spond to a single configuration of knoxels in the conceptual space. To consider a composition of several motions arranged according to a temporal sequence, we introduce the notion of action: an action corresponds to a "scattering" from one situation to another one in the conceptual space. We assume that the situations within an action are separated by instantaneous events. In the transition between two subsequent configurations, a "scattering" of at least one knoxel occurs. A mechanism of focus of attention may be modeled in the conceptual space by letting the agent suitably scan the current sets of knoxels in order to select the most relevant aspects of a perceived scene.

The dynamic conceptual space lets the agent imagine possible future interactions with the objects in the environment: the interaction between the agent and a generic object is represented as a sequence of sets of *knoxels* that is imagined and *simulated* in the conceptual space before the interaction really happens in the real world. This loop of imagination, simulation, and action is at the basis of the planning capabilities of the agent.

Agent self-consciousness may be generated by a second-order conceptual space, in the sense that each second-order knoxel at time t corresponds to the inner perception of the first-order conceptual space by a time t-1; that is, it corresponds to the perception at a previous time of the configuration of first-order knoxels representing the agent itself and the other current entities.

To summarize, a conceptual space may represent all the processes at the basis of appraisal. The space may be easily generalized towards an "affective" dynamic space in order to represent the emotion components. A suitable number of dimensions may be added that take into account the affective evaluations of the perceived entities. In this new "affective" conceptual space, a knoxel or a group of knoxels is now characterized not only by shape and motion, but also by the associated arousal, action tendency, attentional orientation, and so on.

The appraisal-emotion dynamics described by Lewis in terms of triggers, self-amplifications, and self-stabilizations may be modeled in terms of dynamics in the conceptual space: a trigger corresponds to the scattering of knoxels; self-amplifications and self stabilizations may be represented by suitable geometric operators controlling the scattering sequences of knoxels due to the growing up and decaying down of the corresponding affective evaluations.

Therefore, the DS processes described by Lewis and related with the appraisal-emotion processes and their influences of the cognitive capabilities of the agent, may be fully described in terms of geometric operators in an intermediate conceptual space. In this intermediate level, the dynamics described by Lewis at the basis of appraisal and emotions give rise to a sort of "affective geometry."

Enacting emotional interpretations with feeling

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Abstract: This commentary makes three points: (1) There may be no clear-cut distinction between emotion and appraisal "constituents" at neural and psychological levels. (2) The microdevelopment of an emotional interpretation contains a complex microdevelopment of affect. (3) Neurophenomenology is a promising research program for testing Lewis's hypotheses about the neurodynamics of emotion-appraisal amalgams.

One way to think about Lewis's portrayal of appraisal-emotion interactions is by comparison with dynamic sensorimotor approaches to perception and action (Hurley & Noë 2003; O'Regan & Noë 2001; Varela et al. 1991). According to these approaches, perception is as much a motor process as a sensory one. At the neural level, there is "common coding" of sensory and motor processes (e.g., Prinz 1997; Rizzolatti et al. 1997). At the psychological level, action and perception are not simply instrumentally related, as means-to-end, but are constitutively interdependent (Hurley 1998). These and other findings can be described by saying that perception is *enactive*: it is a kind of action (Noë 2004; Varela et al. 1991).

Lewis's target article can be read as presenting a logically analogous way of thinking about cognition and emotion. At the neural level, brain systems traditionally seen as subserving separate functions of appraisal and emotion are inextricably interconnected. Hence "appraisal" and "emotion" cannot be mapped onto separate brain systems. At the psychological level, appraisal and emotion are constitutively interdependent: one is not a mere means to the other (as in the idea that an appraisal is a means to the having of an emotion, and vice versa); rather, they form an integrated and self-organizing emotion-appraisal state, an "emotional interpretation."

