

THE INTRUSION OF EARLY IMPLICIT MEMORY INTO ADULT CONSCIOUSNESS

Louis Cozolino, Ph.D.

Louis Cozolino, Ph.D., is a Professor in the Department of Psychology at Pepperdine University in Culver City, California.

For reprints write Louis Cozolino, Ph.D., Pepperdine University, Graduate School of Education and Psychology, 400 Corporate Pointe, Culver City, CA 90230.

ABSTRACT

Through the first few years of life the central and peripheral nervous systems grow in an exuberant, non-linear progression through a series of structures, organizations, and reorganizations. Evolving sensory, memory, and appraisal systems result in transitory modes of processing which are incorporated, superseded, and/or inhibited by later developing systems. Because of these complexities, little is understood about the phenomenology of early experience and its impact on adult functioning. The present paper hypothesizes about some aspects of early experience and memory and their possible intrusion into adult awareness, using, as an example, reported alien abduction experiences. These experiences are explained as the reinstatement of primordial memories of early caretaking which are misperceived as occurring in the present and interpreted by later developing, socially influenced cortical mechanisms of language and memory.

INTRODUCTION

The nature of an infant's experience is cloaked in mystery. As such, it is the subject of fascination, speculation, and projection – the ideas which follow are no exception. With this in mind, there is considerable neuroanatomical and behavioral evidence that infants are not simply small adults. The architecture of the peripheral and central nervous systems evolves dramatically over the first few years of life through transient structures (Innocenti, 1981) which organize and reorganize, resulting in evolving processes of sensation, perception, affect, and memory. As such, the nature of memories from infancy should reflect available nervous system structures of input, processing, and storage. While the long-term effects of these early experiences are at the core of psychoanalysis, they are relatively unexplored in neurology and neuroscience. Increasing understanding of developmental patterns of neural myelination, connectivity, and networking may extend our understanding of the infant's

world beyond the observational data presently available.

Tens of thousands of times during the first year of life, an infant experiences distress and the caretaker appears. The mother, sensitive to her infant's lack of visual acuity, brings her head close to the child's, makes faces and cooing sounds, and attempts to evoke a smile. The child's imitative smile evokes further smiling and interactions on the part of the mother. Countless times during the first year, the child is lifted, passed from hand-to-hand, presented with familiar and unfamiliar faces, dressed, undressed, and cleaned. It is logical to assume that these vitally important interactions are perceived and stored in a manner consistent with the developmental stage of peripheral and central nervous system structures and networks of learning and memory.

The coordination of the government of neural systems (Damasio, 1994) which participate in adult consciousness, depends on considerable filtration of information from both inner and outer worlds including memories from early life (Schacter, 1990). If these primordial memories are, in fact, qualitatively different from adult memories, their breakthrough into adult consciousness may not be recognized as memories but rather misperceived as paranormal forms of experience. Throughout history, individuals have reported visitations from spirits, demons, and, more recently, space aliens. While the commonality of these reports is often used as proof of their veracity (Siegel, 1984), it is just as likely that their similarity may arise from shared neurological development, similar experiences in childhood, and the co-construction of socially relevant narratives for the unexplained.

As an example of the intrusion of early memories into adult consciousness, the present thesis proposes that the physical appearance of aliens are early visual memories of caretakers as experienced by an immature visual system and encoded in nascent systems of implicit memory (Jacobs & Nadel, 1985; Schacter, 1996). The aspects of the abduction which involve being lifted up and physically explored reflect early sensory-vestibular memories of caretaking experiences. The extreme emotions, ranging from terror and rage to affection, embody the inchoate and dysregulated nature of primitive mental states and the biochemistry of early bonding. These vestibular, motoric, somatic, visual, and emotional memories are linked in subcortical networks of implicit memory and are generally incorporated into or inhibited by later

developing cortico-hippocampal systems of explicit memory and subsequent modes of information processing.

The breakthrough of early memories into adult consciousness awareness may be caused by transient, sub-clinical seizure activity in the temporal lobe (Persinger, 1983; 1994), disinhibition due to hippocampal damage secondary to traumatic injury, the effects of chronic stress (Sapolsky, 1987; 1996), or other normal or pathological dysregulations of the coherence of neural processing such as anxiety and depression (Sheline, Wang, Gado, Csernansky, & Vannier, 1996). These subcortically mediated memories may be experienced as occurring in the present, much like post-traumatic intrusions (flashbacks), because their storage, like some traumatic memory, did not utilize the contextualizing abilities of later developing cortico-hippocampal structures (LeDoux, 1996) which provide memories with "source attribution" (Anderson & Ross, 1980).

Construction of the alien abduction narrative parallels the confabulatory process exhibited by patients with right-hemisphere lesions (Damasio, 1994), commissurotomies (Gazzaniga, 1985), and schizophrenia (Nasrallah, 1985) to anomalous experiences generated via implicit memory and other neural systems which operate outside of conscious, linguistic, left hemisphere processing (Reed, 1974). The emotional, somatic, and ego-alien nature of these memories leads to attributions of paranormal and spiritual origins. The constructed narrative has multiple reinforcers wherein it serves to reduce the anxiety of the unexplained, allows abductees to feel unique, and provides a group for validation and support.

THE ABDUCTION EXPERIENCE AND ABDUCTEES

What are the narratives that are generated from these early memories? The most common alien encountered is the small grey (Prichard, Prichard, Mack, Kasey, & Yapp, 1994) which has disproportionately large eyes, forehead, and truncated chin. The large, black, pupil-less eyes appear to be the focal point for contact with abductees who report being "hypnotized" by their gaze. The nature of the emotional contact is often suggestive of a "bonding experience" (Bryan, 1995, p. 28). The encounters usually occur in dark and isolated places. Many abductees report driving alone for long periods of time on deserted roads while others are lying in bed between sleeping and waking states. The abduction usually includes an experience of being lifted or floating upward and of having genitals and anus inspected with occasional sexual excitement. The aliens are also reported to be interested in mental exploration often described as "mindscan."

The mindscan procedure involves a taller being staring deeply and penetrating into the abductee's eyes from a distance of roughly six inches to actually touching foreheads.

During this agonizing procedure, the abductee cannot close his eyes, nor can he look away...The aliens can bring out profound feelings of fear, terror, rage, shame, guilt, and the like. Often, feelings of attachment, attraction, and even love for the taller beings doing the mindscan can well up in an abductee during this procedure. (Jacobs, 1994, p. 54)

Abductees who have participated in research generally report that their experiences begin at an early age (Johnson, 1994) and have from two to six abductions in their lifetime with consistent and stereotyped features and plot (Jacobson & Bruno, 1994). MMPI cluster analysis reveals a subgroup of abductees who exhibit psychiatric symptomatology as reflected in the 6 (paranoia) and 8 (schizophrenia) scales (Parnell & Sprinkle, 1990; Rodeghier, 1994).

