

Testosterone, cortisol, dominance, and submission: Biologically prepared motivation, no psychological mechanisms involved

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Abstract: Mazur & Booth's (1998) target article concerns basal and reciprocal relations between testosterone and dominance, and has its roots in Mazur's (1985; 1994) model of primate dominance-submissiveness interactions. Threats are exchanged in these interactions and a *psychological* stress-manipulation mechanism is suggested to operate, making sure that face-to-face dominance contests are usually resolved without aggression. In this commentary, a recent line of evidence from human research on the relation between testosterone, cortisol, and vigilant (dominant) and avoidant (submissive) responses to threatening "angry" faces is discussed. Findings, to a certain extent, converge with Mazur & Booth's theorizing. However, the strongest relations have been found in subliminal exposure conditions, suggesting that biological instead of psychological mechanisms are involved.

According to Mazur & Booth (1998; hereafter M&B), dominant status in primates and humans can be established and maintained without aggression. In face-to-face competitions between group members, a psychological stress-manipulation mechanism is operative. Opponents are "outstressed" by the exchange of threats and the endurance of staring. Discomfort can be relieved by submissive gestures, such as eye or gaze aversion. The angry facial expression serves as an important threat signal in these dominance encounters (Öhman et al. 1985). Striding with an angry gaze while keeping direct eye contact signs dominance, whereas averting the eyes or gaze from individuals displaying anger symbolizes submission, and prevents aggression.

van Honk et al. (1999) have used a cognitive-emotional paradigm that appears to be capable of reflecting such staring endurance and gaze aversion: an emotional Stroop task, comparing the color-naming latencies of neutral and angry faces. In the emotional Stroop task, the mean color-naming latencies for emotional stimuli minus the mean color-naming latencies for neutral stimuli are called attentional-bias scores. Positive attentional-bias scores indicate that attention is allocated towards the emotional stimulus (i.e., vigilance), whereas negative attentional-bias scores indicate that attention is allocated away from the emotional stimulus (i.e., avoidance) (see Mathews & McLeod 1994).

van Honk et al. (1999) showed significant positive correlations between baseline salivary testosterone, self-reported anger, and the vigilant response towards the angry face. In follow-up studies, not only supraliminal (unmasked) but also subliminal (masked) versions of this emotional Stroop task were used. After short (30-msec) presentations, the faces were immediately replaced by a masking stimulus to block conscious awareness of emotional valence in the masked task. High levels of self-reported anger were predictive for the vigilant response towards the unmasked angry face, and more strongly towards the masked angry face (van Honk et al. 2001), or even towards the masked angry face exclusively (Putman et al., in press). Furthermore, in the latter study, the self-report measures of the behavioral activation system (BAS) and the behavioral inhibition system (BIS) (Carver & White 1994) indicated that high BAS/low BIS was also associated with vigilant responses towards the masked angry faces exclusively. Notably, in M&B's analysis dominance can be expressed in an antisocial manner, and high BAS/low BIS reflects this antisocial personality, whose lack of fear (low BIS) potentiates the tendency to react aggressively (high BAS) (Carver & White 1994; Keltner et al. 1996).

High basal levels of cortisol (CRT) are, on the other hand, related to socially fearful and submissive behavior (Sapolsky 1990; Schulkin et al. 1998), and should therefore be associated with an

avoidant response towards the angry face in the above-noted emotional Stroop task. In agreement with this rationale, we showed avoidant responses towards angry faces in individuals with high basal levels of salivary cortisol, but only if these faces were masked (van Honk et al. 1998), and we replicated this finding in individuals with high levels of self-reported social anxiety (Putman et al., in press). In sum, our data support, on the one hand, M&B's basal model by showing interrelations between testosterone, anger, antisocial characteristics, and vigilance in the face-to-face confrontation, and, on the other hand, they support Sapolsky's (1990) basal model by showing interrelations between cortisol, social anxiety, and avoidance in the face-to-face confrontation.

According to M&B, the relation between testosterone and (the outcome) of the face-to-face confrontation may, however, be reciprocal: "testosterone rises in winners and declines in losers" (target article, p. 353). If this is true, the vigilant response towards angry faces should lead to testosterone increases, while the avoidant response towards angry faces should lead to testosterone declines. These relations were observed, but again for the masked emotional Stroop task exclusively (van Honk et al. 2000).

The fact that in most of our findings relations were strongest or solely existent for the masked task is a serious problem for the psychological stress-manipulation mechanism, which would be the key operative system in the primate face-to-face encounter according to M&B. Angry facial expressions are suggested to travel via a subcortical and a cortical route to activate the limbic affective system, and masked presentation leads to predominantly subcortical thalamic-amygdala processing (Ledoux 1996), bringing about the biologically prepared emotional response (Öhman 1997). This hypothesis has recently been supported by neuroanatomical evidence in a positron emission tomography (PET) study (Morris et al. 1999).

Interestingly, evidence indicates that the unmasked, but not the masked, emotional Stroop task is vulnerable to psychological regulatory processes (see Mathews & Mackintosh 1998). Furthermore, results from aversive conditioning studies show that physiological responses to unmasked, but not to masked, angry faces can be confounded by the same psychological "whims of consciousness" (Öhman 1997).

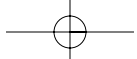
Therefore, it seems that only in unmasked exposure conditions can biologically prepared tendencies be psychologically influenced. The relative weakness of effects we observed for the unmasked emotional Stroop task could, for example, be due to the psychological apparatus pulling up a defense barrier to inhibit risky emotional reactions (Plutchik 1993). This is not an option in the masked task. Likely, attentional and physiological responses to masked angry faces are noncortical adaptive responses to social threat, still functional in humans (Kling & Brothers 1992). These elementary forms of approach and withdrawal are initiated in limbic affective circuits where motivational behavior is largely modulated by hormones such as cortisol and testosterone (Wood 1996). Psychological mechanisms, in our opinion, are at best responsible for the large error variance in relations between testosterone, cortisol, and dominance-submissive behavior, in particular exemplified by the frequent absence of a relation between testosterone and self-reported dominance, as discussed by M&B.

