autonomic concomitants of aggression, but some of its motor patterns and motivational aspects in humans, as well (e.g., Weissenberger et al. 2001). These are additional reasons for including the hypothalamus in the motivated action loop of Figure 3 in the target article. According to Lewis, temporal characteristics might also arise from the "self-amplifying" positive feedback among amygdala, anterior temporal, and orbitofrontal cortices. If so, the reciprocal inhibition between amygdala and dorsolateral frontal cortex (Drevets & Raichle 1998) may explain the decline in dorsolateral frontal cortex-mediated cognition during high levels of anger. To explore these ideas, a reliable, moment-to-moment measure of anger intensity is required (cf. sect. 2.2 of the target article).

5. Quantifying anger. Although the intensity of angry facial expressions can be estimated reliably (Hess et al. 1997), their dynamic range is unknown and they are methodologically difficult to capture. Even here in the 21st century, psychologists still estimate anger from subjective self-reports (e.g., Hoeksma et al. 2004). Peihua Qiu and I have been able to model the overall trajectory of anger based on the time courses of the individual angry behaviors objectively observed in tantrums (Potegal & Davidson 2003). The single latent variable, Momentary Anger, which drives all the individual angry behaviors, would be a suitable output variable in a dynamic systems model (Qiu et al., submitted).

Amalgams and the power of analytical chemistry: Affective science needs to decompose the appraisal-emotion interaction

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Abstract: The issues addressed in this commentary include: (1) the appropriate conceptualization of "appraisal"; (2) the nature and unfolding of emotional episodes over time; (3) the interrelationships between the dynamic elements of the appraisal process and their effects on other emotion components, as well as repercussions on ongoing appraisal in a recursive process; and (4) the use of brain research to constrain and inform models of emotion.

In this BBS target article, an admirable tour de force of scholarship, Lewis presents a formal model of appraisal-emotion relationships and reviews relevant evidence from neurobiology. We found many points in this article with which we agree wholeheartedly, but there are a few major issues on which we beg to disagree. For example, we feel that Lewis unduly equates the psychology of emotion with narrow conceptions of appraisal theory published more than a decade ago and fails to recognize the contribution of cognitive neuroscience to emotion theory (see Davidson et al. 2003; Kosslyn & Koenig 1995; Lane & Nadel 2000; Scherer 1993a; Scherer & Peper 2001). Although Lewis acknowledges that several emotion theorists have proposed appraisal-emotion interactions based on nonlinear dynamics and bidirectional causality, he suspects that the protagonists treat this as "an interesting diversion from more classical modeling" (sect. 2.2 of the target article). It is true that attempts to describe emotions as episodes of subsystem synchronization driven by nonlinear appraisal processes (Scherer 2000), and to specify hysteresis functions in integration models (Scherer 2004), have not progressed beyond a preliminary stage of modeling. Unfortunately, much of nonlinear dynamics theorizing, including the current target article, does not lend itself readily to designing appraisal experiments and analyzing multimodal data. Here we focus on four major issues:

1. The conceptualization of the appraisal process. Google finds 6,700,000 entries for the word "appraisal." Undoubtedly, Lewis's components of appraisal (perception, attention, evaluation, and reflection; see his Fig. 1) are involved in many of these instances. In contrast, appraisal theorists use the term in a more restricted fashion, specifying the *criteria or dimensions* which are constitutive for emotion elicitation and differentiation through event appraisal. These essential elements of appraisal theory are lacking from Lewis's account and readers unfamiliar with the appraisal literature are unlikely to fully comprehend what the discussion is all about. Evidently, the appraisal of these criteria involves *cognitive structures and mechanisms* such as attention, memory, problem solving, and self-representation (Scherer 2001), including multiple levels of processing (Leventhal & Scherer 1987). Appraisal theorists will need to pay greater attention to these cognitive mechanisms – in particular to the executive functions (see Fig. 5.3 in Scherer 2001) – but Lewis's rather general discussion of such "appraisal components" as "evaluation" adds little to our understanding.

