so at a certain phase even if the frequency of theta shows significant variations (between 3.7 and 5.6 Hz in our experiments). But what happens if a change in frequency occurs when the two structures are already connected? We examined this question using segments of recordings in which theta rhythmic activity was elicited in anesthetized rats by tail pinch but in which the rhythm persisted after cessation of the sensory stimulus (Kocsis 2000). It is important to note that during such episodes the frequency of theta decreased without an intervening non-theta state. We found that the firing of many SUM neurons followed the hippocampal theta waves with a constant delay (rather than a constant phase), suggesting that during deceleration associated with a shift from sensory elicited theta to spontaneous theta, this group of neurons was driven by a descending input, most likely from the medial septum.

These findings indicate that SUM is only driving field oscillations in the hippocampus during epochs of sensory elicited theta rhythm, under urethane anesthesia, whereas spontaneous theta in SUM is controlled by descending input from the septohippocampal system. This suggests that although during certain states the rhythmically firing SUM neurons work to accelerate the septal theta oscillator, thereby adding to "global" synchronization of the limbic system, in other states (such as after cessation of the stimulus in these experiments) they surrender to the driving of the slower rhythm of septal origin and assume positions entrained by the superordinate oscillatory network.

Emotional-cognitive integration, the self, and cortical midline structures

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Abstract: Lewis discusses the dynamic mechanisms of emotional-cognitive integration. I argue that he neglects the self and its neural correlate. The self can be characterized as an emotional-cognitive unity, which may be accounted for by the interplay between anterior and posterior medial cortical regions. I propose that these regions form an anatomical, physiological, and psychological unity, the cortical midline structures (CMSs).

Lewis discusses the dynamic mechanisms of emotional-cognitive integration and relates them nicely to various neural networks. These include the orbitomedial prefrontal cortex (OMPFC), the anterior cingulate (AC), the dorsolateral prefrontal cortex (DLPFC), and various subcortical regions (hippocampus, amygdala, nucleus accumbens, brain stem/basal forebrain, ventral tegmental area, ventral pallidum). Though quite exhaustive, his overview neglects two important points. First, he neglects what results from emotional-cognitive integration. I argue that the self as emotional-cognitive unity results from the integration between emotional and cognitive function. Second, Lewis almost entirely neglects posterior and medial cortical structures. He includes the OMPFC and DLPFC, but he does not consider the posterior cingulate (PC) or the medial parietal cortex (MPC). I argue that the interplay between anterior and posterior medial cortical regions generates a functional unit, the cortical midline structures (CMSs). The CMSs are suggested to account for emotional-cognitive unity, the self.

Lewis focuses on the mechanisms of integration rather than on their result. Based on my own review of various emotional and cognitive imaging studies (Northoff & Bermpohl 2004), I argue that the self is what results from emotional-cognitive integration. What is called the self has been associated with the following functions: The feeling of being causally involved in an action has been referred as to as "agency" (Farrer et al. 2003; Frith 2002). Moreover, the own self and its body can be located in space resulting in spatial perspectivity (Ruby & Decety 2001). Another process related to the self is called "ownership." This concerns the experience that one's own body and environment are perceived as personal and closely related to one's own self (Damasio 1999). A further function of the self concerns recognition of the own person and particularly of one's own face, which is called self-awareness or self-recognition (Keenan et al. 2000; 2001). The self is also closely related to its own memories, that is, to autobiographical memories that can be encoded and retrieved (Northoff & Bermpohl 2004).

What is the emotional-cognitive thread linking these processes associated with the self? Damasio (1999) speaks of a "core self," which he describes by the continuous conjunction of intero- and exteroceptive stimuli leading to the experience of the self as a unit. I argue that this unit of the self is an emotional-cognitive unity.

I believe that this emotional-cognitive unity is the processing of self-referential stimuli as distinguished from non-self-referential stimuli. Self-referential stimuli are stimuli that are experienced as strongly related to one's own person. They have also been described as "self-related" or "self-relevant" (Craik 1999; Kelley et al. 2002; Northoff & Bermpohl 2004). The self-relevance of a stimulus is not intrinsic to the stimulus, but rather is determined by the individual and personal context in which it is perceived. I suppose that this is accounted for by linking the stimulus to emotions. The more emotional involvement, the more relevant that particular stimulus is for the person, that is, for its self. Cognitive function then allows for distinguishing these emotionally loaded stimuli from non-emotional ones. Such emotional-cognitive integration leads to the distinction between self-referential and non-self-referential stimuli and ultimately to a self as being distinct from other selves.

