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EVOLUTIONARY APPROACHES TO UNDERSTANDING THE HYPNOTIC EXPERIENCE

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Abstract: Using Tinbergen’s 4 why questions of causation, development, evolution, and function, the authors examine hypnosis from a larger, evolutionary perspective. Reasoning by analogy, they seek to view hypnosis in terms of an action pattern that represents a self-contained behavioral program although not as rigid as seen in lower organisms. In humans, such a program develops within the context of a long developmental sequence emphasizing social connections, imitation of significant figures, and the use of linguistic symbols to regulate both internal and external processes and actions. In terms of a mechanism, the authors speculate on the involvement of the cingulate cortex in achieving in hypnosis the experience of autonomous actions or analgesic sensory processes. Finally, they point to the fact that hypnotizability is associated with an ability to reduce the experience of pain, modulate the immune system, and achieve greater benefits of psychosocial therapies as a functional significance of the hypnotic experience.

In On the Origin of Species, Darwin wrote “Psychology will be based on a new foundation, that of the necessary acquirement of each mental power and capacity by gradation. Light will be thrown on the origin of man and his history” (p. 488, 1886). Although this was written nearly 150 years ago, we are just now beginning to come to grips with the manner in which evolutionary thinking can impact and shape our current conceptualizations. One strong force that supported this perspective can be found in research and theoretical perspectives from cognitive and affective neuroscience, biology, human ethology, and genetics. In the current paper, we attempt to articulate some of the concepts necessary for understanding hypnosis from this perspective. We first suggest important neurophysiological structures and processes involved and...
then draw from ecology to illustrate one possible manner in which these mechanisms may come into play in an organized coherent manner.

**OUTLINE OF THE HYPOTHESIS**

The phenomenon of hypnosis presents important challenges for a theoretical understanding of the psychological and neural mechanisms of the human mind. We hypothesize that hypnotic suggestion engages self-regulatory mechanisms (of the hippocampus and posterior cingulate cortex) that originally evolved to support orienting to the episodic environmental context and then were integrated within attachment and imprinting instincts. Perhaps equally important, hypnosis may require a suspension of other self-regulatory mechanisms (of the amygdala and its input into anterior cingulate cortex) that normally serve to disengage the person from the episodic context.

The fact that volitional control of behavior can be interrupted and modified by external suggestion suggests that, under appropriate conditions, social influence may engage mechanisms of voluntary control at an elementary level. By understanding the process of hypnosis, we may better understand not only this interesting phenomenon but also the mechanisms of self-regulation themselves.

The evolution of self-regulatory capacity has resulted in mechanisms, such as integrating the ongoing episodic context (posterior cingulate) versus disengaging from the context to establish internal control (anterior cingulate) that may not be obvious to psychological analysis. For both avian and mammalian neural evolution, self-regulation has evolved within a social context, in which development of self-regulatory skills is at first facilitated through incorporation of parental regulatory influence. The ontogenetic formation of self-regulatory capacity is closely dependent on effective coordination with parental and peer social regulatory influences. By understanding the neural mechanisms through which both parental influence and internal control are achieved, we may better characterize the substrate that is engaged by hypnotic suggestion.

**EVOLUTION OF ATTACHMENT AND SOCIAL CONTROL**

One important source that contributed to the evolutionary perspective in the 20th century was that of ethology and the pioneering work of Konrad Lorenz (Lorenz, 1970). Ethology, which is derived from the Greek word “ethos,” refers to character or trait focus of the study of animals and their behavior (Cartwright, 2000). Within this field, it is assumed that behavioral processes have been shaped through evolution to be sensitive to environmental conditions. Environment in this
context includes not only the physical characteristics of a particular setting but also the social and cultural environment in which the organism lives. From this perspective, behavior is always understood within the context of the larger environment. Given the complexity of behavior within an environment, the field of ethology has largely focused on particular patterns of behavior that have evolutionary significance and the possible mechanisms that produce these behaviors. In now classic studies, Lorenz showed that orphaned baby birds such as geese and ducks would follow Lorenz as if he were their mother if he came before them during their first two days of life, a process known as “imprinting.” In normal situations, newly hatched birds prefer following females of their own species as compared to other objects, which has a clear evolutionary advantage. Humans have been shown to have similar emotional bonding processes, which Bowlby (1982) referred to as attachment.

Most of the early research in ethology was demonstrational in nature. For example, in the 1930s, Lorenz and Niko Tinbergen experimented with the egg-rolling movement of the greylag goose (Lorenz, 1970). If the goose sees an egg outside of its nest, it will reach past the egg with its bill and then roll it back with the underside of its bill, balancing it carefully into the nest. What Lorenz observed was that if the egg was removed once the rolling behavior had been started, then the behavior continues as if the egg is still there. However, the balancing movement is not seen. This suggests that the balancing movement is sensitive to ongoing stimulation and ceases in its absence, whereas the egg-rolling movement, once begun, does not require sensory stimulation to continue.

The egg-rolling movement is what Lorenz referred to as a fixed-action pattern. A fixed-action pattern is (a) released by a stimulus; (b) has a constant form, i.e., uses the same physiological process (e.g., muscles) to achieve the same sequence of actions; (c) requires no learning; (d) is characteristic of a species; and (e) cannot be unlearned. Once a fixed-action pattern is released, it will continue in the absence of the releasing or triggering stimulus.

Humans also show fixed-action patterns, which are clearly seen in newborn babies in terms of the grasping movements of the feet and hands if touched or the rooting reflex if the lips or cheeks are touched. Research has supported the idea that an infant’s facial features, including large eyes and forehead, may serve as releasing mechanisms that bring forth positively valenced, affectionate responses from adults. Cartoon characters or toys that have similar characteristics are rated as cute across a variety of cultures.