2. The definition of emotion. Lewis adopts the componential view of emotion as advocated by appraisal theorists (Frijda 1986; Scherer 1984). However, the components he identifies in his "skeletal model" in Figure 1 and in the text – such as, "arousal," "feeling tone," or "attentional orientation" – are hardly consensual as representative emotion components. The component of *motor expression* is conspicuously absent. The most serious problem of Lewis's account is the lack of a specification on when an emotion begins and when it ends, as well as of the difference between an emotion episode and the non-emotional background of an individual's experience. Lewis (at the end of sect. 2.3) claims that "a process account should demonstrate how constituent processes give rise to a whole appraisal in the first place," and suggests that such an account is presented in his Figure 1. We have trouble understanding how his Figure 1 explains the unfolding of an emotional episode. If appraisal-emotion relationships are to be explored with respect to their circular causality, there must be a way of delimiting the respective episodes in order to avoid the rather unsatisfactory statement that everything interacts with everything else all the time. One solution is Scherer's (1984; 2000; 2001) suggestion to define the onset of an emotion episode as a certain degree of synchronization of emotion components driven by specific appraisal outcomes.

3. The nature of the appraisal-emotion relationship. Appraisal theorists have never denied that motivation and affect have a strong influence on appraisal. Most theories explicitly integrate the motivational state of the individual as one of the major determinants of appraisal outcomes. Obviously this includes emotion components such as action tendencies that have been produced by prior appraisal. A process-oriented account (see Scherer 2000; 2001), assuming constantly changing appraisal due to new information, would seem to cover bidirectional causality over time. Lewis's "skeletal model," lacking concrete mechanisms and predictions, does not provide a viable alternative to existing models. His terminology, with vague concepts such as appraisal-emotion "amalgam" or "whole," and the absence of suggestions for operationalization or experimental designs for empirical study, raises concerns about the epistemological status of the proposal. One senses an underlying reticence to engage in analytical procedures designed to take the amalgam apart in order to understand its nature. Yet, we need to decompose the appraisal-emotion interaction to understand its nature (just as we require analytical chemistry to study metal amalgams). As an alternative model of the dynamic elements of the appraisal process and their effects on other emotion components, as well as repercussions on ongoing appraisal in a recursive process, we suggest the Component Process Model proposed by Scherer (1984; 2000; 2001; 2004). Our Figure 1 presents a combination of Figures 5.1 and 5.2 in Scherer (2001). We feel that this model is sufficiently well specified to allow posing concrete questions about bidirectional appraisal-emotion interactions.

Contrary to Lewis's model, this model allows a detailed consideration of the effects of emotional processes on attention, memory, and other cognitive processes. In particular, it suggests a distinction between (i) an effect of particular *appraisal criteria* on

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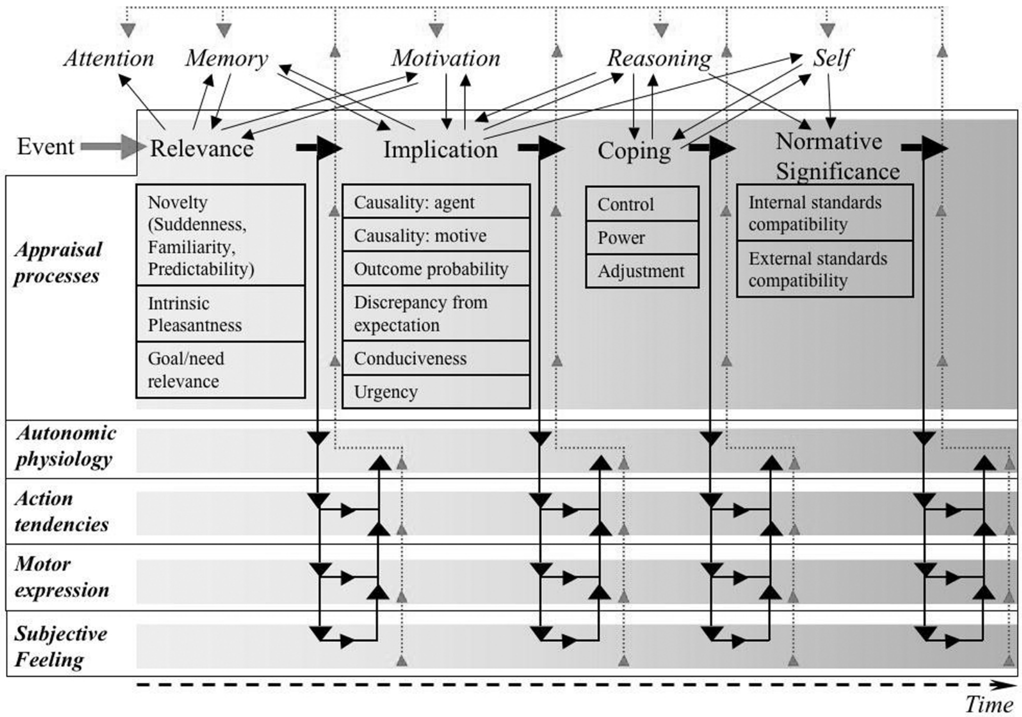