Another study of 22 subjects (Stone-Carmen, 1994) reported that while MMPI profiles were not in the clinical range, over half of the subjects reported a history of suicide attempts. Of his eight subjects, Johnson (1994) anecdotally reports that there appeared to be an equal number of abductees who were less intelligent and poorly adjusted as were abductees who were well-adjusted and articulate.

The consensus among sympathetic researchers appears to be that only a minority of abductees have clinical presentations and psychological testing results which would make one suspicious of the truthfulness of their reports (Johnson, 1994). Based on the available information, it seems that while some abductees suffer serious psychopathology and others may be simply lying, a group exists who appear psychologically healthy yet firmly convinced that they have been abducted by alien beings. Because of this, any theory which attempts to explain the phenomenon from a developmental biopsychosocial perspective should account for the psychologically healthy, as well as unhealthy, abductees. The following description of the development of the visual system conceptualizes how our early caretakers might be visually remembered as small grey aliens. This aspect of developmental neuroanatomy may render some aspects of these experiences more understandable as maturational, versus paranormal, phenomenon.

THE DEVELOPMENT OF THE VISUAL SYSTEM

The human visual system is immature at birth and continues to develop through, at least, the first five years of life (Brown, 1961) as reflected in increases in synaptic density (Huttenlocher & de Courten, 1987), myelinogenesis (Yakovlev & LeCours, 1967), and visual abilities such as the detection of movement (Goren, Sarty, & Wu, 1975), orientation (Braddick, Wattman-Bell, & Atkinson, 1986; Johnson, Dziurawiec, Ellis, & Morton, 1991; Rafal, Henik, & Smith,

1991), habituation (Fantz, 1965), pattern recognition (Fantz, Ordy, & Udelf, 1962), and binocular integration (Braddick, Wattman-Bell, Day, & Atkinson, 1983). The newborn visual system is innately biased towards complex patterns (Fantz, 1963), circles, and human faces (Fantz, 1961). These biases direct the infant to learn about aspects of its world most crucial to survival – the enhancement of bonding and safety, and the stimulation of neural growth and connectivity in systems dedicated to familiarity and affective attunement. The infant's visual system differs from the adult's in both its peripheral sensory apparatus (retina) and central processing (thalamo-cortical circuitry) abilities.

The two receptor cells of the retina, rods and cones, have different developmental timetables and functions: the rods, which are functional soon after birth, are achromatic and highly light sensitive, whereas the cones, which develop postnatally, are responsible for color vision and are less sensitive to light (Pinel, 1997). At birth, the fovea (the area of the retina with the greatest concentration of cones and most powerful visual acuity) is not yet organized (Abramov et al., 1982), thus early vision is primarily extra-foveal. Based on the development of the retina alone, vision during the first year evolves from blurry, peripheral, black and white images, to increasingly clear and colorful images which can be focused on and examined directly. Because the senses of smell, touch, hearing, balance, and fear are "on-line" at birth, vision likely develops in a multi-sensory, visceral-affective context that is linked to these other senses in early memory (Stern, 1985).

Some researchers have suggested that vision in the newborn is controlled exclusively by subcortical structures (Atkinson, 1984; Bronson, 1974). While it is true that much cortical growth is postnatal (Huttenlocher, 1994) and the neonate's cortical responses differ from that of adults (Ellingson, 1960), findings also suggest an interaction of subcortical and cortical structures in early vision (Burkhalter, 1991; Johnson, 1990). The interaction and growth of subcortical and cortical visual systems are observed in the two networks (or streams) for processing information in the visual cortex, the magnocellular (M) and parvocellular (P). The M stream, which develops first and appears to be functional to some degree at birth, is characterized by a high degree of contrast sensitivity, low spatial resolution, and low chromatic sensitivity. The latter developing P system has the opposite characteristics (Burkhalter, 1991).

The M and P systems have been described as being specialized for "location" and "identification," respectively (Schneider, 1969). The sequential development and function of the M and P processing streams parallels the temporal development of rods, cones, and the fovea. Thus, while the infant has some cortical involvement in orientating to the "location" of visual stimuli, the "identification" (affective/survival value) of early visual stimuli appears to be mediated primarily by subcortical structures. Other analyses served by the occipital cortex, such as the perception of move-

ment, depth and spatial relationships (Finkel & Sajda, 1994) slowly become available over the first few years of life. The increasing sophistication of visual processing during the first year reflects the gradually increasing participation of cortical (primary) visual systems (Diamond & Hall, 1969; Huttenlocher et al., 1987; Johnson, 1990) and the development of the retina.

The phylogenetically older subcortical visual system involves the thalamus, hypothalamus, and amygdala. Subcortical visual processing is largely unconscious (Holtzman, 1984) accounting for the phenomenon of blindsight in which a subject with cortical damage to visual areas orients to a flash of light without awareness of its presentation (Bridgeman & Staggs, 1982; Weiskrantz, Warrington, Sanders, & Marshall, 1974). Further evidence for the existence of subcortically stored unconscious memory is supported by the fact that visual stimuli can be stored without recourse to verbal labeling (Bahrick & Boucher, 1968; Cohen & Granstrom, 1970; Levy, Trevarthen, & Sperry, 1972; Taylor, 1969). Prolonged fixation observed in infants, often terminating with what appears to be high levels of distress, may reflect the inability of immature cortical visual-attention mechanisms to inhibit subcortical orienting responses (Johnson, 1990). This obligatory attention (Stechler & Latz, 1966), coupled with affective states of high distress, may later reappear as a component of shared eye gaze during the "mindscan" procedure described by abductees.

For primates, "not all visual stimuli are created equal" (Brothers, 1992, p. 409). Newborns have a preference for circles and faces and can track human faces soon after birth (Fantz, 1961; 1963; Goren et al., 1975; Johnson et al., 1991a; Johnson, Posner, & Rothblat, 1991b). The focus on circles primes the visual system to attend to faces which, in turn, stimulates and builds networks designed to analyze the familiarity (safety) of faces. Research with primates has demonstrated that specific cells in the amygdala selectively respond to faces (Brothers, Ring, & Kling, 1990). The considerable number of afferent connections to the amygdala from the temporal neocortex in adult primates (Herzog & van Hoesen, 1976) reflects the function of networks of facial recognition paired with affective memories of pleasure, fear, attachment, and shame (Schore, 1994) and their essential importance in primate survival.

