Cognition and Emotion
PROCESSING FUNCTIONS AND BRAIN SYSTEMS

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Cognitive science seeks to understand the inner workings of the human mind. By probing the way in which people, animals, and computers conduct mental (or mental-like) operations, the mechanisms of mind come to be understood.

The cognitive mind is in essence a processor of information. It can decode the syntax of a sentence and derive the meaning of an utterance in and out of context. It can perceive visual and auditory patterns and remember lists. It can construct hypotheses and inferences. If it tries especially hard, it can listen to two messages at once. It can even play chess. But the mind being modeled in cognitive science is lacking. Its thoughts are never clouded by happiness, anxiety, or depression. It doesn’t get the punchline of jokes. Love and hate are not part of its repertoire. If it is programmed to cheat at chess, it feels no guilt.

Most cognitive scientists would surely agree that an adequate theory of mind, when it arises, will have to incorporate feeling, affect, emotion, or some such concept as a central construct (see Neisser, 1963; Simon, 1967; Miller & Johnson-Laird, 1976; Zajonc, 1980). Just how feelings, affect, or emotion should be plugged into or at least related to cognitive models in other than trivial ways, however, has remained rather mysterious. Part of the difficulty involves the fact that while the study of emotion has attracted the interest of physiological, social, and clinical psychologists, cognitive science has been dominated by learning, linguistic, and artificial intelligence concerns. Since the theoretical constructs that have emerged reflect the diverse backgrounds of the workers in each field, it is not very surprising that cognitive and emotional constructs bear little relation to one another.

In the final analysis, however, cognition and emotion are closely related; both are mental processes expressed through brain mechanisms. Distinctions between cognition and emotion, while valid and important, reflect the functional properties of the underlying neural systems. An approach to cognition and emotion based on neural mechanisms could thus conceivably provide a common conceptual ground that would enrich our understanding of cognition, emotion, their relationship, and their place in a model of mind.

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Cognition and Emotion as Processing Functions of Neural Systems

To the extent that the brain can be viewed as an information-processing system, cognition and emotion can be viewed as information-processing functions of neural subsystems. While it is commonplace to view cognition as a processing function, this is less the case for emotion. Information-processing analyses focus on afferent mechanisms, tracing the flow and fate of input (Neisser, 1967). Analyses of emotion, on the other hand, have been historically concerned with the efferent mechanisms through which the behavioral and autonomic manifestations of emotional arousal are expressed: Darwin (1859) emphasized facial expressions as emotional signals throughout the animal kingdom; James (1890) equated emotion with peripheral physiological responses of the autonomic nervous system; Watson (1929) treated emotions as learned behavioral reactions based on unlearned response patterns. Although more recent studies and theoretical formulations have placed greater emphasis on input factors, the focus of these has been on the role of cognitive processing in the labeling, appraising, or attribution of causal origin of conscious emotional experiences (e.g., Festinger, 1957; Arnold, 1960; Bowlby, 1969; Schachter, 1975; Mandler, 1975). Affect and emotion in these latter treatments are thus special cases of cognitive processing. What I am going to propose here, however, is that there exists within the brain an affective processing system that is functionally and anatomically separate from the mechanisms underlying cognitive processing. Though they reflect distinct mental functions with unique neural substrates, cognition and affect, as processing functions of neural subsystems, are placed on equal conceptual footing in the present scheme.

The distinction between cognitive and affective processing is hardly novel. It has, in fact, been a central assumption in many neurologically based discussions of emotion. Papez (1937), for example, argued that unique brain pathways subserve the "stream of thought" and the "stream of feeling," with the former involving neocortical zones and the latter involving various regions of what has come to be called the limbic system. At about the same time, Klüver and Bucy (1937) observed that lesions in monkeys involving limbic areas, particularly the medial temporal-amygdala region, produced a striking dissociation, which they referred to as "psychic blindness." Though the animals retained normal vision, visual stimuli lost their affective significance. Many studies, following these early leads, have confirmed the role of limbic regions in the processing of the subjective significance, as opposed to the objective features, of stimuli. The existence of affective processing mechanisms, independent of cognitive mechanisms, would thus hardly come as a surprise to the psychobiologist.

