effect of attention load on emotional response (Cornwell et al. 2011). These top-down modulations do not necessarily imply that stimulus processing depends on consciousness and voluntary attention and hence cannot be interpreted against "automaticity" without distinguishing more precisely between different sources of modulation and different components of automaticity.

Although a continuous framework of resource competition neatly account for number of phenomena (Pessoa 2013), it is not sufficient to explain how reduced resources as a result of increased attention load can affect emotion-specific responses in some brain areas (e.g., prefrontal cortex or visual cortex) without affecting others (e.g., amygdala) (Shafer et al. 2012; Vuilleumier et al. 2001), unless one postulates dissociable sensitivities to these effects. Moreover, in some cases, increased attentional load or suppression from awareness may actually increase emotional responses (e.g., in amygdala) to neutral or positive stimuli relative to low-load conditions (Silvert et al. 2007; Williams et al. 2004). Further, a continuous framework does not take into account that key aspects of selective attention and awareness are nonlinear in nature (Dehaene et al. 2014; Sergent & Dehaene 2004) (and presumably emotion too; Sander et al. 2005). Finally, the central concept of resource is relatively vague and lacks precise neural substrates. By focusing on effects rather than causal mechanisms, a resource account runs into the risk of circularity, for example, when appealing to "residual resources" to explain why emotional effects on behavior or amygdala activity are observed under "high load" conditions, without a more direct measure of resource. Whereas in vision, competition for resources can be mapped neurally onto overlapping receptive fields (Desimone 1998), other forms of competition may exist in other brain systems and be resolved by distinct mechanisms. Models of emotion and cognition interactions need to consider that multiple processes operate in parallel and produce distinct (linear or nonlinear) effects on different nodes within distributed networks (Pourtois et al. 2013; Sander et al. 2005).

Lastly, caution must be taken when drawing conclusions based solely on human neuroimaging studies, which have several limitations because of their poor resolution (spatial and temporal) and vascular origin (BOLD contrast in fMRI). This makes it hard to compare processing conditions when they differ in terms of the onset or duration of neuronal responses (Pourtois et al. 2010) or recruit partly distinct neuronal subpopulations within the same brain structure (Zhang et al. 2013). In particular, the amygdala is not homogenous but made of several subnuclei, each containing multiple type of neurons, which might be sensitive to different sources of sensory inputs and top-down modulations (Vuilleumier 2009). Conscious (vs. nonconscious) and attentive (vs. preattentive) processing might also be characterized by distinctive patterns of rhythmic oscillatory activity or connectivity within and/or between subregions, whose impact on BOLD fMRI or other electrophysiological measures is unresolved. Answering these questions will require finer investigations in animal models or novel technologies in humans.

The issues reviewed by Pessoa (2013) should encourage researchers to go beyond simplistic dichotomies (such as automatic vs. controlled processes). However, it is important to be careful in how psychological terms are used, defined, and related to specific neural substrates. Time is now ripe to formulate precise mechanistic hypotheses in order to elucidate the exact functional circuits implicated in emotion phenomena and define them in terms of information processing systems (i.e., by determining which type of information is represented and/or transmitted in specific pathways – rather than just the "amount" of information as in a continuous resource model). This is an exciting prospect for future research.

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Preferences and motivations with and without inferences

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Abstract: Pessoa (2013) makes an impressive case that emotion, motivation, and cognition are neurally intertwined. Our commentary broadens the discussion to the functional, "mind" level. We argue that philosophical and computational considerations justify some modern "separatist" views. We highlight several psychological phenomena that illustrate independence, including affective and motivational reactions to rudimentary inputs, and the guiding role of such reactions in cognition.

In *The Cognitive-Emotional Brain*, Pessoa (2013) makes an impressive case that emotion, motivation, and cognition are intertwined on the neural level and that many behaviors reflect a tight integration of these processes. Admirably, Pessoa does not deny that it is still useful to characterize certain processes and behaviors using traditional terms *emotion, motivation,* and *cognition,* but he points out that any strict assignments of brain regions and brain networks to these terms obscures the way the mind and brain typically work.

Being in agreement with much of the book, and coming from the primarily psychological, rather than neuroscientific perspective, our commentary aims to broaden the discussion of the relationship between emotion, motivation, and cognition. We do so by first placing the distinction in a historical and philosophical context, which explains and justifies some modern "separatist" views. We then highlight some psychological phenomena that, in our opinion, fit nicely with the idea of at least occasional independence. Again, we will say relatively little about the brain, but because one of the purposes of neuroscience is to better understand the mind and actual behavior, refocusing some of the discussion onto this more psychological level might be useful.

Philosophical and historical background. Pessoa avoids committing himself to any strict definition of affect, emotion, motivation, and cognition. He dislikes dichotomies and views the differences as a matter of degree rather than kind. And, as an empiricist, he prefers the data to guide definitions (see Ch. 1). But it is useful to at least remind ourselves why many modern functionalist frameworks find it useful to view emotion and cognition as different beasts, though, of course, they have long moved from Plato-like fractionation of the mind into the reasoning, the desiring, and the emotive components, and other simplistic frameworks. So, why would modern functionalist care to distinguish cognition and emotion? Most important, because much of what makes human mind and human behavior in society interesting touches on this difference. Why does the heart seem to have reasons that reason cannot know? Why are we afraid of things that we rationally know are safe and do not like things we rationally should? Why does it seem that some of our decisions seem like mere justifications for emotional preferences? Why can powerful bodily and feeling reactions be elicited by simple stimulus features, in every sensory domain, such as gentle touches, baby screams, rancid smells, or seeing heights? And why can perception, thinking, decision and action radically change depending on our emotional state? These important questions seem harder to ask and answer when one blurs the emotion-cognition distinction, yet they have inspired decades of fascinating research and insightful theorizing (e.g., Haidt 2001; Loewenstein et al. 2001; Schwarz 1990; Zajonc 1980).