THE CARETAKER SCENARIO

Given what has been described thus far concerning the visual system, imagine (at your present level of neural development) being the size of an infant lying in a crib. You see a mother hovering over you in full color while your cortex adjusts for the angle of her body so you are not shocked because her head appears as large as the rest of her body or that the top of her head is many times the size of her chin. Though you may have many primitive emotions of attrac-

tion, fear, or rage, your cortical inhibitory systems keep them out of consciousness. You can also reflect on this experience, compare it to others, and have the ability to access and process it at another time.

Now to regress to the infant's experience – change the clear color image to an achromatic, blurred impression. Take away the sophisticated mechanisms of the occipital cortex which keep objects in perspective, and only rely on how much of the retina is stimulated by different aspects of her face and body. This would expand her forehead and eyes and shrink her chin and body. Fixate on and enhance the size of the eyes based both on your visual system's bias towards circles and the emotional value of eyes for safety and danger as assessed by systems of the amygdala. Prolonged fixation may also add to the enhancement of the memory for the eyes and the association between this visual memory and feelings of both attachment and terror. Early subcortical systems of implicit memory may store these images and feelings with the somatic, motor, and vestibular memories – being lifted up, having genitals cleaned, diapers changed, and temperature taken – in interconnected neural networks.

MULTIPLE MEMORY SYSTEMS

Research supports the existence of multiple memory systems, each with its own domain of learning, neural architecture, and ontogeny (Nadel, 1992; Squire, 1987). The two primary forms of memory have been described as implicit, or early memory, and explicit, or late memory. Implicit memory is processed primarily outside of conscious awareness and includes sensory-motor and affective memory. Explicit memory requires conscious awareness, includes semantic and autobiographical memory, and appears to require the hippocampus for encoding and/or retrieval (Siegel, 1996). The clearest evidence for the discontinuity of implicit and explicit memory systems lies in the abundance of implicit learning which takes place during the first few years of life in the absence of memory for facts and events.

As with the visual system, some components of memory are available at birth whereas others take months or years of postnatal development to mature (Nadel & Zola-Morgan, 1984). The gradual development of explicit and autobiographical memory systems over the first two decades of life parallels the maturation of the hippocampal cortical systems (LeDoux, 1996). Overall, the ontogeny of memory reflects the early primacy of implicit memory for sensory-motor-affective learning mediated by the amygdala, thalamus, and orbital-medial prefrontal structures with the gradual addition of explicit memory systems for conscious, contextualized learning mediated via cortico-hippocampal networks.

Scant solid evidence currently exists concerning the ways in which early memories contribute to (or intrude upon) later conscious cognitive processes. In addressing this question, O'Keefe and Nadel (1978) use the terms "taxon"

(early/implicit) and "locale" (late/explicit) to describe these two general memory systems. Jacobs and Nadel (1985) attribute the recovery of fears and phobias by individuals under stress to a breakthrough of early sensory-emotional learning stored in the taxon (thalamo-amygdala) system into the locale (cortico-hippocampal) system. The development of cortical inhibition ensures that early memories are kept out of consciousness through active inhibition as opposed to extinction or loss. As a result, the breakthrough of early fears leave conscious processes to explain their origins and predict their reoccurrence, leading to naive attributions, superstitious behavior, and the development of phobias. Although Jacobs and Nadel focus specifically on fearful stimuli, early sensory, motor, and vestibular experiences are stored in these same memory systems and are also likely to intrude into adult awareness in situations of sensory deprivation and stress.

Because early memories rely on circuits which mediate unconscious sensory-affective-motor memory, they appear to be similar to traumatic flashbacks (re-experiencing) in adults. PTSD victims describe flashbacks as multisensory, egotically alien, cued by sights, smells, sounds, or feelings, and often occurring in the context of other contemporary stressors (van der Kolk & Greenberg, 1987). In addition, post-traumatic memories (like reported abduction experiences) are characteristically repetitive in nature (van der Kolk, Blitz, Burr, Sherry, & Hartman, 1984) suggesting that they are not subject to the assimilating and contextualizing properties of hippocampal memory processing and are instead experienced as powerful sensory-emotional events occurring in the present. Because these memories do not involve cortico-hippocampal circuitry, they are not coupled with a memory of an observing self and are resistant to extinction (Gloor, 1978; LeDoux, Romanski, & Xagoraris, 1989).

THE AMYGDALOID NETWORK

The amygdala, located in the medial portion of the temporal lobes, is a key component of early memory systems involving the anterior temporal poles and the medial prefrontal cortex. The basolateral portions of the amygdala evolved in parallel with the expansion of the cerebral cortex in humans (Stephan & Andy, 1977). The neural connectivity of the amygdala suggests that it participates in polysensory integration with a special emphasis on vision (van Housen, 1981) and further integration of the senses with emotional value (LeDoux, 1986). The amygdala is well developed at birth and has a significant role in emotion and learning in approach-avoidance situations (Sarter & Markowitsch, 1985) for both conditioned and unconditioned stimuli (Davis, 1992).

Two circuits of sensory input reach the amygdala in the adult: the first connects directly from the thalamus, while the second loops through the cortex and hippocampus and

then into the amygdala (LeDoux, 1996). The first system serves to make rapid survival decisions with a minimum of information while the second system adds cortical processing (context and inhibition) to ongoing behaviors. The amygdala's direct neural connectivity with the hypothalamus (Amaral, Veazey, & Cowan, 1982) and limbic-motor circuits promotes rapid appraisal, survival responses, and the unconscious storage of these experiences. Thus, these direct connections greatly enhance the involvement of immediate and intense somatic activation evidenced in phobias and flashbacks.

The amygdala is likely one of the key components of affective memory in infancy and throughout life (Ross, Homan, & Buck, 1994). In the fully developed brain, the amygdala enhances hippocampal memory storage for emotional memory through the release of norepinephrine and glucocorticoids (McGaugh, 1990). Electrical stimulation of the amygdala in humans often results in a wide variety of bodily sensations reflecting its neural connectivity to systems of physiological regulation and movement (Halgren, Walter, Cherlow, & Crandall, 1978). Feelings of anxiety, memory-like hallucinations, and *deja vu* experiences have also been reported (Chapman, Walter, Cortical, Rand, & Crandall, 1967; Penfield & Perot, 1963; Weingarten, Cherlow, & Holmgren, 1977).

