40-43
- Smith J: Senses and Sensibilities. New York, NY, John Wiley & Sons, 1989
- Watson L: *Lifetide: The Biology of the Unconscious*. New York, NY, Simon and Schuster, 1979, pp 213-214
- Khamsi R: Plastic brains help the blind place sounds. *News@Nature.com*. Available at: <http://www.nature.com/news/2005/050124/full/050124-6.html>. Accessed January 25, 2005
- Aron EN: *The Highly Sensitive Person: How to Thrive When the World Overwhelms You*. New York, NY, Carol Publishing Group, 1996
- Heller S: *Too Loud, Too Bright, Too Fast, Too Tight: What To Do If You Are Sensory Defensive in an Overstimulating World*. New York, NY, Harper-Collins, 2002
- Fibromyalgia syndrome: Improving the treatment, unraveling the cause. *Facts of Life newsletter*, Center for the Advancement of Health. Vol 6, No 8, December 2001
- Migraine: Prevention and treatment more effective than most realize. *Facts of Life newsletter*, Center for the Advancement of Health. Vol 7, No 1, February 2002
- Hartmann E: *Boundaries in the Mind*. New York, NY, Basic Books, 1991
- Hartmann E: *Dreams and Nightmares: The New Theory on the Origin and Meaning of Dreams*. New York, NY, Plenum Trade, 1998, pp 227-228
- Slade PD, Bentall RP: *Sensory Deception: A Scientific Analysis of Hallucination*. Baltimore, MD, The Johns Hopkins University Press, 1988, as cited in Glicksohn J, Barrett TR: Absorption and hallucinatory experience. *Appl Cognit Psychol* 17:833-849, 2003
- Wickramasekera I: Secrets kept from the mind but not the body or behavior: The unsolved problems of identifying and treating somatization and psychophysiological disease. *Adv Mind-Body Med* 14:81-132, 1998
- Piechowski MM: Overexcitabilities, in Runco MA, Pritzker S (eds): *Encyclopedia of Creativity*. San Diego, CA, Elsevier Science and Technology Books, 1999
- Tellegen A, Atkinson G: Openness to absorbing and self-altering experiences ('absorption'), a trait related to hypnotic susceptibility. *J Abnorm Psychol* 83:268-277, 1974
- Wilson SC, Barber TX: The fantasy-prone personality: implications for understanding imagery, hypnosis, and parapsychological phenomena, in Anees AS (ed): *Imagery: Current Theory, Research and Application*. New York, NY, John Wiley & Sons, 1983, pp 340-387
- Lynn SJ, Rhue JW: Fantasy proneness: Hypnosis, developmental antecedents, and psychopathology. *Am Psychol* 44:35-44, 1988
- Thalbourne MA: Transliminality: A review. *Int J Parapsychol* 11:1-34, 2000
- Shallis M: *The Electric Connection*. New York, NY, New Amsterdam Books, 1988, pp 9-10
- Lance JW: *Migraines and Other Headaches*. East Roseville, NSW, Australia: Simon and Schuster, 1998
- Schauffhausen J: *Migraine Maladies*. Available at: <http://www.ABCNews.com>. Accessed January 27, 2004
- Lambert-Nehr C: *Ease the Agony of Migraines*. *Detroit News*, June 18, 2003, p H6
- Byrd D: *Earth and Sky* (syndicated radio program). *Noisy Auroras*. Available at: <http://www.earthsky.com/2000/es000112.html>. Accessed January 12, 2000
- Leone B (ed): *Paranormal Phenomena: Opposing Viewpoints*. San Diego, CA, Greenhaven Press, 1997, p 93
- Frick U, Kharraz A, Hauser S, et al: Comparison perception of singular transcranial magnetic stimuli by subjectively electrosensitive subjects and general population controls. *Bioelectromagnetics* 26:287-298, 2005
- Mertz H, Morgan V, Tanner G, et al: Regional cerebral activation in irritable bowel syndrome. *Gastroenterology* 118:842-848, 2000
- Cocke A: *The Science Behind Hypnosis*. *BrainWork* (published by Charles A. Dana Foundation). 11:6, 2001
- Patterson K: *Psychosis Puzzle Pieces*. *Dallas Morning News* June 3, 2002, p C1
- Henkin RI, Levy LM, Lin CS: Taste and smell phantoms revealed by brain functional MRI (fMRI). *J Comput Assist Tomogr* 24:106-123, 2000
- Mlot C: Probing the biology of emotion. *Science* 280:1005-1007, 1998
- Hornik S: For some, pain is orange. *Smithsonian*, February 2001, pp 48-56. Available at: <http://www.smithsonianmag.si.edu/smithsonian/issues01/feb01/synesthesia.html>
- CBS News—60 Minutes II. *A Sixth Sense*, aired August 14, 2002. Available at: <http://www.cbsnews.com/stories/2002/01/08/60II/main323596.shtml>
- National Public Radio (WAMU-FM). *The Diane Rehm Show*, March 6, 2000
- Cytowic RE: Synesthesia: Phenomenology and neuropsychology. *Psyche* Vol 2, No 10, 1995. Available at: <http://www.psyches.monah.edu.au/v2/psyche-2-10-cytowic.htm>
- Houran J, Lange R: *Diary of events in a thoroughly un haunted house*. *Percept Mot Skills* 83:499-502, 1996
- Houran J, Lange R: Hauntings and poltergeist-like episodes as a confluence of conventional phenomena: A general hypothesis. *Percept Mot Skills* 83:1307-1316, 1996
- Houran J, Williams C: Relation of tolerance of ambiguity to global and specific paranormal experience. *Psychol Rep* 83:807-818, 1998
- Lange R, Houran J: The role of fear in delusions of the paranormal. *J Nerv Mental Dis* 187:159-166, 1999
- Jawer M: Environmental sensitivity: A link with apparitional experience? *J Soc Psych Res* 70, 2006 (in press)
- Durden-Smith J, deSimone D: *Sex and the Brain*. New York, NY, Arbor House, 1983, pp 76-77
- Ross CA, Joshi S: Paranormal experiences in the general population. *J Nerv Mental Dis* 180:357-361, 1992
- Irwin HJ: Childhood antecedents of out-of-body and déjà vu experiences. *J Am Soc Psych Res* 90:157-172, 1996
- Irwin HJ: Parapsychological phenomena and the absorption domain. *J Am Soc Psych Res* 79:1-11, 1985
- Irwin HJ: Origins and functions of paranormal belief: The role of childhood trauma and interpersonal control. *J Am Soc Psych Res* 86:199-208, 1992
- Terr LC: Childhood traumas: An outline and overview. *Am J Psychiatry* 148:10-20, 1991
- Bergman P, Escalona SK: Unusual sensitivities in very young children. *Psychoanal Study Child* II:333-352, 1949
- Stockenius S, Brugger P: Perceived electrosensitivity and magical ideation. *Percept Mot Skills* 90:899-900, 2000