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At the interface of the affective, behavioral, and cognitive neurosciences: Decoding the emotional feelings of the brain

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Abstract

This article summarizes recent conceptual and empirical advances in understanding basic affective processes of the mammalian brain and how we might distinguish affective from cognitive processes. Six reasons are advanced for distinguishing the two types of consciousness, including (i) the presence of experienced valence, (ii) cortical sub-cortical locus of control, (iii) different developmental trajectories, (iv) informational vs organic considerations, (v) differences in bodily expressions, (vi) differences in cerebral laterality. The position is advanced that to make progress on understanding the neurobiological nature of affect, we need to utilize experimental strategies different from those that are common in cognitive science.

1. Introduction

It is generally accepted that emotional processes have many attributes including motor-expressive, sensory-perceptual, autonomic-hormonal, cognitive-attentional, and affective-feeling aspects. A general definition of emotion should include all these characteristics, phrased partly in neuroconceptual terms (Panksepp, 1982, 1992, 1993). If one were to ask non-scientists which of these attributes is most important, one would find the last two highest among most lists, with *cognitive* typically being first among those committed to intellectual views and *affective* being foremost among the more emotionally inclined (Panksepp, 1999a, 2000a).

The folk-psychological distinctions between these aspects of mind seem obvious to most, but it all begins to "flicker" when one tries to distinguish the two unambiguously in the laboratory; in most human experiences, they tend to go together. Hence, within the context of the cognitive revolution, many have begun to question the utility of the classic distinction. However, I would encourage us not to discard it, for this very distinction may help us unravel the neurobiological nature of the basic affective coloring of conscious existence, and thereby allow us the swiftest progress in elucidating the fundamental nature of those prepropositional experiences we share with many other animals. Thus, I will defend what has recently become a minority view among psychologists, but which, in my estimation, should remain accepted wisdom. At the same time, I must emphasize that "this view in no way seeks to deny their remarkable blending in our first person subjective experiences, nor the fact that cognitive abilities have co-evolved with affective processes in many higher regions of the brain" (Panksepp, 2000b, p. 29).

Regardless of one's position on this contentious issue, in practical scientific terms our key concern should be whether the cognitive–affective distinction represents some real aspects of neuromental existence or whether it is a fictional parsing of neuropsychological space. I believe that focussed consideration of the basic affects, quite independently of the cognitive activities with which they *always* interact in the intact brain–mind, may promote a deeper and more substantive understanding of the *feeling* aspects of emotional processes than if we perpetually conflate the two. Let me give a paradigmatic example—many drugs can reduce feeding in humans and other animals, but only a few of them do so by simulating the good feeling of normal satiety. For practical clinical control of human weight and appetite problems, we must winnow those specific factors from the greater

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number that make animals sick, dysphoric or otherwise indisposed to eat. The pleasure of sensation strikes me as something that is fundamentally non-cognitive (also see Berridge's contribution in this issue), even though we must, of course, talk about such entities in cognitive terms or we regress to communicating in various grunts, groans, and sighs. Still, we should not deny that hungers, thirst, and many other internal urges and feelings emerge from the ancient regions of all mammalian brains.

I would encourage us to make the evolutionary working-assumption that internally experienced affects are universal capacities of brains in all mammals, and that those seemingly intangible neurodynamic processes can, in fact, be elucidated by triangulating among (i) sensitive behavioral measures, and (ii) our understanding of their brain substrates in animals, combined judiciously with (iii) the study of related affective experiences and psychophysiological changes in humans (Panksepp, 1992, 1998a). It should be emphasized that without the third component, this type of approach could easily be dismissed as meaningless (as it commonly was during the behaviorist era). This strategy, even though it generates abundant new predictions for human research with direct implications for quality of life issues, has yet to be widely employed since many would claim that the experience of affective states is confined to human beings. In this context, it is important to emphasize that independently of that contentious issue, the strategy should still work even if animals have only a smidgen of the neural architecture that is essential for generating such internal experiences.

Now that the cognitive revolution is gradually giving way to an emotion revolution, investigators are gradually exhibiting a new taste for the pursuit of what was once deemed scientifically unpursuable—an understanding of what affective processes really are, even in non-human animals. The new brain imaging tools have been a major force in this transformation. Equally important has been the recognition that at a genetic and subcortical-brain organizational level, all mammals are strikingly similar. Thus, when we encounter homologies in organs, including mammalian brains, we may be able to reveal useful *general principles* for the whole class of animals by devoting a great deal of research effort to a single convenient species. Although this is not to deny the abundant species differences that exist in the details of all systems, but to recognize that those differences are bound to be much greater at cognitive (Hauser, 2000) than basic affective levels of brain organization (Panksepp, 1998a). Within such an intellectual framework, emotional systems of the brain can be studied in any representative species as long as they have not become vestigial—as separation–distress circuitry appear to have become in laboratory rats and fear in species who have no natural predators. There is now a growing recognition that while human neuroimaging can highlight many brain zones where we should focus our attentions, it will be through animal brain research that the underlying operating principles of the relevant neural systems must be revealed. Because of recent advances in neuroscience, few would be willing to decree that affective processes are meaningless concepts, as many neurobehaviorists still did just a few years ago.

