Commentary on Mather, M., Clewett, D., Sakaki, M., & Harley, C.W. (in press). Norepinephrine ignites local hot spots of neuronal excitation: How arousal amplifies selectivity in perception and memory. Behavioral and Brain Sciences.

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Competition Elicits Arousal and Affect

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Abstract: The emotion-cognition integration in the target paper can be extended by specifying the relationship between competition and arousal in the reverse direction. According to affective monitoring competition raises arousal, which when sustained results in negative affect, evoking Theta oscillations, and when resolved in positive affect, evoking Gamma oscillations. Competition should be considered a core process in both cognition and emotion.

Competitive processes in the brain have the potential to account for a much larger range of behavioral functions than only attention and memory. The target article successfully accounts for enhancing and impairing effects of arousal (and NE) on selective attention and memory in terms of neural competition, but still sometimes mixes the brain metaphor with the 'steam-engine' metaphor. If competition is envisaged as mutual inhibition between neural nodes, there is no further need to borrow conservation laws from nineteenth century physics and invoke limited resources to explain interference. Whereas arousal effects are thus predominantly analyzed in terms of neural processes, the source of arousal and emotion is only discussed here on a behavioral level. The analysis can be extended by also grounding arousal and affect in processes of neural competition.

Emotion research abounds in examples where modulatory influences of affect on attention and memory appear to be reciprocal, in that a similar, but not affectively laden, manipulation of attention or memory is able to elicit affect (e.g., Dreisbach & Fischer, 2012; Phaf & Rotteveel, 2005; Rotteveel & Phaf, 2007; Srinivasan & Hanif, 2010). Most relevant for the present discussion may be studies demonstrating distracter devaluation, and target appreciation, in attentional filtering tasks (Goolsby et al., 2009; see also Raymond, Fenske, & Tavassoli, 2003). The present authors explain target selection in attentional tasks by biased competition (Desimone & Duncan, 1995; Duncan, 1996; see also Phaf, van der Heijden, & Hudson, 1990), so the appreciation and devaluation may also follow from competitive processes. Phaf and Rotteveel (2012) have argued that affect is the consequence of competition (i.e., conflicting neural representations; cf, Murre, Phaf, & Wolters, 1992), and that negative affect arises when it is sustained, but positive affect when it is quickly resolved. Fluent, competition-less, processing in itself is not sufficient to raise positive affect (but see, Fazendeiro, Chenier, & Winkielman, 2007). The common denominator in both positive and negative affect is the initial competition, which may thus correspond with arousal. The largely similar effects of positive and negative arousal (e.g., Sutherland & Mather, under review) may thus result from this initial phase of competition.

Gamma and Theta, oscillations are involved but not well integrated by the authors in their competitive framework. Such an integration, however, serendipitously emerged from our evolutionary simulations (Heerebout & Phaf, 2010ab). Random variation combined with selection of the fittest individuals led to the development of both competition and oscillations in neural networks that controlled agents roaming an artificial environment. The fitness measure combined the amount of food gathered and the time the agent managed to escape from predators. The serendipitous emergence of oscillations coincided with a near-doubling of fitness, indicating that they were very functional to the agents. In fact, the same feedback loops between excitatory and inhibitory nodes developed autonomously in the evolutionary simulations as were suggested in the target article. Heerebout and Phaf (2010a) investigated the behavior of these agents and found that oscillations had a complementary function to competition. Competition enables the selection of representations, and oscillations allow for a reset of winners (i.e., switching of representations).

Attentional flexibility is more functional with positive than with negative affect. When searching for food, it is highly adaptive to be able to quickly shift attention towards an approaching predator. When running from a predator it is highly maladaptive to switch attention to some palatable food (i.e., it is better to miss dinner than to be dinner). We hypothesized that low-frequency, presumably Theta, oscillations are evoked by competition, whereas high-frequency, presumably Gamma, oscillations arise when the competition is solved. Similar to arousal (and NE), the former increase selectivity and narrow attentional focus, whereas the latter enhance switching between representations and attentional flexibility (Bauer, Cheadle, Parton, Müller, & Usher, 2009; Heerebout, Tap, Rotteveel, & Phaf, 2012). Crucially, in this view Theta oscillations (i.e., resulting from competition) precede Gamma oscillations, and may thus be the most primary reflection of arousal. According to this framework, without competition there is no arousal, Theta synchrony (i.e., negative affect), or eventual Gamma synchrony (i.e., positive affect). Doubtlessly, the functioning of biological networks is more complex than in these simple models, which however provide a useful starting point for the integration of such disparate functions as attention, memory, arousal, affect, and neural oscillations.

The target paper attempts to break down the traditional distinction between hot emotional and cold cognitive processes by discussing emotional modulation of cognition. Not only however are there modulatory effects of arousal and emotion on attention and memory for neutral material, but the elicitation of arousal and affect from the processing of neutral material can also be observed (e.g., from novelty, conflict in classical Stroop etc., Phaf & Rotteveel, 2012). The reverse modulation of emotion by cognition further strengthens such attempts at integration. With respect to neuronal organization, this must imply that specialized emotional and cognitive modules should not be distinguished, but that a more distributed picture of dynamic coalitions of multifunctional brain regions emerges (cf, Pessoa, 2008). Neural competition does not only seem an obvious candidate for the regulation of these processing streams, but it can also serve to account in an almost mechanical fashion for both emotional and cognitive sub-processes. Unfortunately, at the end Mather and co-authors seem to qualify this role again by arguing that the GANE model does not require competition to be a fundamental mechanism, but that it applies to whatever priority mechanism is acting. If this refers to the resources from the steam-engine metaphor, it is unclear how they can also account for the elicitation of arousal and affect. To paraphrase the beginning of the authors' conclusion: Competition is the core of what allows both our emotional and cognitive systems to function effectively.

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