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Letters "a" and "r" appearing before authors' initials refer to target article and response, respectively.

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Allan Mazur & Alan Booth have declined to respond to the above continuing commentaries.

Commentary on Lawrence W. Barsalou (1999). Perceptual symbol systems. *BBS* 22(4):577–660.

Abstract of the original article: Prior to the twentieth century, theories of knowledge were inherently perceptual. Since then, developments in logic, statistics, and programming languages have inspired amodal theories that rest on principles fundamentally different from those underlying perception. In addition, perceptual approaches have become widely viewed as untenable because they are assumed to implement recording systems, not conceptual systems. A perceptual theory of knowledge is developed here in the context of current cognitive science and neuroscience. During perceptual experience, association areas in the brain capture bottom-up patterns of activation in sensory-motor areas. Later, in a top-down manner, association areas partially reactivate sensory-motor areas to implement perceptual symbols. The storage and reactivation of perceptual symbols operates at the level of perceptual components – not at the level of holistic perceptual experiences. Through the use of selective attention, schematic representations of perceptual components are extracted from experience and stored in memory (e.g., individual memories of *green*, *purr*, *hot*). As memories of the same component become organized around a common frame, they implement a simulator that produces limitless simulations of the component (e.g., simulations of *purr*). Not only do such simulators develop for aspects of sensory experience, they also develop for aspects of proprioception (e.g., *lift*, *run*) and introspection (e.g., *compare*, *memory*, *happy*, *hungry*). Once established, these simulators implement a basic conceptual system that represents types, supports categorization, and produces categorical inferences. These simulators further support productivity, propositions, and abstract concepts, thereby implementing a fully functional conceptual system. Productivity results from integrating simulators combinatorially and recursively to produce complex simulations. Propositions result from binding simulators to perceived individuals to represent type-token relations. Abstract concepts are grounded in complex simulations of combined physical and introspective events. Thus, a perceptual theory of knowledge can implement a fully functional conceptual system while avoiding problems associated with amodal symbol systems. Implications for cognition, neuroscience, evolution, development, and artificial intelligence are explored.

Amodal or perceptual symbol systems: A false dichotomy?

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Abstract: Although Barsalou is right in identifying the importance of perceptual symbols as a means of carrying certain kinds of content, he is wrong in playing down the inferential resources available to amodal symbols. I argue that the case for perceptual symbol systems amounts to a false dichotomy and that it is feasible to help oneself to both kinds of content as extreme ends on a content continuum. The continuum thesis I advance argues for the inferential content at one end and perceptual content at the other. In between the extremes, symbols might have aspects that are either perceptual or propositional-linguistic in character. I argue that this way of characterising the issue preserves the good sense of Barsalou's recognition of perceptual representations and yet avoids the tendency to minimise the gains won with symbolic representations vital to contemporary cognitive science.

In his target article, Lawrence Barsalou (1999t) has argued the case for a perceptual symbol systems approach in cognitive science on the grounds that the current orthodoxy, the amodal approach, has too many flaws. Barsalou identifies six central problems for amodalism: (1) there is no evidence that amodal symbols exist; (2) neuroscientific evidence points to activity in sensory motor regions of the brain on certain tasks; (3) amodal symbols have problems coping with representing certain cognitive processes such as spatio-temporal knowledge; (4) there is no satisfactory way in which amodal symbols can be mapped onto the perceptual states that caused them (the “transduction” problem); (5) there is no clear account of the manner in which amodal symbols can be mapped back onto perceptual states in the world (the “symbol grounding” problem); and finally, (6) amodal symbols are power-

fully explanatory and predictive in a post hoc fashion but not in any other way – a feature that makes them unfalsifiable.

Many of these difficulties can be levelled just as easily at the perceptual symbol approach, I suspect. Even some of the strongest evidence for perceptual imagery (e.g., Kosslyn 1994; Lang 1979; Shepard & Metzler 1971) suggest only principled support for the existence of imagery, not direct evidence. Equally, while it can also be fairly said that amodal symbols do not handle many aspects of cognition, so it is also true that perceptual symbols cannot handle other aspects, or do so with great difficulty. As for the claim about falsifiability (sect. 1.2.2 of the target article), in the current climate this seems equally true of perceptual symbols, and the debate so far is zero gain for either camp.

As for the neuroscientific evidence (sects. 2.1, 2.2, and 2.3 of Barsalou 1999t), it can hardly be argued that this is unambiguous evidence for either view. We surely know very little about the brain. Only if one conflates *correlations* and *causes* is there any hope of identifying certain brain processes with the mechanisms that are their supposed casual antecedents. Spring is correlated with the presence of bees in the air, but it would be a mistake to identify the two or to ground one in terms of the other. Likewise, it is a mistake to identify activation of sensory-motor regions of the brain with either perceptual or amodal symbolic processes. Research might have identified categorical reasoning as strongly *correlated* with sensory-motor regions (sect. 2.1), but this is not a sufficiently strong claim to warrant a rejection of amodalist approaches that are perfectly consistent with such evidence (other commentators, Adams & Campbell 1999; Aydede 1999; Zwann et al. 1999, have made a similar point, though with different emphasis). In his response to the commentaries, Barsalou has replied to this general argument on the grounds that amodal approaches do not fit with behavioral findings involving occlusion and size perception, and that patients showing sensory motor – but not conceptual knowledge – deficits would be frequently observed if

