Ellis R, Newton N, eds. *Consciousness and Emotion.* Amsterdam-Philadelphia: J. Benjamins Publishing Company; 2005, p. 23–55.

# Energetic effects of emotions on cognitions
## - complementary psychobiological and psychosocial findings

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**Abstract.**
**The aim of this paper was to seek complementary themes between psychosocial and neuroscientific approaches to understanding interactions between emotions and cognitions, using the "affect-logic" approach of Ciompi and the "affective neuroscience" approach of Panksepp. Both view envision meaningful distinctions between emotional and cognitive processes, with the former being large-scale energetic states of brain and body that reflect evolutionarily adaptive action systems of the internal world, while the latter are more informationally encapsulated perception based processes that distinguish differences in the external world. In the intact organism, they are fully interactive; each can control the other. Emotions establish global, non-linear dynamic control over perceptual processes, memory and learning, and cognitions can trigger and regulate emotional processes. A variety of research strategies and predictions, ranging from the neurobiological to the psychosocial, are entertained.**

During the last two decades, it has become increasingly evident both in neuroscience (Damasio, 2000; Davidson, 2000; Derryberry & Tucker, 1992; Lane & Nadel, 2000; LeDoux, 1996; Panksepp, 1998) and in psychology (Dalgleish & Power, 1999; Lazarus 1999) psychopathology (Ciompi, 1988,1997a and c; 1999; Flack & Laird, 1998), social psychology (Forgas, 2000a and b; Kowalsky, 1999; Lawler & Thye, 1999; Parrott, 2001) and affect science (Davidson, Scherer & Goldsmith, 2003; Manstead, Frijda & Fischer, 2004) that emotions and cognitions are continually interacting in almost all mental activities. This, of course, does not mean that they cannot be meaningfully distinguished at either psychological and/or neural levels; they most certainly can (Panksepp

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2003a). However, the exact nature of these interactions remains far from clear, despite decade-long debates between leading psychologists on the relative primacy of affect over cognition or vice-versa (cf. Clore & Ortony, 2000; Lazarus, 1999; Zajonc, 2000).

Certain authors argue that emotions and cognitions are so intimately connected that it makes little sense to hold the classic distinction between passions and reason (e.g., Lane & Nadel, 2000). Others maintain that most data speak for bidirectional causality with emotions often activated by cognitive stimuli, and cognitive processes that can be selected and regulated by emotions (Damasio, 1994; Derryberry & Tucker, 1992; Forgas, 2000a and b; Izard, 1993; Lazarus, 1999; LeDoux, 2000; Panksepp, 1998a, 2004). The study of affective-cognitive interactions is further hampered by the fact that there exist no generally recognized definitions of the key-concepts of emotion and cognition, nor any consensus on their precise delimitations. The interdisciplinary exchange and comparison of data is therefore difficult, and new insights that might result from multidisciplinary approaches are not fostered.

In this paper, we seek to overcome some of these difficulties by comparing selected findings on affective-cognitive interactions from two different perspectives, between which remarkable convergences are gradually emerging: A low-level neuroscientific approach on the one side, and a high-level psychosocial[3] approach on the other. In line with our previously developed concepts of "affect-logic" (Ciompi 1988, 1997a and c, 2003) and "affective neuroscience" (Panksepp, 1982, 1998, 2001, 2003), we will defend the view that the distinction between emotion and cognition is not only possible and meaningful, but essential for understanding how they actually interact. While adhering to the notion of circular causality, we will mainly focus on the largely neglected problem of regulating and energizing influences that emotions, in our view, continually exert on almost all cognitive functions. The overall aim of this interdisciplinary dialog is to identify new working hypotheses for research that might be more evident in a truly bifocal view. In addition, an effort is made to clarify some aspects of the above-mentioned definitional problems on the basis of differential evolutionary roots of emotions and cognitions, and to bring certain nonlinear dynamic perspectives to bear on the cognition-emotion interaction debate (also see Lewis & Granic, 2000).

Our coverage of the literature must be highly selective, since both fields are expanding remarkably rapidly during the current "affect revolution". Moreover, our attention will be focused on a few so-called basic emotions like interest/curiosity, fear/panic, anger, joy or sadness (cf. e.g. Ekman 1984; Izard, 1971, 1992) for which the neurobiological substrata have been provisionally identified (Panksepp 1982, 1998a). Concerning countless additional nuances, our position is that many of the more complex emotions reflect epigenetic emergents of cognitive and socio-cultural abilities interacting with basic emotional systems (Ciompi 1997c; Panksepp & Panksepp 2000). Terms like affects, emotions or feelings are provisionally used here according to their largely overlapping meanings in different related fields of research. In the final discussion, we propose, however, a possible partial solution of the definitional issues.

## I. Neurobiological Perspectives

### Distinctions between affective and cognitive structures

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[3] We use the term "psychosocial" as a supraordinate notion including several overlapping fields like psychology, social psychology, psychopathology and sociology

From the perspective of affective neuroscience, the core affective/emotional systems of the brain (very largely sub-neocortical, and limbic/paleocortical) can be distinguished from the more recently evolved higher cognitive structures (thalamic-neocortical axis) on the basis of various criteria outlined previously (Panksepp, 2003a**)** and summarized in Table 1.

Table 1: Distinct characteristics of emotional/affective and cognitive/informational systems of the brain.

| Affective processes (Values) | Cognitive processes (Information) |
|---|---|
| • more subcortical | more neocortical |
| • less computational (analog) | more computational (digital) |
| • intentions in action | intentions to act |
| • action to perception | perception to action |
| • neuromodulator codes (e.g., more neuropeptidergic) | neurotransmitter codes (e.g., more glutamatergic, etc.). |

These distinctions force us to consider emotional brain functions in quite different ways than has been traditional (e.g., as just another form of information-processing), and recognize that core emotional systems operate in holistic dynamic ways (i.e., networks of neurons yield energetic brain and bodily *field-dynamics*) as opposed to discrete information processing algorithms. Such distinctions provide novel ways of looking at those pervasive emotion-cognition interactions that are currently of great interest to psychologists and other brain/mind scientists. Let us first briefly discuss the meaning of these six distinctions (derived from Panksepp, 2003a), for they are essential for the types of emotion-cognition interaction perspectives we plan to share. At the most fundamental level, we view the core of affective/emotional processes to be more deeply organic (i.e., their status cannot be understood without a "network doctrine" and molecular coding approaches to global neurodynamics) while cognitions are more deeply informational (i.e., their status may be dramatically clarified by information-only approaches). Thus, the governance of mind and behavior is a multi-tiered, hierarchical process with several distinct types of mechanisms —some more instinctual and built into the system by evolution, and the other more flexible and deliberative, relaying heavily on learning mechanisms.

