emotion process in which events lead to appraisals leading to emotional responses. Instead, it presents an appealing model of emotion generation as a process over time that allows for the many things that can happen during that time, and in which a triggering phase, a self-amplification phase, and a self-stabilization phase can be meaningfully distinguished. Each phase is described as guided by ongoing processes that the triggering event impinged upon, by the effects of those processes on subsequent processes, and by the self-organizing interactions between the various outcomes that augment, counteract, dampen, or stabilize the processes that caused them. The article thus sets the agenda for research on the time course of emotion arousal. In fact, considerable research is emerging that substantiates the hypothesis that many things do happen when an emotion is aroused, and before it obtains its distinct contours. Examples are the evidence produced by varying prime exposure times in priming experiments (e.g., Murphy & Zajonc 1993; Stapel & Koomen 2000), and by changes in responses to emotional stimuli over exposure time, which led to the defensive cascade model (e.g., Bradley & Lang 2000).

Second, the target article beautifully describes the processes of emotion generation as an intimate intertwining of appraisal and response generation sub-processes rather than of appraisals preceding emotions. Feedback from intermediate action components steers appraisal processes, but, in addition, appraisals are steered to support ongoing action components and may well be shaped and augmented by what would be needed to select from among available response options. A primary example comes from the impact of one of the major appraisal components in appraisal theory, that of appraised coping competence, which appears as a result of ongoing interactions rather than of prior appraisal. Also, appraisals often reflect accessed action modules rather than determining such access: many stimuli (e.g., human faces) are appraised as attractive or frightening because they happen to elicit an approach or avoidance tendency. One may well hypothesize (I do) that appraisal patterns are shaped and stabilized by what the action modes happen to be responsive to, which responsiveness thus filters out (and makes demands on) the available information. For this intertwining, too, evidence of various sorts exists, both from self-reports and from experimentally shown effects of ongoing emotional responses upon information pick-up and interpretation. I am of the opinion that both the temporal development and the appraisal-response-reciprocities should become elements of any standard account of emotion generation.

Part of this analysis is the view that "emotions" are not considered as wholes but as more or less integrated sets of components, each of which can be separately influenced by appraisal, and can separately act upon appraisal. I agree with Lewis that this is the only viable viewpoint in any process analysis; it is, I think, shared by most current emotion researchers. Emotion words – fear, joy, anger, and so forth – should be avoided unless it is simultaneously specified which component or combination of components in the given analysis they refer to.

The dynamic systems perspective is obviously a third major aspect of Lewis's treatment. Appraisal components presumably organize into "whole appraisals"; appraisal-emotion amalgams somehow tend to stabilize; and higher-level states or structures emerge that constrain the more elementary processes. Lewis proposes that order in the entire domain of emotional phenomena and appraisal-emotion relationships is much more a function of self-organization than of prewired or even of learned structures. The proposal is enticing. It can accommodate salient structure in the phenomena as well as deviations from such salient structures, and phase transitions from one structure to another. It is a promising perspective, considering its achievements in, for example, shedding light on the variability of facial expressions (Camras 2000) and the emergence of patterns in interactional behaviors (Fogel 1985), and in considering the possibility of self-stabilizing in parallel constraint satisfaction networks. Yet, with regard to appraisal and emotion relationships, the dynamic systems perspective still remains mainly a promise. The notion of "whole appraisals" in Lewis's target article is not defined or substantiated. Whether an appraisal of "threat" is more than a linear combination of its constituent components (except when mediated by the word "threat") remains to be demonstrated, though studies by Lazarus and Smith (1988) and Chwelos and Oatley (1994) represent efforts in that direction. Whether actually occurring appraisal patterns indeed form only a small subset of theoretically possible patterns (as Lewis asserts they do), has, to my knowledge, not yet been examined. Whether appraisals indeed stabilize, and if they do, for what reasons, also awaits evidence. Probably, evidence in these regards is not too difficult to come by. So far, little effort has been devoted to analyzing the variability of appraisal patterns linked to a given emotion class. De Boeck and his colleagues (Kuppens et al. 2003) have recently begun work on that issue.

