

THE CORE EMOTIONAL SYSTEMS OF THE MAMMALIAN BRAIN

The fundamental substrates of human emotions

Jaak Panksepp

If we take a neuro-evolutionarily informed approach to the mental apparatus, we must recognize that our minds contain the rudiments of many fundamental psychological processes that emerged long before humans walked the face of the earth. Among the most important for understanding psychiatric disorders are the basic emotional tendencies of the brain: fear, anger, sexual urges, maternal devotion, separation distress and social bonding, playfulness, and a general desire-SEEKING system for seeking all life-sustaining objects of the world.¹ All non-human mammals exhibit all of these basic emotional tendencies, and to the best of our knowledge, they also experience the associated affective feelings. Although we humans can cognitively reflect on these feelings and can even make art out of our emotions, using our higher symbolic capacities, the raw affects that lie at the foundation of our mental life reflect ancient brain/mind value-encoding processes that are shared remarkably homologously by all living mammals and many other vertebrates. Because of advances in neuroscience, we finally have credible scientific approaches to understand the neurobiological nature of core affective processes in humans by studying the brains and behaviours of these kindred animals (Panksepp 1998a, 2005b). Since the core emotional mechanisms are concentrated in deep and ancient regions of the brain, they cannot be studied in any detail in our own species, despite recent advances in human brain imaging. Thus, animal brain research is essential to make progress on the details of these poorly understood brain functions.

A guiding premise of the affective neuroscience approach is that various emotional feelings and other affective states reflect primitive states of consciousness that emerge substantially from the neurodynamics of brain circuits that control instinctual emotional behaviours in animal brains. The possibility that two very different processes, such as emotional actions and emotional feelings, arise from substantially the same brain mechanisms is a critical aspect of the *dual-aspect monism* strategy that has guided my own research for four decades. According to such a view, a close study of the neural substrates of instinctual emotional behaviours of other animals may reveal the neural principles that generate raw

emotional feelings in humans. However, there are many other affective feelings beside emotional ones, including a large array of sensory affects (i.e., the pleasures and displeasures of sensations) and various bodily feelings, including the hungers and thirsts that reflect the bodily balances that are critical for life. To understand them, we also need animal brain research, but here I will largely focus on the emotional affects that are most readily studied in animal models. Such action tendencies are commonly inhibited by higher cerebral processes in humans, leading to various methodological difficulties for studying primary-process mentation, as well as heightened prevalence of psychiatric and psychosomatic disorders from repressed bodily urges. Animal brain research provides the clearest entry point into the nature of such systems.

This approach is finally allowing us some detailed access to the brain mechanisms of affect. Of course, the vast cognitive abilities of humans add special dimensions to how emotional feelings are elaborated within the human mental apparatus. Although free-running and excessive affect is a common aspect of psychiatrically significant mental distress, certain combinations of cognitive and affective capacities, especially the memory aspects, allow humans to become especially susceptible to psychiatric disorders. It is our unique human tendency to dwell on, and hence to sustain, our emotional disturbances that casts a longer shadow on our mental life than is common in animals. It is from our highly interwoven affective and cognitive nature that so much sustained emotional turmoil arises. With intense emotional arousal, our obsessive ruminative tendencies are massively amplified. Thus, our emotions can disrupt and narrow the breadth of our thinking patterns when they are intense, just as they can intensify and energize our cognitive concerns at milder levels of arousal.

To highlight these points, let me share two verses from Robert Burns' 'To a Mouse'. While ploughing a field in November of 1785, Burns overturned the nest of a field mouse. In eight poignant verses he meditates upon human and animal conditions. The second verse laments:

I'm truly sorry man's dominion
Has broken Nature's social union
An' justifies that ill opinion
Which makes thee startle
At me, thy poor, earth-born companion
An' fellow mortal!

In the final verse Burns concludes

Still thou art blest, compar'd wi' me!
The present only toucheth thee
But och! I backward cast my e'e
On prospects drear
An' forward, tho' I canna see
I guess an' fear.

(*'To a Mouse, 1785*)

This is the human dilemma: through our remarkable cognitive abilities, we create complex mental lives, with unique intrapsychic tensions that often require the help of friendly and supportive others to facilitate more productive and happy outcomes. Because of our vast ability to look far back in memory and to imagine dreadful future problems, we humans are prone to sustain internally generated emotional arousal and disturbances much more than other animals. Through primary-process, affectively driven intrapsychic processes – the attributions, judgements, beliefs and construals, driven by the primal emotional ‘energies’ of anxiety, anger, desire and grief – humans commonly sustain affective arousal long after the precipitating circumstances have passed. Thereby our expansive cognitive nature becomes a critical agent in creating our own emotional problems. Such cognitive aspects of the emotional equations may never be as well modelled in other animals as the unconditional nature of the core affects. Since the neural mechanisms of experienced thoughts are more difficult to fathom than affective processes, we may never know to what extent other mammals are able to approximate levels of internally self-generated distressing thoughts that are common features of human life. However, a study of animal brains can tell us much about the nature of our raw emotional feelings. Although science has no mind-scopes, animal brain research finally informs us, perhaps for the first time in human intellectual history, of the nature of those deep evolutionary emotional processes without which psychiatric disorders could not exist (Panksepp, 2004). My aim here is briefly to summarize the emotional affective aspects of various neuropsychological equations that can lead to psychiatric disturbances.

Sustained emotional arousal can also lead to sustained turmoil in our bodies, yielding various psychosomatic disorders and disturbances in our everyday quality of life. Similar effects can also be observed in animal models. In the midst of emotional disequilibrium it is often difficult, for both animals and humans, to find the affective comfort zones that are essential for mental equilibrium. At least half of the scientific problem for understanding mental disorders is a clarification of the neural nature of affective processes in the brain. It is this part of the overall equation that the animal brain research can finally clarify. In doing so, it opens up the possibility of discoveries of new affective chemistries within the mammalian brain, for instance emotion specific neuropeptides that are excellent targets for new drug development (Panksepp and Harro, 2004).