My interest in the functional independence and anatomical separation of affective and cognitive processing systems was stimulated by the results of experimental studies of split-brain patients, persons in whom interhemispheric fiber tracts have been sectioned in an effort to relieve intractable epilepsy. Numerous studies (see Gazzaniga, 1970; Gazzaniga & LeDoux, 1978) have demonstrated that the interhemispheric flow of cognitive information is disrupted when the brain is split. Thus, visual stimuli exclusively presented to the right hemisphere by way of the left visual field cannot be verbally described by split-brain patients, since the speech mechanisms in the left hemisphere have been surgically disconnected from the right hemisphere. In the testing of one patient, however, we noticed that visual stimuli presented to the right hemisphere
on occasion elicited vocal responses relevant to the stimulus (Gazzaniga & LeDoux, 1978; LeDoux, Wilson, & Gazzaniga, 1978). But these responses seemed to reflect the affective significance or emotional tone of the stimuli more than their cognitive, perceptual, objective properties. They suggested that although cognitive input from the right hemisphere was surgically blocked, the left hemisphere was receiving affective information concerning the stimuli. An experiment was designed to test this possibility more directly.

A series of stimuli were presented to the patient’s right or left visual field. Following each trial, he was asked to verbally rate the stimulus on a 5-point scale, ranging from dislike very much to like very much. In addition, he was asked to describe the objective properties of the stimulus. Since these verbal ratings and descriptions could come only from his left hemisphere, the left hemisphere sometimes rated the stimuli it saw (right visual field) and sometimes rated the stimuli seen only by the right hemisphere (left visual field).

The results were striking and clear. While only the right-visual-field items were accurately described by the left hemisphere, the verbal ratings were largely identical for the two visual fields. While the affective tone of the stimuli reached the left hemisphere, the objective, cognitive, perceptual features of the stimuli did not. The subjective significance of the stimuli, completely stripped of objective real-world reference, was thus transferred across the cerebral midline. Cognitive and affective processing functions were, in other words, surgically dissociated.

It is of interest to consider the possible neural basis of this dissociation. The patient had undergone section of the corpus callosum. This fiber tract interconnects the neocortical regions of the two hemispheres, regions generally thought to play a crucial role in the ability to recognize and identify external stimuli (see Hubel & Weisel, 1968; Blakemore, 1975; Mishkin, 1966; Gross, Rocha-Miranda, & Bender, 1972). Severence of the fiber tracts interconnecting the neocortical regions thus prevents cognitive processing in one hemisphere from reaching the other. However, other interhemispheric pathways were not disturbed in the patient. Of particular relevance is the anterior commissure, which is made up of fibers interconnecting cortical as well as subcortical regions of the limbic system (Klinger & Gloor, 1960; Jouandet & Gazzaniga, 1979). Limbic areas, as noted, have long been implicated in emotional behavior. It is thus conceivable that interlimbic connections through the anterior commissure made possible the interhemisphere transfer of affective processing, dissociated from the cognitive processing of objective stimulus features.

The implications of these experimental findings are clear: The central neural pathways through which the affective significance of environmental stimulation is processed are distinct from the pathways through which objective stimulus features are processed. Affective and cognitive processing, in other words, reflect unique processing functions of distinct neural systems.

**Affective Processing and Emotion**

Thus far, I have used the terms affective processing, feeling, and emotion interchangeably. This vagueness reflects the current state of the field, to a large extent. In
the remainder of the chapter, however, I will distinguish between affective processing, on the one hand, and emotion and feeling on the other.

To define emotion, which has been conceived of and studied in so many ways and with so little consensus, as a single scientific concept is difficult. Part of the difficulty involves a confusion between emotion as an area of inquiry and emotion as feeling. As feeling, emotion refers to conscious experiences. As an area of inquiry, however, emotion includes these conscious feelings, together with certain unconscious mental states, behavioral responses, and autonomic reactions. For simplicity and clarity, the term emotion is used here only as a description of conscious feeling states. As a result, the concept to be explained will not be confused with one of its component parts. Emotion as feeling, in other words, is not the central construct to be explained; it is, instead, one component of a larger domain of related concepts.

What, then, is the central organizing concept in this confusing field? My proposal is that an affective processing system in the brain underlies, directly or indirectly, behaviors, autonomic changes, unconscious states, and conscious feelings typically described as emotional. The behaviors, autonomic changes, and unconscious states will be referred to as affective behaviors, affective autonomic responses, and affective unconscious states, while affectively charged conscious feelings will be referred to as emotions. The value of these distinctions will become apparent as the relation between affective processing and conscious feelings and the role of the affective processing system in the regulation of affective behaviors and autonomic reactions is considered in the following.