Only through the integration of human and animal approaches can deep knowledge in this field be achieved. If we conflate emotions and cognitions too much in our thinking (even though, I must repeat, they may be quite impossible to separate unambiguously in most human inquiries), we may retard a fundamental understanding of affective processes and thereby, a real understanding of how cognitive activities are modified by emotional states. Many now agree that many cognitive processes are coded by mood congruent principles, and specific kinds of "affect logic" prevail in cognitive deliberations (Frank, 1988; Shand, 1920; Wimmer & Ciompi, 1995). I would submit that the brain substrates for affect are most easily decoded in animal models even though all conclusions must be provisional until validated in humans. At times I do fear that cognitive-imperialism, the prevailing view in mind sciences, will continue to suffocate the need for focused research on affective issues, and thereby, continue to delay a scientific analysis of such matters of foremost concern for understanding the existential inner qualities of human lives.

For instance, within the information-processing models of mind that the cognitive revolution continues to advance, there is an increasing, and in my estimation unjustified, tendency to assume that information-only strategies constitute an optimal methodology for understanding emotions. After all, it is tempting to focus on the finding that neurons do process "information" in remarkably similar ways regardless of their functions in the brain. Despite the fact that nothing resembling a *Rosetta Stone* has yet been found (Rieke, Warland, de Ruyter van Steveninck, & Bialek, 1997), abundant hope persists that digital neuronal codes will be found for psychological processes as instantiated in the temporal flow of action potentials. Since action potentials do constitute a universal neuronal "language," many investigators still assume that the cognitive and affective processes of the brain are little more than variants on similar neurocomputational themes. According to such views, emerging conceptual frameworks such as "affective neuroscience" may seem redundant, unnecessary, and at times threatening to the hegemony of the increasingly popular cognitive-computational views of brain–mind functions (LeDoux, 1999, 2000).

Having coined the concept of "affective neuroscience" a decade ago (Panksepp, 1990a, 1991, 1992; also see Davidson, Jackson, & Kalin, 2000; Davidson & Sutton, 1995), followed by several theoretical syntheses

(Panksepp, 1996, 1998a, 1998b, 2000a, 2000b), I would like to discuss why our willingness to distinguish affective and cognitive processes may advance incisive work in this long-neglected area of neuroscience. My main point is that affective feelings are, to a substantial degree, distinct neurobiological processes in terms of anatomical, neurochemical, and various functional criteria, including peripheral bodily interactions. Emotional and motivational feelings are unique experientially valenced "state spaces" that help organisms make cognitive choices—e.g., to find food when hungry, water when thirsty, warmth when cold, and companionship when lonely or lusty. If affective organic processes, ancient adaptive solutions that they are in brain evolution, are to a substantial degree distinct from those that mediate cognitive deliberation (even though they obviously co-evolved in recent brain evolution), then we must develop special strategies to understand them in neural terms. Biological solutions to such problems may promote the emergence of a solid foundation for the construction of a coherent mind science as well as providing a substantive grounding for psychiatric therapeutics, both pharmacological and psychological. It may also encourage investigators to better characterize how cognitive appraisals are modified by such noteworthy urges such as hunger, thirst, etc., as well as the more transient emotional storms.

In my estimation, affective/emotional processes provide intrinsic values—organic "pressures" and "drives"—for the guidance of behavior. I believe such "energy" metaphors were prematurely discarded in psychology with the advent of digital computers and the information-processing revolution. To the best of our knowledge, the ancient analog processes that constitute the core of our emotional and motivational processes emerged largely from evolutionarily prepared "instinctual" action-generating systems as well as from homeostatic, visceral-type interoreceptors, situated largely subcortically (Panksepp, 1998a). These robust but slowly firing systems help generate "intentions in action," to use Searle's (1983) felicitous phrase, and in so doing may generate raw affective experiences without any need to interact with higher cognitive mechanisms. Cognitive processes, on the other hand, are linked closely to rapidly firing exteroceptive sensory systems, *comparatively* free of any intrinsic affects, which allow organisms to navigate effectively in space, time, and among the object of the world (often toward affective goals), yielding, in some species, "intentions to act" (Heyes & Dickinson, 1990).

In line with long-standing traditions, the way we perceive the external world and our resulting propositional thoughts about those perceptions are what constitute our cognitive terrain. Those functions emerge largely from higher, more recently evolved, neocortical regions of the brain. They are linked closely to what has traditionally been called the "somatic nervous system" concentrated in the thalamic–neocortical axis—the rapidly firing neuronal systems that interface organisms with the outside world. Its highest manifestation in our species is the capacity to use symbols and metaphor (Lakoff & Johnson, 1999) and to create "the prison-house of language" that is not well designed for cogent scientific discourse about the basic neuropsychological substrates for affect.