At risk of overemphasis, the animal work provides little insight into the cognitive interventions and restructurings that are essential for effective psychotherapies. Although the cognitive aspects of emotional disorders must be studied through human first-person self-reports, a knowledge of cross-species emotional systems provides coherent systemic views about the nature of core affective states, including the social nature of placebo effects that are so useful in most effective psychotherapeutic interventions. It is often a relief for clients to learn that they have fundamental affect generating and mood regulating systems in the brain that can become overwhelmed. By blending the neuroscientific affective and psychological cognitive knowledge, we can achieve more robust understanding than by

either alone, leading to blended disciplines such as the robust emerging synthesis known as neuropsychanalysis (Solms and Turnbull, 2002).

In sum, since various affective feelings encourage individuals to obtain and retain resources, they may hold the keys to how we prioritize actions, as well as the associated cognitive plans. Although adult human intellectual structures may seem totally intertwined with emotional feelings, affects need to be distinguished as distinct brain processes that have profound developmental consequences for the emergence of cognitive structures. For instance, when we engage positive emotional feeling in children, so their intellectual passions are aroused, we open up robust possibilities for the construction of new cognitive terrain. Persistent negative feelings, many emerging from ambivalent love relations, can promote the emergence of distinct cognitive structures that can have lifelong implications for attitudes and behavioural strategies (Schore, 2001). The core emotions of animals (just like those of young children) are not hidden under layers of neocortical inhibitions – of symbolic repressions and other defences – so their feelings are expressed more directly and more intensely, which makes their affective attitudes especially informative through careful neurobehavioural inquiries.

On the neglect of affect in neuroscience

It is remarkable that, through most of the twentieth century, brain science has had so little to say about how affective experience is created in the brain. Indeed, most brain researchers and philosophers still believe that the existence of subjective experience remains an impenetrable mystery to science. Of course, how mind emerges from the physiochemical processes of the brain remains a major challenge for modern neuroscience, but the neural nature of many basic emotional experiences in humans are now penetrable because all mammals share the foundational processes for affective consciousness. As already noted, emotional feelings are only one of several distinct types of affects. There are also the various pleasures and pains of sensation (sensory affects). Another major category may be the many homeostatic arousals and moods (hungers, thirsts, etc.) and post-consummatory satisfactions, as well as various general bodily feelings of exhilaration and tiredness (interoceptive affects). My focus here will be on the emotional affects which seem to be organized around instinctual action coordinates in the brain. I follow the view of William James that

Instinct is usually defined as the faculty of acting in such a way as to produce certain ends, without foresight of the ends, and without previous education in the performance.

(James 1890: 383).

I make/accept the additional assumption that most affective processes are also instinctual, and emerge largely from the underlying neural substrates that generate the corresponding instinctual-emotional actions. These underlying affects are, I believe, the main sources of what behaviourists typically call rewards, punishments and reinforcements.

Table 2.1 Distinct attributes types of cognitive and affective consciousness (see Panksepp 2003)

<i>Affective</i>	<i>Cognitive</i>
State functions	Channel functions
Less computational	More computational
More analogue	More digital
Intentions-in-action	Intentions-to-act
Action-to-perception	Perceptions-to-action
Neuromodulator codes (e.g. Neuropeptides)	No Neurotransmitter codes (e.g., heavily glutamatergic)
More sub-neocortical	More neocortical

How the multidimensional nature of affective consciousness is integrated with various form of cognitive consciousness within the human mind remains largely unexplored territory in neuroscience, although there is currently much excitement about such topics. By contrast, such issues are well developed in the clinical psychological/psychiatric approaches to mental disturbances. However, despite the profound interpenetration of affective and cognitive dimensions of mental life, it is important to envision the many differences between these types of mentation (see Table 2.1). Briefly, cognitive aspects of mind are those that arise from the harvesting and processing of information from the exteroceptive senses, while affective aspects of mind are intrapsychic processes that are more closely linked to interoceptive processes and evolved brain states.

Such distinctions between cognitive and affective aspects of mind (Table 2.1) allow us to restore ‘energetic’ concepts to the intellectual agenda in the mind sciences. With modern affective neuroscience research strategies, we can now envision how affect is actually generated within the brain (Panksepp, 2003, 2005b). For instance affective consciousness is reflected in various intentions that are part and parcel of instinctual actions, while cognitive consciousness is more involved in intentions *to* act. Further, during emotional arousal, actions guide perceptions, while during cognitive mentation, perceptions guide actions. While affective consciousness is more closely affiliated with concepts such as ‘energetic field dynamics’ in the brain (whereby enormous neural ensembles work together to establish characteristic tensions and movements in the body), cognitive consciousness is based more on ‘information processing’ principles. For effective higher cognitive activities, the lower emotional substrates are often kept under tonic regulatory inhibition. Presumably one major goal of psychotherapy is to promote cognitive regulation of affective processes, in the many ways that may happen, without losing touch with one’s feelings.

One of the most important distinctions between emotional feelings and thoughts is that the primary locus of control for affective consciousness is sub-neocortical, while that of cognitive consciousness is neocortical. It is important to note that when the primary-process affective zones are damaged, the whole mental apparatus tends to collapse. In contrast, damage to neocortical zones tends to impair more

specific tools of cognitive consciousness, while basic capacity for affective livingness is retained (Shewmon et al., 1999). This distinction lies, I believe, at the root of one of William James's classic assertions about consciousness:

The traditional psychology talks like one who should say a river consists of nothing but pailful, spoonful, quartpotsful, barrelsful, and other moulded forms of water. Even where the pails and the pots are actually standing in the stream, still between them the free water would continue to flow. It is just this free water of consciousness that psychologists resolutely overlook. Every definite image in the mind is steeped and dyed in the free water that flows around it. With it goes the sense of its relations, near and remote, the dying echo of whence it came to us, the dawning sense of whither it is to lead. The significance, the value, of the image is all in this halo or penumbra that surrounds and escorts it, – or rather that is fused into one with it and has become bone of its bone and flesh of its flesh.

(James, 1890: 255)

If the 'free-water' of affect has embedded within it a vast number of 'pailfuls' and 'spoonfuls' of cognitions (most of them epigenetically created), we can better appreciate why we need special research strategies to clarify the affective flow of mind.