The amygdala's low seizure threshold may result in increased sensitivity to transient, low-level seizure activity resulting in the reactivation of normally inhibited, remote polysensory memories (Sarter & Markowitsch, 1985) unprocessed by the contextualizing hippocampal networks.

Individuals with temporal lobe epilepsy often express extreme religiosity (Benson, 1994) suggesting that stimulation of the amygdala and other medial temporal structures triggers emotional experiences which can be understood as deeply significant or paranormal. The central nucleus of the amygdala has a high density of opioid receptors (Goodman, Snyder, Kuhar, & Young, 1980) which are a prime biochemical correlate of bonding and attachment behavior (Kalin, Shelton, & Lynn, 1995). Heightened opioid secretion during the breakthrough of these early memories may enhance the "bonding like" quality of alien-abductee experience with concurrent feelings of intense love, safety, and a sense of well-being.

THE HIPPOCAMPAL NETWORK

The neural connectivity, ontogeny, and evolution of the hippocampus supports its hypothesized role in the consolidation and contextualization of explicit memory in cooperation with the cerebral cortex (Brodal, 1992; Squire, 1992; Zola-Morgan & Squire, 1990). Although the hippocampus and amygdala have few direct connections, their interaction is primarily mediated via their input to the hypothalamic-pituitary-adrenocortical axis (Jacobson & Sapolsky, 1991) and

limbic-motor circuits (Mogenson, Brudzynski, Wu, Yang, & Yim, 1993).

Douglas and Pribram (1966) suggested that the amygdala and hippocampus have opposite roles in an "attention directing process." The role of the amygdala is to heighten awareness through generalization, whereas the hippocampus inhibits prepotent responses, attention, and/or stimulus input (Douglas, 1967; Kimble, 1968; Sherry & Schacter, 1987) through the accentuation of small differences between inputs (Marr, 1971). These functions reflect the roles of the amygdala and hippocampus in processing memory in taxon (implicit-affective) and locale (explicit-cognitive) memory systems, respectively.

It is logical to assume that early memory is a powerful component of internal-unconscious processing which is more likely to intrude into conscious experience in situations of decreasing contextual cues such as hypnogogic or near sleep states (Schacter, 1976) and conditions of sensory deprivation (Siegel, 1984), both consistently reported by abductees. Given the reciprocal nature of amygdaloid and hippocampal circuits, impairment of the hippocampus would lead to an increased influence of the amygdala in directing memory, emotion, and behavior and could result in the disinhibition of early polysensory and affective learning. Jacobs & Nadel (1985) assert that "once control has devolved on the taxon systems, retrieval or sudden relearning pertinent to these previously inaccessible residues of early experience become possible" (p. 518). Hippocampal damage may also result in dysfunctions of episodic memory contributing to perceptual disorganization, decreased reality testing, and an increased reliance on amygdaloid/taxon processing.

Primitive affective memory intrusion may also occur in states of stress and post-traumatic arousal (Jacobs & Nadel, 1985; van der Kolk & Greenberg, 1987). Individuals with a history of stress or present stressful experiences may be particularly vulnerable to the intrusion of implicit memories due to hippocampal damage and dysfunction. Both sensory deprivation before "contact" and histories of chronic stress and depression are commonly reported by abductees (Stone-Carmen, 1994).

The hippocampus, noted both for its late developmental maturation and sensitivity to traumatic insult, is relatively unmyelinated until the fifth or sixth year of life with the myelination of cortical-hippocampal circuits continuing into late adolescence (Benes, 1989). The late development of the hippocampus and its connectivity with the cortex reflect both its delayed functional availability and prolonged sensitivity to developmental disruption. Research indicates that sustained stress results in excessive exposure of the hippocampus to glucocorticoids, a catabolic hormone involved in the response to acute stress (Sapolsky, 1987). In turn, prolonged exposure to glucocorticoids can result in dendritic degeneration (Woolley, Gould, & McEwen, 1990), cell

death, increased vulnerability to future neurological insult (Packan & Sapolsky, 1990; Sapolsky, 1996), and inhibited hippocampal functioning (Micco, McEwen, & Shein, 1979). Hippocampal damage correlates with deficits of encoding short-term into long-term and episodic memory (Scoville & Milner, 1957; Squire, 1992). Patients suffering from post-traumatic stress disorder (Bremner et al., 1997; Pitman & Orr, 1990), prolonged depression (Sheline et al., 1996), temporal lobe epilepsy (de Lanerolle, Kim, Robbins, & Spencer, 1989), schizophrenia (Shenton et al., 1992), and Cushing's Disease (Starkman, Gebarski, Berent, & Schteingart, 1992) have also been shown to have hippocampal cell loss hypothesized to be related to increased levels of glucocorticoids and other neurotoxins.

While individuals with psychopathology may be more vulnerable to the intrusion of early memories, common patterns of neural development and life experience suggest that most people share the types of memories which become disinhibited in some individuals who report abduction experiences. Abductees and non-abductees may differ in the quality of cortico-hippocampal inhibitory functions and other properties of memory as well as their attributions of the intrusion of primitive states into conscious awareness. These attributional processes lead to the construction of the abduction narrative.

CREATING THE ABDUCTION NARRATIVE: THE ROLE OF THE LEFT HEMISPHERE

The neurology literature is replete with disruptions of the continuity and organization of conscious experience secondary to a variety of trauma (Benson, 1994). Symptoms of neglect, anosognosia (a denial of a gross neurological deficit), and confabulation, as well as separations of conscious awareness in dissociative and commissurotomy patients, reveal divisions of awareness and hemispheric differences in cognitive and affective processing strategies (LeDoux, Wilson, & Gazzaniga, 1977; Sperry, 1968). For most individuals, the right hemisphere appears to process information in an holistic-syncretic fashion (Galín, 1974; Levy et al., 1972) with direct connections to the viscera and limbic brain (Schore, 1994). The left hemisphere processes information in a linear, language-based manner, capable of filtering input from the right hemisphere (Galín, 1974). The hemispheres appear to communicate primarily via the corpus callosum (Innocenti, 1981). The left hemisphere appears to govern conscious coping and problem-solving abilities while functioning primarily in the middle range of affect. The right hemisphere is more involved in survival situations, the rapid and unconscious emotional appraisal of environmental stimuli, and functioning in the context of intense emotion (Schore, 1994). Decreased functioning of the left hemisphere during depression (Baxter et al., 1989) may cause a decreased inhibition of right hemisphere processing, resulting in elevation of anx-

ety, fear, and the possibility of the intrusion of early memories. Anesthesia of the left hemisphere results in greater expressions of negative emotion and less pro-social explanation of experience (Ross et al., 1994).

