

Emotional memory: from affective relevance to arousal

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Abstract: Arousal is typically conceived as a key component of emotional response. We describe here the psychological processes thought to elicit arousal, in particular the processes involved in the appraisal of affective relevance. The key role of relevance in attentional and memory processing, and its links with arousal, is discussed with respect to the GANE model presented by Mather et al.

Mather et al. provide an innovative and integrative model aimed at explaining, at the neural level, how arousal can both enhance and impair cognitive processing, such as perception and memory. The Glutamate Amplifies Noradrenergic Effects (GANE) model proposed by the authors accounts for results indicating that increased norepinephrine under arousal affects prioritization of information processing, e.g., enhances memory for salient information at the expense of mundane information. Mather et al. consider arousal to be the critical factor that amplifies the perception of emotional stimuli while impairing the perception of other concurrent stimuli, as has been proposed in the Arousal-Biased Competition (ABC) theory (Mather & Sutherland, 2011). Mather et al. are particularly interested in analyzing the effect of selectivity in the perception and memory of *emotional* stimuli under *arousal*; however, the construct “arousal” is not conceptually

clear if one considers how it is used in the affective sciences literature, especially concerning theories of emotion. More generally, the relationship between emotion and arousal is far from being consensual, notably when it comes to modeling the psychological mechanism that elicits different types of arousal (see Sander, 2013). For instance, Frijda (1986) distinguished between three response systems that embrace the construct of arousal or activation: autonomic arousal, electrocortical arousal, and behavioral activation. Traditionally, theories of emotion refer to arousal mainly in terms of either (1) the consciously felt activation dimension of the experienced affect or (2) the bodily reaction during an emotional episode, specifically the sympathetic nervous system. Dimensional theories propose that any experienced affect can be described as a particular feeling on a continuum in terms of an activated (e.g., as in surprise) or deactivated (e.g., as in boredom) state (Feldman, 1995; Russell, 1989). On the other hand, the bodily reaction can be measured in terms of a psychophysiological state driven by the activation of the sympathetic nervous system (SNS). Emotion researchers typically use the construct of arousal to refer to the activation of the SNS, and physiological measures (e.g., skin conductance response or pupil dilation) are often used as measures of emotion intensity, as they are also considered to mirror subjective affective ratings (see Bradley, Miccoli, Escrig, & Lang, 2008; Lang, Greenwald, Bradley, & Hamm, 1993).

The effect of arousal on performance has been revealed in various research domains and is consistent with the model proposed by Mather et al., suggesting that—under arousal—neutral stimuli with a high priority are processed preferentially.

The priority factor is essential to memory enhancement. Indeed, it has been proposed that arousal per se is not sufficient to explain memory improvement for neutral information (Reisberg & Heuer, 2004). For instance, a study that manipulated arousal by injection of adrenalin versus saline showed no difference in the results of memory performance for verbal descriptors (e.g., name, occupation) presented previously with neutral faces, although heart rate and skin conductance increased in the group with adrenalin injections (Christianson & Mjörndal, 1985). The information presented did not differ in terms of priority. This notion of priority, especially when related to the well-being or major

concerns of the individual, is considered to be of key importance in explaining emotion elicitation. Indeed, appraisal theories of emotion suggest that stimuli that are appraised as relevant for an individual's concerns (e.g., that relate to goals, needs, and values) are typically those that have the competency to elicit an emotional response by driving changes in action tendencies, in expressions, in the peripheral nervous system, and in the conscious feeling (e.g., Sander, Grandjean, & Scherer, 2005). With respect to arousal, a conceptually interesting advantage of such models is that an explanation for the elicitation of arousal is proposed: only concern-relevant events elicit arousal. Evidence indicates that stimuli that are appraised as concern relevant not only elicit such emotional responses, but are also prioritized in attention (see Pool, Brosch, Delplanque, & Sander, in press). For instance, a recent meta-analysis revealed that the magnitude of the attentional bias for positive stimuli varies as a function of arousal, but also that this bias is significantly larger when the stimulus is relevant to specific concerns (e.g., hunger) of the participants compared with other positive stimuli that are less relevant to the participants' concerns (Pool et al., in press). Interestingly, in this meta-analysis, when arousal and relevance moderators were tested by statistically controlling their respective variances, only relevance remained a significant predictor of the magnitude of this bias in emotional attention. Emotional attention is a process that has been suggested to strongly rely on the amygdala (Vuilleumier, 2005), a region that has also been suggested to be critical for the process of appraised relevance (e.g., Cunningham & Brosh, 2012; Sander, Grafman, & Zalla, 2003), and, of importance, to promote memory consolidation, as described by Mather et al. (Roosendaal & McGaugh, 2011, for review).

Studies supporting the ABC theory (e.g., Sutherland & Mather, 2012) and GANE models are largely based on experimental manipulation showing that high-priority neutral information under external arousal is enhanced in memory (as compared with low-priority neutral information). Showing that goal-relevant events, which are intrinsically neutral, are processed preferentially might extend the model proposed by Mather et al. For instance, the goal-relevance hypothesis of memory facilitation has been tested in a game-like study in which the goal of the participant was to win points. Participants showed better memory performance for initially neutral items that signaled a gain (i.e.,

goal-conducive items) than they did for initially neutral items that were goal irrelevant (Montagrin, Brosch, & Sander, 2013).

Our suggestion is that events that are relevant for one's goals elicit an arousal response, capture attention, and facilitate memory. A fascinating research question, for which both the GANE model and the ABC theory can be particularly well articulated with appraisal theories of emotion, is to understand the causal relationships between relevance detection, arousal, attention, and memory.

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