Although cognitions and affects obviously merge in phenomenological experience, currently there is an all too common imperialistic tendency among cognitive neuroscientists to conflate emotions and cognitions to an extent that may hinder our capacity to focus scientifically on the distinct neural aspects of the core affects. It is a great flaw, I believe, not to recognize the distinct neuro-evolutionary nature of affect, a form of primary process phenomenal experience that is more ancient than most of our cognitive capacities to think, reflect and exhibit reasoned judgement. If we just consider the evolutionary layering of the brain (MacLean 1990), the raw affective substrates of mind have a more ancient evolutionary history than our sense of cognitive awareness (Panksepp 1998b). Of course they eventually co-evolved in higher limbic regions of the brain, but not to recognize their independent interoceptive and exteroceptive sources may be as scientifically muddled as not to recognize the distinct, albeit functionally integrated, functions of liver and the kidney within medical science. By making disciplined distinctions between affective and cognitive forms of consciousness, one can better study and integrate neurobiological and psychological approaches to psychiatric imbalances, without neglecting the obvious, that these two mental abilities are thoroughly blended in our mature cognitive experiences.

I suspect that the desire to conflate emotions and cognitions has three sources. *The first* is the obvious fact that so much of our cognitive life revolves around our feelings, and in adult mental experience, certain types of cognitive and emotional arousals tend to go together. Obviously, during the first years of human life, children can have intense affects that are not accompanied by rich cognitive reflections. *The second* may be related to the fact that it is much easier to conceptualize the

affective-cognitive interactions in human mental life than to implement scientific strategies which can get at the neuro-causal underpinnings of the ancient pre-propositional (objectless) affective states, which requires animal brain research and, it is hoped, conducted with an emotional sensitivity that has not always been a characteristic of animal research. *The third* may be the power of constructivist perspectives in human affect science and cultural studies: everything in our minds seems to be largely constructed by our experiences in the world. It is hard for many to imagine that affect can exist independently of thoughts – that in their initial developmental form they are largely object-less states of mind which, through various types of learning, come to imbue the material-cognitive world with values (leading to fully blended object-relations processes during development). From practical clinical perspectives, if we do not fully consider both the cognitive dispositions of our clients and the affective tools they possess as gifts of nature, we cannot work optimally with the many ways emotional energies are skewing their lives. By recognizing affective, energetic states of mind as distinct entities, we can bring a large number of novel neurological insights to bear on psychiatric problems (Panksepp 2004).

It is largely through our search for the neuro-causal mechanisms of the various affects in animal models that we can aspire to study emotional-affective mechanisms independently of the infinitude of possible associated cognitions that clinicians need to consider. For instance, we can instigate affective states simply by electrically and chemically stimulating specific areas of the brain, with no intervening cognitions. Regrettably, there are only a handful of investigators who pursue such neuro-evolutionary psychobiological inquiries. Hence most still find it hard to conceive that evolution could have constructed any mental contents in brain dynamics that are independent of environmentally driven cognitions. However, raw affects, as primary-process value systems, may be initially objectless in newborn mental lives. We can experience fear without having an object of fear, which may lead to free-floating anxieties. Certain states of the nervous system may have affectively experienced contents without any objects in the world to which they are *intrinsically* attached. In other words we can feel exhilarated desires without knowing what in the world has aroused them. Our instinctual feelings are neither initially nor intrinsically linked to many distinct object and events in the world. However, such linkages, often perceived as causal, are rapidly created within the mental apparatus. We then readily project such states onto stimuli that then become cognitively fear-filled. We can feel both sad and joyous without those feelings being associated with distinct states of the world, even though those feelings readily get linked to a variety of world events. Although classical conditioning is a useful technique for studying some of these learned linkages, we remain far from understanding how higher cognitive affective-perceptual merging transpires in the brain. The image that may be most correct is that large-scale emotional-affective attractor landscapes, that are intrinsically (non-reflectively) intentional, pull in relevant cognitive relationships the way strong weather systems embrace and change the landscape, often in a lasting way.

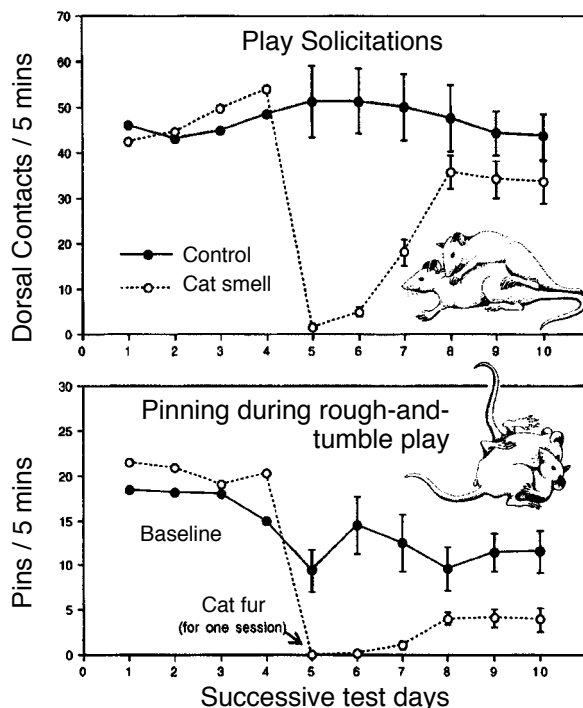


Figure 2.1 A single exposure to a small ~20 mg sample of cat hair on the fifth day of testing inhibited rat rough and tumble play completely, and this contextual fear response continued for up to five subsequent test days, at higher levels with the measure of pinning (bottom) and less with the dorsal contact measure of play solicitation (top). Reprinted from Figure 1.1 of *Affective Neuroscience* (Panksepp 1998a) with permission of Oxford University Press.