That these proposals are mostly promises does not detract from their plausibility. Certain appraisal patterns may have more internal coherence than others, or their components may be more related; they do, as patterns, have meaningful relationships to particular action readiness modes because they represent precisely what the action readiness modes aim to modify. Action readiness also may well entrain particular actions and physiological activations, and may even form coordinative structures. Attractors may be shaped on those grounds. The dynamic systems approach thus points to focused research in those directions. But appeal and plausibility are dampened by the question that emerges upon reading the article: What are the phenomena that make analysis in terms of self-organization notions desirable?

The fourth contribution of this target article is its detailed review of neurobiological findings that are relevant to emotion processes. The complex neurobiological interactions parallel the complex interactions described at the psychological level. The analysis arrives at three plausible high-level neurophysiological loops. Surprisingly, considering the author's reservations regarding the appraisal–response distinction (confusingly termed the appraisal–emotion distinction), the loops identify appraisal (here called "object evaluation") and action as distinguishable major functional circuits, together with process monitoring.

Exploring psychological complexity through dynamic systems theory: A complement to reductionism

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Abstract: Dynamic systems theory (DS) provides tools for exploring how simpler elements can interact to produce complex psychological configurations. It may, as Lewis demonstrates, provide means for explicating relationships between two reductionist approaches to overlapping sets of phenomena. The result is a description of psychological phenomena at a level that begins to achieve the richness we would hope to achieve in examining psychological life as it is experienced and explored in psychoanalysis.

It has long been evident that the clarity and testablity reached through the reduction of complex psychological phenomena is achieved at the price of the loss of the richness people hope for from psychological explanations. Whether in terms of emotion theory, neuroscience, psychoanalytic theory, or any number of other efforts to reduce personal experience to underlying mechanisms, it is rare for individuals to feel that the theory has achieved an explanatory power adequate to their own experience. One result has been an ongoing tension between the psychological theories and experiential descriptions. This tension is especially evident in clinical work, where the ever-present search for the bases for complex particular psychological states rapidly comes up

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against the wall of the limitations of empirically testable theories, to the frustration of patients and therapists alike. As a result many clinicians abandoned reductionist approaches, preferring to catalog the phenomena they have observed and to provide explanations in terms of an expanded commonsense psychology.

For many investigators the study of nonlinear systems suggests a route toward a theory that encompasses more of the richness of experience. Coincident with the first efforts to use feedback controls in the design of any but the simplest mechanical and electronic devices, it became evident that the intrinsic nonlinear properties of feedback-driven systems introduced elements suggestive of the sort of richness of action characteristic of living and thinking beings (Arbib 1972; Wiener 1948; 1950; Wiener & Schadé 1965). Wiener quickly realized, as he worked to develop a general theory of feedback systems, that the complexity and richness of behavior of such systems results from the nonlinear dynamics intrinsic to them. As the richness of the phenomena that could result from nonlinear dynamics became increasingly well understood, several authors suggested that some of the richness apparent in everyday psychology resulted from the operation of nonlinear dynamics (Galatzer-Levy 1978; Langs & Badalamenti 1991; Ruelle 1991; Sashin 1985; Sashin & Callahan 1990; Spruiell 1993). However, while this work promised that answers to the origins of common psychological richness might well lie within the intrinsic qualities of dynamic systems, it yielded no specific models of psychological phenomena, much less models the could be tested. Actual modeling of psychological phenomena began to appear with regularity in the mid- to late 1990s and, as might be expected, has been most successful in such areas as the study of the development of locomotion, in which well-defined parameters can be observed. Lewis cites many examples of such models.

In terms of psychological theories, dynamic systems models of neural networks seemed particularly promising because it is clear that psychological phenomenon must in some sense be an expression of the operation of such networks; and the more specific descriptions of these networks as dynamic systems seemed like good models for some moderately complex psychological phenomena (Rumelhart et al. 1986b; Spitzer1999).

Another approach to the use of DS in psychology has been to suggest that phenomenon that appeared to be mysterious or unreal because no satisfactory explanation for them were available, may seem more unlikely than they are because our common sense has been educated to linear conceptualizations (Galatzer-Levy 2004). For example, emergence and phase transitions are not encompassed well within a linear worldview. The mere appreciation that such phenomena can occur makes it possible to recognize them within the context of psychological investigations.