Affects reflect our internal feelings of goodness and badness, in the many varieties that those evolutionarily honed neurodynamic arise, typically through organismic interactions with the outside world. There are reasons to believe that affective feelings emerge largely from specific subcortical circuits where slowly firing neural systems abound, rich in various function-specific neuropeptides that are also abundant in the enteric nervous system of the viscera (Panksepp, 1993). Emotional responses, including their intrinsic affective attributes, probably emerge from "limbic" regions that are more evolutionarily conserved in vertebrates than those that mediate cognitive capacities (MacLean, 1990). In my estimation, the increasingly prevalent limbic-system bashing among emotion researchers reflects a misreading of the history of the field and the role of general concepts in promoting research and communication (e.g., LeDoux, 2000).

Of course, there is now extensive blending of affective and cognitive processes in many brain areas, and if conceptual distinction cannot be cashed out scientifically, they are bound to be counterproductive. I believe it has already been cashed out in the abundant number of new predictions concerning human affects that have arisen from animal brain research (Panksepp, 1998a). Still, there is a massive reluctance among most neuroscientists to utilize such information since many prefer to deny that the animals they study experience anything. That, I believe, is a hangover of Cartesian dualism along with the prevailing assumption that subjective brain–mind issues, since they cannot be directly measured, should not be deemed a topic of disciplined scientific discourse or inquiry. That is a rather counterproductive and narrow-minded view if neuroaffective processes do exist in animal brains and have causal efficacy in the long-term regulation of their behaviors. In fact, these subtle issues can now be empirically approached through cross-species theories that make explicit behavioral and brain predictions (e.g., Damasio, 1999; Panksepp, 1998a).

2. A brief history of the recent emotion–cognition debate

To help set the stage a bit further before proceeding to specifics, let us review the dispute over the primacy of affect or cognition in understanding emotions as represented in the now classic Lazarus–Zajonc debate on whether affect could be aroused without preceding cognitions or whether cognitive appraisal is an essential prelude to emotional arousal (for the most recent statement, see Zajonc, 2000). Ultimately, the dispute became stranded on semantic issues such as the point in sensory processing and conscious perception where one could justifiably distinguish cognitive from non-cognitive processes. Indeed, if we focus on somatic-sensory issues, especially after a great deal of emotional conditioning has transpired during ontogenesis, one would be hard-put to convince skeptics that an adequate distinction could ever be made. Unfortunately, that debate was not premised on a thorough discussion of relevant brain, developmental, and evolutionary factors; nor were brain somatic and visceral processes fully considered as objective distinguishing criteria.

A more relevant debate for our present concerns is one that has emerged among neuroscientifically informed investigators during the past decade. There are at least three noteworthy examples of this controversy. A major position was enunciated by Jeffrey Gray (1990) in a special issue of *Emotion and Cognition*, where he argued, on the basis of largely psychopharmacological data, that the distinction between emotional and cognitive processes was counterproductive since so many peripheral pharmacological manipulations modified both processes. I was an outside reviewer of that paper, and proceeded to submit an extensive signed critique highlighting the alternative point of view—that the distinction was both conceptually useful and neurobiologically meaningful. I will not summarize details, but would simply highlight that Gray, the editor of that issue (albeit not the action editor on his own contribution), chose not to respond but recommended that my contribution be published alongside his own. And so it was (Panksepp, 1990b), but the issues raised have yet to be addressed.

A selective pro-Gray perspective on this controversy was provided by Parrot and Schulkin (1993). Their main point was that sensory processes, which commonly instigate both cognitive and emotional responses, cannot be clearly categorized into either realm (resurrecting the specter of the Lazarus–Zajonc debate). However, their failure to distinguish somatic and visceral processes in the brain again weakened their analysis. Visceral–emotional processes are medially situated within the neuroaxis, highlighting their more ancient status, while exteroceptive and higher cognitive systems are concentrated more laterally and rostrally in the neuroaxis. Not only can they be distinguished anatomically and neurophysiologically but the weight of evidence is that the core emotional/affective processes are more closely linked to visceral–neuropeptide systems than the somatic functions of the brain.

A third example of this debate has been between LeDoux (1999) and myself (Panksepp, 1999a, 1999b). While I have championed the view that affect is an ancient form of consciousness shared by all mammals (e.g., Panksepp, 1998a, 1999a, 2000a, 2000b), LeDoux (1996, 2000) has argued that affect is a minor and distracting aspect of emotion research; indeed, he has suggested that affect may largely be an epiphenomenal emergent that arises from unconscious subcortical processes interacting with a uniquely human cortical workspace for consciousness [a variant of this type of view has more recently been advanced by Rolls (1999)]. LeDoux (1999) has also suggested that an "affective neuroscience" perspective has no obvious utility, and that all relevant work could be conducted under a general "mind science" umbrella rooted in the cognitive-neuroscience, information-processing, neurocomputationalist tradition. Meanwhile, I have continued to argue that affective and cognitive types of consciousness may be quite distinctly organized in the brain, with affective forms arising directly from lower regions where executive systems for emotional responses are organized (Panksepp, 1998a, 1998b, 1999a, 1999b, 2000a, 2000b). These contrasting views were also aired in an electronic seminar organized by Watt (1998). I think most would consider the controversy unresolved, but at least key issues are finally being discussed.