The basic emotional systems, at the outset of infant psychological development, are only weakly linked to the objects of the world, and often in surprising ways. For instance, rats are not intrinsically afraid of the sight of cats. However, states of fearful trepidation are aroused by the mere smell of predators such as cats and ferrets (Figure 2.1), and only when such fearful smells are associated with predatory intent, do rats gradually become afraid of the sight of cats. However, such intrinsic olfactory fears are not evident in primates. For them, sudden looming objects are fearful. There are also other universal cross-species 'objects' of fearfulness. For instance, pain can arouse fearfulness in all mammals. However, there are few intrinsic object-related fears; most are learned. The FEAR system can be linked, through associative learning, to a large variety of external stimuli (some being prepared for ultra fast learning, such as snakes and spiders for humans, while other stimuli are difficult to link up, such as the taste of sweetness).

It is an open question how many intrinsic 'objects' the other basic emotional systems have. Surely, bodily restraint may be a common primal source of anger.

Gentle touch may activate nurturance. Whether sexual lust has intrinsic links to any distance receptors in human, such as the perceptual features of a nubile, symmetrical and healthy body, seems likely but unproved. On the other hand moths and many other animals are aroused and attracted intrinsically by sexual pheromones. Human eroticism is probably robustly linked to certain kinds of somatosensory inputs, but most linkages are learned, leading to possibilities for a variety of sexual preferences and fetishes.

The concept that raw affects are initially objectless in the brain, allows a fruitful rapprochement between basic emotion theory and constructivist views of emotions. The basic affective tools that evolution has provided – the ancestral voices of the genes to use one provocative phrase – emerge in brain development without initial strong intrinsic connections to world events. It is through life experiences, both individual and cultural, that such linkages are forged. Constructivist theories of emotions obviously need some basic tools for anything useful to be constructed. The intrinsic, evolutionarily provided emotional abilities revealed by affective neuroscience are such tools. Even though such emotionally valenced systems cluster into constellations of positive and negative affects, it seems unlikely that only two primal types of affective feelings are the raw materials from which all other affects are created within mammalian brains. Indeed, affect has to be grounded in action tendencies, and cannot be an independent sensory function of the brain.

In psychoanalytic terms, each individual's experiences cathect the important objects in their world. Through learning, as well as through the guiding role of initial genetic variability in emotional systems, each person becomes a unique affective being through their individual genetic inheritance and epigenetic experiences in the world. In behavioural terms, fluctuating affective processes serve as reinforcements for learned behavioural change. However, to conceptualize 'reinforcement' without any affective content, as is still popular in neurobehaviourism, reflects, I believe, a flawed materialistic ontology. It leads to the arrogance of a ruthless, fine-scale neuronal reductionism, that does not adequately reflect the large-scale neural network dynamics of the brain.

As William James almost surmised in Chapter 24 of his *Principles*, raw affective experiences reflect an instinctual form of consciousness (James 1890). Also, as Freud once noted:

No knowledge would be more valuable as a foundation for true psychological science than an approximate grasp of the common characteristics and possible distinctive features of the instincts, but in no region of psychology were we groping more in the dark.

(Freud 1920: 31–2)

Unfortunately, such concepts were largely discarded at the beginning of the cognitive revolution when computer-computational based information-processing became the prevailing metaphor for mind. Instinctual responses, which could have encouraged development of energetic concepts were neglected, partly because

there was no efficient way to study them in the human laboratory and partly because adult humans are adept at developmentally emergent, culturally promoted inhibitions over instinctual displays. With the victories of first the behaviourist and then the cognitivist revolutions in twentieth century psychology, it was gradually forgotten that such instinctual displays reflect ancient mechanisms of mind that we still share with other animals. However, now that the affective neuroscience revolution is ripening, a careful analysis of emotional-instinctual behaviours in animal models may finally garner insights into the nature of the energetic instincts from which raw emotional-affective experiences emerge. And in using the concept of ‘instinct’ I am not arguing that they simply reflect genetic programmes of the brain, but rather, the genetic heritage interacting with early environments that construct categorically distinct developmental neural landscapes in the brain-mind.

In sum, the guiding premise of the ethology-inspired affective neuroscience approach, inspired by a *dual-aspect monism* ontology and epistemology, is that emotional instinctual behaviour generating systems in mammals are the fundamental substrates of emotional feelings. Thereby, we can use instinctual emotional behaviours as reasonably veridical measures of certain basic affective feelings. In other words, angry behaviours reflect angry feelings; fearful behaviours reflect certain anxieties; separation distress systems may help create sadness. According to this view, all basic emotions in the brain have dedicated, evolutionarily derived, circuits for the mediation of certain core psychobehavioural states. Indeed, since Walter Hess’s classic work (Hess 1957), we have known that one can evoke angry behaviour in all mammals during localized electrical stimulation of the brain (ESB) from electrode sites situated in essentially identical subcortical neural regions. He found that complex behaviour patterns, responsive to the environment, as well as a symphony of physiological changes to support such emotional states went together as a unified package.

Many other emotional states can be evoked in this way, and when we ask animals whether they like or dislike such brain stimulation, they are rarely neutral about such states. Such states are also accompanied by sudden affective shifts in humans (Panksepp 1985; Heath 1996), and one can obtain antidepressant effects from certain brain areas (Mayberg et al., 2005). It is through a study of such ESB-evoked emotional states that a lasting understanding of the basic emotions can be achieved. We can be certain that these emotions are organized by intrinsic genetically dictated systems of the brain, since we can activate them by placing electrical ‘noise’ with no intrinsic informational content, and obtain coherent emotional responses in all mammals that have been studied. If these regions of the brain are damaged, consciousness is seriously impaired. A great deal has already been learned about these complex anatomies and neurochemistries of these circuits (Panksepp 1982, 1985, 1998a, 2005b), but a great deal more needs to be learned. An overview, constructed with synoptic inspiration from Doug Watt (1999), is available in Table 2.2.

