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GANEing on Emotion and Emotion Regulation

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Abstract: The function of emotion and its underlying neural mechanisms are often left underspecified. We extend the GANE model by examining its success in accounting for findings in emotion regulation. We also identify points of alignment with construction models of emotion and with the hypothesis that emotion states function to push neural activity toward rapid and efficient action.

What is emotion? Why did it evolve and what is its purpose? Several models of the origin and function of emotion have been given (see Gross & Barrett, 2011 for review). For the sake of brevity we identify two broad and encompassing approaches. One pursues questions related to why and how *emotions* evolved (Ekman, 1993; Tooby & Cosmides, 1990), referred to as the entity view. The other focuses on why *emotion* evolved (Lindquist, Kober, Bliss-Moreau, & Barrett, 2012; Simon, 1967), which we will call the process view. At first glance it is a subtle difference, but it is a difference that matters greatly for how we understand emotion, its underlying mechanisms, and its adaptive functions.

On the entity view, individual emotions served specific functions in the past that were important for survival and so were preserved. Each emotion is structured like an organ that has feature detectors for identifying relevant stimuli that then trigger a coordinated set of action tendencies that enhance survival (Panksepp, 2007). The challenge for modern humans is to regulate these inherited responses in order to conform to the much changed present-day environment. The process view on the other hand allows for a nearly unlimited variety of emotional states and responses. Principles of neural computation are often an important part of this account (Lindquist et al., 2012), and can be augmented by stipulating that the function of emotion is to enable neurological systems to minimize exploration over the current problem space in order to more rapidly bring about efficient action (cf. Donoso, Collins, & Koechlin, 2014; Simon, 1967), something we will refer to as computational expediency.

GANE is an intriguing mechanism supportive and suggestive of the process view of emotion in so far as it binds any variety of prioritized cortical representations to arousal and core affective states, rather than assuming that an individual category of emotion (sadness or fear, for example) produces stereotyped cognitive and behavioral effects. Thus, GANE suggests that there is a great deal of flexibility in the formation of emotion states and that no special neural substrates or modules of particular emotions are needed to account for the adaptive, and sometimes maladaptive, nature of emotional memory and responding. This accords with the increasingly influential models of emotion construction, however, a full exposition is beyond the scope of this commentary.

We would like to focus on the principle of computational expediency within the framework of GANE by drawing on findings from emotion regulation. An inability to modulate arousal may lead to difficulties in adapting to present circumstances, not because emotional states are geared towards environments from our phylogenetic past, but because alternative and more adaptive forms of responding may not reach priority in the cortex. If one’s affective learning history prioritizes maladaptive cortical representations due to social modeling, maltreatment or potentially traumatic low probability events, GANE suggests that unless there is a dampening of arousal, or assistance in pushing subthreshold representations into greater excitation, or both, it will be difficult to alter behavioral responses. Less clinically, because the neural categorization of stimuli and situations is probabilistic (Donoso et al., 2014), cortical activity that represents situations will inevitably err from time to time. Giving oneself space to explore alternatives through arousal regulation efforts is likely to help individuals recover from misattributions and behave more adaptively. Reducing arousal through emotion regulation would provide an opportunity for neural activity representing alternatives to reach priority and thus have an impact on action and memory.

For these reasons emotion regulation is a ubiquitous human activity (Gross, 2015) and recent research indicates that it can take on a variety of forms depending on the situation and one's goals. Humans often increase emotional states that they believe will enhance their performance (Tamir, Bigman, Rhodes, Salerno, & Schreier, 2015). For example, when preparing for an upcoming negotiation, individuals will increase negative emotional states (such as anger) to increase the likelihood of obtaining their goal. We could speculate that the arousal and prioritized representations we label as anger in this instance provide a singularity of focus and purpose unencumbered by the deliberation of alternative states as suggested by GANE mechanisms. Relatedly, the strategy of distraction is more effective for high intensity stimuli, whereas altering one's interpretations (a strategy called reappraisal) is more effective for low intensity stimuli (Sheppes et al., 2014). We suggest that distraction during high arousal events helps to reduce the tendency towards computational expediency of prioritized representations in order to allow for further exploration of the dangers, demands and opportunities of the situation. When arousal is low, reappraisal is more successful at prioritizing new representations so that new memories can be formed that change how one would respond to the stimulus in the future (Denny, Inhoff, Zerubavel, Davachi, & Ochsner, 2015). Importantly, the success of reappraisal is severely impaired if stress and arousal are high (Raio, Orederu, Palazzolo, Shurick, & Phelps, 2013), perhaps because cortical activity representing alternative interpretations is unable to reach the high arousal threshold and achieve priority.

A final intriguing case is the impact that cognitive load has on reducing hedonic arousal and temptation (Van Dillen, Papies, & Hofmann, 2013). As the target article notes, many models of cognition and emotion assume that emotionally evocative stimuli always take priority over attention. However, findings that cognitive load interferes with the introduction of new emotion states further supports the GANE model by demonstrating how current prioritized representations are maintained by arousal to the exclusion of alternative representations, even those that would otherwise be emotional given one's affective learning history.

It is not our intention to argue that all aspects of emotion, emotion regulation, or psychopathology can be accounted for by the GANE model. Numerous other neurotransmitters and neuromodulators will also play decisive roles. However, the GANE model offers a neural mechanism that helps to unify cognition and emotion while drawing attention to neurocomputational effects that align with previous theorizing on the function of emotion in ways that are suggestive of future research on the mechanistic bases of emotion regulation.

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