Since then, there has been a growing awareness among investigators that the issue of emotional feelings must assume critical importance in both human (Damasio, 1999) and animal research (Bekoff, 2000a, 2000b). Thus, even though many psychologists and neuroscientists continue to believe, on the basis of important symbolic–linguistic considerations, that consciousness is not a property of animal minds (e.g., Rolls, 1999), others are beginning to disagree. No doubt they are using the term "consciousness" in slightly different ways. Some accept that primary-process sensory and affective consciousness has a long evolutionary history while others would like to restrict the concept to higher forms mediated by uniquely human symbolic/metaphoric abilities.

In any event, modern evolutionary views, not to mention our massively shared genetic inheritance, remind us to respect, more than ever before, the deep ancestral relationships among all life forms. We should remain open to the possibility that the fundamental ability of neural tissue to elaborate primary-process forms of affective experience evolved long before human brain evolution allowed us to think and to talk about such things. The way this issue can eventually be resolved empirically is through a determination of whether other animals have the neural processes that generate affective experiences within the human brain–mind (Panksepp, 1998a, 1998b). Since we have a long way to go before that is achieved, all reasonable points of view should be given an open hearing around the scientific table as well as those where funding decisions are made.

That was not the case during the 20th century where the integrative brain–mind functions were rarely given their due.

3. Framing the forthcoming affect–cognition debate

The recent appearance of a major contribution to the emotion literature from the cognitively oriented tradition entitled the "Cognitive Neuroscience of Emotion" further helps frame some of the key issues that need to be aired. Lane and Nadel (2000) not only provide a useful summary of the human emotion research that is being conducted from a neuroscience perspective, but they also highlight the fact that *affective neuroscience* "could be construed as perpetuating a misguided antagonism between emotion and cognition." They proceed to suggest that there may be "no such things as pure cognition without emotion, or pure emotion without cognition," and to advance the reasonable point of view that "we must integrate the different components of the mind to understand how they work together in daily life" (p. 6). I think all would agree that feelings and thoughts may never be *practically* separated in the human brain–mind (as we apparently can with decortication in young rats). Unfortunately, the implicit assumption again appears to be that more purely affective-motivational views of certain brain functions may have little to offer. This marginalization, I would also note, is also all too common in animal learning and cognitive ethology circles (e.g., Shettleworth, 1998). In respectful disagreement, I would suggest that primitive affective and motivational processes—primary-process forms of brain arousal we share with other animals—may well have been foundational for the emergence of many cognitive processes in brain evolution. If so, the time should eventually be ripe to have a compendium of the "Affective Neuroscience of Cognitions" (thanks to Doug Watt for suggesting that bit of cheekiness).

At the same time, Lane and Nadel (2000) correctly worry that it could "be argued that what distinguishes emotion from cognition may be its 'embodiment,' in that the autonomic, neuroendocrine, and musculo-skeletal concomitants of emotional responses distinguish them from cognitive processes" (p. 7). This, of course, should be an enormous worry, when so many cognitivists still assume that simply because digital information-processing can be instantiated on many distinct material platforms, lasting insights into the nature of affect can emerge from computational approaches rather than biologic ones (e.g., Pinker, 1997). This is a view with which many in affective neuroscience—indeed, neuroscience in general—should strongly disagree. From what we currently know, it seems likely that the embodied affective components of mind simply cannot be computed in any credible manner because they emerge from processes that are so deeply organic and analog (e.g., Panksepp, 2000a, 2000b).

4. The role of brain imaging and circuit analysis

The roots of affective neuroscience go back to: (i) behavioral brain research on animals (for overviews, see Buck, 1999; Panksepp, 1998a), (ii) the neuropsychological tradition of studying brain damaged humans and the effects of drug challenges (Borod, 2000), and (iii) most recently, our capacity to image functional changes within the human brain (Toga & Mazziotta, 2000). It would have been lovely if all the approaches had rapidly dovetailed, but they did not, yielding two distinct intellectual traditions (Fig. 1). Since there is currently remarkably little cross-talk between them, it may be instructive to consider what each truly has to offer an eventual synthesis.

As summarized by Borod (2000) and Lane and Nadel (2000), the neuropsychological and human brain-imaging traditions are now routinely highlighting higher regions of interest in telencephalic areas (but for a striking and compelling exception, see Damasio et al., 2000).