Table 2.2 Summary of the key neuroanatomical and neurochemical factors that contribute to the construction of basic emotions within the mammalian brain

<i>Basic emotional systems</i>	<i>Key brain areas</i>	<i>Key neuromodulators</i>
General positive motivation SEEKING /expectancy system	Nucleus accumbens – VTA Mesolimbic and mesocortical outputs Lateral hypothalamus – PAG	Dopamine (+), glutamate (+), Opioids (+), neurotensin (+), many other neuropeptides
RAGE /anger	Medial amygdala to BNST , medial and perifornical hypothalamic to PAG	Substance P (+), ACh (+), glutamate (+)
FEAR /anxiety	Central and lateral amygdala to medial hypothalamus and dorsal PAG	Glutamate (+), CRH , CCK , DBI , alpha- MSH , NPY
LUST /sexuality	Cortico-medial amygdala, BNST , preoptic hypothalamus, VMH , PAG	Steroids (+), vasopressin , oxytocin , LH-RH , CCK .
CARE /nurturance	Anterior cingulate, BNST Preoptic area, VTA , PAG	Oxytocin (+), prolactin (+) Dopamine (+), opioids (+/-)
PANIC /separation/distress	Anterior cingulate, BNST and preoptic area Dorsomedial thalamus, PAG	Opioids (-), oxytocin (-) Prolactin (-), CRF (+) Glutamate (+)
PLAY /joy	Dorso-medial diencephalon Parafascicular area, PAG	Opioids (+/-), glutamate (+) ACh (+), TRH ?

Some terms are presented in bold (a) if there is massive anatomical convergence of emotional primes (i.e. **PAG** in the second column) or (b) if they are neuropeptide regulators that may be targets for new medicinal development (i.e. those in the third column).

The monoamines serotonin, NE (norepinephrine) and DA (dopamine) are typically not indicated as they participate to some extent in all emotions. Also, the higher cortical zones devoted to emotionality, for which there is modest preclinical data (albeit considerable human data), mostly in frontal, temporal and insular cortices are not indicated.

Index:

ACh acetylcholine	alpha- MSH alpha melanocyte stimulating hormone
BNST bed nucleus of the stria terminalis	NPY neuropeptide Y
CCK cholecystokinin	PAG , periaqueductal grey
CRH corticotrophin releasing hormone,	VMH ventromedial hypothalamus
DBI diazepam-binding inhibitor	VTA ventral tegmental area
LH-RH lutenizing hormone-releasing hormone	

Minus signs indicate inhibition of an emotional process, and plus signs activations

Source: Data derived largely from Panksepp (1998a), as first abstracted by Watt (1999)

Brief functions summaries of basic emotional systems

Considerable evidence from animal brain research suggests that at least seven basic emotional systems are concentrated in subcortical regions of the brain and are situated in essentially the same brain regions in all mammals (Panksepp 1998a). This knowledge has been derived by the powerful causal technique of electrically and chemically stimulating specific regions of the brain. The seven basic systems identified so far are those that mediate SEEKING, FEAR, RAGE, LUST, CARE, PANIC and PLAYfulness. Modern neuroscience is providing a detailed understanding of many critical parts of integrated brain systems but should have no pretense at having clarified the psychological whole. As already indicated, the many interactions with cognitive processes remain largely unstudied at basic neuroscience levels, and indeed such psychological questions are easier to pursue in humans, where introspective reports are more readily harvested. Indeed, cognition–emotion interactions may need to be studied on a species by species basis. However, since the general principles of core emotional systems are evolutionarily conserved across mammalian species, as well as some other vertebrates, we can finally understand the rudiments of our nature by understanding the emotional neurology of our fellow creatures. These psychobehavioural ‘endophenotypes’ can provide a new foundation for biological psychiatry (Panksepp 2004, 2006).

Let me focus on the Big Seven by starting with the most intriguing and highly generalized emotional system and one that has not been well recognized in most psychological theories. This system helps mediate the exhilaration and euphoria that is often characteristic of intense goal-seeking behaviours. In behavioural terminology, it would be considered the ‘appetitive motivational system’ that mediates the exploration, search and foraging for resources, with many neural subcomponents (Ikemoto and Panksepp 1999). In more psychological terms, it energizes desire and the many rich and energetic engagements with the world, as individuals seek goods from the environment as well as meaning from the everyday occurrences of life.

First, a remarkable system that has emerged from brain research is that which mediates the appetitive desire to find and harvest the fruits of the world, a state perhaps similar to the psychoanalytic concept of libido. I originally called this the EXPECTANCY desire system, but when that did not attract much attention, as did a subsequently advanced ‘wanting’ conceptualization of this system (Berridge and Robinson 2003), I have relabelled it the SEEKING system to sustain the ethological-behavioural focus that every emotional system deserves. To my relief, this has now proved to be a more attractive label, even though the core concept has not changed. We can now also recognize this system as a major foundational substrate for Spinoza’s concept of *conatus* (Spinoza 1985). Animals ‘love’ to self-activate – to self-stimulate – this system in addictive ways. This system should be conceptualized as a basic, positively motivated action system that helps mediate our desires, our foraging and our many positive expectancies about the world, rather than the behaviouristic concept of ‘reinforcement’ (Panksepp and Moskal

2006). Although highly resolved cognitive information descends into this system, the output is much less resolved, coaxing the animal to behave in libidinal, appetitively aroused, goal-directed ways. The many interactions of this system with higher brain regions help highlight the degree to which basic emotive state control systems can link up with cognitive systems that mediate secondary-process awareness and appraisals. This system operates in both positive and negative emotional situations (e.g., seeking safety) and helps maintain fluidity in behaviour as well as learning and other cognitive activities (Ikemoto and Panksepp 1999). This system can help generate various energetic mental states and delusional behaviours that are characteristic of acute-florid psychotic breaks, where one's imagination, and ability to make causal inferences from correlated events, can become excessive. Indeed, all basic emotional systems help mediate learning. Within the normative range of activities, such learning is clearly adaptive, but with over or under arousal, delusional claims become amplified, yielding various mental health consequences.