Although the target article ends with this kind of account (see in particular the last two paragraphs), the beginning seems more traditional. Lewis individuates emotion components and appraisal components, and maps them onto distinct brain systems. Emotion and appraisal have some components in common (attentional systems in particular), and their components are highly distributed. Nevertheless, some brain systems and functions are only emotional and do not belong to appraisal (e.g., arousal and feeling), and some belong only to appraisal and not emotion (e.g., planning). Some brain systems constitute either emotion or appraisal (or both), and some merely interact with one or the other.

Lewis presents the emotion/appraisal distinction as an initial heuristic for looking at brain processes. We agree that one must start somewhere. Yet we wonder how much conceptual change Lewis thinks his view of a deeply integrated and dynamic brain implies for the psychological taxonomy with which he began. Consider that his dynamic approach is consistent with other, different views of the relationship between emotion and appraisal. Scherer (2000), for instance, also believes that appraisal and emotion components interact in a way best explained in dynamical terms, but he sees appraisal as a component of emotion. Freeman (2000) thinks that emotion is an endogenously generated (mainly limbic) dynamic activity pattern that mediates sensorimotor loops by providing different degrees of salience to events. According to this view, emotion is a constitutive element of any cognitive process, so that there is no theoretical room for non-emotional appraisals. This neurodynamic account is consistent with phenomenological accounts, according to which perception and evaluation are emotive and valenced (Thompson, forthcoming; Varela & Depraz 2000).

Although we cannot argue the case here, and although we realize this view is outside the mainstream of emotion theory with which Lewis is concerned to communicate, we nevertheless believe that it may ultimately prove unproductive even to try to differentiate distinct "appraisal constituents" and "emotion constituents," which then "interact" in the formation of an emotional interpretation. Rather, we suspect that there may be no appraisal constituent that is not also an emotion constituent, and vice versa. Take feeling, for instance. Lewis describes feeling as a component of emotion, but not appraisal. When an emotional interpretation starts to emerge, feeling plays an important role in modulating appraisals, but it is not itself an appraisal constituent (see what happens to Mr. Smart in the target article). Yet there is a "feeling of appraisal," and appraisal can be seen as constitutive of emotion experience (Frijda 1986). Hence, categorizing feeling as an emotion constituent but not also an appraisal constituent seems limited.

Although feeling plays an important motivational role in Lewis's model, he does not explore the phenomenology of affect (the experiential aspect of emotion) in relation to the emergence of an emotional interpretation. Yet the microdevelopment of an emo-

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tional interpretation contains within it a complex microdevelopment of affect. Consider a momentary emotional interpretation, such as seeing a stranger's angry face glaring at you as you walk by. One can point to a number of concurrent components of affect in such an episode (see also Watt 1998):

A precipitating event or trigger, which can be perceptual or imaginary, or both. This component corresponds to the trigger phase in Lewis's model.

An emergence of affective salience, involving a sense of the precipitating event's significance. The emotion/appraisal processes leading to the emergence of this affective salience could reflect the kind of self-amplification and self-stablization processes Lewis describes.

A hedonic tone, along a pleasant/unpleasant polarity.

A motor embodiment, in the form of facial and posture changes, and differential action tendencies or global intentions for acting on the world.

A visceral-interoceptive embodiment, in the form of complex autonomic-physiological changes (to cardiopulmonary parameters, skin conductance, muscle tone, and endocrine and immune system activities).

Neuroscientists have recently emphasized the link between affect and "core consciousness" or the feeling of self (Damasio 1999; Panksepp 1998b), an idea also central to phenomenological philosophy. These two streams of neuroscience and phenomenology intersect in the research program of "neurophenomenology" (Lutz & Thompson 2003; Thompson et al., in press; Varela 1996). Lewis's (2000a) model of emotion-appraisal amalgams at multiple time-scales, together with a richer account of the role of affect in the development of emotional interpretations, can both inform neurophenomenological research on emotion, and also benefit from its rigorous way of linking first-person phenomenological reports and neurodynamical studies of large-scale integration (see Lutz et al. 2002). In particular, neurophenomenology provides a promising research program for exploring and testing Lewis's hypotheses about synchronous/asynchronous interactions across gamma and theta frequency bands in corticolimbic systems (see also Friston 2000; Varela et al. 2001).