Anosognosia is far more frequent following right versus left sided damage suggesting that denial of right hemisphere processing is characteristic of the left hemisphere mode of processing experience (Galín, 1974). Research with patients with a variety of neurological deficits indicates that the construction of social narratives, which filter sensory and affective experience for social presentation, are most often formed by the left hemisphere (Ross et al., 1994). Excessive filtration of right hemisphere processing could result in disorders such as alexithymia (Zeitlin, Lane, O'Leary, & Schrift, 1989) while inadequate filtration of right hemisphere processing may result in the disruption of reality testing and the coherence of cognitive and affective processing as seen in schizophrenia (Rotenberg, 1994). Thus, mental health seems to involve a balance of communication and inhibition between the cerebral hemispheres.

It would appear that the left cerebral hemisphere attempts to make sense out of nonsense reflecting the basic human motivation to engage in explanatory behavior (Banaji & Kihlstrom, 1996). The left cerebral hemisphere is "eminently equipped to provide rationalizations" (van der Kolk, 1993, p. 223) for experiences and reactions which appear discontinuous with other aspects of reality testing. This concept has previously been used to explain the development of paranormal beliefs and experiences (Persinger, 1983, 1992, 1993; Siegel, 1984), schizophrenic delusional systems (Maher, 1974; Nasrallah, 1985) and the development of religious beliefs in the face of the unknown (Gazzaniga, 1985). The verbal, left neocortex organizes conscious experience (Gazzaniga, 1985; Nasrallah, 1985), and embodies the "social self" as arbiter of rules, expectations, and socio-emotional presentation (Ross et al., 1994). The construction of a social narrative is at work to some degree in the confabulations of stroke patients and schizophrenics, the defense mechanisms of neurotic, and the day-to-day construction of reality in healthy individuals. This same process most likely explains the creation of abduction narratives secondary to the intrusion of early memories.

CONCLUSION

To review, I suggest that the alien abduction narrative is a confabulatory explanation of intrusions of primordial memories into conscious adult awareness. These early memories are products of circuitry and processing capacity of the available neural systems during the first year of life. The capabilities and biases of early systems of vision account for the physical appearance of aliens while early (implicit) memory systems account for the association of these visual memories with vestibular, motor, sensory, and emotional memo-

ries from that time. When these early memories intrude into adult awareness as "anomalous" experiences, they are interpreted by the adult brain in a confabulatory manner designed to reduce anxiety by making sense out of nonsense. This phenomenon closely parallels what is seen in a variety of neurological and psychiatric disorders which disrupt the coherence of conscious processing. The data used to support the various components of this theory were drawn primarily from developmental neuroscience and neurology.

An understanding of the relationship between early experiences and adult consciousness requires the discovery of the nature of the processing capacities available to the infant. While psychoanalysis has explored this from a phenomenological and theoretical viewpoint, the addition of a neurological perspective may prove enlightening. The correctness of the proposed relationship between early implicit memory and alien abduction experiences is of little actual importance. It serves the purpose of taking a popular phenomenon and using it to help students remember some basic concepts in neurology and neuroscience. What is more important, and the primary thrust of the present work, is the attempt to understand human experience utilizing a developmental biopsychosocial model in an interdisciplinary context. The reunification of psychological and neurological models is breathing new life into psychological theorizing and treatment.

As more information about neural development, memory systems, and the organization and coherence of consciousness is gathered, the neuropsychological correlates of a variety of paranormal experiences might be uncovered. The primitive fear mechanism of the amygdala and related structures are a powerful artifact of our evolutionary history. Now that there are virtually no unexplored places or peoples on earth, the creation of extraterrestrial beings by human brains may reflect more a reverberation of our evolutionary past than a glimpse of an intergalactic future. While this area of inquiry may be viewed as reductionistic by some, I have confidence that any true extraterrestrial beings or spiritual forces will not be deterred from making themselves known by the very human endeavor of attempting to understand experience. ■

REFERENCES

- Abramov, I., Gordon, J., Henrickson, A., Hainline, L., Dobson, V., & LaBossiere, E. (1982). The retina of the newborn infant. *Science*, 217 (16), 265-267.
- Amaral, D.G., Veazey, R.B., & Cowan, W.M. (1982). Some observations on the hypothalamo-amygdaloid connections in the monkey. *Brain Research*, 252, 13-27.
- Anderson, J.R., & Ross, B.H. (1980). Evidence against a semantic-episodic distinction. *Journal of Experimental Psychology, Human Learning, and Memory*, 6, 441-465.
- Atkinson, J. (1984). Human visual development over the first six months of life: A review and a hypothesis. *Human Neurobiology*, 3, 61-74.
- Bahrack, H.P., & Boucher, B. (1968). Retention of visual and verbal codes of the same stimuli. *Journal of Experimental Psychology*, 78, 417-422.
- Banaji, M.R., & Kihlstrom, J.F. (1996). The ordinary nature of alien abduction memories. *Psychological Inquiry*, 7 (2), 132-135.
- Baxter, L.R., Schwartz, J.M., Phelps, M.E., Mazziotta, J.C., Guze, B. H., Selin, C.E., Gerner, R.H., & Sumida, R.M. (1989). Reduction of prefrontal cortex glucose metabolism common to three types of depression. *Archives of General Psychiatry*, 46, 243-250.
- Benes, F.M. (1989). Myelination of cortical-hippocampal relays during late adolescence. *Schizophrenia Bulletin*, 15 (4), 585-593.
- Benson, F.D. (1994). *The neurology of thinking*. New York: Oxford University Press.
- Braddick, O., Wattman-Bell, J., Day, J., & Atkinson, J. (1983). The onset of binocular function in human infants. *Human Neurobiology*, 2, 65-69.
- Braddick, O., Wattman-Bell, J., & Atkinson, J. (1986). Orientation-specific cortical responses develop in early infancy. *Nature*, 320, 617-619.
- Bremner, J.D., Randall, P., Vermetten, E., Staib, L., Bronen, R.A., Mazure, C., Capelli, S., McCarthy, G., Innis, R.B., & Charney, D.S. (1997). Magnetic resonance imaging-based measurement of hippocampal volume in post-traumatic stress disorder related to childhood physical and sexual abuse: A preliminary report. *Biological Psychiatry*, 41, 23-32.
- Bridgeman, B., & Staggs, D. (1982). Plasticity in human blindsight. *Vision Research*, 22, 1199-1203.
- Brodal, P. (1992). *The central nervous system*. New York: Oxford University Press.
- Bronson, G. (1974). The postnatal growth of visual capacity. *Child Development*, 45, 873-890.
- Brothers, L. (1992). Perception of social acts in primates: Cognition and neurobiology. *The Neurosciences*, 4, 409-414.
- Brothers, L., Ring, B., & Kling, A. (1990). Responses of neurons in the macaque amygdala to complex social stimuli. *Behavioral Brain Research*, 41, 199-213.
- Brown, C.A. (1961). The development of visual capacity in the infant and young child. *Cerebral Palsy Bulletin*, 3(4), 364-372.
- Bryan, C.D.B. (1995). *Close encounters of the fourth kind: Alien abduction, UFOs, and the conference at M.I.T.* New York: Alfred A. Knopf.
- Burkhalter, A. (1991). Developmental status of intrinsic connections in visual cortex of newborn infants. In P. Bagnoli & W. Hodos (Eds.), *The changing visual system: Maturation and aging in the central nervous system* (pp.247-254). New York: Plenum Press.