Second, the core structure of one of our major FEAR systems, very similar across all mammalian species, courses from central amygdaloid regions down to the periaqueductal grey (PAG). This system seems to generate a pure form of trepidation and flight through various types of learning from simple associative to conceptual. This energetic state, of uptight trepidation, can become associated with many events. Our worlds have abundant dangers, many of which we need to learn about, and others which we intrinsically fear. For instance, most young humans do not enjoy either unprotected heights or strange dark places where one's mind is readily captivated by fear. Rats, on the other hand, enjoy darkness more than light; as already noted, they become extremely timid in the presence of small samples of cat fur. That emotional response has been wired in by evolution to help rats avoid places where predators hang around. Neuroscientists have unravelled the details of classical conditioning that regulate fear. They have tended to focus on information that enters the FEAR system via so called 'high-roads' (more cognitive-perceptual inputs), and via 'low-roads' (the more primitive sensory inputs). Regrettably most have ignored the 'Royal Road' – the evolved FEAR system itself, which governs the instinctual action apparatus that intrinsically helps animals avoid danger (Panksepp 2004). There are other distinct anxiety systems in the brain, for instance those that mediate separation anxiety, and there may be others that have yet to be clearly conceptualized. In any event, the arousal of these systems evokes or leads to mental tensions that characterize various anxiety disorders (Panksepp 1990). Most of the many chemistries of this system (Table 2.1) remain undeveloped in human biological psychiatry. One can anticipate that future medicines that regulate these systems will be most effective when applied in psycho-supporting therapeutic contexts.

Third, animals need to protect life-sustaining resources, and a major emotional response to achieve that emerges from the RAGE system. This system can also be aroused by restraint and frustration, and at times, even fear. If we do not get what we want, it is likely that there will be more activity in our RAGE system than there would be otherwise. This system has been intensively studied under

the rubric of the defence motivation system (Siegel 2005). As with every other subcortically concentrated emotional system, higher cortico-cognitive process can provide inhibition, guidance and other forms of higher regulation over such emotional impulses, more effectively in adults than children. We presently have no psychotropic medications that can specifically control pathological anger, but the chemistries that are concentrated along this circuit (e.g., Substance P to activate and opioids to inhibit) may eventually yield such neurochemical tools to facilitate emotional self-regulation in conjunction with the education of higher cognitive processes (Panksepp and Zellner 2004). The neuroscientific analysis of RAGE circuitry NO Comma will yield other new medicines, even though the critical importance of work on this system for understanding aggressive urges is not as well recognized as it should be.

Fourth, sexual courtship and orientations are strongly built into the brain LUST circuits of all mammals. Only humans can exercise extensive cognitive choice in such matters, because of the richness of their higher cerebral mechanisms. In any event, male and female sexual systems are laid down early in development, while babies are still gestating, but they are not brought fully into action until puberty, when maturing gonadal hormone secretions begin to spawn male and female sexual desires. However, because of the way the brain and body get organized, female-type desires can flower in male brains, and male-type desires can thrive in female brains. However, like all emotional systems, especially through reciprocal controls with cognitive processes, there is abundant plasticity to allow learning and culture to promote a complexity that cannot be disentangled in animal-based neuroscience. Still, it is noteworthy that orgasmic feelings in humans arise from the deep subcortical brain systems that mediate animal sexuality (Holstege et al., 2003).

Fifth, after reproductively successful sexual congress, the next generation could not thrive if it were not for CARE systems that encourage parents, especially mothers, obsessively and pleasurably to care for their offspring. The maternal instinct, so rich in every species of mammal (and bird too), allows young organisms to prosper. The more devoted the care, such as abundant ano-genital licking in rats, the stronger psychobehavioural resilience and competitiveness of the next generation (Meaney 2001). How does the female brain change from a non-maternal to a maternal state? The changing tides of peripheral oestrogen, progesterone, prolactin and brain oxytocin figure heavily in such neural transformations, but the sustained exposure of both females and male rats can also sensitize the CARE giving circuitry. Perhaps humans could simply sustain maternal care with their higher cognitive-conceptual abilities, but that is an assumption rather than a demonstrated fact. Because males and females have such large differences in these brain and body systems, males require more emotional education to become fully nurturant, engaged caretakers. Only in species where paternal participation in infant care is critical for the proper nutrition of the lactating mother, as in Titi monkeys and penguins, is paternal nurturance as natural as the maternal variety. To have left the CARE urge to chance, or the vagaries of individual learning, would

have probably assured the extinction of those species. Although there are many details to be clarified, hormonally promoted sensitization of CARE circuitry, probably by genetic activations that remain to be documented, encourage all mammals to respond supportively to their newborn babies – those squiggly infant lives that carry our hopes and our recombined packages of genes into the future.

Sixth, when young children get lost, they are thrown into a PANIC. They cry out for care, and their feelings of sudden aloneness and distress probably reflect the same ancestral neural codes from which adult sadness and grief are built. A critical brain system for the feeling of social loss is that which yields separation distress calls (crying) in all mammalian species. Brain chemistries that exacerbate feelings of distress (e.g., Corticotrophin Releasing Factor) and those that powerfully alleviate distress (e.g., brain opioids, oxytocin and prolactin) are the ones that figure heavily in the genesis of social attachments and probably the regulation of depressive affect (Nelson and Panksepp 1998). These are the chemistries that can assist or defeat us in our desire to create intersubjective spaces with others, where we can learn the emotional ways of our kind. Many social chemistries remain to be found, but when they are, we will eventually have new ways to help those whose social emotional ‘energies’ are more or less than they desire (Panksepp 2003). Precipitate arousal of this system may be one of the underlying causes for panic attacks. This knowledge may also link up with a better understanding of childhood disorders such as autism, since some children with this condition may be socially aloof if they are addicted to their own self-released opioids as opposed to those activated by significant others (Panksepp et al., 1991).