*State functions vs. channel functions.* Marcel Mesulam (2000) highlighted that some aspects of the brain operate via discrete information channels (e.g., sensory-perceptual processes) while others operate more globally to control wide swaths of brain activity (e.g., obvious examples are the biogenic amine transmitter, brain-wide "spritzers" such as norepinephrine, dopamine and serotonin, that regulate neuronal arousability in global ways, but many neuropeptides also operate similarly to organize discrete emotions and motivations). In our estimation, those systems represent the best understood global state controls, but they are rather non-specific in terms of discrete emotions. In line with such a distinction, we envision emotional operating systems to consist of large ensembles of neurons working together, under the "symphonic" control of neuropeptides to produce coherent organic *pressures for action, thought and feelings* (from such a conception, an "energy" dimension for the core emotional state control systems is apt, and is supported by various affective neuroscience research strategies, especially neuropeptide regulation of such global processes - Panksepp, 1998a; Panksepp & Harro, 2004). This distinction can help us conceptually differentiate brain processes that produce highly resolved perceptual qualia from those aspects that are less sensorially distinct, holistic-energetic, and in the category of raw feels. The global *state-patterns* elaborated by such brain networks may generate an essential psychoneural context for perceptual consciousness - establishing a solid organic grounding for specific cognitive mental activities linked to discrete information-processing channels.

*Computational vs. non-computational forms of consciousness.* This view claims that channel-functions, since they are dependent on the coding of neuronal firing patterns in anatomically delimited channels, may be instantiated using symbol-manipulating computational models. On the other hand, the more organically instantiated forms of affective consciousness, although also dependent on neuronal systems, are not computational in the same sense. These systems depend on extensive networks in which the patterns of neuronal firings do not convey discreet information, but rather ensembles of neurons develop analog pressures within the brain/mind, creating certain types of holistic feelings and actions. We believe that these global state envelopes, most evident in the instinctual emotional urges of animals, are critically dependent on not only a variety of generalized multi-functional chemistries (e.g., amino acids and biogenic amines) but also emotion and motivation specific neurochemistries that are emerging as promising targets for new psychiatric drug development (Panksepp & Harro, 2004**).**

*Intentions-in-action* vs. *intentions-to-act.* During mind-brain evolution, the state-control systems of the brain help to establish embodied instinctual behavioral patterns along with internally experienced affective states (Panksepp, 1998a,b). These instinctual arousals constitute ancient psycho-behavioral controls allowing fundamental forms of cognitive activity and intentionality to emerge as an intrinsic part of the action apparatus. This, we believe, is what John Searle (1983) was referring to in his classic distinction between *intention in action* and *intentions to act*. Only with a more differentiated sensory-perceptual cognitive apparatus, such as that which emerged with higher cortical encephalization, can certain organisms operate in a virtual reality of cognitive-type activities, and thereby select and generate more deliberative behavioral choices (i.e., intentions to act) based upon the nuances of their perceptual fields.

*Action-to-perception processes* vs. *perception-to-action processes.* This distinction overlaps with the previous one. It assumes that the affective/emotional state-control systems help direct and focus specific attentional-perceptual fields. Only with the emergence of cognitive neural mechanisms capable of resolving highly detailed perceptual fields did the possibility emerge of buffering decision-making by higher executive processes (largely through the working-memory capacities of frontal lobes). Thus, sensorial awareness was transformed into perceptual guidance devices, permitting higher-order cognitive actions by organisms (yielding eventually the widely accepted perception-to-action processes, which are closely related to intentions-to-act processes). If ancient action-to-perception processes are fundamental for affective experience and primary-process intentionality (i.e., intentions-in-action), we may be better able to generate some general principles whereby emotion-cognition interactions transpire in the brain (i.e., certain perceptions and cognitions may be strongly linked to the field dynamics of emotional systems).

*Neurochemical codes vs. general glutamatergic computations.* Neuroscientists have long recognized that a distinction needs to be made between the rapidly acting neurotransmitters that directly generate action potentials (with glutamate being the prime example of an excitatory transmitter), and those neuromodulatory influences which bias how effectively the rapidly acting transmitters operate (with the abundant neuropeptides being prime examples of neuromodulators that may regulate emotionally and motivationally specific state-variables in widely-ramifying neural networks). In other words, there are distinct neurochemical codes for the core states of the nervous system, and a better understanding of these codes will allow us to better conceptualize how *state* functions become dynamic governors of *channel* functions, with the former weighing more heavily in generating distinct forms of affective consciousness and the latter being more important in resolving cognitive details. For instance, there will be neuropeptides that are able to conduct a neurotransmitter orchestra into new global field-dynamics (Panksepp, Panksepp & Harro, 2004). In this view, one can conceptualize how affective and cognitive processes are remarkably interpenetrant, while at the same time recognizing that the conceptual distinction can help guide both neuroscientific and psychosocial inquiries.

**Neurobiological aspects of affective-cognitive interactions**

We will first consider *three general ways in which affective-cognitive interactions may emerge*: i) How "low energy" cognitive attributions provoke "high energy" emotional responses; ii) How aroused emotional responses may lead to global shifts in attention, perceptual and cognitive encodings; and ii) How aroused emotional systems activate not only emotion-dependent actions but also a rapid retrieval of state-dependent cognitive information, which can become chronically changed because of the use-dependent plasticity of all basic emotional systems.

*Attributional triggers.* The fact that very small cognitive changes are able to precipitate enormous emotional outbursts is one key reason we need cognition-emotion distinctions. An interpretation of a glance, a shift in the tone of the voice, or an ambiguous comment that can be interpreted as an insult, can all provoke high energetic states that we call emotions. The fact that fairly modest changes in the informational content of an incoming cognitive signal can have such large effects provides striking support for the conclusion that there are evolutionarily prepared emotional states of the nervous system. How these "trigger spots" emerge as a function of emotional learning has been studied extensively through the use of classical conditioning paradigms in animals, such as the influential fear conditioning studies of LeDoux (1996), although such basic learning studies provide little insight into the evolutionary nature of the core emotional systems.

These types of trigger interactions are embedded in another global cognition-emotion interaction: Namely, that high cortical activity generally tends to inhibit subcortical emotional systems, and when individuals become intensely emotionally aroused (i.e., the felt affective intensity of an emotion is high), those states are generally accompanied by decreased cortical processing (for an overview of such brain imaging work, see Liotti & Panksepp, 2004). Clearly cortico-cognitive processes can inhibit emotional arousal, as has been demonstrated in fMRI studies where the subcortical arousals that accompany erotic feelings can be actively inhibited by recruiting higher frontal cortical executive functions (Beauregard, et al., 2001). It is only during mild emotional states that the cognitive and affective processes may be operating more synergistically, which may suggest that there are quite different forms of affect logic for low and high emotional arousals, following perhaps a classic Yerkes-Dodson inverted-U related functions between arousal and optimal behavioural control**.**

*Emotionally induced shifts in attention, perceptual focusing and cognitive encodings.* Although it is widely accepted that emotional arousal has such cognitive consequences, including distinct effects on attention, decision-making, judgments and memory (Burke & Mathews, 1992; Lowenstein, et al., 2001), there is, in fact, only modest neuroscience data highlighting how these interactions operate, for instance in cognition-emotion interactions such as temporal lobe inputs to amygdala (McGaugh & Cahill, 2003). The neurobiological mechanisms by which such effects are achieved in humans remain largely unknown. However, in animal research there is quite a large literature on pharmacologically and physiologically induced state-dependent learning (Cameron, 2002; Colpaert & Balster, 1988), and many of the molecules that have been used are mood modifiers in humans (Panksepp, 2004a**).**

*Use-dependent plasticities of emotional systems and retrieval of mood-congruent information.* In addition to emotion-specific learning capacities, the animal work has indicated that every emotional system can exhibit semi-permanent changes in the vigor of the emotional system itself. This has been most clearly demonstrated for fearfulness and irritability, where the stimulation of subcortical fear and anger systems can chronically shift an animal's long-term temperamental bias (Adamec & Young, 2000). These effects should have long-term consequences on cognitive tendencies, as has been most clearly exhibited in the flash-backs and ruminative tendencies of individuals suffering of post-traumatic stress disorders (PTSD) (van der Kolk, 2004). One of the ongoing challenges is to determine how such long-term neural changes can be reversed.