- Chapman, L.F., Walter, R.D., Cortical, C.H., Rand, R.W., & Crandall, P.H. (1967). Memory changes induced by stimulation of hippocampus or amygdala in epilepsy patients with implanted electrodes. *Transactions of the American Neurological Association*, 92, 50-56.
- Cohen, R.L., & Granstrom, K. (1970). Reproduction and recognition in short-term visual memory. *Quarterly Journal of Experimental Psychology*, 22, 450-457.
- Damasio, A.R. (1994). *Descartes' error*. New York: Putnam Books.
- Davis, M. (1992). The role of the amygdala in fear and anxiety. *Annual Review of Neuroscience*, 15, 353-375.
- de Lanerolle, N.C., Kim, J.H., Robbins, R.J., & Spencer, D.D. (1989). Hippocampal interneuron loss and plasticity in human temporal lobe epilepsy. *Brain Research*, 495, 387-395.
- Diamond, I.T., & Hall, W.C. (1969). Evolution of neocortex. *Science*, 164, 251-262.
- Douglas, R.J. (1967). The hippocampus and behavior. *Psychological Bulletin*, 67 (6), 416-442.
- Douglas, R.J., & Pribram, K.H. (1966). Learning and limbic lesions. *Neuropsychologia*, 4, 197-220.
- Ellingson, R.J. (1960). Cortical electrical responses to visual stimulation in the human infant. *EEG Clinical Neurophysiology*, 12, 663-677.
- Fantz, R.L. (1961). The origin of form perception. *Scientific American*, 204 (5), 66-72.
- Fantz, R.L. (1963). Pattern vision in newborn infants. *Science*, 140, 296-297.
- Fantz, R.L. (1965). Visual perception from birth as shown by pattern selectivity. *Annals of the New York Academy of Sciences*, 118, 793-814.
- Fantz, R.L., Ordy, J.M., & Udelf, M.S. (1962). Maturation of pattern vision in infants during the first six months. *Journal of Comparative and Physiological Psychology*, 55(6), 907-917.
- Finkel, L.H., & Sajda, P. (1994). Constructing visual perception. *American Scientist*, 82(3), 224-237.
- Galín, D. (1974). Implications for psychiatry of left and right cerebral specialization: A neurophysiological context for unconscious processes. *Archives of General Psychiatry*, 31, 572-583.
- Gazzaniga, M.S. (1985). *The social brain: Discovering the networks of the mind*. New York: Basic Books.
- Gloor, P. (1978). Inputs and outputs of the amygdala: What the amygdala is trying to tell the rest of the brain. In K.E. Livingston & O. Hornykiewicz (Eds.), *Limbic mechanisms: The continuing evolution of the limbic system concept* (pp. 189-209). New York: Plenum Press.
- Goodman, R.R., Snyder, S.H., Kuhar, M.J., & Young, W.S. III. (1980). Differential of delta and mu opiate receptor localizations by light microscope autoradiography. *Proceedings of the National Academy of Sciences USA*, 77, 2167-2174.
- Goren, C.C., Sarty, M., & Wu, P.Y.K. (1975). Visual following and pattern discrimination of face-like stimuli by newborn infants. *Pediatrics*, 56, 544-549.
- Halgren, E., Walter, R.D., Cherlow, D.G., & Crandall, P.H. (1978). Mental phenomena evoked by electrical stimulation of the human hippocampal formation and amygdala. *Brain*, 101, 83-117.
- Herzog, A.G., & van Hoesen, G.W. (1976). Temporal neocortical afferent connections to the amygdala in the rhesus monkey. *Brain Research*, 115, 57-69.
- Holtzman, J.D. (1984). Interaction between cortical and subcortical visual areas: Evidence from human commissurotomy patients. *Vision Research*, 24 (8), 801-813.
- Huttenlocher, P.R. (1994). Synaptogenesis in human cerebral cortex. In G. Dawson & K.W. Fischer (Eds.), *Human behavior and the developing brain* (pp. 137-152). New York: Guilford.
- Huttenlocher, P.R., & de Courten, C. (1987). The development of synapses in the striate cortex of man. *Human Neurobiology*, 6, 1-9.
- Innocenti, G.M. (1981). The development of interhemispheric connections. *Trends in Neuroscience*, 4, 142-144.
- Jacobs, D.M. (1994). Medical examination and subsequent procedure. In A. Prichard, D.E. Prichard, J.E. Mack, P. Kasey, & C. Yapp (Eds.), *Alien discussions: Proceedings of the abduction study conference at M.I.T.* (pp. 53-55). Cambridge, MA: North Cambridge Press.
- Jacobs, W.J., & Nadel, L. (1985). Stress-induced recovery of fears and phobias. *Psychological Review*, 92, 512-531.
- Jacobson, E., & Bruno, J. (1994). Narrative variants and major psychiatric illnesses in close encounter and abduction narrators. In A. Prichard, D.E. Prichard, J.E. Mack, P. Kasey, & C. Yapp (Eds.), *Alien discussions: Proceedings of the abduction study conference at M.I.T.* (pp. 304-308). Cambridge, MA: North Cambridge Press.
- Jacobson, L., & Sapolsky, R. (1991). The role of the hippocampus in feedback regulation of the hypothalamic-pituitary-adrenocortical axis. *Endocrine Reviews*, 12(2), 118-134.
- Johnson, D.A. (1994). Personality characteristics of U.F.O. abductees. In A. Prichard, D.E. Prichard, J.E. Mack, P. Kasey, & C. Yapp (Eds.), *Alien discussions: Proceedings of the abduction study conference at M.I.T.* (pp. 316-319). Cambridge, MA: North Cambridge Press.
- Johnson, M.H. (1990). Cortical maturation and the development of visual attention in early infancy. *Journal of Cognitive Neuroscience*, 2(2), 81-95.
- Johnson, M.H., Dziurawiec, S., Ellis, H., & Morton, J. (1991a). Newborn preferential tracking of face-like stimuli and its subsequent decline. *Cognition*, 40, 1-19.
- Johnson, M.H., Posner, M.I., & Rothbart, M.K. (1991b). Components of visual orienting in early infancy: Contingency learning, anticipatory looking, and disengaging. *Journal of Cognitive Neuroscience*, 3(4), 335-344.
- Kalin, N.H., Shelton, S.E., & Lynn, D.E. (1995). Opiate systems in mother and infant primates coordinate intimate contact during reunion. *Psychoneuroendocrinology*, 20(7), 735-742.