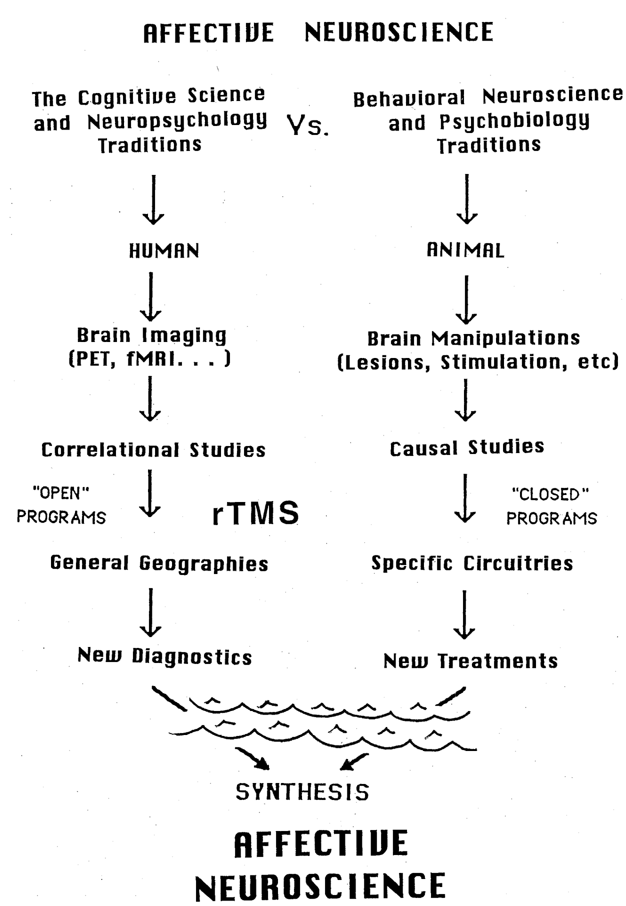

Fig. 1. Affective neuroscience in the cognitive (left) and behavioral neuroscience traditions (right).

Aside from a limited number of neurochemical interventions, one of the few manipulative tools that can be used in human neuroscience studies is rTMS (rapid Transcranial Magnentic Stimulation), which is presently emerging as a new anti-depressant intervention (George et al., 2000), that has strong indirect effects on subcortical processes (Speer et al., 2000). In contrast, the tradition of animal research has long focused on deeper subcortical processes in the control of emotions. The animal brain research approach is characterized by a host of experimental manipulations that can resolve mechanistic/causal issues.

These two approaches to emotion have emerged relatively independently. The lack of continuing cross-fertilization between the two has emerged partly because their findings have not been strikingly concordant. One approach—the animal brain research tradition—has produced a deep subcortical view of emotions. The other—the human brain-imaging/neuropsychological approach—has yielded more cortico-centric perspectives. How the two approaches can eventually be coordinated and synthesized will be a most interesting chapter in this new field of inquiry. There are already signs that a clear distinction between higher brain areas where environmental events provoke emotions and the lower ones that are the sources of emotional feelings may be a key to this dilemma (Damasio et al., 2000; Lane et al., 1997). For instance, the brain area (amygdala) that has become symbolic for understanding emotions in our era seems to have comparatively little to do with the mediation of emotional feelings (Damasio et al., 2000), even though it certainly initiates emotional arousal as a result of certain perceptual inputs (Whalen, 1998, but see Davidson, 2000). Because of biases against affective views, the importance of the amygdala for understanding emotions has been remarkably exaggerated in the popular press. It has also been inflated in the minds of some investigators who do not acknowledge (or perhaps even appreciate) the importance of affective issues for understanding emotions.

5. A half dozen key distinctions between affects and cognitions

I will now briefly summarize a half-dozen specific, albeit partially overlapping, reasons to support the belief that affective views may provide more critical insights into the fundamental emotional organization of the brain than traditional cognitive views. Because of space constraints, I will be brief; many related issues are detailed elsewhere (Panksepp, 1998a, 1999a, 1999b, 2000a, 2000b).

(1) *True emotional states are intrinsically valenced—characterized by various positive or negative feelings that do not accompany pure cognitions*. On the basis of abundant data, it is reasonable to suppose that various basic emotional and motivational responses and the accompanying feelings (types of valence) reflect intrinsic evolutionarily dictated states of the nervous system (for overview, see Buck, 1999, Panksepp, 1998a). These capacities of the brain are not constructed simply from the perception of external events and the propositional thoughts that follow (i.e., cognitions). They have an intrinsic structure of their own. However, from this perspective it is not difficult to give cognitive views their due—emotions are not just disturbances of the interior mileu, they also help control the way we perceive the world. As a corollary, we may need to consider that the ancient affective processes in the brain may have constituted the essential neural foundation for the adaptive creation of "meaning" in brain evolution (Freeman, 1999), thereby setting the stage for the emergence of propositional-cognitive forms of consciousness (Panksepp, 1998b).

(2) *Emotional responses, and apparently many basic affective tendencies, survive many forms of brain damage that severely impair cognitions*. This is highlighted well by the simple fact that early decortication of neonatal rats results in animals that are severely deficient in the ability to learn, although they remain competent in the emotional and motivational behaviors that constitute their instinctual repertoire (see Kolb & Tees, 1990; Panksepp, Normansell, Cox, & Siviy, 1994). Recent human work, highlighted dramatically by the Adolphs and Damasio contribution to this volume, may also support such a view for humans (even though, as they indicate, the higher somatosensory cortices may still be important in the generation of affect). In any event, since many emotional feelings can be triggered robustly by direct electrical stimulation of subcortical brain systems (Heath, 1996; Panksepp, 1985), it would seem that the deep organizational structures of affect can, to a substantial degree, be distinguished from those higher brain systems that are essential for most cognitive activities.