There is also only modest neuroscience data on how mood-congruent information is actually retrieved in the brain. Hence we will simply highlight some of the ways in which such issues can be studied in humans. In general, it is harder to do good cognitive work in animals, just as it is easier to do good basic emotion research on the animal models. An example of the type of work that could be achieved is highlighted by a recent paper by Zack & Poulos (2004), indicating that arousal of brain dopamine systems (which has been conceptualized as a SEEKING-Wanting-Expectancy system) with amphetamine in problem gamblers leads them to have urges to gamble and their semantic networks are primed to generate thoughts related to gambling. As additional emotion-specific chemistries are discovered, it will be most important to carefully study how the dynamics of mental contents shift as a function of affect biasing molecules (Panksepp, 1999; Panksepp & Harro, 2004).

**Basic emotional systems**

Several basic emotional systems in sub-neocortical regions of the brain have recently been identified. Cognitive interactions with them need to be worked out on a system by system basis, since each one has its own characteristics, as in sadness promoting pessimistic cognition and happiness promoting more optimistic cognitions (e.g., MacLeod & Salaminiou, 2001). Here we will briefly summarize the types of cognitive changes that we should expect from three major negative affect systems (FEAR, RAGE and PANIC, or sadness) and three positive affect systems (CARE, PLAY and SEEKING). Although each of these emotional systems remains sparsely studied in cognitive and psychosocial contexts, they all presumably follow the same patterns as the basic motivations such as thirst, hunger, and lust. When one is very thirsty or hungry, it is almost impossible to keep the cognitive apparatus from dwelling on the intensity of the feelings and how one might be able to alleviate the sustained distress. The same goes for various feelings of pain as well the urgent feelings of sexual arousal. It is an especially well demonstrated fact how frequently sexual thoughts emerge in the mind of young males, and presumably this is because there neurochemistries of sexuality can sustain certain types of pressures and biases on the cognitive apparatus (Panksepp, 1998a).

Again, we would emphasize that during intense emotional arousal, much of the cortico-cognitive apparatus becomes less active (Liotti & Panksepp, 2003), and probably more obsessive in terms of ideational flexibility, at least for the negative emotions. On the other hand, the positive emotions tend to broaden decision making processes, allowing one to recruit new ideas into an ever widening network of associations (Fredrickson, 2002) and increasingly productive social interactions (Isen, 2004).

Let us briefly consider each of the emotional systems mentioned above. Since it is difficult to access the cognitions and thoughts of other species in which the details of the core emotional circuits have been extensively studied, we must focus here on classically conditioned learning issues and use-dependent plasticities. In our estimation the semi-permanent changes in the reactivity of these systems that can emerge through experience (i.e., "use-dependent plasticity") may link up especially well to chronic psychiatric conditions, and we will provide one prominent exemplar of that type of change for each of the following six basic emotional systems.

FEAR: Classical conditioning of fear (i.e., the development of unconscious trigger points to the FEAR circuitry) has been extensively studied (Davis, 1999; LeDoux, 1996), and attempts have been made to envision this type of research within the context of basic emotion theory (for a recent summary, see Panksepp, 2004b). These trigger spots may help explain the development of specific phobias, but such classical conditioning models are not as important for understanding the chronic changes that can occur in FEAR systems to provoke chronic anxiety. For this, the kindling models are very useful, whereby one electrically stimulates the FEAR system briefly each day for about a week until an epileptogenic sensitisation has emerged.**.** Once the system has been thus sensitized, animals (e.g., cats) exhibit chronic changes in fearful reactivity, cowering and being fearful of stimuli (e.g., rats) to which they would normally respond with curiosity and predatory intent (Adamec & Young, 2000). Although, no one has found ways to reduce this type of sensitization once it has developed, a few neurochemical manipulations (e.g. choleocystokinin receptor antagonism) have been effective in aborting the emergence of the sensitization (Adamec, Shallow & Budgell, 1997). Presumably if such maneuvers were implemented in humans during traumatic experiences, one might be able to abort the emergence of chronic anxieties such as those that characterize post-traumatic stress disorders (PTSD).

RAGE: The study of the details of anger in the brain, and the description of how this system learns has diminished to a trickle during the past 30 years. However, we know much about the anatomy and neurochemistry of the system (Siegel, Roeling, Gregg, & Kruk 1999), and it is well established that one of the major environmental triggers of anger is frustrative non-reward. The cognitive consequences of anger are obsessive thoughts of retribution and revenge for perceived slights, offenses or other abuses of one's freedom and dignity. Presumably there are cortical zones that are especially likely to dwell on such issues (Murphy, Nimmo-Smith, & Lawrence, 2003). However, more important for psychiatrically significant irritability are the changes in aggressive temperament that can be achieved by stimulating the RAGE system in a manner similar to that just described for the FEAR system (Adamec & Young, 2000). Animals with kindling of such systems exhibit a very "short fuse" and are likely to attack to minimal provocations/attributions.

PANIC (separation distress): During grief, the mind obsessionally returns to mental images of the lost loved one, to dwell on how the loss of the attachment bonds might have been averted. The natural mental landscape needs to be better described for this and all the other basic emotional responses. There has been no work on the use-dependent plasticity of this system, but it is likely to be related to panic attacks and variants of PTSD and as pervasive and profound for mental life as the changes in the better studied FEAR system of the brain, which may operate synergistically. Related to this issue, it is reasonably well established that early social loss has long-term consequences which facilitate a depressive outlook on life, and social loss long been considered to be a major factor that contributes to susceptibility to clinically significant depression (Heim & Nemeroff, 1999)

CARE: When one is sad, the effects of caring social contacts are especially powerful mood facilitators that can lead to rebound from depressive ruminations. Nurturant maternal urges - tender loving care, in the vernacular - can be sensitized by exposure of animals to infants (Panksepp, 1998). Rat mothers exhibt a species-typical type of care - ano-genital and other bodily licking - which has recently been shown to have life-long positive effects on the offspring. The positive effects include widespread benefits for the nervous system that can be encapsulated in a phrase - the offspring are more inquisitive, courageous and less likely to be severely influenced by stress (Meaney, 2001). These benefits become permanent habits, the benefits of which are then passed on trans-generationally in non-genetic ways.