Lewis's contribution is interesting not only because he provides a plausible bridge between neuroscience and emotion theory, but also because it suggests a method for approaching the integration of seemingly disparate reductionist viewpoints regarding complex phenomena. Freud's efforts to create a discipline based in the neuroscience of his times foundered not only because of the limitations of the field at that time (the neuron had just been discovered), but because he lacked any means to integrate the reduction achieved through neuroscience modeling and that achieved by reference to abstract structures such as the id, the ego, and superego which seemed to have explanatory value as psychological entities. Neuroscience models pertinent to psychoanalysis are in a far better state than they were in Freud's time, and many psychoanalytically relevant phenomena can now be addressed from the point of view of neuroscience (Solms & Turnbull 2002). The discipline of neuropsychoanalysis has emerged complete with its own journal, and interesting correlates between brain and complex psychological function have been suggested. However, models integrating the regularities described in psychoanalytic psychology with brain functioning remain largely to be developed. Lewis's iterative approach would seem to be applicable in this situation as well is in the study of emotion theory.

Although dynamic systems theory clearly shows that surprising configurations can emerge within systems that seem improbable and incomprehensible to our linearly trained "common sense," this rich picture of potential worlds must be carefully distinguished from that which has been systematically demonstrated. The history of the study of nonlinear dynamics is full of instances in which investigators confused plausible similarities between observed phenomena and mathematical models with actual demonstrations that those models encompassed the phenomena. Therefore, it seems prudent to be suspicious of verbal arguments about what are essentially mathematical models. Lewis is careful to point this out. Nevertheless, repeated recognition of this limitation of the methodology, as it is currently used, is essential if investigators are not to fall prey to the trap of believing that they have demonstrated more than they in fact have. However, with this word of caution, it would seem that Lewis has hit upon a method that can be extended to the exploration of complicated psychological phenomena and the several possible reductions that can often be found for those phenomena.

START: A bridge between emotion theory and neurobiology through dynamic system modeling

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Abstract: Lewis proposes a "reconceptualization" of how to link the psychology and neurobiology of emotion and cognitive-emotional interactions. His main proposed themes have actually been actively and quantitatively developed in the neural modeling literature for more than 30 years. This commentary summarizes some of these themes and points to areas of particularly active research in this area.

Lewis's stimulating account of data and concepts concerning emotional and cognitive-emotional processing claims that "there is simply no overarching framework available, to date, for synchronizing psychological and neural perspectives on emotion," and that "dynamic systems ideas . . . have never been applied to developing such a framework" (sect. 1, para. 5), before proposing that dynamic system modeling can offer "a common language for psychological and neurobiological models" (target article, Abstract). Lewis frames his proposal after asking "why do the psychology and neurobiology of emotion remain largely isolated?" (sect. 1, para. 1). His own proposal is, ironically, an example of this isolation, for he has ignored the most developed neural models of emotion and cognitive-emotional behavior, which have been building such a framework for more than 30 years. Lewis provides no quantitative models, but this ignored framework does.

All of Lewis's concepts of "nested feedback interactions, global effects of neuromodulation, vertical integration, action-monitoring, and synaptic plasticity . . . modeled in terms of both functional integration and temporal synchronization" (Abstract) are explicated in these neural models of emotion and cognitive-emotional interactions, and are used to explain and predict many behavioral and brain data. When I published my first articles in this area (Grossberg 1971; 1972a; 1972b; 1974; 1975; 1978), there were, as Lewis notes, divisions in the field that prevented an integration of psychological, neural, and modeling perspectives. Since that time, however, the connectionist and computational neuroscience revolutions have occurred, and renewed interest in behavioral and neural modeling and models of the type that Lewis espouses have been published throughout the mainstream literature (e.g., Brown et al. 1999; 2004; Carpenter & Grossberg 1991; Commons et al. 1991; Fiala et al. 1996; Grossberg 1980; 1982a; 1982b; 1984a; 1984b; 1987; 1988; 2000a; 2000b; Grossberg & Gutowski 1987; Grossberg & Levine 1987; Grossberg & Merrill 1992; 1996;