Following this tradition, we can consider hypnosis from an ethological perspective and evaluate it as a fixed-action pattern. We first consider if the five characteristics of a fixed-action pattern are present.
First, hypnosis is clearly released by a stimulus, which consists of a safe environment in which a suggestion to enter into the hypnotic state is made. Second, the form in terms of physiology and experience appears constant over various hypnotic experiences. Subjectively, hypnosis has been characterized by deep mental relaxation; mental absorption; diminished tendency to judge; a suspension of orientation toward time, location, or sense of self; and the experience of one’s own response as automatic (Price, 1996). On a physiological level, similar processes (e.g., EEG theta activity and the involvement of the anterior cingulate) have been reported in a variety of studies. Third, hypnosis on the part of high hypnotizable individuals is assumed not to require learning, although there is some debate as to whether low hypnotizable individuals can be taught the experience. Fourth, hypnosis as it has been studied scientifically is not a characteristic of all humans. In this sense, hypnosis might be better considered as process, such as attachment in which there exist different types or classes of responding to the invoking stimuli. This would suggest that hypnotic susceptibility is part of a larger developmental process resulting in a stability of susceptibility. Fifth, although it’s an unresearched area, there exists little evidence to suggest that the ability to be hypnotized can be unlearned.

In terms of an ethological perspective, Tinbergen (1963) suggested that there were four “whys” to be considered in terms of behavior: causation, development, evolution, and function. First, what are the mechanisms that cause the behavior? Cause in this case refers to physiological mechanisms that are activated by environmental cues. Second, how does the behavior come to develop in the individual? Third, how has the behavior evolved? And fourth, what is the function or survival value of the behavior? Considering hypnosis within the broader context of these questions allows one to cut across many dichotomies found in the current debates concerning the most appropriate model for understanding hypnosis (e.g., Kihlstrom, 1998; Kirsch & Lynn, 1998; Woody & Sadler, 1998).

**Hypnosis and Mechanisms of the Executive Functions**

We begin by considering Tinbergen’s first question as to what mechanisms are activated by environmental conditions to produce the hypnotic experience. As shown by the name given to the phenomenon, the early studies of hypnosis attempted to understand it in relation to the mechanisms of sleep. Although this approach remains highly relevant, largely because we have such a poor understanding of the alterations in consciousness and mental status in relation to the neural mechanisms of sleep, a theoretical account of hypnosis must go beyond the changes in arousal and level of consciousness to consider...
the executive monitoring and control of behavior. Several neurophysiological findings present interesting clues in this direction.

In the 1800s, James Braid not only introduced the term hypnosis but also proposed a physiological basis for the hypnotic process (Braid, 1843/1960; Kravis, 1988). Much of the early work emphasized the nature of the hypnotic experience, especially its relationship to sleep. Pavlov (1927), for example, saw both hypnosis and sleep as cortical inhibitory processes. Later work began to differentiate hypnosis and sleep. In the late 1940s, Gordon (1949) reported that an EEG recorded during hypnosis was less like sleep and more similar to being awake. During the next decade, there was a shift to suggest that hypnosis most resembles light sleep (cf. Barker & Burgwin, 1949; Franck, 1950). With the arrival of more sophisticated signal processing techniques, there was a trend to move toward questions concerning which physiological markers are associated with hypnotic processes. The classic example was the examination of EEG activity in the alpha band (8–12 Hz) and its later interpretation as a reflection of differential hemispheric activity. However, during the past 50 years, this work has not presented a consistent picture of the hypnotic process.

The most solid relationship between electrocortical activity, hypnosis, and hypnotizability exists in the EEG theta frequency range (cf. Graf, Ray, & Lundy, 1995; Isotani et al., 2001; Sabourin, Cutcomb, Crawford, & Pribram, 1990; see also Crawford & Gruzelier, 1992, for a review). Galbraith, London, Leibovitz, Cooper, and Hart (1970), using stepwise regression methods, reported that baseline EEG activity in the theta range was most predictive of hypnotic susceptibility. This has been replicated in other studies showing a strong relationship between theta and hypnotic susceptibility across a wide variety of sites as well as the presence of theta during a hypnotic induction (cf. Crawford & Gruzelier, 1992; Galbraith et al., 1970; Sabourin et al., 1990). In our own lab, we have replicated our previous work showing greater theta activity by high susceptible individuals within the context of the hypnotic experience. In a follow-up study, we invited high and low susceptible individuals to the lab for a startle study outside of a hypnosis context and did not find EEG theta differences. This suggests that increased theta activity is not a product of high susceptibility alone but requires an appropriate context and the hypnotic experience.

Why would we expect to see EEG theta associated with hypnotic processes? Historically, theta has been associated with a variety of processes, including hypnagogic imagery, meditation, REM sleep, problem solving, focused attention, memory processes, and the cessation of a pleasurable activity (Kahana, Seelig, & Madsen, 2001; Schacter, 1976, 1977; Walter, 1953; see Ray, 1990; Basar-Eroglu, Basar, Demiralp, & Schürmann, 1992; Basar, Basar-Eroglu, Karakas, & Schürmann, 2001; Ray, 1990; for a discussion of EEG including theta). In general, theta has
been associated with continuous concentration of attention (Bruneau, Sylvie, Guérin, Garreau, & Lelord, 1993; Ishihara & Yoshii, 1972; Mizuki, Kanaka, Isozaki, Nishijima, & Inanaga, 1980), selective attention (Basar-Eroglu et al., 1992), and memory retrieval (Klimesch, 1999; Raghavachari et al., 2001).

Animal research suggests that theta may index the adaptive adjustments required for the ongoing regulation of action. For example, theta activity is only observed after the animal shows evidence of coherent, learned behavior, suggesting that the animal had established the context for action (Pickenhain & Klingberg, 1967). Theta habituates after repeated presentation of a stimulus (Miller, 1991). In humans, as task difficulty is increased by inducing time pressures or raising demands on working memory, frontal midline theta activity also increases (Gevins, Smith, McEvoy, & Yu, 1997). In our lab, when we asked individuals to play a video game, we found enhancement of frontal midline theta on successful trials, and these findings were more pronounced in a time-pressure condition (Slobounov, Fukada, Simon, Rearick, & Ray, 2000).