- Kimble, D.P. (1968). Hippocampus and internal inhibition. *Psychological Bulletin*, 70(5), 285-295.
- LeDoux, J.E. (1986). Sensory systems and emotion: A model of affective processing. *Integrative Psychiatry*, 4, 237-243.
- LeDoux, J. E. (1996). *The emotional brain*. New York: Simon and Schuster.
- LeDoux, J.E., Romanski, L.M., & Xagoraris, A.E. (1989). Indelibility of subcortical emotional memories. *Journal of Cognitive Neuroscience*, 1, 238-243.
- LeDoux, J.E., Wilson, D.H., & Gazzaniga, M.S. (1977). A divided mind: Observations on the conscious properties of the separated hemispheres. *Annals of Neurology*, 2, 417-421.
- Levy, J., Trevarthen, C., & Sperry, R.W. (1972). Perception of bilateral chimeric figures following hemispheric disconnection. *Brain*, 95, 61-78.
- Maher, B.A. (1974). Delusional thinking and perceptual disorder. *Journal of Individual Psychology*, 30, 98-113.
- Marr, D. (1971). A theory of archicortex. *Philosophical Transactions of the Royal Society*, 262, 23-81.
- McGaugh, J.L. (1990). Significance and remembrance: The role of neuromodulatory systems. *Psychological Science*, 1(1), 15-25.
- Micco, D.J., McEwen, B.S., & Shein, W. (1979). Modulation of behavioral inhibition in appetitive extinction following manipulation of adrenal steroids in rats: Implications for involvement of the hippocampus. *Journal of Comparative and Physiological Psychology*, 93(2), 323-329.
- Mogenson, G.J., Brudzynski, S.M., Wu, M., Yang, C.R., & Yim, C.C.Y. (1993). From motivation to action: A review of dopaminergic regulation of limbic-nucleus accumbens-ventral pallidum-pedunculo-pontine nucleus circuitries involved in limbic-motor integration. In P.W. Kalivas & C.D. Barnes (Eds.), *Limbic motor circuits and neuropsychiatry* (pp.193-235). Boca Raton, FL: CRC Press.
- Nadel, L. (1992). Multiple memory systems: What and why. *Journal of Cognitive Neuroscience*, 4(3), 179-188.
- Nadel, L., & Zola-Morgan, S. (1984). Infantile amnesia: A neurobiological perspective. In M. Moscovitch (Ed.), *Infant memory: Its relation to normal and pathological memory in humans and other animals* (pp.145-172). New York: Plenum Press.
- Nasrallah, H.A. (1985). The unintegrated right cerebral hemispheric consciousness as alien intruder: A possible mechanism for Schneiderian delusions in schizophrenia. *Comprehensive Psychiatry*, 26(3), 273-282.
- O'Keefe, J., & Nadel, L. (1978). *The hippocampus as a cognitive map*. Oxford: The Clarendon Press.
- Packan, D.R., & Sapolsky, R.M. (1990). Glucocorticoid endangerment of the hippocampus: Tissue, steroid and receptor specificity. *Neuroendocrinology*, 51, 613-618.
- Parnell, J.O., & Sprinkle, L. (1990). Personality characteristics of persons who claim UFO experiences. *Journal of UFO Studies*, 2, 45-58.
- Penfield, W., & Perot, P. (1963). The brain's record of auditory and visual experience. *Brain*, 86, 595-696.
- Persinger, M.A. (1983). Religious and mystical experiences as artifacts of temporal lobe function: A general hypothesis. *Perceptual and Motor Skills*, 57, 1255-1262.
- Persinger, M.A. (1992). Neuropsychological profiles of adults who report "sudden remembering" of early childhood memories: Implications for claims of sex abuse and alien visitation/abduction experiences. *Perceptual and Motor Skills*, 75, 259-266.
- Persinger, M.A. (1993). Vectorial cerebral hemisphericity as differential sources for the sensed presence, mystical experiences and religious conversions. *Perceptual and Motor Skills*, 76, 915-930.
- Persinger, M.A. (1994). Elicitation of "childhood memories" in hypnotic-like settings is associated with complex partial epileptic-like signs for women but not for men: Implications for false memory syndrome. *Perceptual and Motor Skills*, 78, 643-651.
- Pinel, J.P.J. (1997). *Biopsychology*. Boston: Allyn and Bacon.
- Pitman, R.K., & Orr, S.P. (1990). Twenty-four hour urinary cortisol and catecholamine excretion in combat-related post-traumatic stress disorder. *Biological Psychiatry*, 27, 245-247.
- Prichard, A., Prichard, D.E., Mack, J.E., Kasey, P., & Yapp, C. (Eds.). (1994). *Alien discussions: Proceedings of the abduction study conference at M.I.T.* Cambridge, MA: North Cambridge Press.
- Rafal, R., Henik, A., & Smith, J. (1991). Extrageniculate contributions to reflex visual orienting in normal humans: A temporal hemifield advantage. *Journal of Cognitive Neuroscience*, 3(4), 322-328.
- Reed, G. (1974). *The psychology of anomalous experiences: A cognitive approach*. Boston: Houghton Mifflin.
- Rodeghier, M. (1994). Evidence for abuse among abductees. In A. Prichard, D.E. Prichard, J.E. Mack, P. Kasey, & C. Yapp (Eds.), *Alien discussions: Proceedings of the abduction study conference at M.I.T.* (pp. 316-319). Cambridge, MA: North Cambridge Press.
- Ross, E.D., Homan, R.W., & Buck, R. (1994). Differential hemispheric lateralization of primary and social emotions: Implications for developing a comprehensive neurology for emotions, repression, and the subconscious. *Neuropsychology and Behavioral Neurology*, 7(1), 1-19.
- Rotenberg, V.S. (1994). An integrative psychophysiological approach to brain hemisphere functions in schizophrenia. *Neuroscience and Biobehavioral Reviews*, 18(4), 487-495.
- Sapolsky, R.M. (1987). Glucocorticoids and hippocampal damage. *Trends in Neuroscience*, 10(9), 346-349.
- Sapolsky, R.M. (1996). Why stress is bad for your brain. *Science*, 273(9), 749-750.