Lewis's DS approach is a tool, not a theory

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Abstract: Lewis argues convincingly that a DS approach to emotion theory will be fruitful. He also appears to hold that there are DS principles that constitute a theory or are substantial empirical claims. I argue that this latter move is a mistake.

Dynamics is of course just some mathematics, and a dynamic systems (DS) approach as described by Lewis is the application of such mathematics, inspired also by analogies with other relationships described in other applications of dynamics. As such, a theory adopting the DS approach must ultimately be evaluated on whether it is more fruitful or convenient. The questions we should ask must be something like: If we use these tools to describe these phenomena, will this enable or ease or even just inspire the production of better theories than do some of the alternative tools being used now by other theories? Lewis makes a compelling case that this is so. For example, he rightly observes that we often have been trapped into misleading and simplistic questions about one-directional causal influences from cognition to emotion, or from emotion to cognition. Using tools that allow us to better formulate such relationships as reciprocal is very likely to foster more accurate theories. I conclude that Lewis is offering us valuable suggestions on how we should consider developing future theories in emotion research, and that these future theories are very likely to use the DS approach.

There are theories, or at least substantive claims, that have been made about the mind or brain which we might call DS theories. Van Gelder has described one kind of DS approach as nonrepresentational (1995). He has argued that we can explain much more of our mental phenomena using these nonrepresentational dynamic approaches than we typically assume. This is a substantive, perhaps ultimately falsifiable, albeit very general, claim for a form of DS approach. Lewis is not committed to expunging representations or other semantic kinds, and makes no explicit substantive claim about the DS approach that I could discern.

I have a concern, however, that there are something like substantive claims lurking in Lewis's account, and in much of the pro-DS literature. Lewis argues that DS "principles" will bridge emotion theory and neurobiology. These principles appear to be legion, but include that "Nonlinear dynamic systems operate through reciprocal, recursive, and multiple causal processes" (target article, sect. 1, para. 3). If I understand him correctly, these principles are claims about the kind of empirical relationships that exist. But this list of principles does not distinguish DS from other approaches. Almost every classical, discrete-state, linear AI model, for example, has reciprocal functional modules that can act on each other, and will use recursion. Also, these principles do not seem to describe any systems in a way that is falsifiable. Suppose we find we must admit some nonreciprocal relations and single causal processes into our descriptions of some brain function – is it then no longer dynamic? Also, if we are using the mathematics of dynamics, are not nonreciprocal relations and single-cause processes just particular cases of reciprocal relations and causal processes? Just so, there is nothing in Lewis's novel predictions that specifically contrasts DS principles with non-DS alternatives. His predictions are instead exciting empirical predictions for phenomena that are perhaps best described using the tools of dynamics.

The DS approach as Lewis (and most other defenders) conceive of it is not a theory but a tool and a set of very valuable analogies. We should encourage each other to use these tools and analogies when they are appropriate, but we would be bordering upon a misunderstanding if we ever, for example, argued the merits of a theory in terms of whether it uses a DS approach. To call a theory a DS approach (in Lewis's sense of DS) can at most mean that a certain form of mathematics is in use, or that some of the kinds of relationships described by this mathematics in other theories when applied in other domains are also present in the descriptions of this theory in this domain. That alone does not, and should not, make much of a difference in evaluating our theories.

Keeping this clear can help us avoid potentially distracting confusions as scientists like Lewis develop emotion theory and other theories described using dynamics.

The contribution of cross-cultural study to dynamic systems modeling of emotions

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Abstract: Lewis neglects cross-cultural data in his dynamic systems model of emotion, probably because appraisal theory disregards behavior and because anthropologists have not engaged discussions of neural plasticity in the brain sciences. Considering cultural variation in emotion-related behavior, such as grieving, indigenous descriptions of emotions, and alternative developmental regimens, such as sport, opens up avenues to test dynamic systems models.

Lewis's recasting of emotion theories and neurobiology in dynamic systems theory (DST) is extraordinarily promising. DST of-

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