Because of the above perspectives, we may also wish to pointedly conclude that: *Cognitions are largely cortical while affects are largely subcortical*. This classic viewpoint has been brought into question by imaging studies in which many higher brain areas "light up" during the induction of emotions. However, now it seems that many of those studies may simply reflect the higher cognitive inputs into affective systems (Whalen, 1998). In the most comprehensive PET study of intensely experienced emotions (Damasio et al., 2000), it was evident that human affective arousal emerges largely from subcortical functions. A gross overall re-depiction of the data provided by Damasios' group is provided in Fig. 2. Of the 189 brain sites exhibiting significant changes in blood flow, the great majority exhibiting arousal effects were found below the neocortex and were medially situated in the brainstem and closely connected

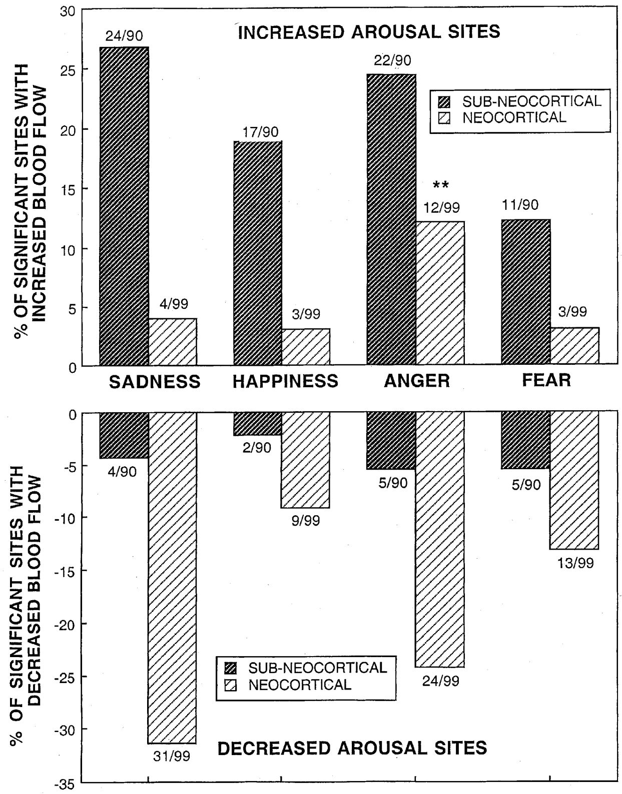

Fig. 2. In Damasio et al.'s (2000) imaging of human affect, 189 brain sites exhibited significant changes in blood flow. The top graph indicates the percentage of those that exhibited arousal were located in neocortical areas vs. those that were in more primitive brain areas. The bottom graph indicates the same for the brain areas that exhibited reductions in blood flow. Clearly, neocortical areas tended to exhibit decreases in arousal for each of the emotions, while those below the neocortex tended to exhibit the preponderance of increases. Overall, sadness and anger had the biggest effects on the human brain while happiness and fear had smaller overall effects. However, please note that anger had the largest relative arousal effects on the neocortex, which may suggest the largest invigoration of cognitive activities.

higher limbic cortical areas. On the other hand, those that exhibited decreases in arousal were mainly found in the neocortex (the bastion of higher cognitive activities and reason) situated more rostrally and laterally (and included the somatosensory areas of the parietal lobes). Clearly, *deeply* experienced human affect is characterized by vast amounts of subcortical arousal and cortical dysarousal. In practically all cognitive tasks, cortical arousal prevails (Toga & Mazziotta, 2000).

(3) In agreement with the above, *affects are more powerful and easier to induce in the young; sophisticated cognitive activities prevail among adults.* To put it bluntly, kids are very emotionally alive—affectively arousable and temperamental. This everyday observation suggests that affective competence *is* elaborated more by earlier maturing medial brain systems than more rostrally and laterally situated cognitive systems. This further affirms that the basic affects are more likely to be evolutionary "givens" as opposed to experiential "emergents." The higher cortico-cognitive processes that inhibit (and thereby help regulate) emotionality emerge only gradually as organisms mature.

(4) *Cognitions may be generated more by digital-type computations, while affects are generated more by analog types of neurohumoral processes.* In part, this may be due to the fact that emotional systems are enriched in neuropeptide and other long-acting paracrine controls (Panksepp, 1993, 1998a), while thalamic and related cortico-cognitive systems are much less so (Tohyama & Takatsuji, 1998). A corollary of this principle (in combination with #1, above) may be that long-term emotional learning consists of the conditioning of holistic "state" responses, while cognitive learning consists of more informationally and temporally resolved formal operations and propositions. This may also help explain why it is hard to activate cognitions by direct brain stimulation but quite easy to activate coherent affective responses which are comparatively preorganized within subcortical areas (for overviews, see Heath, 1996; Panksepp, 1985).