**Limbic Theta and Action Regulation**

One interpretation of these findings on theta and performance in humans is that increasing working-memory load increases demands for monitoring performance outcome, which require entrainment of multiple regions of the limbic system regulating working memory. Overall, limbic theta appears to index the adaptive adjustments required for the executive monitoring and self-regulation of behavior. These executive functions are often related to a higher-order, homuncular director of more elementary cognitive and memory operations. However, recent theoretical approaches to neural mechanisms of self-regulation have suggested that executive capacities can arise from elementary mechanisms of action regulation.

Action regulation can be described as a process that involves learning which behavior is relevant in a given context, monitoring the outcome of an action, and switching to a different behavior when expected outcomes are violated. A primary candidate for implementing this process across cortical, limbic, and diencephalic regions is the Papez circuit (Papez, 1937), which includes the cingulate cortex, hippocampus, anterior and medial nuclei of the thalamus, and mamillary body. Recent speculation has linked theta activity with these areas, especially the anterior cingulate (Allman, Hakeem, Erwin, Nimchinsky, & Hof, 2001; Luu & Tucker, in press).

The cingulate cortex was named because it forms a *cingulum* or collar around the corpus callosum and forms the dorsal of the limbic lobe originally described by Broca. In the 1930s, Papez saw it as the area that
interpreted emotional information coming from the hypothalamic region (Papez, 1937). From an evolutionary developmental perspective, Papez saw the cingulate cortex as part of an ancient system. Likewise, MacLean in his concept of the triune brain suggested that brain development over the ages evolved in a series of three concentric structures, with the cingulate being part of the earliest of these (MacLean, 1990).

Overall, research has suggested that the anterior cingulate (ACC) is involved in the type of executive function that allows one to drive down the street and ignore one set of signs while paying attention to another (Awh & Gehring, 1999). Current research with both EEG and PET studies suggests that within the ACC the execution and monitoring of a response can be separated from the monitoring of the context in which the action is executed (Elliot & Dolan, 1998; Luu & Tucker, in press). For example, Elliot and Dolan found that the dorsal ACC was active when subjects generated a hypothesis concerning what would be a correct response, whereas the ventral ACC was active when a choice was made. Others have suggested that dorsal ventral differences reflect cognitive versus emotional processes as well as executive versus evaluative (Bush, Luu, & Posner, 2000). For example, stimulation of the central part produces intense fear or pleasure, whereas the dorsal part produces a sense of anticipation of movement. Studying stroke patients with lesions of the anterior cingulate, Damasio and Van Hoesen (1983) described one patient who reported her mind was empty. This patient had a remarkable recovery and knowledge of conversations that had taken place among doctors even during the early stages of her recovery. However, when asked why she did not reply, she reported that she had nothing to say and felt no will to reply to the questions. Other lesion studies have reported a similar reduction in verbal responses and spontaneous behavior (Cohen et al., 1999).

In terms of hypnotic modulation of experience, the ACC consistently is shown to be involved. In a series of PET studies, Rainville and his colleagues have shown that neural activity in the brain stem, thalamus, and ACC contribute to the experience of being hypnotized (Rainville, Carrier, Hofbauer, Bushnell, & Duncan, 1999; Rainville, Hofbauer, Bushnell, Duncan, & Price, 2002). In particular, these authors report absorption related changes in the more rostral regions of the ACC. In an earlier hypnotic study involving painful stimuli, Rainville and his colleagues (Rainville, Duncan, Price, Carrier, & Bushnell, 1997) found that activity in the ACC closely paralleled subjective experience and that it reflected the emotional component (i.e., unpleasantness) but not the sensory component of the painful stimuli. The right anterior cingulate has also been implicated in the hallucination but not the imagining of external stimuli in high hypnotizable individuals (Szechtman, Woody, Bowers, & Nahmias, 1998). At this point, we can answer Tinbergen’s first
question and suggest that EEG theta activity and the cingulate cortex are two important physiological mechanisms that are active during the hypnotic experience. Although based on a single case study, it is tempting to speculate and note the similarities between a patient with a lesion in the cingulate and an individual experiencing hypnosis. In both cases, the individual reports a lack of desire to initiate activity although completely aware of events in the external environment. If, indeed, hypnosis represents a functional inhibition of normal cingulate functioning, then this would have a variety of implications. First, hypnosis would represent a simpler and more primitive cognitive/emotional/motor process than some theories have suggested. Second, theories that place an emphasis on higher level neocortical cognitive functioning as an aspect of hypnosis would be inappropriate for understanding the basic phenomenon. And third, using tools such as imaging techniques directed at reflecting cingulate activity or theta activity, it will now be possible to begin to address many of the questions that have plagued the field or been considered unanswerable.