The Affective Processing System

The affective processing system, as conceived of here, receives afferent input, assesses the subjective significance of the input, and selects and regulates behavioral and autonomic adjustments on the basis of the affective analysis. When an organism becomes consciously aware of any aspect of these activities, emotion or feeling is the result. Each of these components of affective processing is elaborated on in the following discussion.

Afferent Input into the Affective Processing System

Afferent input into any mental system can originate in the external environment, from receptors within the body, or from other neural (or mental) systems. As we move from environmental, to bodily, to mental afference, our knowledge of how the nervous system processes the signal decreases substantially. For simplicity’s sake, then, this discussion concentrates on affective processing based on the afferent analysis of environmental stimulation.

Afferent processing of environmental stimulation is generally thought of in terms of peripheral sensory receptors, subcortical relay nuclei, and neocortical perceptual mechanisms. Where in this chain of cognition does affective processing enter? The
most intuitively appealing answer would be that affective processing is postcognitive. After we know what a stimulus is, we figure out what it means to us. However, in the split-brain experiment described above, the left hemisphere monitored affective signals without any clue to the nature of the objective stimulus. Affective processing, in that instance, was clearly not based on perceptual processing.

If not postperceptual, then what? Zajonc (e.g., 1980) and his colleagues have conducted an especially interesting series of experiments that have provided compelling psychological evidence of a preperceptual basis for affective reactions. Making use of the fact that people and animals develop preferences for familiar stimuli (Zajonc, 1968), Kunst-Wilson and Zajonc (1980) demonstrated that preferences developed even when the stimuli were presented too fast for recognition. Though the subjects had no recognition memory for preexposed nonsense shapes, they developed strong preferences for those items over novel items. On the basis of this and other studies of normal humans, Zajonc (1980) has argued for a distinction between affect and cognition similar to the neurologically based distinction being promoted here.

The neurological question that Zajonc’s work raises is this: How does preperceptual affective processing take place? Where, in other words, in the afferent chain from sensory receptors to the neocortex does the affective processing system receive its input? There is little experimental evidence directly relevant to this question, but a reasonable hypothesis is suggested by existing anatomical data. While the sensory projection pathways are often thought of as a single linear projection to the cortex, the so-called nonspecific pathways involving collateral sensory input into the reticular formation and the limbic system constitute a means through which afferent input could reach affective processing areas. Moreover, certain thalamic sensory-relay nuclei, in addition to innervating the neocortical perceptual processing areas, send fibers to subcortical regions of the limbic system. For example, thalamic areas involved in the visual, auditory, somatosensory, gustatory, and olfactory systems each send fibers to the amygdala (LeDoux et al., in press; Nitecka, 1979; Fujii, 1979; Kawamura, Fukushima, Hattori, & Tashiro, 1978). Electrical stimulation of the amygdala in conscious animals elicits defensive behaviors and autonomic adjustments (Hilton & Zbrozyna, 1963; Reis & Gunne, 1965; Kapp, Gallagher, Underwood, McNall, & Whitehorn, 1982) and lesions of the amygdala disrupt the organism’s ability to assess the significance (i.e., threatening vs. benign; edible vs. inedible) of environmental stimuli (Kluver & Bucy, 1937; Downer, 1962; Blanchard & Blanchard, 1972). Precortical afferent input into the amygdala and other limbic areas (LeDoux et al., in press; Nitecka, 1979; Fujii, 1979; Kawamura et al., 1978; Swanson, Cowan, & Jones, 1974) thus provides a potential afferent basis for precognitive affective processing. The amygdala observations are particularly cogent since the anterior commissure, the fiber tract hypothesized above as the pathway underlying the interhemispheric transfer of affective processing in the split-brain study, is extensively contributed to by the interamygdala connections (Klinger & Gloor, 1960; Jouandet & Gazzaniga, 1979).

It is difficult to imagine what precognitive sensory input is like. How can we know what a stimulus means before we know what it is? The difficulty arises, though, because we view the neural system receiving the noncognitive input in terms of our conscious access to our own cognitive processes. This is, in effect, a violation of
Morgan’s nineteenth-century canon, which warned against interpreting animal behavior in terms of our firsthand knowledge of the human mind. In the present case, one mental system (our conscious self) is evoking its criteria for stimulus coding in order to explain the nature of processing in some other mental system (the affective processing system). However, it may be necessary to shed our powerful inclination to think of sensory input only in terms of its role in the build up of cognitive content in order to understand the nature of precognitive sensory input into the affective processing system.