(5) *Emotions generate spontaneous, trans-cultural, facial and bodily expressions as well as prosodic vocal changes; cognitions do not.* These, of course, are the kinds of observations, first popularized by Darwin (1872/1998) that led, after a hiatus of a century, to the revival of emotion research in psychology. Although the importance of facial expressions in the study of emotional feelings has been extensively debated, it is fairly clear that such emotional actions can promote congruent feelings (Flack, 2000). In this context, it is informative that following cortical damage, full emotional expressions are difficult to generate voluntarily by cognitive means, but they are still easily aroused by spontaneous emotional states (Borod, 2000; Rinn, 1984).

(6) *In general, our right cerebral hemisphere tends to be more emotionally deep and perhaps negativistic (or realistic) as compared to the more cognitively skilled and positively valenced left hemisphere.* When the left hemisphere is injured, people have more catastrophic emotional responses than following similar damage to the right side (Gainotti, 2001). Left hemisphere-damaged individuals are very much aware of their post-stroke plight. By comparison, when the more emotionally introspective right hemisphere is damaged, the linguistically proficient left hemisphere commonly carries on as if nothing very serious has transpired. It appears predisposed to repress negative emotions, and even chooses to confabulate as it persistently fails to acknowledge the severity of the ongoing medical condition (Feinberg, 2001). However, disorienting strategies such as caloric stimulation of the left ear (Ramachandran, 1994), or depth-psychological approaches, can provoke an affective recognition of the gravity of the situation for short spans of time (Kaplan-Solms & Solms, 2000). These syndromes highlight how extensively cognitive responses

may be shaped by affective changes; such peculiar cognitive symptoms make little sense if we do not clearly envision the uniqueness of the affective life.

Indeed, it may be useful to dwell on this issue a bit: The linguistically and analytically enriched left-hemisphere may be more influenced by social-desirability factors, and thereby more readily falls prey to dissembling and confabulatory urges. At its most extreme, right hemisphere damaged patients often deny that their left side is even paralyzed when it so clearly is at an objective level (Feinberg, 2001; Kaplan-Solms & Solms, 2000). This tendency should be of great concern for all mind scientists. If it were to turn out that the left hemisphere is more influential in most of our scientific inquiries than the right (which seems highly likely), might that constitute a biasing influence on the types of scientific perspectives we cultivate? To what extent might investigators' own personalities influence the types of inquiries, theories and methodologies they support and pursue (Panksepp, 2000c)? These are troublesome issues that emotion scientists may eventually wish to address empirically. Progress toward an understanding of affective processes may be slow and theoretically lopsided (i.e., biased toward the informational aspects of emotions) if selectively pursued by individuals enriched in left hemisphere skills but impoverished in those of the right.

6. We are prisoners of our times

We are all constrained by prevailing cultural assumptions within our mind sciences and cognitive perspectives remain foremost in the views of most investigators. As a result, affective issues have suffered a massive neglect. But now there is a dawning recognition that too many experimental psychologists may have been pursuing their circumscribed cognitive interests with all too little regard for the accompanying feelings experienced by their subjects. Indeed, too many studies that evaluate unconscious emotional processing have routinely failed to evaluate the affective changes their subjects may be experiencing (Öhman & Wiens, 2001). However, the argument that feelings are part and parcel of cognitive processes may be a compelling way, in a strategic sense, to encourage more investigators to consider long-neglected affective issues.

Although most concerned investigators appreciate that in healthy humans every emotion is accompanied by cognitive changes, it does not follow that affect, as a fundamental brain process, can be understood within prevailing cognitivistic research paradigms. I personally do not see how that could happen. I trust I have been able to convince a few that a more pointed focus on affect and the universal subcortical substrates of emotion may yield even more robust strategies. I would also encourage us to consider the need to develop new neuropsychoanalytic approaches to study the deep nature of affect in human beings (Kaplan-Solms & Solms, 2000; Panksepp, 1999a, 1999b; Solms & Nersessian, 1999). As Bownds (1999, p. 29) put it: "The rambling internal narrative of our thought is like a swimmer in the sea of emotions." We need better ways to describe the dynamics of the "swimmer" and the "sea" scientifically.

Thus, even though emotions and cognitions interact massively, especially in the higher regions of the brain, there are many reasons to view them as distinct species. Perhaps the metaphor of parasite–host relations would be apt, but I would not wish to suggest which is which. Perhaps the image of predator–prey would be even more apt. We would never conflate prey and predator as we study their relations scientifically, even though their fates, just as those of the emotions and cognitions, are inextricably intertwined in real life. If we just limit ourselves to psychological views, we will never be able to disentangle emotions and cognitions. Thus, in any final account, the distinctions between them must include biological considerations (as in the six points highlighted above).