Attachment and Internalized Self-Regulation

We now turn to Tinbergen’s second question, related to the development and ontogeny of the hypnotic experience. Are there developmental processes that help explain the nature of hypnosis? Our hypothesis proposes that there are such processes and that they mediate the child’s sensitivity to social influence. We begin by noting that motor behaviors, either in terms of performing an action or an inability to perform, have traditionally played an important role in the hypnotic process. At an elementary level, there are neural mechanisms that plan and monitor a variety of actions. These mechanisms form the neurophysiological basis for what we experience as voluntary control over behavior. Throughout development, the child’s self-regulatory mechanisms are closely tuned to social influence. Human infants instinctually respond to parental communications. Such responses allow the infants to incorporate parental regulatory influences to supplement their immature self-regulatory capacities. The incorporation of parental control is integral to cognitive development, such that internalized parental dialogs form a foundation for self-regulation throughout life. The mind’s direction of behavior is best understood not as a pristine and powerful act of personal volition but as an amalgam of urges and self-regulatory algorithms, and one critical algorithm for self-control is private speech. In this section, we approach Tinbergen’s developmental question by proposing that hypnosis is achieved through a diversion of the normal self-regulatory algorithm of internal speech, facilitated in large part because this algorithm develops through internalization of what was initially an overt parental dialog.
Human infants are neotenous. Their development is retarded, allowing an extensive period of social communication, over a decade or more, to shape their developing brains (Tucker, 1993). In the first year, the normal human infant is not only highly responsive to social communication, exhibiting emotions and communications that support the attachment process, but also fails to exhibit emotions such as hostility and negativism that may disrupt the parental bond (Mahler, 1968). A similar delay of hostile displays is seen in rhesus monkeys as described by Harlow, and Suomi suggested that the developmental progression facilitating attachment may be a generic feature of primate social development. In the second year of human development, the maturation of motor control and language acquisition is accompanied by motivational substrates, including hostility and negativism that support the child’s individuation and autonomy (Mahler, 1968). For both these critical developmental stages, the mechanisms of self-regulation are tightly coordinated with the mechanisms of social influence. Recent theorists have emphasized that the parent’s control is important to supplement the infant’s immature self-regulatory capacity (Rothbart & Posner, 1985). Because self- and social regulation inevitably diverge as causal influences on behavior, the coordination of dependence and independence is a key theme for not only early development but also for psychological organization throughout the life span.

In considering how hypnotic suggestion could become effective in controlling an individual’s experience and behavior, it may be important to consider early psychological orientations, both those that facilitate the incorporation of social influences within self-regulatory systems and those that reject social influences in order to establish autonomy. Effective hypnosis would seem to require a strong dominance of the incorporation orientation over the rejection orientation.

Although the early, preverbal motivational and cognitive orientation must be a critical substrate for experience in a social context, the child’s capacity for verbal representation of thought soon becomes an essential medium for not only social influence but internal control of behavior. Developmental theorists have emphasized the self-regulatory functions of the child’s own speech, which is often used overtly to organize behavioral plans in young children, and then becomes internalized as a private guide for actions (Vygotsky, 1934/1962).

Although the explicit verbal form of private speech may be important as an organization and memory device in the child’s behavior planning, there also may be more abstract social representational functions provided by private speech, in which the child guides his or her actions by representing the viewpoint of the parent or other significant figure as an observer of the behavior. Freud’s (1940/1953) formulation of the superego emphasized the importance of incorporated parental viewpoints and directives as elements of the self.
object-relations theorists came to understand that the early social-relation patterns, although they may result in parental introjects, are also fundamental to the development of the ego itself (e.g., Horney, 1945; Mahler, 1968). Recent research on language acquisition (Baldwin, 1993) has converged with these traditional formulations in an interesting way. The young child learns the meaning of words in large part through careful attention to the perspective and intention of the parent. Although classic approaches to language have long emphasized the speaker’s intention in interpreting the utterance, we have only recently recognized that forming a mental representation of the parent’s intention is an elementary process that is formative in the development of verbal thought as early as the second year of life. Research on representation of others’ mental states has also emphasized the importance of the cognitive representation of social perspective and the intention of others for the development of the self. The normal volitional control of behavior emerges out of these elementary structures of self-in-social-context. Although the complexities of social cognition remain poorly understood, we can expect that hypnotic control must be understood in relation to the social influences that engage, at a primitive level, the mental representations that motivate, direct, and monitor behavioral actions.

The Fragility of the Will and the Strength of Closure

Hypnosis violates our assumptions about the voluntary control of behavior. A fundamental assumption of human nature in western culture is that, as a mature personality is created through the course of child development, an adult comes to exert voluntary choice in each action. It is therefore surprising and disturbing when hypnotic suggestions appear to subvert voluntary control. Although it is important to consider the mechanisms of social influence, it may also be useful to challenge the assumption of voluntary control of behavior. Both psychological analysis and experimental evidence suggest that the common assumptions about voluntary control of the mind and behavior may be naïve.

When William James examined his own behavior to look for evidence of willed action, he found that the agentive capacity of the mind, a capacity that seems to be universally assumed in our culture, was difficult to support with behavioral evidence. He found clear examples, such as when intending to get out of a warm bed on a cold morning, that the will is weak. James could represent the necessary action to himself with great intentional vigor but remain inert. Yet, a few minutes later, upon remembering an important appointment, he suddenly found himself out of bed getting ready for the day, with no recollection of willful intention intervening in the effective act.
Given the strong belief in the efficacy of human intentionality, among philosophers as well as ordinary people, one might be tempted to question whether James’ introspection should be taken as a lesson on human nature or a confession of personal inadequacy. A good deal of modern experimental evidence supports James’ assertion that the conscious will is overrated (Wegner, 2001). Furthermore, from the naïve perspective on the mind, we assume that we have conscious access to the intentional process, and yet social psychological research has provided many examples of instances in which this assumption is also invalid (Nisbett & Wilson, 1977). If the account from social-cognition research is correct, then behavior is regulated not by a robust and effective conscious volition but by a loose assemblage of urges, habits, and contextual constraints. In such a framework, it may be less surprising that hypnotic instructions could supplant the internal control of behavior.

Although we may not have effective voluntary control over behavior, we may need to maintain the illusion that we do (Wegner, 2001). Clinical observation of the self-regulatory deficits of schizophrenics provides important examples of the disorganization that occurs when the sense of agency is disrupted. Through mechanisms that are not well understood, the schizophrenic loses the experience of being in control of thoughts and actions. This experience is profoundly unsettling and leads to a search for explanations for this state that often become the defining features of the syndrome, in relation to paranoid interpretations or delusions of thought insertion. The social-cognitive framework of self-regulation is invariably significant, as the schizophrenic attempts to understand the conspiracy or other bizarre mechanisms that must be responsible for the theft of personal agency.