Lewis's second neglect concerns posterior and medial cortical regions, the PC and MPC. I argue that the neural correlate of the self as emotional-cognitive unity consists in the collaboration between anterior and posterior cortical midline regions (see also Northoff & Bermpohl 2004). These regions form an anatomical, physiological, and psychological unit which I call cortical midline structures (CMS). CMS include the OMPFC, the AC, the dorsomedial prefrontal cortex (DMPFC), the medial parietal cortex (MPC), and the PC.

Anatomically, the various regions within the CMS maintain strong and reciprocal projections among each other. Furthermore, they show a similar pattern of connectivity to other cortical and subcortical brain regions. These mostly include the regions Lewis discusses, the DLPFC, hippocampus, amygdala, nucleus accumbens, brain stem/basal forebrain, ventral tegmental area, and ventral pallidum (Ongur & Price 2000). The subcortical connections may account for top-down modulation of subcortical regions by CMS (see, e.g., Nagai et al. 2004; Northoff 2002).

Physiologically, the CMS exhibit a high level of neural activity during so-called resting conditions such as fixation task (Raichle et al. 2001). They show the highest level of neural activity during the resting state among all brain regions; this has been characterized as "physiological baseline" or "default mode" (Gusnard & Raichle 2001; Raichle et al. 2001). The CMS are involved in various emotional and cognitive processes, all involved in the processing of self-referential stimuli (see Northoff & Bermpohl 2004). The high resting level of neural activity in the CMS may thus be reflected in continuous emotional-cognitive integration, reflecting self-referential processing, and ultimately in ongoing experience of a self as "psychological baseline."

Functionally, the question for the mechanisms of how the different CMS regions are integrated into a functional unit remains. Among others, Lewis mentions effective connectivity and pattern of activation and deactivation as potential mechanisms of integration. Interestingly, both mechanisms have been described in CMS. A recent study (Greicius et al. 2003) observed increased effective connectivity between OMPFC and PC only in the resting state, whereas during cognitive processing it decreased. Some studies have demonstrated coactivation of anterior and posterior cortical midline regions in emotion (Heinzel et al. 2004), social interaction (Iacoboni et al. 2004), and autobiographical memory (see Fink et al. 1996). All of the different tasks involved self-referential processing, which may account for involvement of CMS. Another mechanism for distinguishing the CMS as a functional unit from other regions is the pattern of neural activity. The CMS regions show coactivation among themselves. By contrast, they do not show coactivation with other regions, such as lateral prefrontal regions. Instead, opposite patterns of activity – concurrent activation and deactivation – have been described between these regions (see Bush et al. 2000; Drevets & Raichle 1998; Goel & Dolan 2003; Northoff et al. 2004). Future research may reveal further details about dynamic mechanisms for integrating CMS regions into a functional unit and, at the same time, distinguishing them from other regions.

ACKNOWLEDGMENT
I am grateful to Felix Bermpohl who critically commented on an earlier version of this article.

Emotional dynamics of the organism and its parts

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Abstract: Emotion-science without basic brain-science is only superficially satisfying. Dynamic systems approaches to emotions presently provide a compelling metaphor that raises more difficult empirical questions than substantive scientific answers. How might we close the gap between theory and empirical observations? Such theoretical views still need to be guided by linear cross-species experimental approaches more easily implement in the laboratory.

Credibly "docking" psychological states in neural processes remains a great challenge for psychobiology. In conceptualizing affective states, dynamic systems analysis should be more productive than telephone switchboard and computer models of the past (Ciompi & Panksepp 2004). As I have previously noted (Panksepp 1998a, p. 3), we "look forward to a day when" such topics

> can be encompassed within the conceptual schemes of sophisticated dynamic approaches. The basic emotional systems may act as "attractors" within widespread neural networks that exert a type of "neurogravitational force" on many ongoing activities of the brain, from physiological to cognitive. Unfortunately, at present we can utilize such dynamic concepts only in vague and metaphoric ways.