At the same time, I would again reemphasize that I am not denying a role for higher cognitive processes in the regulation of emotional affairs. The higher regions of the human brain clearly allow complex inter-digitations of emotions and cognitions that enrich human lives in so many ways. Our cerebral cortex adds unique and fully blended emotional–cognitive–cultural complexities to the basic plans located below, yielding art, dance, and music—the truly remarkable emotional–cognitive accomplishments of the human brain–mind. Hence, we would encourage the cultivation of new perspectives such as experimental neuroaesthetics. However, to understand what the basic affects really are, we must be more willing to become conversant with ancient viscerally oriented brain systems that we still share with many other animals. Although the way emotions and higher mental activities influence each other may appear inextricably unified from a human psychological point of view, they are not as much of an inextricable tangle in the brain as many currently wish to believe.

7. Affect and consciousness

Ultimately, our ideas about the nature of affect depend on our conceptions of how consciousness is organized in the brain. We will eventually need to consider whether several distinct forms of consciousness have emerged in mammalian brain evolution. My own view is that the experience of affect reflects a more ancient form of consciousness than that which subserves most of our cognitive abilities (Panksepp, 1998b, 2000a, 2000b). Indeed, higher forms of consciousness may have arisen from the more essential primitive forms. If that is a reasonable view, the time-honored distinction between emotional and cognitive processes will always need to be sustained to some extent.

At our present primitive level of understanding it would be wise to have vigorous brain research programs directed at that biggest and most profound remaining questions of emotion research which, in my estimation, are "What are the fundamental neurobiological substrates of affect?" The forthcoming answers, many of which must come from behavioral brain research on other animals pursued in unison with a new generation of human studies, will be of foremost importance for understanding the nature of psychiatric disorders and the emergence of a new generation of neurochemical interventions. Of course, in this infant field of affective neuroscience, many interesting controversies are bound to emerge. Indeed, there are many *informational* and unconscious aspects of emotions where a conflation of emotions and cognitions may promote incisive research (LeDoux, 1996). Surely, our massive working memory spaces in the cortex add important new dimensions to affective experience. However, in our initial inquiries into the deep nature of affect, perhaps we should not forget Descartes' third rule of scientific inquiry—to think in an orderly fashion when concerned with the search for truth, beginning with the things which were simplest and easiest to understand, and gradually and by degrees reaching toward more complex knowledge, even treating, as though ordered, materials which were not necessarily so.

In sum, one guiding premise of "affective neuroscience" is that a natural neurobiological function of the brain is to generate a menagerie of positively and negatively valenced affective states, of various degrees and types of arousal, that help guide organisms in life-sustaining activities. In pursuing this knowledge, we do not have to subscribe to any form of mind–brain dualism and hence be immobilized by a counter-productive agnosticism. The basic affects may directly reflect certain types of ancient neuroinstinctual systems in action—yielding wide-scale neurodynamics that permeate the quality of our movements, actions, and higher cognitive activities. Emotions are not simply informationally encapsulated brain processes as some cognitively oriented investigators seem to believe (LeDoux, 2000). Emotional systems have an integrity that was created through evolutionary selection rather than simply through the life experiences of organisms.

Many psychologists have long accepted affective states as primitives in their theorizing, but regrettably, they have not developed modes of inquiry into the nature of those "urges" and "powers" much beyond a verbal description of surface appearances. Indeed, they could not have added much without immersing themselves in brain issues. Accordingly, almost a century ago psychologists gave up even the vague hope of understanding such processes in deep scientific terms. This failure is well symbolized by Freud hiding his *Project for a Scientific Psychology* in a drawer for eventual destruction, but saved for us like a reverberating echo of a lost dream after his death. And now we should all begin to recognize that the only way to really understand what affect is, is through neurobiologically informed research that does not arbitrarily deny those subtleties within either human or other animal minds. To really make intensive progress on these issues of ultimate human concern, we will need to nurture interdisciplinary initiatives that have the will to bridge the study of human experience and the essential ancient sources of those behaviorally linked experiences in the animal brain–mind. To succeed in this intellectual journey, we must cultivate deep neuroevolutionary points of view (Panksepp & Panksepp, 2000) that link up with cognitive learning–theory approaches to emotions (LeDoux, 2000; Rolls, 1999).

The necessary research strategy, as in all aspects of consciousness studies, is straightforward and difficult. First, we must specify the neural correlates of affective states—namely the regions of arousal in the brain and the relevant neural circuitries, neurochemistries, and neurodynamics (Figs. 1 and 2). Second, we must evaluate whether the correlates have causal influences on the generation of affective states and the corresponding emotional behaviors and bodily changes. Much of that will have to be pursued in animal models (Fig. 1), with major findings being validated in human inquiries (a project that has barely begun, but see Fig. 2). Finally, we must generate theories concerning how the underlying brain processes actually operate, and how they interact with other functional processes of the brain (and on that score, there are hardly any ideas on the table yet). Obviously, much of the neural machinery to achieve this will be unconscious (Öhman, Flykt, & Lundqvist, 2000), but the most interesting aspects for our lives and perhaps for psychiatric practice are the parts that are experienced. Although this project has barely been initiated, as highlighted by the following contributions, the future is full of promise.

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