At the same time, precognitive afferent input into the affective processing system does not preclude a cognitive contribution. While precognitive sensory input may be sufficient for the initiation of affective analysis, the availability of perceptual knowledge about objective stimulus features would seem to be a useful addition to the assessment of affective significance. The classic pathway through which perceptual processing is thought to contribute to the emotional functions of the limbic system is the Papez–MacLean circuit, which involves the subiculum, the cingulate cortex, the mamillary bodies, and the hippocampus (Papez, 1937; MacLean, 1949; Shipley, 1974). Alternatively, those subcortical relay nuclei discussed above that send fibers to the neocortex and the limbic system also receive fibers from the same neocortical regions (Nitecka, 1979; Fujii, 1979; Kawamura et al., 1978; Swanson et al., 1974), thus providing another viable channel through which sensory processing might contribute to affective analysis. (See also Jones & Mishkin, 1972; LeDoux et al., in press.)

By focusing on the pathways through which sensory information from the external environment might contribute to affective processing, this discussion has ignored the equally important, though less understood, contributions of input from within the body and from other mental systems. The role of visceral and muscular sensations in conscious feeling states is clearly substantial. Without going into detail, afference from the body by way of neural projection is largely identical (except in anatomical particulars) to that from peripheral sensory receptors tuned to the external environment. Moreover, hormonal feedback from the body to the brain has been implicated in a variety of behaviors (McEwen, 1981). But in addition to these relatively direct contributions, a more circuitous pathway exists. That is, we may become aware of our internal physiological state through our external sensory receptors. Heart rate, breathing, dryness of the mouth, wetness of the palms, and other physiological responses are available as afferent cues to sensory receptors tuned to the external environment. Our body, in effect, is a part of our brain’s environment.

While it is easy to envision the manner in which bodily afference contributes to affective processing, this is less the case for mental afference. If the afferent input is a thought, an idea, or a memory instead of a sensory signal, the task of identifying the afferent pathway to the affective processing system is held up by the even more formidable task of identifying the neural source of the thought, the idea, or the memory.

**Affective Analysis**

Affective analysis of afferent input has been conceived of in terms of appraisal (Bowlby, 1969; Arnold, 1960; Lazarus, 1968); attribution (Schachter, 1975; Valins,
1970); meaning analysis (Mandler, 1975); mismatch (Pribram, 1967); and expectancy
(Rescorla & Solomon, 1967; Bolles, 1970). In general, these models have viewed
postperceptual cognitive analysis as the origin of conscious feeling states. Here, how-
ever, we are concerned with affective analysis of afferent input as a nonconscious
function. The relationship between conscious feelings and affective analysis is dis-
cussed later.

The arrival of afferent input into the affective processing system is the initiating
factor for affective analysis. While some forms of input elicit affective reactions, others
do not. How does the affective processing system make the determinations?

The primary requirements of an affective processing system are two: the capacity
to screen input for its subjective, personal significance and the capacity to organize
responses appropriate to the input. The screening function must be capable of relatively
consistent determinations, for inconsistent determinations would lead to a disorganized
mental life and behavioral personality. Consistency, of course, could come only by
rapid comparison of input with stored information. These requirements are largely met
by Bowlby’s set-point model.

In Bowlby’s (1969) model, afferent input is compared with internal set points or
standards. Some of these standards are environmentally stable, remaining unchanged
throughout life and varying little from individual to individual, while other standards
are environmentally labile, with the setting determined by experience and varying
regularly to reflect the current state of the organism. A comparison of sensory
information with standards leads to the selection of general forms of behavior and phys-
iological changes (including no behavior or physiological change) appropriate to the
situation.

Affective analysis, following Bowlby, is thus largely based on the evaluation of
afferent input in relation to invariant, species-typical, preprogrammed internal stan-
dards or in terms of labile standards built up through experience and constantly altered.
The word memory is explicitly avoided here (although it is used in Bowlby’s discussion)
because of the close relationship between remembering and conscious thought processes
in humans. Comparisons of afferent input with internal standards are automatic and
make no demands on conscious processing, regardless of whether those standards are
set genetically or are acquired through conscious or unconscious learning.