Figure 1 (Sander & Scherer). Comprehensive illustration of the Component Process Model of Emotion (adapted from Scherer 2001).

other cognitive processes and (ii) an effect of particular *emotion components* on these cognitive processes. Moreover, *direct versus indirect* types of emotional effects on appraisal criteria can be distinguished. Direct effects would consist in the modulation of appraisal criteria by other emotion components. Indirect effects would consist in an effect of these components on particular cognitive processes that, in turn, can influence appraisal criteria (see Figure 1). It can be expected that most effects are indirect – in the sense of individual emotion components affecting attention, memory, and other cognitive processes or representations.

4. The role of the underlying neural architecture. Identifying the neural mechanisms subserving emotional processes serves to constrain and inform models of emotion (see Davidson 2000; Sander & Koenig 2002). Unfortunately, Lewis's extensive review of the vast literature concerning the cerebral basis of major cognitive functions and other psychological processes is of limited use for this purpose because the information is often too general to allow inferences concerning specific functional architectures. The treatment of the amygdala is a good example: According to Lewis, the role of the amygdala in the evaluative component of appraisal consists of a "basic pattern-matching function" (sect. 4.2.2). However, a more specific account of the function of the amygdala, as based on recent research, is required to constrain and inform models of emotion. Contrary to the assumption that the amygdala is central to a "fear module" (Öhman & Mineka 2001), presumably supporting a discrete emotion model, patient data and brain imaging studies clearly demonstrate that this structure contributes to the processing of a much wider range of negative affective stimuli (for a review, see Sander et al. 2003). As the amygdala seems also involved in the processing of positive events, it was suggested that it modulates arousal, independently of the valence of the elicitor (e.g., Anderson et al. 2003) – potentially supporting dimensional theories of emotion. However, it has been shown that equally intense stimuli differentially activate the dorsal amygdala (e.g., Whalen et al. 2001), and that arousal ratings in a patient with an amygdala lesion are impaired for negative, but not positive, emotions (Adolphs et al. 1999). These results seem to contradict the view that the amygdala codes arousal irrespective of valence. Converging evidence supports the view that the computational profile of the human amygdala meets the core appraisal concept of *relevance detection* (for a detailed analysis, see Sander et al. 2003), a view which integrates established findings on the amygdala and suggests that it may be central in processing self-relevant information. Although this type of neural architecture can be directly integrated into appraisal models like the one shown in our Figure 1, it is difficult to see how it informs very general models like the one presented by Lewis.

Developmental affective neuroscience describes mechanisms at the core of dynamic systems theory

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Abstract: Lewis describes the developmental core of dynamic systems theory. I offer recent data from developmental neuroscience on the sequential experience-dependent maturation of components of the limbic system over the stages of infancy. Increasing interconnectivity within the vertically integrated limbic system allows for more complex appraisals of emotional value. The earliest organization of limbic structures has an enduring impact on all later emotional processing.

In this target article, as in all of his writings, Marc Lewis describes the essential developmental core of self-organization theory, a theory that fundamentally models the emergence of novel patterns or structures, and the appearance of new levels of integration and organization in existing structures. In light of his contributions and research in developmental psychology, it is curious that he offers little in the way of data from developmental psychology or developmental affective neuroscience that may bear directly upon his model of self-organizing emotional appraisals. In his neurobiology he emphasizes the roles of the amygdala, anterior cingulate, and

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