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Computational analysis, appraised concern-relevance, and the amygdala: The algorithmic value of appraisal processes in emotion

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At the core of the interdisciplinary "human affectome" framework is the proposal that "*algorithms that address affective concerns indicate the relevance of a physical or mental object by suggesting actions regarding that object*" (Schiller et al., 2024, Fig. 1, p. 11). In this commentary, we focus on two central notions of this proposal. First, we address the very notion of such "*algorithms*" in emotion theories. Second, we address the notion of appraised concern-relevance as an algorithmic solution to the computational problem of inferring the relevance of objects. Finally, we illustrate the algorithmic value of appraisal processes in emotional learning.

Schiller et al. (2024) define algorithms as "*sequences of steps articulable in words, equations, or code that are executed for specific goals or to solve particular computational problems*" (p. 8). The search for such algorithms has been pivotal to cognitive sciences with respect to many cognitive processes like perception, attention, learning, memory, and action preparation. According to David Marr's levels of analysis, a computational analysis can be defined as a logical exercise aimed at determining which processing subsystems are necessary to produce a specific output, given specific inputs. Although computational analyses of emotions are relatively recent (see Sander and Koenig, 2002), promising computational advances are increasing in affective sciences, to the point where some functional architectures of emotion are sufficiently explicit to be tested using a combination of computational, neuroscientific, and psychological methods. Here, we suggest that appraisal theories of emotion are particularly well-suited to specify the algorithms addressing affective concerns. Appraisal theorists have adopted early on an algorithmic-like manner of thinking about the subprocesses—and their interactions—that are necessary to subserve the components of emotions and their constitutive mechanisms (see Scherer et al., 2001), rendering appraisal theories highly compatible with computational approaches. In line with this view, Emanuel and Eldar (2023) have recently proposed a novel computational approach to emotion that is inherently grounded in appraisal theory, resonating with the field of affective computing where several influential computational models of emotion are based on appraisal theory (Gratch et al., 2015).

A computational approach to concern-relevance may be the domain in which the algorithmic value of appraisal processes is most evident as a solution to the computational problem of inferring the relevance of objects. Indeed, a central affective element involved in both emotion elicitation and modulation of cognitive processes is *appraised concern-relevance*. Appraised concern-relevance is conceptualized as a fast mechanism enabling the organism to establish whether a stimulus event is relevant to their concerns (e.g., Frijda, 1986) and shaping a multi-componential emotional response involving action tendencies, autonomic reactions, expressions, and feelings (Sander, 2024). Within the human affectome framework, concern-relevance is at the intersection of

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a teleological principle of why there are affective phenomena (*to enact relevance*) and a constituent of what affective phenomena are (*affective concerns*). Despite their conceptual similarities, concern-relevance differs from enactive relevance and affective concerns. Whereas enactive relevance is determined by the actions suggested by affective concerns regarding an object, appraisal theories would posit that an object is appraised as concern-relevant if it increases the probability of (dis) satisfaction toward a major concern of the organism (Sander, 2024). The function of concern-relevance is thus not directly to make an object meaningful based on its actionability, but to appraise the impact of that object in relation to the organism's concerns, including its goals, needs, values, and wellbeing. As such, concern-relevance is inextricably linked to the organism's current concerns in a given situation at a given time, the salience and hierarchy of which can flexibly and rapidly change based on environmental contingencies that are not necessarily related to metabolic or homeostatic considerations.

Circling back to Marr's levels of analysis, it has been suggested that the amygdala is a key brain region for the implementation of concern-relevance appraisal. Growing evidence supports the idea that the amygdala is not dedicated to threat processing or fear elicitation, but rather plays a broader role in detecting concern-relevant events (see Sander, 2024). With the development of multivariate analyses in functional brain imaging of emotion, elucidating the implementational level of appraised concern-relevance, along with other appraisal processes of critical algorithmic value, holds promise for uncovering how brain networks—rather than individual brain regions—subserve appraisal processes and specific emotions (see Kragel et al., 2024).

Concern-relevance can be operationalized to study its effects not only on the emotional response but also on various cognitive processes. In this respect, emotional learning is a process that illustrates particularly well how appraised concern-relevance possesses high algorithmic value when adopting a computational approach to emotion. Researchers investigating emotional learning have been at the forefront of utilizing computational approaches to model the dynamics of learning processes. Moreover, understanding how emotional stimuli modulate these learning dynamics is of key interest to affective scientists. Integrating these aspects, research on Pavlovian conditioning—a fundamental form of learning whereby animals and humans attribute value to their environment—has revealed that, akin to threat-relevant stimuli (e.g., snakes, angry faces), concern-relevant positive emotional stimuli (e.g., baby faces, erotic images) are likewise more rapidly and persistently associated with an aversive event than less relevant stimuli (e.g., neutral faces) beyond threat value and valence (Stussi et al., 2018, 2021). At the algorithmic level, concern-relevant stimuli were associated with a lower learning rate for negative prediction errors (i.e., when the aversive event was expected but omitted), enhancing the persistence of their association with the aversive event (Stussi et al., 2018, 2021). These findings thus highlight the prominent influence concern-relevance can exert on basic determinants of learning.

In the context of the current rise of *affectivism* (Dukes et al., 2021) that we may witness in the development of models of mind, brain, and behavior, joint efforts such as the human affectome are especially timely and relevant because they offer affective scientists shared frameworks to collaborate. Encouraging such joint efforts—without neglecting existing conceptual debates and methodological diversity—is likely to foster our understanding of affective phenomena and move the field forward.

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