The translation of Bowlby’s set-point model into neural mechanisms is a fruitful
area for future research concerned with the biological basis of information analysis,
storage, and retrieval. Although precise relations cannot at present be specified, the
general features can be accounted for by limbic system function. Lesions of limbic
areas such as the amygdala and the septum disrupt the appropriateness of the organism’s
reactions to environmental cues, whereas lesions of the hippocampus and the mam-
illary bodies result in disturbances in information storage and retrieval (see Isaacson,
1974). These are greatly simplified conclusions concerning complex brain regions.
However, these and other limbic regions, as discussed, have long been associated with
the domain of processes called emotional, and many of the data concerning these areas
are consistent with the postulation of their role in screening input for its affective
significance and in regulating organized autonomic adjustments and behavioral reac-
tions appropriate to the affective analysis.
Efferent Regulation

The affective processing system, then, assesses the subjective significance of afferent input from the environment, from the body, and from within the brain by comparison with internal standards. When afference violates momentary set-point criteria, efferent activity is often initiated. This is so because set-point violation signals the existence of a subjectively significant stimulus situation, probably requiring action. The detection of food is a subjectively significant stimulus to a hungry animal, as is the sight of a predator. While the former elicits approach behavior, defensive behavior is elicited by the latter. In each case, however, behaviors appropriate to the afferent situation are selected. This selection process is one of the key functions of the affective processing system. While we know little at present about how the brain executes and controls such selections, studies of the efferent consequences (behavioral and autonomic) of affective arousal provide a relevant approach to the problem.

The expression of any behavior is accompanied by complex autonomic adjustments appropriate to the behavior. The autonomic changes during feeding are distinct from those during exploratory behavior and sleep (LeDoux et al., 1982). These changes, which often actually precede the behavior (Cohen & Obrist, 1975), are selected to support the behavior. During fighting and other defensive behaviors, for example, the distribution of blood is shifted away from the superficial vessels of the skin (Zanchetti, 1971). This redistribution provides the deep muscles with metabolic support and protects the organism against excessive hemorrhaging from surface wounds. Any discussion of efferent regulation must thus account for both autonomic and behavioral regulation and for the mechanisms through which autonomic responses are coupled to behavior.

To the extent that affective behaviors and autonomic reactions reflect the operation of the affective processing system, tracing backward into the CNS the mechanisms that underlie the two response classes (behavioral and autonomic) and their integration into a unified physiological reaction provides a useful approach to the problem of how efferent responses are selected and regulated. The working hypothesis underlying this approach is that the autonomic and behavioral consequences of set-point violation are dissociable within the CNS. If so, identification of the site and/or the mechanism of integration of each response class is a first step in the determination of how behavioral and autonomic responses appropriate to affective analysis are selected and coupled. Tracing backward further from each mechanism could, in other words, lead to the identification of a common integrative mechanism that might underlie response selection and perhaps even affective analysis.

Recent studies support the hypothesis that the autonomic and behavioral manifestations of affective arousal are dissociable in the CNS. The studies involved spontaneously hypertensive rats (SHRs), a Wistar strain selectively bred to develop hypertension (Okamota & Aori, 1963). When subjected to classical fear conditioning and subsequently presented with the conditioned stimulus during extinction trials, SHRs exhibit a greatly exaggerated change in blood pressure relative to Wistar Kyoto control rats (WKYs) (LeDoux, Sakaguchi, & Reis, 1982). This exaggerated response, moreover, appears related to the heightened sympathetic tone (Judy, Watanabe, Henry, Besch, Murphy, & Hockel, 1976; Schramm & Barton, 1979) and the enhanced sympathoadrenal release of catecholamines during stressful stimulation (McCarty, Chiu,
& Kopin, 1978; McCarty, Kvetnansky, Lake, Thoa, & Kopin, 1979) characteristic of
SHRs. In contrast to this autonomic hyperarousal during conditioned fear, SHRs exhibit
a greatly reduced behavioral reaction to the fear-provoking stimulus (i.e., they spend
less time freezing in the presence of the CS and the CS produces less suppression of
appetitive behavior than in WKYs) (LeDoux et al., 1982). Thus, autonomic changes
are exaggerated, but behavioral responses are reduced in SHRs during conditioned
fear reactions.

While the foregoing observation suggests a directional dissociation in the regu-
lation of the autonomic and behavioral components of affective reactions in SHRs,
the dissociability can be pushed further by considering the results of pharmacologi-
cal studies. Treatment of SHRs with a centrally acting alpha-adrenergic agonist normalizes
the conditioned blood-pressure response but has no effect on conditioned fear behavior
(LeDoux, Sakaguchi, Tucker, & Reis, 1981). These observations suggest that unique
CNS transmitter systems underlie the expression of the behavioral and autonomic
aspects of the same affective reaction and that natural (genetic) variation in transmitter
regulation might account for individual differences in affective reactions to environ-
mental cues within a single species.