Fragments of early object relations are often manifested as unconnected external agents with the dissolution of the schizophrenic’s agentic sense of experience. The hallucinated voices often provide critical, parent-like monitoring of behavior, and their origin in private speech is suggested by several forms of evidence. Consistent with the importance of the ACC to normal self-monitoring (Luu & Tucker, in press), there are syndromes of defective agency that occur with extensive lesions of the ACC and associated midline frontal cortex (Goldberg, 1985). In the “alien hand sign,” the patient’s own actions are observed but not sensed as willed. In a direct parallel to schizophrenic control delusions, the patient with ACC lesions interprets the actions as caused by an outside force.

There are many remarkable implications of the normal illusion of agency and the delusions of control that occur with the loss of the sense of agency in schizophrenia or in frontolimbic lesions. What may be most instructive in relation to hypnosis is not only the fragility of conscious control of behavior but the strong tendency of the mind to
attempt to maintain a causal coherence of experience. When the hypnotic induction causes one’s actions to begin to seem under external control, an apparently strong requirement for closure in causal attribution seems to lead to a progressive strengthening of hypnotic control. To draw from a more general instance in which causal coherence appears to emerge spontaneously in human reasoning, if the will didn’t exist, it would need to be created.

The Trait of Hypnotic Susceptibility

Although we can examine fundamental mechanisms of social influence and self-regulation in development that may contribute to the hypnotic process, there is a problem with a developmental explanation of hypnosis in relation to those mechanisms. Hypnotic susceptibility should vary as a function of personality outcomes of early experiences with attachment, self-regulation, and the establishment of the sense of personal agency. Yet it has proven remarkably difficult to find personality differences that are consistently related to hypnotic susceptibility (Glisky, Tataryn, & Kihlstrom, 1995; Glisky, Tataryn, Tobias, Kihlstrom, & McConkey, 1991; Hilgard, 1992; Kihlstrom, 1985; Nadon, Hoyt, Register, & Kihlstrom, 1991; Ray, 2000). One interpretation of this lack of result is, of course, that hypnotic susceptibility is not a stable trait. However, high test-retest correlations ($r > .70$) have been observed for hypnotic susceptibility measured over 10, 15, and even 25 years (Piccione, Hilgard, & Zimbardo, 1989). Furthermore, there is a substantial correlation ($r = .60$) of different hypnotic susceptibility measures (Bowers, 1983). Finally, the heritability of susceptibility is among the highest of any psychological individual difference measure identified to date (Morgan, 1973; Morgan, Hilgard, & Davert, 1970) (see Table 1). One alternative is that hypnotic susceptibility, like attachment, is an action pattern that is unique and has its own developmental history and does not overlap with traditional psychological measures of individual differences. It is therefore an important scientific problem that such a stable tendency is not correlated with other traditional individual-difference measures.

Evolution of Cognitive Control

Although more speculative, it may also be useful to consider the question of the evolutionary substrate of hypnotic suggestion. In many ways, this question returns us to the question of physiological mechanism, because the human brain’s cognitive mechanisms are built upon circuits that cross the hierarchy of vertebrate neural architecture, including not only telencephalic (cortex, amygdala, hippocampus, neostriatum) but also diencephalic (thalamus, hypothalamus) and mesencephalic (brain stem reticular system) levels. Examining fossil
Table 1
Heritability of Susceptibility

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<th>Morgan, Hilgard &amp; Davert, 1970</th>
<th>Morgan, 1973</th>
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<tr>
<td>Twins (monozygotic)</td>
<td>.63</td>
<td>.54 (male)</td>
</tr>
<tr>
<td>Twins (dizygotic)</td>
<td>.08 (same sex) .04 (different sex)</td>
<td>.18 (same sex) .15 (different sex)</td>
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<tr>
<td>Sibling</td>
<td>.22 (same sex) .01 (different sex)</td>
<td>.25 (male) .10 (different sex)</td>
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records along with the brains of a variety of organisms has suggested that our current brain can be viewed as having the features of three basic evolutionary formations: that of reptiles, that of early mammals, and that of recent mammals (MacLean, 1990). MacLean’s formulation, which is referred to as the triune brain, suggests that through rich interconnections our brains can process a variety of information in three somewhat independent although not autonomous manners.

The first level is that of the reptilian brain involving the brain stem and cerebellum that processes major life requirements such as breathing, temperature regulation, and sleep-wake cycles. The second level is that of paleomammalian, which is seen to involve the limbic system and its involvement in emotional processing. MacLean points to three developments that took place evolutionarily in the transition from reptiles to mammals. These are (a) nursing in conjunction with maternal care, (b) audio-vocal communication that maintained maternal-offspring contact, and (c) play. The third level of the triune brain is that of neomammalian and is related to the neocortex and thalamic structures. This level is generally associated with problem solving, executive control, and an orientation toward the external world with an emphasis on linguistic functions. Although MacLean’s anatomical framework is highly schematic and more detailed analysis is required to understand exactly how mammalian self-regulation achieved the advances in behavioral flexibility and social coordination, his approach has been highly influential in emphasizing the integral social basis of the evolution of higher levels of psychological function. Thinking in these terms, we would conclude that such processes as a sense of control as well as conscious self-awareness and consciousness would come late in evolution.

Considering hypnosis, we propose that our ability to model or imitate others has evolutionarily preceded a fully developed sense of willed voluntary action. We would further suggest that hypnosis as a process finds its evolutionary heritage in the interplay of the cortical and limbic levels. By considering the multiple levels of corticolimbic networks, we can understand the process of executive control not only from the perspective of conscious and linguistic mechanisms that are the obvious medium of hypnotic suggestion but also from the pre-conscious formative processes that may be the critical mechanisms through which social influence operates.