PLAY: The cognitive relationships to rough-and-tumble PLAY systems have been even less well mapped than the other emotions, but it is likely that this type of emotional engagement helps solidify social habits that can promote a better understanding of what one can and cannot do in social situations. While captivated by playful energies, one's mind tends to go quite naturally to new associations that have the potential for sustaining and amplifying the fun. Perhaps these short-term changes can help widen behavioural options that the organisms has in all future types of emotional encounters. Some longer term social-emotional consequences of play have been documented (Panksepp, Burgdorf, Turner & Gordon, 2003), and the possibility that play can have long term therapeutic effects for various childhood disorders, especially attention-hyperactivity problems has been addressed (Panksepp, Burgdorf, Gordon & Turner, 2002). At present, the overall concept is that play may not only facilitate the programming of social circuits, but also provide tonic effects on neuronal growth factors (Gordon, et al., 2003) which may facilitate frontal lobe maturation, and thereby executive psychological functions for promote a more thoughtful engagement with the world and other lives (Panksepp, 2001a).

SEEKING-Wanting-Expectancy: The pursuit of every resource—from food to romatic love--requires the energetization of this general purpose systems for our desires, or appetitive engagements with the various fruits of the environment. A great deal of work has been conducted on how this system participates in learning (Berridge & Robinson, 2003; Ikemoto & Panksepp, 1999; Schulz, 2002) leading to a variety of terminologies that is often detracting from communicative clarity. However, most ideas are converging on the assumption that the system is essential for appetitive eagerness, regardless of the reward that is being pursued (Panksepp & Moskal, 2004). The remarkable fact is that this system readily sensitises when animals are exposed to psychostimulants like amphetamines and cocaine that activate this system, and the sensitised animals then exhibit a general elevation of pursuit strength for a variety of incentives (Nocjar & Panksepp, 2002). It is to be expected that a psychostimulant sensitised brain would tend to exhibit different types of thought patterns than "normal," but there is very little psycho-ethological work on that issue (Panksepp, 2003b,c; Panksepp, Nocjar, Burdgorf, Panksepp & Huber, 2004).

The scientific analysis of how the "mental apparatus" is modified by chronic changes in the arousability of brain emotional systems remains in its infancy. To do this properly, new psychological approaches such as "psycho-ethology" need to be implemented that permit the analysis of fluctuating psychological contents of the mental apparatus under various conditions. In general, we favor the view that a much greater amount of the overall interactive equation will be solved by focusing on how basic emotional arousals modify the cognitive apparatus than in the way cognitive attributions provoke emotions. In other words, once an emotional episode is triggered, then the resulting ruminations are pulled into self-organizing orbits that are substantially broader than the initial attributional instigators of the emotional episodes (see Parkinson, 1995 for a fuller development of this interactive cascade).

In addition, the three following general neuroscience concepts are of great interest from psychosocial perspectives:

*1) Emotion-related and cognition-related circuits are anatomically and functionally very closely linked and intertwined.* Emotional, cognitive and behavioural components implied in the above mentioned systems *form inborn functional entities* that are further differentiated by learning and other mechanisms of neural plasticity. Although the subcortical emotional operating systems are concentrated in primitive brain areas that have not been typically thought of in cognitive terms, they do interact with many higher brain areas, that may be "centers of gravity" for emotion-cognition interactions (Panksepp, 1988) many now confirmed with modern brain imaging (Murphy, et al., 2003; Phan, et al., 2002). The main areas are anterior cingulate, insula, temporal and various frontal cortical zones. Exactly what type of processing occurs in those regions is by no means clear, but from a neurodynamic perspective, we envision that basic emotional systems serve as attractors for various perceptual and cortico-cognitive activities, yielding individual and personality specific attractor landscapes for how different people cope with emotional situations.

*2) All incoming cognitive stimuli are linked with a situation-dependent emotional value or "color".* This phenomenon has important consequences for all further information processing, as will be discussed in the psychosocial section. Typically the one way linear-causal approach to this issue is based on systematic studies of classical conditioning, where neutral conditional stimuli become capable of generating specific emotional responses (e.g., conditioned fear, such as freezing) when paired with unconditionally aversive events such a foot shock (LeDoux, 1996). There are, however, enormous limits to such simple one-way causal analyzes to model what might actually be happening in the human mind. The dynamic systems perspective provides a compelling metaphor of how non-linear causal processes may operate in higher brain areas such as described above to yield attractor basins, in which ruminating cognitive activities may be trapped, as in fear or rage thoughts that prevail in chronic conflict-situations (Panksepp, 2000).

*3) Subcortical circuits for quick emergency reactions have recently been detected that provide a neural substratum for largely sub-conscious emotional regulations of cognition* (Davis, 1999; LeDoux, 1996). These important findings, so far mainly restricted to fear-related circuits at the neurobiological level, provide compelling neurobiological models for unconscious cognitive activities, similar to those for long postulated by psychoanalysts. Although these phenomena may appear to be unconscious from the perspective of cognitive consciousness, they may, however, be the very core of the affective energies that should be recognized as a distinct form of affective consciousness (Panksepp, 2003a).

## II. Psychosocial Perspectives

Much of the reported neuroscientific evidence corresponds to well known phenomena on the mental and social level. However, because of linguistically-mediated psychological access, numerous additional emotion-cognition interactions can be observed on this level that might, potentially, lead to new questions and hypotheses. In the following, we firstly point to a number of striking convergences between psychosocial and neurobiological findings, and move on then to psychosocial phenomena for which neurobiological evidence remains scanty.

**Converging neurobiological and psychosocial findings**

First, affective and cognitive emotional phenomena are also clearly distinguishable on the psychosocial level. To reiterate, *cognitive phenomena* might essentially be understood as sensory distinctions or, on a more differentiated level, as distinctions of distinctions of distinctions, and their further computation (Ciompi, 1997c; Spencer-Brown, 1979). *Emotions* are, in contrast, much more comprehensive phenomena with multiple mental and somatic aspects. For instance, at the conclusion of their comprehensive overview on definitional issues, Kleinginna & Kleinginna (1981) describe emotions as "… a complex set of interactions among subjective and objective factors, mediated by neural/hormonal systems, which can (a) give rise to affective experiences such as feelings of arousal, pleasure/displeasure; (b) generate cognitive processes such as emotionally relevant perceptual effects, appraisals, labelling processes; (c) activate widespread physiological adjustments to the arousing conditions; and (d) lead to behaviour that is often, but not always, expressive, goal-directed, and adaptive." Both on the neurobiological and on the psychosocial level, cognitions thus appear as much more specific, discrete, "digital" and "computational" phenomena than emotions which have a definitely more global, holistic, and generally also a longer lasting character. In addition, emotions include important energetic and dynamic aspects that are lacking in purely cognitive phenomena.

The detection of a few distinct emotional brain systems, too, closely corresponds to a long established psychological view: Namely the notion of *a limited number of evolutionary rooted basic emotions* whose exact nature and number remains, however, controversial. Thus, Ekman (1984) postulated 6 basic emotions (anger, disgust, fear, joy, sadness, surprise) on the basis of his extended transcultural studies, while other authors also include feelings like shame, guilt and several other emotions (for details, see Ciompi, 1997c; Izard, 1971, Ortony & Turner, 1990). Hopefully, the ongoing neurobiological research will be able to clarify which emotions should truly be considered as “basic” and evolutionary rooted, and which ones rather represent epigenetic-learning and culture-dependent cognitive modulations.