- Sarter, M., & Markowitsch, H.J. (1985). The amygdala's role in human mnemonic processing. *Cortex*, 21, 7-24.
- Schacter, D.L. (1976). The hypnagogic state: A critical review of the literature. *Psychological Bulletin*, 83(3), 452-481.
- Schacter, D.L. (1990). Perceptual representational systems and implicit memory: Toward a resolution of the multiple memory system debate. *Annals of the New York Academy of Sciences*, 608, 543-571.
- Schacter, D.L. (1996). *Searching for memory*. New York: Basic Books.
- Schneider, G.E. (1969). Two visual systems. *Science*, 163, 895-902.
- Schore, A.N. (1994). *Affect regulation and the origin of the self*. Hillsdale, New Jersey: Lawrence Erlbaum Associates.
- Scoville, W.B., & Milner, B. (1957). Loss of recent memory after bilateral hippocampal lesions. *Journal of Neurology, Neurosurgery and Psychiatry*, 20, 11-21.
- Sheline, Y.L., Wang, P.W., Gado, M.H., Csernansky, G.J., & Vannier, M.W. (1996). Hippocampal atrophy in recurrent major depression. *Proceedings of the National Academy of Sciences USA*, 93, 3908-3913.
- Shenton, M.E., Kikinis, R., Jolesz, F.A., Pollak, S.D., LeMay, M., Wible, C. G., Hokama, H., Martin, J., Metcalf, D., Coleman, M., & McCarthy, R.W. (1992). Abnormalities of the left temporal lobe and thought disorder in schizophrenia: A quantitative magnetic resonance imaging study. *New England Journal of Medicine*, 327(9), 604-612.
- Sherry, D.F., & Schacter, D.L. (1987). The evolution of multiple memory systems. *Psychological Review*, 94, 439-454.
- Siegel, D.J. (1996). Cognition, memory, and dissociation. *Child and Adolescent Clinics of North America*, 5(2), 509-536.
- Siegel, R.K. (1984). Hostage hallucinations: Visual imagery induced by isolation and life threatening stress. *The Journal of Nervous and Mental Disease*, 172(5), 264-272.
- Sperry, R.W. (1968). Hemispheric disconnection and unity in conscious awareness. *American Psychologist*, 23, 723-733.
- Squire, L.R. (1987). *Memory and brain*. New York: Oxford University Press.
- Squire, L.R. (1992). Memory and the hippocampus: A synthesis from findings with rats, monkeys, and humans. *Psychological Review*, 99(2), 195-231.
- Starkman, M.N., Gebarski, S.S., Berent, S., & Schteingart, D.E. (1992). Hippocampal formation volume, memory dysfunction, and cortisol levels in patients with Cushing's syndrome. *Biological Psychiatry*, 32, 756-765.
- Stechler, G., & Latz, E. (1966). Some observations on attention and arousal in the human infant. *Journal of the American Academy of Child Psychiatry*, 5, 517-525.
- Stephan, H., & Andy, O.J. (1977). Quantitative comparison of the amygdala in insectivores and primates. *Acta Anatomica*, 98, 130-153.
- Stern, D.N. (1985). *The interpersonal world of the infant*. New York: Basic Books.
- Stone-Carmen, J. (1994). A descriptive study of people reporting abduction by UFOs. In A. Prichard, D.E. Prichard, J.E. Mack, P. Kasey, & C. Yapp (Eds.), *Alien discussions: Proceedings of the abduction study conference at M.I.T.* (pp. 309-315). Cambridge, MA: North Cambridge Press.
- Taylor, R.L. (1969). Comparison of short-term memory and visual sensory analysis as sources of information. *Journal of Experimental Psychology*, 81, 515-522.
- van der Kolk, B.A. (1993). Biological considerations about emotions, trauma, memory, and the brain. In S.L. Ablon, D. Brown, E.J. Khantzian, & J.E. Mack (Eds.), *Human feelings: Explorations in affect development and meaning* (pp. 221-240). Hillsdale, NJ: The Analytic Press.
- van der Kolk, B.A., Blitz, R., Burr, W., Sherry, S., & Hartmann, E. (1984). Nightmares and trauma: A comparison of nightmares after combat with lifelong nightmares in veterans. *American Journal of Psychiatry*, 141, 187-190.
- van der Kolk, B.A., & Greenberg, M.S. (1987). The psychobiology of the traumatic response: Hyperarousal, constriction, and addiction to traumatic reexposure. In B.A. van der Kolk (Ed.), *Psychological trauma* (pp. 63-87). Washington, D.C.: American Psychiatric Press.
- van Hoesen, G.W. (1981). The differential distribution, diversity and sprouting of cortical projections to the amygdala in the rhesus monkey. In Y. Ben-Ari (Ed.), *The amygdaloid complex* (pp. 77-90). Amsterdam: Elsevier/North Holland Biomedical Press.
- Weingarten, S.M., Cherlow, D.G., & Holmgren, E. (1977). The relationship of hallucinations to the depth structures of the temporal lobe. *Acta Neurochirurgica, Supplement*, 24, 199-216.
- Weiskrantz, L., Warrington, E.K., Sanders, M.D., & Marshall, J. (1974). Visual capacity in the hemianopic field following a restricted optical ablation. *Brain*, 97, 709-728.
- Woolley, C.S., Gould, E., & McEwen, B.S. (1990). Exposure to excess glucocorticoids alters dendritic morphology of adult hippocampal pyramidal neurons. *Brain Research*, 531, 225-231.
- Yakovlev, P.I., & LeCours, A. (1967). The myelogenetic cycles of regional maturation of the brain. In A. Minkowski (Ed.), *Regional development of the brain in early life*. Philadelphia: Davis.
- Zeitlin, S.B., Lane, R.D., O'Leary, D.S., & Schrift, M.J. (1989). Interhemispheric transfer deficit and alexithymia. *American Journal of Psychiatry*, 146(11), 1434-1439.
- Zola-Morgan, S.M., & Squire, L.R. (1990). The primate hippocampal formation: Evidence for a time-limited role in memory storage. *Science*, 250, 288-290.