Corticolimbic Architecture

Theoretical advances in cognitive neuroscience may offer new insight into the process of psychological development. The dual mechanisms of neural plasticity, indiscriminant synaptogenesis, and activity-dependent pruning of unused connections appear to articulate the connectional structure of both the cortex and memory. At the same
time, general principles of function in massive parallel networks are being suggested by computational models. The theoretical power of these advances is considerable. A major reformulation of neuropsychological development may soon be possible in which a common set of principles is able to describe both neurophysiological and psychological differentiation across the life span.

Because researchers in neuropsychology adopted the cognitive paradigm from psychology, the research has considered memory to be a specific, isolated mental operation. Therefore, the literature on limbic system contributions to motivation, emotion, and psychopathology has had little influence on the literature on limbic contributions to memory. Thus, we need to be speculative as we consider memory-related aspects of hypnosis such as amnesia. The importance of a more integrated biological approach to neuropsychology has become obvious as anatomical studies have illuminated the general architecture of mammalian cortex. The limbic cortices are the first to have evolved, and they form a core from which the neocortical networks have expanded (Pandya, Seltzer, & Barbas, 1988). The critical role of the limbic areas in both motivational and mnemonic processes shows that even the massive cortex of humans is organized developmentally, with the extensive neocortical representational capacity remaining dependent on the adaptive control of consolidation provided by the limbic core (Tucker, 1993). With their close connectivity with the hypothalamus and brain-stem circuits, the limbic cortices are closely modulated by internal need states (Mesulam, 1985). Retracing the progressive differentiation of neocortex from primitive limbic cortices in phylogensis, the primate neocortex has been found to comprise multiple representational networks emanating from paralimbic (allocortical and paralallocortical) areas through traditional “associational” areas to the finely differentiated isocortex of “primary” sensory and motor areas (Pandya et al., 1988). The general organization of the cortex therefore begins with a limbic core representing the internal milieu and progresses toward an isocortical interface with the external environment (Mesulam). The general picture of the connectivity is one in which the evolution of each more differentiated network of isocortex created an onion architecture, in which each new superficial network interposed itself between the thalamic input/output connections (the environmental interface) and the paralimbic core (Tucker, 1993).

In this architecture, the paralimbic core provides the essential adaptive control that regulates memory consolidation according to the significance of events in relation to past history and current needs (Tucker, 1993). The connectivity is such that integrated brain function is achieved primarily at the core. The sensory and motor isocortices are isolated “islands” with limited connectivity. If connectivity indicates functional integration, we should expect limbic networks to be essential for abstract semantic function. This is what has been observed, in fact,
in aphasia. Lesions that produce semantic deficits are consistently found to encroach on limbic cortices (Brown, 1989).

The key theoretical challenge for understanding this general architecture of the brain may be to interpret how representations are transformed across the multiple linked networks from sensory and motor cortices to the paralimbic core. Processing is more “abstract” at the paralimbic level, but it is also “bound” within a syncretic matrix of multimodal constructs, motivational constraints, and incipient action dispositions. The functional integration of the brain cannot be attributed to any network level but must be framed as a task for synchronizing multiple networks in concert.

In the sensory systems, the reentrant traffic across these networks serves to consolidate an integrated perception through combining the mnemonic representations of past experience with the new sensory data. The corticolimbic consolidation is very likely energized by limbic excitement. At the neurophysiological level, electrical stimulation of any area of cortex results in kindling or recruitment of increased electrical excitement in limbic areas (Doane & Livingston, 1986). Assuming a simple isomorphism of physiology and function, we can speculate that corticolimbic consolidation of memory proceeds similarly, with the vigor of reentrant consolidation tuned by the adaptive resonance within limbic tissue.

The Visceral Basis of Action Regulation

We propose that an analysis of corticolimbic network architecture points to self-regulatory mechanisms that integrate not only the sensorimotor interface with the environment mediated by neocortical networks but also the visceral interface with the internal bodily milieus mediated by limbic networks (Tucker, 2001). Within the cingulate gyrus, the most primitive limbic networks are specialized for visceromotor functions (Neafsey, Terreberry, Hurley, Ruit, & Frysztak, 1993). Within the insula and associated ventral limbic networks, the most primitive networks are specialized for viscerosensory functions (Neafsey et al.). To find the executive functions, through which specific cognitive processes are selected, prioritized, and regulated, it may be time to give up the search for a higher-order “supervisor” of cognition, in the sense of a homuncular administrative agency of the brain. Instead, the executive functions may be found to emerge from the complex forms of human elaboration of elementary neural systems for action regulation, systems responsible not only for control of motor activity but motivated learning and memory as well (Luu & Tucker, in press). Key questions are how these elementary systems operate at the neurophysiological level and how they can be understood at the experiential level.
Consciousness and Social Influence

One interesting possibility suggested by a literal interpretation of corticolimbic architecture is that consciousness requires extensive representation in neocortical sensorimotor modules, whereas the most generic, distributed representations of deep semantics may be inherently preconscious. Articulation into acts, including words and/or images, is generally required before thought is fully conscious. In contrast, representations in the most integrative and holistic networks of the cortex, the paralimbic networks (cortices next to the limbic circuits centering on the amygdala, septal nuclei, and hippocampus) are incipient, diffuse, and may be largely unconscious. Of course, there are degrees of awareness of more “premotor” or “preperceptual” representations, certainly in hunches and certainly in more abstract forms of cognition that may be either preverbal or nonverbal. But articulation is integral to conscious intentionality. We speculate that hypnotic influence must engage not only at the conscious articulated level of experience, at which subjects can provide some degree of veridical introspection, but also at the preconscious (paralimbic) level of the motivational and intentional substrate of actions.

What are the key mechanisms of behavior control within limbic circuits? Several lines of evidence suggest that the mammalian learning system is not the passive associator assumed by behaviorists but comprises circuits that apply strategic biases to processes of attention and memory consolidation. These circuits integrate not only sensory gating and attentional controls in the thalamus but also elementary arousal and autonomic responses regulated by the hypothalamus. The systems that comprise linked diencephalic (thalamic, hypothalamic) and limbic (hippocampal, cingulate) circuits have long been recognized as essential for both memory and emotion (Papez, 1937). Together, the multiple limbic-thalamic-hypothalamic circuits achieve memory consolidation that is continually regulated by adaptive needs in strategic fashion.