Another essential neurobiological finding - namely the fact that *emotion-related and cognition-related cerebral circuits are closely intertwined and continually interacting in almost all mental activities* – corresponds to a great number of psychological observations that all speak for practically ubiquitous affective-cognitive interactions. Already Freud emphasized the omnipresence of emotional influences on thinking, and vice- versa. Piaget’s monumental research on the genesis of cognitive structures in humans lead him to the same conclusion, in spite of the predominantly cognitive focus of his “genetic epistemology” (Piaget, 1981). The same is true for the extended psychosocial studies on conditioned reflexes, learning and operant conditioning (e.g. through the systematic application of rewards or punishments), and hence for almost all learning theories from Pavlov to Skinner and Hull, even though their emotional aspects were routinely neglected.

Striking convergences exist, furthermore, between the reported obligatory neuronal *linking of incoming cognitive stimuli with simultaneously experienced emotions* and a wealth of analogue psychosocial phenomena, among them again, especially, conditioned reflexes and learning experiences, and also the afore mentioned posttraumatic stress disorders. It is very likely that the above reported possibilities of neuronal sensitisation of emotional systems (e.g. by the so-called kindling mechanisms) play an important role in the pathogenesis of PTSD and of various other psychiatric conditions (e.g. phobic or obsessional disorders) that are characterized by overanxious or overaggressive reactions at minimal stimulations. Sensitisation by traumatic events may also be implied in the (individual or collective) emergence of a so-called “fear-logic”, “hate-logic”, or “logics of war” whereby predominating affects like fear or rage literally “enslave” all thinking and behaving (Ciompi, 1997c). In all these phenomena, the afore-mentioned attractor-like properties of basic emotions become particularly obvious.

**General and specific operator-effects of emotions on cognition**

We turn now to emotion-cognition interactions that have mainly been observed on the psychosocial-phenomenological level, with few notions concerning the underlying neurobiological mechanisms. Among them, a number of so-called *operator-effects of emotions on attention, memory and combinatory thought* (Ciompi, 1997c) are of particular interest. An operator is a variable that acts on another variable and modifies it. A striking example of the immediate modification of form and content of cognition under the influence of emotions like surprise, interest or fear is already provided by the evolutionary rooted attention reaction that can be observed both in newborn and adult humans, as well as in most animals. Attention-shifting effects of emotions, for which some neurobiological evidence is just beginning to appear (Anderson, et al. 2004; LeDoux, 2000; Matthews & Wells, 1999), are since ancient times intuitively used in all kinds of everyday activities like selling, advertising, political or religious rhetoric. They are well known also in clinical psychology, psychopathology and psychoanalysis. Recent systematic psychosocial research confirms a variety of focusing or defocusing, stimulating or inhibiting, hierarchy-creating and organising effects of emotions on attention and perception (Mathews & Wells, 1999), on memory (Eich & Macauley, 2000; Ellis & Moore, 1999), and on comprehensive thought (Berkowitz, et al., 2000; Niedenthal & Halberstadt, 2000).

There are two types of operator-effects of emotions on cognitions: General ones that are basically similar in all kind of emotions, and specific ones that differ from one emotion to another (Ciompi, 1997c).

G*eneral operator-effects* include the fact that emotions

- stimulate or, on the contrary, inhibit cognitive activities, that is, that they act on them as energy-regulating “motors” or “brakes”
- focus the attention on emotion-congruent cognitive objects, thus tending to establish an emotion-dependent hierarchy of perceiving and thinking
- preferentially store and mobilize emotion-congruent cognitions in memory, and
- tend to link emotion-congruent cognitive elements and to combine them in larger cognitive entities. A good example is the emergence of global affective-cognitive judgements of the type “a nice person”, “an ugly town”, “a wonderfull country” etc. that are the result of an agglomeration of a great number of single affective-cognitive elements of corresponding affective value.
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*Specific operator-effect*s include the fact that

- interest and curiosity arouse emotional energies and direct them toward specific cognitive objects (Ciompi, 1997c; Panksepp, 1998a)
- fear and anxiety increase the distance or induce flight from anxiogenic objects (Le Doux, 1996).

- aggression or rage defend or extend ones own borders. Additional evolutionary rooted functions are defending the offspring, catching preys, concurring against rivals, and reacting at frustrations of all kind (Lorenz, 1966; Panksepp, 1998a).
- pleasure, joy and other “positive feelings” decrease the distance and create emotional bonds with cognitive objects such as specific persons, places, situations, theories and ideologies (Bowlby, 1973; Ciompi, 1997c).
- sadness, mourning and grief have the vital function of loosening dysfunctional bonds by detaching emotional energies from lost objects and thus permitting to re-establish contact with significant others after a severe loss.

Far from being “irrational”, both general and specific operator effects of emotions on cognition have highly survival-relevant functions. Their common function is the experience-based simplification of the infinite complexity of the cognitive world, by reducing it to a few behaviour-relevant categories like interesting/indifferent, harmless/dangerous, usefull/useless, etc through corresponding adaptations of attention, memory and combinatory thought.

Such effects are by no means only present in clearly manifest emotional states, but also in numerous apparently unemotional every-day phenomena such as culture-dependent prejudices and mentalities, fashions, value systems, political or religious ideologies, etc., where regulating and integrating effects of initially intense feelings gradually become automatic and almost unconscious by habituation. Emotion-regulated patterns are progressively consolidated by the fact that once established, pleasantand easy going ways of thinking and behaving are continually repeated, whilst unpleasant (conflicting, tension-creating) ways are as much as possible avoided. Similar mechanisms are covertly at work, even in seemingly neutral scientific and other rational thinking, given that abstract contradictions and conflicts, too, are emotionally unpleasant and uneconomic, whereas good solutions are pleasant and economic, and therefore attractive (Ciompi 1988, 1997b).

**The energetic dimension of emotions**

Another particularly important aspect of emotions in our view, namely their energetic dimension remains astonishingly neglected in both neurobiological and psychosocial research, in spite of having for a long time been integrated in several comprehensive models of mental functioning: Already the psychoanalytic approach located the energy for all thinking and behaving in innate drives and corresponding basic emotions, and Piaget's systematic studies on the genesis of mind and thought in children also identified emotional energies as the essential “motors” or energizers of all cognitive activity (Piaget, 1981). In the theory of affect-logic, too, basic affects are understood as directed energetic states selected by evolution, each basic affect being characterized by a specific pattern of energy consumption (Ciompi 1988, 1997b). It must be emphasised that the notion of energy is not used just as a metaphor in this context, but in the sense of measurable patterns of goal-directed conventional biological energy consumption, as already well-known in stressful sympathetic arousal states that are related to fear, rage and tension (especially in flight or fight), in contrast to the relaxed parasympathetic states that are related to “positive feelings” like pleasure, joy or lust which characterise activities like food-intake, rest, socialisation, sexuality, etc. (Selye, 1946). To our knowledge, only one study has, so far, attempted a precise quantification of a diversity of emotion-energetic patterns as reflected in expressive movements (Clynes, 1987). However, different emotion-specific patterns of energy distribution both in brain and body could nowadays be localized and quantified (e.g. by current imaging and/or bioelectric techniques).