As Lewis recognizes in this seminal vision set forth in the target article, such compelling conceptual metaphors must now be cashed out empirically. To the degree that Lewis's synthesis generates many falsifiable predictions and supportive new findings, it will have served us well.

Despite advances in human brain imaging, the underlying neural details upon which Lewis builds his theorizing remain largely inaccessible in human brain research. In contrast, animal investigations allow sufficiently detailed access to homologous brain mechanisms, concentrated sub-neocortically, which are essential for emotional feelings (Panksepp 1998a; 2000). However, here is the rub: Cognitive-appraisals, so evident in human emotional mentation, are not readily deciphered through animal models. With as little association cortex as most other animals have, we can question whether their sensory-perceptual abilities can lead to cognitive activity that would resemble human thought. Therefore, how might we dock the human-type cognitive appraisals, which motivate Lewis's analysis, with the type of basic neuro-emotional mechanisms that can only be detailed in animal models?

Lewis proposes five lines of research to evaluate his overarching theory. Might he flesh out his "novel predictions" with the eight foundational principles of self-organization he describes in section 3.2 of the target article?

1. Cortical theta band activity seems to be quite sensitive to both cognitive and emotional processing in both adults (e.g., Klimesch 1999; Krause et al. 2000) and infants (Maulsby 1971), but what might the time-locked indicators of "emotional relevance" be in such studies? Can theta discriminate positive and negative affective relevance? Subcortical theta, which is so important in the overall functions of extended, hippocampus-centered, limbic networks that promote emotional information processing (Buzsaki 2002; Vertes & Kocsis 1997), may not be the same theta that is evident on the human cortical surface (Buzaki & Draguhn 2004; Sederberg et al. 2003).

2. A study of correlations among various brain and peripheral physiologies is a valuable empirical pursuit. What aspects of multidimensional scaling might confirm or disconfirm dynamic system viewpoints?

3. "Vertical integration" is probably best studied in animal models. What criteria would one use to identify recording sites, and what types of prototypic emotions would one seek to contrast? Where does Lewis stand on the issue of emotional "primes"? Affective processes are treated rather globally in the target article. What measures, within dynamic systems schemes, might distinguish one type of emotional response from another?

4. How might we validate that event-related potential changes shortly after perceptual events have any causal relations to thoughtful appraisal processes? If an unconsciously initiated "appraisal" response to a briefly presented stimulus does not exhibit certain event-related potential (ERP) components, would Lewis predict that there will be no resulting consciously perceived attributional process? If so, what neural changes might indicate specific psychological changes?

5. The temporal analysis of emotional episodes is much understudied. It would be stupendous if early childhood ERPs could predict trajectories of the multi-dimensional aspects of affective personality development (Davis et al. 2003), but how might we study the temporal dynamics of such diverse emotional tendencies in the EEG laboratory? At present we do not have compelling data about the natural time courses of emotional episodes.

Clearly, the devil dwells in the methodological and empirical details. It is understandable that impressive unifying visions such as this are bound to be short on such critical dimensions initially, but how do we move from a mere correlational toward a causal analysis? Brain correlates and theoretical functional decompositions, important as they are, will not give us much causal satisfaction (Schutter et al. 2004). How might causal experiments capitalize on the conceptual wealth of dynamic systems approaches, or must we still rely on simpler one-way linear models? If so, how can the analytic and synthetic perspectives be fruitfully merged?

Reductionistic-dissective analyses give us the components that need to be dynamically reconstructed into the whole, but, so far, that can only be achieved in our imagination (Panksepp 2000). When we dissect the many "organs" of the brain-mind, we see that cognitions (the partitioning of external differences) are vastly different species of brain activities than emotions (which "energetically" valuate perceptions and actions; Ciompi & Panksepp 2004). Only when we consider the intact organism, working as a whole, can we claim "that cognition and emotion were never two distinct systems at all." In fact, they can be scientifically distinguished (Panksepp 2003). Even though the liver and kidneys rely on each other completely, if we do not conceptualize their parts well, we cannot learn much about their more holistic, emergence-producing interactions. How might a synthetic dynamic view help us to analyze the necessary parts?

Lewis is correct in his view that a deep scientific understanding of human emotions cannot be achieved without neuroscience. However, a great deal of that understanding must still be reached using traditional parametric approaches that have sustained mind-brain science for more than a century. Such approaches have