A key circuit is centered on the posterior cingulate cortex (PCC), integrating control input from the hippocampus and providing output to the anterior thalamic nuclei to modulate ongoing learning (Gabriel, Sparenborg, & Kubota, 1989). On the basis of learning studies in the rabbit, Gabriel and associates have proposed that this circuit appears to operate through gradual modification of the internal representation in response to environmental events that are generally consistent with the representation. In many ways, this circuit would be a good candidate to represent the process of “context updating” described in cognitive psychophysiology (Donchin & Coles, 1988).

In contrast, when gradual shaping of the internal representation of the context is not adequate to adapt to abrupt changes in the
environmental contingencies, the ACC is required to achieve more rapid, radical shifts in behavior than can be accomplished by the gradual PCC context-appropriate learning mechanism. Gabriel proposed that, in this way, the ACC is capable of “salience compensation” for normally weak or nonsalient stimuli, when these stimuli are recognized to be critical for disengaging from the existing context and establishing a new predictive model.

Gabriel’s model has become highly explanatory for understanding recent evidence on contributions of the cingulate gyrus to human motivation and attention (Luu & Tucker, in press). Although developed to account for simple conditioned learning in rabbits, Gabriel’s model explains a number of findings on the activity of the ACC in human executive processes, including effortful attention, monitoring of errors, detecting conflict, and evaluating significant events (Luu & Tucker). The importance of both social and emotional responses to the control of actions by the ACC is shown by a number of findings, including those on response to pain, chronic anxiety, emotional vocalization, and the preferential sensitivity of cingulate cortex to opiates (Bush et al., 2000).

In relation to volitional control of actions, the ACC is well-situated to mediate between limbic motivational influences and the adjacent sensory motor areas that regulates premotor organization of behavior. Consistent with this anatomy, lesions of the ACC and associated medial frontal regions produce akinetic syndromes, in which patients do not engage in actions even though they are capable of doing so when pressed. With impaired influence from the ACC, they appear to lack the motivation to act (Bush et al., 2000). Consistent with these findings are the affective changes with ACC lesions. Psychosurgery has often targeted the ACC to alleviate chronic pain or decrease the symptoms of anxiety. Although ineffective in improving the cognitive disorganization of psychiatric disorders, ACC lesions, whether intentional or accidental, invariably decrease the patient’s concern over life problems.

The picture emerging from neurophysiological studies of the cingulate gyrus and its relation to human behavior suggests that the self-regulation of action integrates two poles, the somatomotor cortices in the neocortex and the visceromotor cortices in the limbic regions. Closely associated with visceromotor functions, the anterior cingulate gyrus appears to have evolved as an essential substrate for motivational control, contributing to emotional evaluation and significance as well as to the initiation of action. Notably, the evidence on emotional vocalization and the action of opiates suggests that the cingulate gyrus is critical to social motivations specifically (Bush et al., 2000).

If we look to limbic circuits for the motivational, preconscious base of self-regulation of actions, where hypnosis may achieve its effects, it may be useful to consider Gabriel’s evidence on the differing roles of ACC and PCC. Hypnosis may operate through the gradual
context-updating operations of the PCC, as the hypnotist carefully and gradually adapts the subject’s contextual model of the world. In this manner, hypnotic induction and suggestion may achieve a gradual manipulation of context representation similar to other forms of social influence, including seduction.

In contrast, the context-disrupting function of the ACC may work against the hypnotic process and may need to be disengaged in order to allow the context-altering seduction to occur. In this respect, it is interesting that certain forms of hypnotic induction rely on paradoxical intentions, in which the subject’s intentionality is challenged by a suggestion, such as holding out one’s arm and feeling it get heavy that makes the subject’s intention ineffective in relation to the hypnotist’s suggestion. When manipulations such as this are applied, they may allow the external source of instructions to achieve effective causal closure while at the same time demonstrating the inadequacy of the internal will. In neurophysiological terms, such a manipulation may allow the context-updating of the PCC to continue uninterrupted by the ACC, therefore allowing the hypnotist to establish an information context that dominates the subject’s episodic reality.

Evolutionary Advantage of Hypnosis

We now approach Tinbergen’s fourth question and ask what is the function and survival value of being able to enter into the hypnotic experience? That is, we ask the question: Is there any survival value to those individuals who are able to enter a hypnotic experience as compared to those who are not? We first must consider the possibility that there is no value to the hypnotic experience and that it remains an epiphenomenon that may have served a purpose in the past but does not any longer. For example, human infants at birth will close their fingers and toes around an object such as a rope tightly enough to allow them to hold their own weight. Clearly this is not a task that human infants are required to do in their environment. However, given that one of the best stimuli for eliciting the response is a clump of hair, it may be that the response is related to the nonhuman primate infant grasping his mother as she moves through the trees, which does have great survival value. Thus, what has functional significance for nonhuman primates may have little for human infants. However, the grasping reflex still exists in humans.

