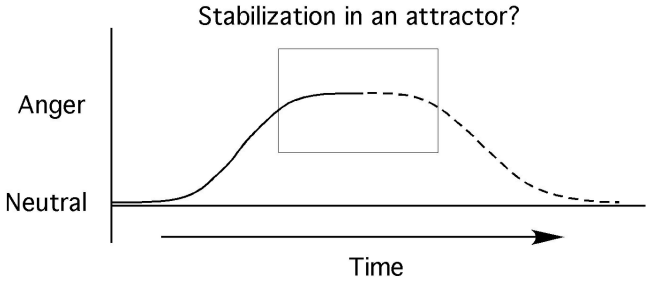

Figure 1 (Carver). Affect across time: Stabilization in an attractor, or gradual countering of a perturbation?

back to my second emotion-theory interest: the behavioral (and eventually affective) consequences of emotion. Behavioral consequences address the emotion's source (removing the obstruction, or reorganizing one's goal system to diminish its importance). When these behaviors are successful, the emotion diminishes (thus, the behavioral consequences have emotional consequences). Toward the end of section 3.3.3, Lewis brings up the possibility that functions pertaining to action play some role in stabilization. That seems far too little too late, however. Functions related to action are critical here.

Indeed, this view leads to skepticism that self-stabilization actually occurs. If affect emerges with registration of the violation, action tendencies emerge simultaneously to counter the violation (a point Lewis makes in the neuroscience part of the article, sect. 5.1). When those action tendencies yield perceived results, the anger diminishes. What appears to be stabilization may actually be the affect-countering effect of the actions (see Figure 1). Because the action often requires time to be fully effective, the emotion may cease to rise, yet fail to display immediate reduction, creating the illusion that stabilizing forces are acting to maintain it at that level. In this case, however, two directional forces are at work (one pushing emotion higher, the other dampening it) rather than a stabilizing force. To interpret this situation as a negative feedback loop maintaining the emotion at that level seems very misleading.

A final note: I am among those inclined to ignore the assumption that appraisal and emotion are distinct functions. How can appraising an event as having adverse implications for the self not imply negative affect? How can negative affect exist apart from registering (at some level, not necessarily conscious) that an event has adverse implications for the self? These seem two sides of the same coin.

I do not think abandoning the distinction renders emotion just another class of cognition, however. Valence, which is intrinsic to emotion, renders this class of experience distinctly different from others. Emotions differ from cognitions in other ways, too. The term emotion connotes physiological changes preparing the body to act. These changes are part of registering that the event has an adverse implication for the self, because adverse implications prompt behavioral responses. Such changes are not part of registering that an event constitutes a tree. This also makes emotions different from other experiences called cognition.

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An intermediate level between the psychological and the neurobiological levels of descriptions of appraisal-emotion dynamics

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Abstract: Conceptual space is proposed as an intermediate representation level between the psychological and the neurobiological levels of descriptions of appraisal and emotions. The main advantage of the proposed intermediate representation is that the appraisal and emotions dynamics are described by using the terms of geometry.

Lewis proposes two levels of description of appraisal and emotion dynamics. The higher, psychological level is characterized by perception, attention, evaluation, and reflection for the appraisal process, and by arousal, action tendency, and feeling tone for the emotion process (see Fig.1 of the target article). The lower, neurobiological level is characterized by the interaction among several parts and circuits of the brain.

An intermediate "conceptual" level of representation of appraisal and emotion is proposed and discussed, based on conceptual spaces (Gärdenfors 2000). A conceptual space is a geometric level of concept representation which is intermediate, in the sense of Jackendoff (1987), between the lower subsymbolic level characterized by descriptions in terms of dynamics of neural networks, as in the neurobiological level put forth by Lewis, and the higher level characterized by linguistic descriptions of emotion dynamics, as in the psychological level he describes.

As sketched below, the conceptual space level of representation has all the capabilities to describe the perception, attention, planning, and reflection processes discussed by Lewis as the basis of appraisal. Moreover, the conceptual space may be easily generalized in order to represent emotions.

The main advantage of this intermediate description is that the appraisal-emotion dynamics described by Lewis may be expressed in terms of geometry – that is, in terms of vectors, dimensions, geometrics operators, metric functions, and so forth. Geometric descriptions of cognitive processes are easy to model and to manipulate, as discussed in detail in Gärdenfors (2000); moreover, they may be immediately implemented in an artificial agent by standard geometric programming techniques.

A conceptual space is a metric space whose dimensions are related to the quantities processed by the agent sensors. Examples of dimensions could be color, pitch, volume, spatial coordinates. In any case, dimensions do not depend on any specific linguistic description: a generic conceptual space comes before any symbolic-propositional characterization of cognitive phenomena.

A *knoxel* (in analogy with *pixel*) is a point in the conceptual space that represents the epistemologically primitive perceptive element at the considered level of analysis. In an implemented robot vision system (Chella et al. 1997), in the case of static scenes, a knoxel corresponds to a *geon*-like three-dimensional geometric primitive (Biederman 1985). The agent itself is a knoxel in its conceptual space. Therefore, the perceived objects, like the agent itself, other agents, and the surrounding obstacles, are all reconstructed by means of geons and they correspond to suitable sets of knoxels in the agent's conceptual space.

Conceptual spaces may represent moving and interacting entities (Chella et al. 2000). Every knoxel now corresponds to a simple motion of a geon, expressed by adding suitable dimensions in the conceptual space that describe the variation in time of the knoxel. For example, consider the knoxel describing a rolling ball: the robot's dynamic conceptual space takes into account not only the shape and position of the ball, but also its *speed* and *acceleration* as added dimensions (Marr & Vaina 1982).

The example corresponds to a situation in the sense that the motions in the scene occur simultaneously; that is, they corre-

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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