That emotions have an energetic dimension has also been repeatedly revealed in the preceding section on biological aspects, so for instance, when emotional states exert an "organic pressure" on cognition, when they energize the context-relevant neuronal networks, or act as dynamic governors for different modes of thinking and behaving. This dimension appears, however, with particular clarity on various psychosocial levels. Activating or inhibiting energetic effects of emotions on speed, form and content of cognition are already frequently observed in normal everyday mood fluctuations. Under exceptional circumstances such as sudden joys or griefs, traumatic events etc., they become, however, much more obvious, especially when individual emotions spread out on various collective levels, thanks to the mechanisms of “emotional contagion”, as described by Hatfield, et al. (1994). The potentially devastating effects of mass-phenomena like mass-panic, mass-aggression or mass-enthusiasm, too, are primarily related to the huge polarized emotional energies that collective emotions may liberate.

Spectacular effects of the activating or, on the contrary inhibiting power of emotions are also observed in psychopathological conditions like mania or melancholia: In elated manic states, the acceleration of all cognitive functions may reach the degree of a so-called logorrhea (relentless high-speed thinking and speaking activity, with continually changing associations and progressive destructuring of syntax, approaching incoherence). Simultaneously, all psychomotor functions are accelerated, while the need for sleep and food intake is dramatically diminished. In pathological depression or melancholia, on the contrary, ideation, speech and all other cognition-guided activities are severely inhibited and impoverished, with a general slowing down that may reach the degree of complete mutism and immobility (cf. Ciompi 1997a and c; DSM III-R, 1987; Flack & Laird, 1998). Simultaneously, attention, memory and thought are narrowly focused on sad contents, thanks to the described operator-effects of melancholic feelings. Facial expression, voice, bodily posture and practically all other psychomotor and vegetative functions are equally inhibited. In states of fear, panic or rage, too, speed and energetic pressure of cognitive functions are generally increased, with, however, the possibility of a sudden shift to the evolutionary-based phenomenon of freezing at a critical point of emotional tension. In the normally relaxed or mildly emotional state, cognitive activity is, in contrast, characterized by a modally flexible, quick and economic mode of thinking and feeling, without major fluctuations to affective extremes.

Fully acknowledging the energetic dimension of emotions has important theoretical and practical implications: It clearly identifies the relevant dynamic forces at work both behind individual and collective affective-cognitive dynamics, it explains their direction and the organising effects of emotion on cognition, and it also opens new ways of understanding the dynamics of sudden non-linear shifts of the prevailing affective-cognitive patterns of functioning that are addressed in the next paragraph. In psychopathology, psychotherapy and pharmacotherapy, too, a full conceptual integration of the energetic aspects of emotions leads to numerous practical and theoretical consequences (Ciompi, 1997c).

**Non-linear aspects of emotion-cognition interactions**

Mental and social systems are certainly among the most complex systems we know. It is therefore not at all surprising that they show nonlinear dynamics under certain conditions. Preliminary neurobiological studies have already revealed that so-called "chaotic" brain-dynamics can appear in the dopamine-metabolism (King & Barchas, 1983 ), and in the EEG of epileptics (Babloyantz & Destenxhe, 1986; Kovalik & Elbers, 1994) or of psychotics (Koukkou, et al, 1993). Here again, more extended information is, however, only available in the domain of psychosocial phenomena.

Of particular interest is the observation that *increasing emotional tensions are capable of provoking, at a critical breaking point, a sudden global reorganization of the prevailing feeling-thinking-behaving patterns* (Ciompi 1997b and c, 1999; Freeman, 2004; Kelso, 1995; Mechsner, et al., 2001; Paulus, 2003; Gottschalk, et al., 1995; Tschacher & Dauwalder 1999). Such nonlinear bifurcations occur, for instance, when a conflict suddenly escalates from verbal to physical violence, or when a generally prevailing "logic of peace" turns into a "logic of war". Similar mechanisms are at work in religious conversions or political revolutions (Ciompi, 1988; Sargant, 1957). Critically increasing emotional tensions often also play a crucial role in the outbreak of schizophrenic psychosis, as confirmed by numerous empirical studies on the impact of so-called "expressed emotions" (see Ciompi, 1997c; Kavanagh, 1992; Leff and Vaugh, 1985).

In addition, so-called *butterfly-effects* (small causes having enormous effects) can occur in unstable mental and social systems, such as, e.g., sudden outbursts of disproportioned rage and aggression after minimal provocation. If we assume that emotions correspond to goal-directed biologic energies, and that emotional energies play an analogue role in psychosocial systems as conventional energy plays in physical or chemical systems, all these observations are consistent with a dynamical systems approach, and in particular with the observation that in all kind of open dynamic systems, the input of energy operates as a critical control parameter capable of provoking, at a critical level, a sudden nonlinear bifurcation from one overall mode of functioning to another (Haken, 1990; Prigogine & Stengers, 1983; Schuster 1989).

Another interesting aspect of nonlinear psychosocial dynamics is the already noticed emergence of *attractor-like effects of emotions* on both individual and collective thought and behaviour processes. In chronic family conflicts, for instance, or in obsessive, depressive or manic states, all thinking and feeling may endlessly circle along the same inescapable trajectories, under the influence of the described operator-effects of emotions on attention, memory and thought. Typically *a*ttractor-like affective-cognitive dynamics (e.g. in the sense of the mentioned "logic of fear" or "logic of hate"), that may be propagated by emotional contagion, can also be observed on various macro- or microsocial levels - the former for instance in the endless Israel-Palestine conflict, where for decades huge parts of both individual and collective feeling and thinking has been trapped in escalating circles of mutual hate and violence. All these observations suggest that affective-cognitive processes may have a so-called *fractal structure* (Mandelbrot, 1983), that is that they show self-similar dynamics on any mental or social scale, in terms of dynamic systems theory. The main mechanism that leads to these scale-independent self-similarities is very probably the omnipresence of the described operator-effects of emotions on cognitions on all psychosocial (and possibly also neurobiological) levels (Ciompi, 1997b,d; Ciompi & Baatz, 2004).

## III. Discussion and resulting working hypotheses

A comprehensive picture of affective-cognitive interactions in humans and higher mammalians is gradually emerging from the reported puzzle of neurobiological and psychosocial findings. It can be summarized as follows: It is very likely that emotions and cognitions are circularly interacting in most mental activities. On the one hand, specific cognitions activate specific emotions on the basis of a limited number of affective-cognitive-behavioral systems selected by evolution that are further differentiated by experience. On the other hand, specific emotions mobilize and regulate specific cognitions by their inborn operator-effects on perception, attention, memory and thought. All incoming cognitions get an experience-based emotional value or "colour" that greatly influences all subsequent information processing. Cognitions with similar emotional values tend to become agglomerated. Thanks to its operator effects and attractor-like properties, each basic emotion is related to its particular mode of regulating perception, its distinct memory banks, and its own way of combining both in the complex emotion-cognition activating and/or inhibiting processes that we call "thinking". Affects thus function as the essential “switchers” from one type of thinking to another. Rapidly increasing emotional tensions are, in addition, capable of provoking sudden nonlinear modifications of the prevailing thinking and behaving patterns. All these interactions appear to be self-similar (or "fractal") on any individual and social level.