Seventh, young animals PLAY with each other, in order to navigate social possibilities in joyous ways. The urge to play was also not left to chance by evolution, but is built into the instinctual action apparatus of the mammalian brain. It could be argued that PLAY is that experience expectant process which brings young animals to the perimeter of their social-knowledge, to psychic places where one must pause to contemplate what one can or cannot do to others. Play allows animals to be woven into their social structures in effective ways. It may achieve this by utilizing the many plasticities of the brain to create social-brains that will work optimally in the environments in which young animals find themselves. Perhaps social brains are created as much by a few basic social-emotional tools as any type of refined evolutionary moulding of higher cognitive-type brain ‘modules’. We know less about this emotional system than any other, partly because so few are willing to recognize that such gifts could be derived as much from mother nature as our kindest nurture. We have challenged our colleagues to consider that joyous ‘laughter’, so common in human play, also exists in other species (Panksepp and Burgdorf 2003), and that if we do not build social-structures that promote real childhood play, we may be promoting cultures that have more problems such as Attention Deficit Hyperactivity Disorders. Human children, just like rats that are not allowed safe places to exercise their ludic energies – their urges for rough-and-tumble engagement – may release such energies more readily in classroom situations. To be too playfully impulsive within the classroom is to increase the likelihood

that one will be labelled as an ADHD-type troublemaker, destined to be quietened with play urge reducing amphetamine and cocaine-like psycho-stimulants drugs. The animal model work already indicates that ADHD-type organisms can benefit from extra rations of rough-and-tumble activities each and every day (Panksepp et al., 2003). Early play may be essential for emergence of well-modulated social abilities, perhaps partly by activating many genetically controlled pro-social brain plasticities that are finally being clarified.

The above is not necessarily an inclusive list of basic emotions, but it is one that can be rigorously and well defended on the basis of neuro-psychobehavioural facts – a full triangulation among the essential research strategies. One can easily suggest the existence of other basic emotional systems, from disgust to dominance, but there is presently not yet enough compelling data to include them as fundamental *emotional systems*. Obviously, *disgust* is a basic sensory affect, but it might be a mistake to consider the neural substrates as constituting a blue-ribbon, grade-A emotional system. On the other hand, even though it is easy to generate an evolutionary scenario for the emergence of *dominance* as a basic system, its aspirations would by necessity be defeated in many members of each species. It is as likely that dominance emerges from the interactive confluence of many brain basic emotional systems – of PLAY, RAGE, FEAR, SEEKING and LUST, or some permutation of them.

Likewise, there are many socially constructed emotions, from pride to shame, that may arise from our ability to experience second-order awareness in various socio-cognitive contexts that arouse patterned symphonic activities in several basic emotional systems. However, no one has yet generated a scientific strategy to identify how, precisely, they may emerge. Human brain imaging is really not of much use in adjudicating such issues, since it is not well suited to clearly visualizing densely packed opponent-process systems in subcortical regions of the brain, where energetic states are created as much by the power of molecules as by the abundance of action potentials. Still, it is easy to envision how cold non-emotional cognitions could be transformed into hot affect-drenched appraisals through the widespread influence of a few emotional primes and the various attentional state control systems of the brain. Most of that remains uncharted research territory, but the basic emotional systems may be essential tools for the construction of many unique mental complexities in our species.

My short list of seven basic emotional systems is not meant to suggest that there are no other affects. For instance, the pleasures and displeasures of sensation are numerous, but they are not appropriately placed in the *emotion* category, for they are not dependent on ‘moving out’ dynamically to engage the environment in emotion characteristic ways. There are also a large variety of bodily states, from many hungers to fatigued states of the flesh, that need to be considered in any comprehensive affect science. My focus here has been only on the basic emotional systems shared by all mammals, systems that are not yet widely accepted, or even acknowledged, by neurobehaviouristically focused investigators who would deny mentality to the other animals, as if all of that was created through the special creation of the human neocortex.

We remain at the tail end of an era ruled by rather stark behavioural biases – that mental complexities are created by learning through systematic correspondences of certain behaviours with unified reward and punishment processes (Rolls 1999), which create generalized approach and avoidance tendencies. My reading of the evidence is that there are many distinct rewards and punishments in the brain, and only some should be deemed emotional. On the positive emotional reward side, we have the euphoria of SEEKING, the appetitive eroticism and orgasmic pleasures of LUST, the maternal devotions of CARE, and the exhilarating joy of PLAY. Among the distinct punishments we have the trepidation of FEAR, the pain of grief-ridden PANIC, and the powerful intensity of RAGE. In addition there are a large number of sensory rewards and punishments, and bodily homeostatic states that feel good and bad. For their fulfillment, via learning, all need the SEEKING system.

Thus, the positive emotion of SEEKING serves a super-ordinate function, as an essential infrastructure and scaffolding for all of the other basic emotions. It facilitates the goal-directedness of all the positive affects, and may promote the seeking of safety (exhilarated flight when FEAR is too intense) or the seeking of victory (when RAGE has promoted intra-specific combat over resources). Thus, even intense negative emotions are tinged with the support of a goal-directed SEEKING urge.

It is one of the tragedies of academic psychology that so few experimentalists are willing to discuss the full complexities of affective life and the indirect cross-species empirical strategies we must pursue to understand them. This is largely because the affective aspects of mind can never be directly observed, only through the neurally controlled actions of organisms. Most experimentalists believe that one can simply discard the affective aspects of the neural network functions, and simply talk about neural control of behaviour. This type of ruthless reductionism is fundamentally flawed if the affective aspects of these circuits are fully considered. Instead of proceeding with gentle reductionistic strategies that do not marginalize the mentality of other animals, there is all too abundant and often simple-minded academic jousting over the priority of perspectives handed down to us from the pre-neuroscientific behaviourist and cognitive eras (Davidson 2003).

The neglect of affect in neuroscience and psychology may also be partly due to the fact that scientists are often in denial about their own emotional feelings, partly because of temperamental factors and perhaps even due to their abundant cortically based rational intelligence, which tends to inhibit primary process emotionality (Panksepp 2004). Evolution built more complexity into the mammalian nervous system than has yet been widely recognized by academic psychology, but clinicians cannot ignore this if they desire to help people. By working out the neurodynamic and neurochemical details of core emotional circuits in animal models, we can generate robust new knowledge to facilitate the psychotherapeutic enterprise.

Notes

- 1 Capitalizations (such as 'SEEKING') are used not only to emphasize that these words are not used in their everyday sense but refer to systems based on a brain analysis, but also and to minimize mereological fallacies, or part-whole confusions, which are so prevalent in modern cognitive neuroscience.