Feelings: Conscious Awareness of Affective Processing

The function of the affective processing system is thus the analysis of the subjective
significance of environmental, bodily, or mental afference and the selection and regu-
lation of the behavioral and physiological adjustments precipitated by affective anal-
ysis. These activities are continuous, regardless of the focus of conscious attention.
Only when conscious attention is directed to some aspect of affective processing does
feeling or emotion result.

The capacity to assess the subjective significance of events is widespread through-
out the animal kingdom. Without such a capacity, an organism could not survive. The
existence of an affective processing system is thus not predicated on the presence of
consciousness, which is unquestionably characteristic of humans but difficult at best
to verify in other creatures. By distinguishing between affective processing and con-
scious feeling, the present formulation allows animals to have affective reactions,
which they surely do, without requiring that they consciously experience the reaction,
which they may not.

Feeling—that is, conscious awareness of affective processing—is thus a cognitive
processing function. Since cognitive processing and affective processing involve unique
neural subsystems, feeling must involve interactions between the subsystems. Such
interactions can be conceived of as taking place either directly or indirectly.

Direct (neural) interactions between cognitive and affective processing systems
are determined by the anatomical-physiological links between the systems. Such links
provide the conscious person with on-line access to the affective analysis of input and
the regulation of affective output. However, direct neural interplay between the cog-
nitive and the affective processing systems appears limited. This limitation is suggested
by our usually poor ability to account accurately for our own affective reactions.
Observers, according to Hebb (1946), are far more accurate than the experiencing
person in naming affective responses. The success of artificial intelligence models (which typically ignore affective processing and its consequence) of language and other cognitive processes may, in fact, reflect this relative isolation of cognitive and affective processing systems in the brain.

Indirect interactions between cognitive and affective processing systems are a key feature of human emotion. Though the conscious self has limited direct neural access to affective processing, the behavioral and autonomic consequences of affective processing, as well as the environmental situation, are available for conscious scrutiny. Schacter's (1975) classic studies demonstrate how autonomic arousal in context provides the conscious self with a basis for inferring feeling, and dissonance and other cognitive consistency models (Festinger, 1957) show how our acts and thoughts can influence our conscious interpretation of how we feel. The compelling human tendency to interpret behaviors of unknown origin is also illustrated by the verbal output of the left hemisphere of split-brain patients in response to actions experimentally elicited from the right hemisphere (Gazzaniga & LeDoux, 1978; LeDoux, Wilson, & Gazzaniga, 1978). Indirect interactions between cognitive and affective subsystems are thus commonplace.

Certain anatomical facts are consistent with the view that direct connections between the cognitive and affective processing systems are limited. The linguistically based cognitive system is relatively new in evolutionary history, and there is evidence that its evolution involved adaptations in the inferior parietal cortex (IPL) in ancestral primate brains (Geschwind, 1965; Luria, 1973; LeDoux, 1982). This region, as Geschwind noted some years ago (1965), is extensively interconnected with other cortical areas, but it has limited interconnections with limbic regions. More recent studies have demonstrated greater connectivity between the IPL and limbic areas (Mesulam, Van Hoesen, Pandya, & Geschwind, 1977). However, relative to the extensive connectivity of the IPL with other cortical zones, connections with limbic regions are rather sparse.

One implication of these observations is that as humans, our ability to know ourselves consciously is limited by the patterns of anatomical connectivity between the cognitive and affective processing systems and by our cognitive skill in constructing interpretations of affective processing on the basis of limited data from our own behavior and autonomic reactions and from our physical and social environment. Unless the human brain someday evolves in such a way that direct neural interactions between the cognitive and affective processing systems supercede indirect interactions, firsthand knowledge of the motivational conditions that underlie much of adaptive behavior will remain inaccessible to the conscious, feeling person.

References


Kapp, B. S., Gallagher, M., Underwood, M. D., McNall, C. L., & Whitehorn, D. Cardiovascular responses elicited by electrical stimulation of the amygdala central nucleus in the rabbit. Brain Research, 1982, 234, 251–262.


Reis, D. J., & Gunne, L. Brain catecholamines: Relation to the defence reaction evoked by amygdaloid stimulation in cat. *Science*, 1965, 149, 3682.