All this speaks for our central assumption that basic emotions correspond to evolution-selected patterns of energy flow and consumption both on the brain/mind and on the brain/body level. Directed motional energies orient all thinking and behavior by preferentially focusing conscious attention on new, important, potentially dangerous, difficult or otherwise particularly “exciting” cognitions. By habituation and differentiation, such initially high energetic modes of processing are, however, gradually transformed into the more economic modes of semi-automatic everyday functioning in which low emotional energies operate on largely subconscious levels, without, however, loosing their regulating operator-effects on both thought and behavior. In sum, affects appear as elementary forces with Janus-like properties: Comparable to natural physical forces like fire, water or wind, on the one hand there energies are capable, when adequately channelled and modulated, of promoting subtle individual or socio-cultural performances. But when out of control, the same energies can, on the other hand, have  disruptive effects on all possible levels of cognitive information processing and behaviour.

This integrative view of emotions expands on the traditional understanding of emotions as rather short, conscious and typically reactive events accompanied by a cluster of expressive and neuro-vegetative processes. This is, of course, essentially a question of definition. Without going into a lengthy discussion of definitional issues that are tangled, as mentioned, by widely variable meanings given to terms like feeling, affect/affectivity, emotion and mood, we wish, however, to emphasize our conviction that a superordinate concept reflecting the underlying deep functional and phenomenological unity of all these emotion-like phenomena (subjective and objective, mental and somatic, energetic and phenomenological, conscious and unconscious, short-term and long-term) is desperately needed. On such a base, which also recognizes the energetic dimension and the self-similar effects of emotions on various hierarchical levels, substantial progress in the study of affective-cognitive interactions might be possible.

It is precisely on such an interdisciplinary basis that we propose to include all phenomena commonly called feelings, emotions, affects or moods under the general definition of *specifically directed psycho-somatic energetic states of variable quality, intensity, duration and degree of consciousness*. Cognitions, in contrast, may be defined as *the capacity of perceiving and further processing sensory differences* (Ciompi, 1988, 1997c, 2004). Both definitions are deeply evolution-rooted: In fact, already unicellular organisms function by sensory distinctions (e.g. between basic or acid, warm or cold, bright or dark milieus) that interact with global organismic states (e.g. relaxed or tense, or parasympathetic and sympathetic states) in which we might see the first glimmers of systemic changes that are eventually experienced and expressed as conscious "emotions" or "affects". Simultaneously, the proposed definitions have the advantage of being mutually exclusive. The clear separation of two different but constantly interacting classes of phenomena should greatly facilitate the study of their interactions. They also integrate all known aspects of both emotions and cognitions without major contradictions to existing semantic traditions, and should thus promote interdisciplinary communication and collaboration. Furthermore, the proposed definitions put emotion-like phenomena appropriately close to psychosomatic states like hunger, thirst, lust or pain, whereas cognitive phenomena remain close to digital information-processing and computer-like cybernetics. Last but not least, the proposed inclusion of the energetic aspect of emotions brings a powerful dynamic element, commonly neglected, to the forefront in the currently prevailing cognition-based understandings of both mental and social processes. This is not to deny that in most "civilized" social interactions, a common aim is to keep the emotional energies at a sufficiently low lever that they not impair the flow of well-monitored cognitive information flow.

A major problem is that there probably exists no generally acceptable term for such an enlarged notion of emotion-like phenomena, given that the two best candidates - namely "emotion" or "affect" - are already used, but in opposite senses, as supraordinate notions by different authors who have recently been reflecting on definitional problems: Ciompi (1988,1997c), Clore & Ortony (2000), Damasio (2000), Ellis & Moore (1999) and Forgas (2000a), for instance, propose the term *affect* (or affectivity) as an "umbrella notion", whereas Kleinginna & Kleinginna (1981), Panksepp (1998a, 2000a and b, 2001a and b) and others understand emotion as the supraordinate term, tending to restrict the notion of affect to the conscious subjective experience of an emotion, as did Freud (see Solms & Nersessian, 1999 for discussion) and to distinguish, on this basis, between the supra-ordinate category of emotional processes, of which “affective feelings” are a subcomponent. Standard sources like the “Oxford English Dictionary” or the “Webster” are of no help, because they truly mirror the mentioned scientific ambiguities. A third possible solution, namely "thymic phenomena" (from the greek *thymos* that means both "feeling" and " the forces of life") that is already used in this sense in "thymoleptics"( = emotion-normalizing antidepressive drugs) is probably too remote from current semantic practice for having a chance of being accepted.

In the hope that some terminological consensus will eventually emerge by sheer necessity, we leave this question open and move on to finally proposing *eight tentative working hypotheses* as result of our reflections and possible guidelines for further research. Some of them are already well supported, but others are not. Again, we focus essentially on emotions for which the neurobiological bases are already partly known. Methodological issues will not be addressed in any detail.

1. *Different basic emotional states correspond to different pattern of energy consumption in both body and brain.*

As discussed above, this hypothesis and its numerous practical and theoretical implications is the central - and probably most innovative - aspect of our understanding of emotions. It could primarily be tested by modern measures of local and global bio-energetic flows, and secondarily by additional psychosocial and neuro-vegetative measures. If adequately confirmed, it should put the whole field of emotion-research on more precise quantitative grounds. Last but not least, it would eventually permit investigators to use both basic and differentiated energetic patterns as indicators for different emotions that, so far, are mostly assessed by indirect conventional research methods. This could be advanced by development of approaches such as those pioneered by Clynes (1987), as well as metabolic and neurophysiological brain imaging procedures such as PET and fMRI (Liotti & Panksepp, 2004).

2. *Mild to modest emotional arousal generally increases the overall amount of cognitive processing, while intense arousal tends to inhibit it.*

This hypothesis appears as a consequence of the preceding one. Both neurobiological and psychosocial evidence suggest, however, that it must be further differentiated, because different emotions and different emotional intensities apparently activate (or sometimes, as in panic, rage or depressive states, slow down or even block) cognition in quite different ways (Liotti & Panksepp, 2004). An additional difficulty is the fact that adequate methods for quantifying cognitions are still widely lacking on the neurobiological level, and methods for following the flow of thought in humans, such as the study of psychoanalytic transcripts under different emotional states, remains poorly developed, but should be capable of being implemented with automated voice recording and data analysis approaches (Panksepp, 1999).

*3. Incoming cognitive stimuli associated with emotional arousal are automatically linked and stored with the accompanying emotional quality or value.*
This hypothesis, too, is, as reported, already partly confirmed both in neurobiology and on the mental and social level, especially by studies on classical conditioning. We further believe that once established affective-cognitive connections have wide-ranging consequences for all further information processing (see hypotheses 4-6). More research on all levels is consequently needed in order to identify how affective-cognitive connections are neurobiologically established, and how they are further processed.