The alternative to considering hypnosis as a vestigial response is to examine areas in which there is functional value. If we examine the data in terms of the current functional value of hypnosis, we are drawn to such areas as pain management (Holroyd, 1996), modulation of the immune system (Kiecolt-Glaser, Marucha, Atkinson, & Glaser, 2001), and its ability to enhance treatment effectiveness (Kirsch, Montgomery,
A variety of studies including a special issue of the *International Journal of Clinical and Experimental Hypnosis* (April 2000) have reviewed these areas and shown that hypnotic procedures enhance cognitive-behavioral treatments for a variety of problems. Given that one meta-analysis (Kirsch, Montgomery, & Sapirstein) suggested that there are few procedural differences between hypnotic and non-hypnotic treatments, one might conclude that the positive benefits of hypnotic procedures lie with the individual and his or her susceptibility to hypnotic procedures. Whether this susceptibility level can in turn result in a greater level of adaptability or ability to produce offspring as would be suggested by evolutionary fitness is an open question. However, the fact that hypnotizability is associated with an ability to reduce the experience of pain, modulate the immune system, and achieve greater benefits of psychosocial therapies is, of course, of great functional significance. Another approach to the question of functional significance of the hypnotic experience is the examination of animal models. The obvious question is what characteristics of the human hypnotic experience would one seek in animal models? In 1646, an Austrian monk published a detailed account describing how he had hypnotized a chicken by holding its head on the ground and forcing the animal to fixate on a line drawn away from its beak (Völgyesi, 1966). From that time to the present, there have been a variety of stories of how alligators, rabbits, chickens, and other animals could be immobilized, generally by rubbing or stroking the animal, although eye-fatigue through fixation has also been used. Pavlov (1927) describes the manner in which inducing hypnosis in animals and humans utilizes similar mechanisms and its relation to cortical inhibition. In the second half of the 20th century, a variety of studies examined the concept of animal hypnosis (Gallup, 1974) with some suggesting its value for understanding the hypnotic experience in humans (Draper & Klemm, 1967). A variety of animal hypnosis studies suggest that in this condition the animals show an analgesia-like response to needle pricks and electric shock. Draper and Klemm, using a conditioning procedure in rabbits, suggest that the dominant feature of animal hypnosis is a disconnection of overt motor functions without conspicuous inhibition of sensory functions. Not unlike human hypnosis, immobilization in chickens has been characterized in three stages: (a) vocalizations and continuously open eyes; (b) suppressed vocal behavior and eye flutters; and (c) eyes closed, occasional body twitches, and lack of vocalizations (Rovee & Luciano, 1973). Research has shown that once tonic immobility is induced, it remains for anywhere from 10 minutes in chickens to more than 8 hours in lizards.

The nature of the immobilization response in animals is consistent with an action pattern described by ethologists. The survival value of
the immobilization response is typically seen in the context of predator/prey responses in that predators tend to be sensitive to movement and without it they lose interest and become distracted allowing the prey to escape. This connection is also supported by the finding that placing a stuffed hawk in the chicken’s presence increased the period of tonic immobility by a factor of 5 or 6. Follow-up studies suggested it was the hawk’s eyes that served as the eliciting stimuli and similar results were also seen with lizards. Interestingly, human eye contact, as well as an artificial eye alone, could also prolong the immobilization response in chickens (see Gallup, 1974, for a review of this literature). Overall, immobilization is both protective and related to dominance. Whether the human hypnotic experience is related to or grew out of this evolutionarily significant event is, of course, an open question.

SUMMARY AND CONCLUSION

Using Tinbergen’s four why questions, that of causation, development, evolution, and function, we examined hypnosis from a larger evolutionary perspective. Reasoning by analogy, we sought to view hypnosis in terms of an action pattern that represents a self-contained behavioral program although not as rigid as seen in lower organisms. In humans, such a program develops within the context of a long development sequence emphasizing social connections, imitation of significant figures, and the use of linguistic symbols to regulate both internal and external processes and actions. In terms of a mechanism, we speculated on the involvement of the cingulate cortex in achieving in hypnosis the experience of autonomous actions or analgesic sensory processes. Finally, we point to the fact that hypnotizability is associated with an ability to reduce the experience of pain, modulate the immune system, and achieve greater benefits of psychosocial therapies as a functional significance of the hypnotic experience.

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**Ein evolutionärer Zugang zum Verständnis des hypnotischen Erlebens**

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**Les approches évolutionistes permettant de comprendre l’expérience hypnotique**

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Résumé: En utilisant les 4 «pourquoi?» de Tinbergen sur la causalité, le développement, l’évolution et le fonctionnement, les auteurs examinent
l’hypnose sous une plus grande perspective évolutionniste. Raisonnant par analogie, ils cherchent à percevoir l’hypnose en termes de modèle d’action représentant un programme comportemental d’un seul bloc, mais moins rigide, comme cela s’observe dans les organisations inférieures. Chez l’homme, un tel programme se développe dans le contexte d’une longue séquence de développement soulignant les connexions sociales, l’imitation des figures significatives, et l’utilisation des symboles linguistiques pour régler les processus internes, externes et les actions. En termes de mécanisme, les auteurs spéculent sur la participation du cortex cingulaire en réalisant dans l’expérience hypnotique des actions autonomes ou des processus sensoriels analgésiques. En conclusion, ils indiquent que l’hypnotisabilité est associée à une capacité de réduction de l’expérience de la douleur, de modulation du système immunitaire et, comme signification fonctionnelle de l’expérience hypnotique, l’obtention de plus grands avantages dans les thérapies psychosociales.

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Enfoques evolutivos para comprender la experiencia hipnótica

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Resumen: Los autores usan las cuatro preguntas de tinbergen sobre causalidad, desarrollo, evolución, y función, para examinar a la hipnosis desde una perspectiva evolutiva. Razonando analógicamente, ven a la hipnosis desde el punto de vista de un modelo de acción que representa un programa conductual interno, aunque no tan rígido como el de organismos más inferiores. En los humanos, tal programa se desarrolla dentro del contexto de una larga secuencia de desarrollo que enfatiza conexiones sociales, imitación de figuras importantes, y el uso de símbolos lingüísticos para regular procesos y acciones tanto internos como externos. Con respecto al mecanismo, los autores proponen la involucración de la corteza cingulada para lograr en la hipnosis la experiencia de acciones autónomas o procesos sensoriales analgésicos. Finalmente, indican que la hipnotizabilidad está asociada con la capacidad para reducir la experiencia de dolor, modular el sistema inmunológico, y lograr beneficios mayores en las terapias psicosociales, como una funcional importante de la experiencia hipnótica.

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