References

- Berridge, K.C. and Robinson, T.E. (2003) 'Parsing reward', *Trends in Neurosciences* 9: 507–13.
- Burns, R. (1785) 'To a Mouse'. Online. Available <http://www.readytogoebbooks.com/RB79.html> (accessed 4 January 2006).
- Davidson, R.J. (2003) 'Seven sins in the study of emotion: correctives from affective neuroscience', *Brain and Cognition* 52: 129–32.
- Freud, S. (1920) *Beyond the Pleasure Principle, Standard Edition*, ed. J. Strachey, Vol. 18, London: Hogarth Press.
- Heath, R.G. (1996) *Exploring the mind-body relationship*, Baton Rouge, LA: Moran Printing.
- Hess, W.R. (1957) *The Functional Organization of the Diencephalon*, London and New York: Grune and Stratton.
- Holstege, G., Georgiadis, J.R., Paans, A.M., Meiners, L.C., van der Graaf, F.H. and Reinders, A.A. (2003) 'Brain activation during human male ejaculation', *Journal of Neuroscience* 23: 9185–93.
- Ikemoto, S. and Panksepp, J. (1999), 'The role of nucleus accumbens DA in motivated behaviour, a unifying interpretation with special reference to reward-seeking', *Brain Research Reviews* 31: 6–41.
- James, W. (1890) *The Principles of Psychology*, New York: Henry Holt.
- MacLean, P.D. (1990) *The Triune Brain in Evolution*, New York: Plenum
- Mayberg, H.S., Lozano, A.M., Voon, V., McNeely, H.E., Seminowicz, D., Hamani, C., Schwab, J.M. and Kennedy, S.H. (2005) 'Deep brain stimulation for treatment-resistant depression', *Neuron* 45: 651–60.
- Meaney, M.J. (2001) 'Maternal care, gene expression, and the transmission of individual differences in stress reactivity across generations', *Annual Review of Neuroscience* 24: 1161–92.
- Nelson, E. and Panksepp, J. (1998) 'Brain substrates of infant-mother attachment: contributions of opioids, oxytocin, and norepinephrine', *Neuroscience Biobehavioural Reviews* 22: 437–52.
- Panksepp, J. (1982) 'Toward a general psychobiological theory of emotions', *Behavioural and Brain Sciences* 5: 407–67.
- (1985) 'Mood changes', in *Handbook of Clinical Neurology, Vol. 1 (45), Clinical Neuropsychology*, Amsterdam: Elsevier Science.
- (1990) 'The psychoneurology of fear: evolutionary perspectives and the role of animal models in understanding human anxiety', in *Handbook of Anxiety*, Amsterdam: Elsevier/North-Holland Biomedical Press.
- (1998a) *Affective Neuroscience: The Foundations of Human and Animal Emotions*, New York: Oxford University Press.
- (1998b) 'The periconscious substrates of consciousness: affective states and the evolutionary origins of the SELF', *Journal of Consciousness Studies* 5: 566–82.

- (2003) ‘At the interface of affective, behavioural and cognitive neurosciences: decoding the emotional feelings of the brain’, *Brain and Cognition* 52: 4–14.
- (ed.) (2004) *Textbook of Biological Psychiatry*, New York: Wiley.
- (2005a) ‘Affective consciousness: core emotional feelings in animals and humans’, *Consciousness and Cognition* 14: 19–69.
- (2005b) ‘On the embodied neural nature of core emotional affects’, *Journal of Consciousness Studies* 12: 161–87.
- (2006) ‘Emotional endophenotypes in evolutionary psychiatry’, *Progress in NeuroPsychopharmacology and Biological Psychiatry* in press.
- Panksepp, J. and Burgdorf, J. (2003) “Laughing” rats and the evolutionary antecedents of human joy?, *Physiology and Behaviour* 79: 533–47.
- Panksepp, J. and Harro, J. (2004) ‘The future of neuropeptides in biological psychiatry and emotional psychopharmacology: goals and strategies’, in J. Panksepp, (ed.) *Textbook of Biological Psychiatry*, Hoboken, NJ: Wiley.
- Panksepp, J. and Moskal, J. (2006) ‘Dopamine, pleasure and appetitive eagerness: an emotional systems overview of the trans-hypothalamic “reward” system in the genesis of addictive urges’, in S. Barsch, (ed.) *The Cognitive, Behavioural and Affective Neurosciences in Psychiatric Disorders* in press.
- Panksepp, J. and Zellner, M. (2004) ‘Towards a neurobiologically based unified theory of aggression’, *Revue Internationale de Psychologie Sociale/International Review of Social Psychology* 17: 37–61.
- Panksepp, J., Lensing, P., Leboyer, M. and Bouvard, M.P. (1991) ‘Naltrexone and other potential new pharmacological treatments of autism’, *Brain Dysfunction* 4: 281–300.
- Panksepp, J., Burgdorf, J., Turner, C. and Gordon, N. (2003) ‘Modeling ADHD-type arousal with unilateral frontal cortex damage in rats and beneficial effects of play therapy’, *Brain and Cognition* 52: 97–105.
- Rolls, E.T. (1999) *The Brain and Emotion*, Oxford: Oxford University Press.
- Schore, A.N. (ed.) (2001) ‘Contributions for the decade of the brain to infant mental health’, in Special issue of *Infant Mental Health Journal*, 22 (1–2): 1–269.
- Shewmon, D.A., Holmes, D.A. and Byrne, P.A. (1999) ‘Consciousness in congenitally decorticate children: developmental vegetative state as self-fulfilling prophecy’, *Developmental Medicine and Child Neurology* 41: 364–74.
- Siegel, A. (2005) *The Neurobiology of Aggression and Rage*, Boca Raton, FL: CRC Press.
- Solms, M. and Turnbull, O. (2002) *The Brain and the Inner World*, New York: Other Press.
- Spinoza, B. (1985) On the Origins and Nature of Ethics, in E. Curley (ed. and trans.) *The Collected Works of Spinoza*, Princeton, NJ: Princeton University Press.
- Watt, D. (1999) ‘Consciousness and emotion: review of Jaak Panksepp’s “Affective Neuroscience”’, *Journal of Consciousness Studies* 6: 191–200.