*4. In different basic emotional states, different sets of cognitions are preferentially stored and/or reactivated in memory .*
This hypothesis summarizes an essential aspect of the described operator-effects of emotion on cognition. Although closely related to the empirically well known phenomenon of state-dependent learning, it needs more psychosocial and especially neurobiological empirical consolidation, too. As we begin to understand some of the unique chemistries of specific emotional systems (e.g., neuropeptides, as discussed by Panksepp & Harro, 2004), it will be probably possible to determine the extent to which various emotion-related memories and cognitive patterns can be reactivated by specific neurochemical brain conditions. The number of neuropeptides that have emotion specific effects should allow robust evaluation of such connections.

5. *Cognitions with a similar emotional value are preferentially assembled into higher-order affective-cognitive-behavioral units*
This assumption represents another important aspect of the reported operator-effects of emotion on cognition. It is at the basis of the attractor-like emergence of comprehensive affect-specific "logics" (e.g. “fear-logic”, “hate-logic” etc.) and of specifically “coloured” personal or cultural value-systems, belief-systems, prejudices and ideologies. This phenomenon is also sustained by the activity of one or more of the above described emotion-dominated brain systems that integrate extended cognitive, affective, hormonal-neurovegetative and behavioral patterns into higher-order functional units. Over time, such patterns might be stabilized and become chronic by various neuronal plasticity and kindling mechanisms.

6. *Sudden non-linear shifts from one prevailing global affective-cognitive pattern to another can occur, when the degree of emotional tension reaches a critical level.* This hypothesis is derived, as explained above, from a dynamical systems interpretation of a great variety of unexpected psychological and psychopathological phenomena (e.g. the shift from a “logic of peace” to a “logic of war”, or from normal to psychotic modes of thinking and behaving). Already Pavlov's experiences with dogs, which were confirmed by numerous empirical studies both on the animal and the human level, have revealed sudden overall behavioural changes provoked by increasingly difficult and stressful cognitive tasks Given the frequency of nonlinear mental and social processes, this approach seems quite promising, especially when combined with the proposed energetic understanding of emotions. Here, too, much additional research is, however, needed. One additional

experimental possibility would be to study mental reactions in response to artistic stimuli (music, film, dance, etc.) where there are sudden shifts of prevailing emotional moods and dynamics (Panksepp & Bernatzky, 2002). Likewise, in studying humour, one could try to capture such global shifts before and after people “get” a joke. Increasing social tensions could presumably be quantified by classifying, counting and comparing emotion-loaded titles in newspapers and other media.

7. *At least for the basic emotions, the described affective-cognitive interactions are self-similar in both small-scale and large-scale psychosocial processes.*
This assumption, too, stems from dynamic systems theory. It is suggested by numerous psychosocial observations which speak for analogue individual and collective reactions, for instance to frightening or, on the contrary, to pleasant stimuli. This issue has not yet been explored by formal research, to our knowledge. Several methods could be used for assessing self-similar individual and collective emotion-cognition interactions, among them the reported measurement of expressive movements (Clynes, 1987) and other emotion-specific features (e.g. vocalization or body-posture) in real life emotional situations such as sports, artistic, or mob movement patterns.

*8. A similar specific "affective imprint" is necessary not only for the generation and maturation, but also for the eventual reactivation of functional affective-cognitive circuits.*

This "inprint-hypothesis", first formulated by Ciompi (1988) on the base of mainly psychosocial observations, is now also supported by the above mentioned neurobiological findings in animals that speak for beneficial effects of body-care and play on the maturation of certain crucially important limbo-prefrontal circuits. Numerous empirical data on early parent-infant relations and pro-social behaviour in humans point in the same direction (Bowlby 1973; Fivaz-Depeursinge, 1999; Stern, 1995). The assumption that the same affective tuning that initially facilitates, the neuronal maturation of specific affective-cognitive circuits could eventually stimulate the reactivation (and possible further differentiation) of these very circuits in similar situations providing a very parsimonious explanation for most of the previously reported "operator" effects of emotions: Coherent electrodynamic/neurochemical mechanisms, such as certain brain activity rhythms, may be responsible not only for the establishment of specific affective-cognitive-behavioural links, but also for the preferential focusing of attention on affect-congruent cognitions, for the preferential storage and remobilization of affect-congruent cognition from memory, and for the tendency of assembling cognitions with similar affective colour into larger cognitive entities (cf. hypotheses 3 – 5). This last integrative hypothesis, albeit conceptually reasonable, presently has no clear neurobiological evidence.

## IV. Conclusions

Comparing recent neurobiological and psychosocial findings on interactions between emotion and cognition from the perspective of two largely complementary models - namely "affective neuroscience" on the one hand, and "affect-logic" on the other - seems to lead, as hoped, to some innovative ideas and predictions capable of stimulating further research. However, some inherent difficulties and weaknesses of such interdisciplinary efforts also became evident, even if they are not fully discussed here. They range from "soft" and often subtle differences in the use of concepts, theoretical orientations and value systems, to hard-core questions of specific methodologies on how to best pursue research efforts. We hope, however, to have at least partly succeeded in overcoming such difficulties, thanks to a common commitment to empirical research as base for all scientific progress, especially in the complex field of emotion and cognition.

Obviously, the neurobiological basis of a great number of conceptually well recognized mental and social phenomena remain to be empirically elucidated. Psychosocial phenomenology is, therefore, an ongoing challenge for neuroscience – and vice-versa. One of the more important outcomes of this interdisciplinary comparison is, in fact, the recognition that each approach has different strengths to add to an eventual synthesis. For instance, despite advances in imaging brain correlates (e.g., Liotti & Panksepp, 2004; Mayberg, 2004), it will be hard to specify how the detailed flow of cognitive activity (e.g., the progression of thoughts) could ever be quantified or causally manipulated at the basic neuroscience level, and it will clearly continue to be easier and more germane from a "mental apparatus" perspective to evaluate these issues at the human psychological level, especially with causal manipulations such as Transcranial Magnetic Stimulation (Schutter, Van Honk & Panksepp, 2004).

Phenomena like subjectivity and consciousness can hardly be explored on other but the mental level in humans, even though credible approaches to the study of affective feelings are emerging in the neruoscience community (Knutson, Burgdorf & Panksepp, 2002; Panksepp, 1998a). This is important because basic emotional systems and their evolutionary roots and effects can only be studied in great neuronal detail in animal models. Neuroscience also provides powerful new tools, such as neurochemical ones to modify specific brain systems, some of which can be employed in humans to see what consequences there are for the intensity and flow of psychological output. Because of the abundance of new causal manipulations, such as neuropharmaceuticals that can modulate specific neuropeptides systems, there is a real possibility of bridging such seemingly distant approaches (Panksepp & Harro, 2004). Such hard-core methods for testing new hypotheses should be interfaced with the uniquely rich field of psychosocial observation. Thus, in our estimation, there is much to be gained scientifically by allowing such very different paradigms to work synergistically toward a mutually desired and desirable synthesis.

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