More conceptually, it just seems useful to view cognition as processes concerned primarily with "representing" and "judging" – transformations of representations that aim to be "truth preserving" and which often take a propositional form. In contrast, it seems useful to reserve terms like *affect*, *emotion*, and *motivation* for processes primarily aimed at getting the organism to "care about" and to "do" something, and recruiting necessary physiological and experiential states to handle its concerns (Frijda 1988; Zajonc 1980). Critically, some affective processes can involve precognitive mechanisms of sensation and perception, and even completely noncognitive mechanisms, such as global neuromodulation (Panksepp & Biven 2012). In fact, some of these mechanisms are so basic that they are shared with species with clearly noncognitive status (e.g., neuromodulation of anxiety-like behaviors in species like crayfish, Fossat et al. 2014). Reflecting these insights, there are several modern philosophical works that emphasize low-level, nonpropositional, perceptual, or embodied components of affect and emotion (e.g., Charland 1995; Goldie 2000; Prinz 2006a).

In psychology, the noncognitivist view has always been amply represented, going back to the founding fathers of psychology like Wundt and James, but it found perhaps the most eloquent and passionate expression in the writings of Robert Zajonc (1980; 2000). His proposals of "affective primacy," as well as his notion that "preferences need no inference," still inspire contemporary research (see Niedenthal et al. 2010; Winkielman 2010). As such, it is perhaps worth visiting some of the claims that affect, emotion, and motivation can be induced with minimal significant perceptual and conceptual processing and work in relative dissociation from the explicit belief system.

Affect with minimal cognition. We've already mentioned that basic affective states (simple, bivalent reactions) can be induced by rudimentary sensation-like processes. As Zajonc (1980; 2000) has pointed out, inspired by James, affective states can also be influenced by noncognitive manipulations of bodily states, including peripheral and central somatosensory feedback mechanisms (for a recent review, Winkielman et al. 2015). Social psychologists have also provided plenty of examples for implicit, or even unconscious contributions to preferences, attitudes, and prejudices, some of which appear to involve simple learning mechanisms and are impervious to rational interventions (Greenwald & Banaji 1995; Winkielman et al. 2011). Interestingly, there is even a class of phenomena where affect appears to result from the simple dynamics of processing. The best known is the "mere exposure effect" – enhancement of liking as a function of sheer stimulus repetition. But enhancement of liking, as measured with a variety of means, can also be obtained by enhancing perceptual clarity, contrast, or reducing visual noise – all low-level perceptual manipulations. The current view on such phenomena holds that there is a link between greater perceptual fluency and positive affect. Some accounts of this link are inferential in nature, but others merely propose that easy and fast dynamics, nonspecific signals of familiarity, and low conflict are fundamentally, perhaps innately, marked as communicating positive states of affairs (for a recent review, see Winkielman et al. 2012). So, perhaps in the same sense that one does not need to learn or "infer" that sugar tastes good and that injuries are painful, organisms know to "dislike" disfluency and processing conflict. In short, some seemingly "cognitive" phenomena actually illustrate the minimal conditions for affect induction, without much elaborating, structuring, categorizing, or cognitive interpreting needed to explain preferences.

Motivation with minimal cognition. Pessoa proposes that motivational processes are also highly dependent on associated cognition. However, several phenomena highlight the possibility of rudimentary, "subcognitive" influences on motivation. For example, approach-avoidance motivation can be changed by simple manipulations of embodiment, such as direct stimulation of body-related brain areas and actual body position (e.g., Price et al. 2012). They can also be manipulated by direct biological interventions into the underlying brain chemistry, biofeedback, and direct stimulation (for a recent review, see Harmon-Jones et al. 2013). Further, basic motivational signals and states (including reward signals) can spill over to completely unrelated stimuli, highlighting that they are not tightly bound to any particular cognitive representation and operate with a different dynamics (e.g., Inzlicht & Al-Khindi 2012; Knutson et al. 2008; Winkielman et al. 2005). Though Pessoa nicely highlights the neural and computational sophistication of "reward" processing, this analysis slightly detracts from the fact that on a psychological, "person" level such processing often leads to irrational pursuits and alienated desires (Berridge 2003). Though addiction is often taken as a best example of such irrational wanting, psychologically oriented economists have highlighted a wealth of similar phenomena in daily life (Loewenstein 2007).

Cognition without affect is powerless. Notice also that taking a "separatist" perspective highlights key aspects of psychological processes that would otherwise be missed. A low-level example is that most animal learning research relies on the use of unconditioned stimuli and most unconditioned stimuli are emotive. This research illustrates that learning rarely occurs without affective input (though this point is not emphasized often enough in this research literature; Panksepp 2011). A higher-level example is the case of cognitive control – nicely discussed by Pessoa. To remind, cognitive control refers to the mental processes that allow behavior to vary adaptively from moment to moment, with one of its core functions being to inhibit unwanted, yet dominant response tendencies. Often seen as the paragon of higher cognition, recent evidence suggests that cognitive control is often aided by emotion (e.g., Koban & Pourtois 2014; Shackman et al. 2011), with a recent model suggesting that control is initiated when goal conflicts produce phasic twinges of negative affect that not only focus attention but also energize goal-directed behavior (Inzlicht & Legault 2014). Emotional change, according to this view, is at the heart of control, and when emotion is removed by misattributions (Inzlicht & Al-Khindi 2012), reappraisals (Hobson et al. 2014), or using pharmaceutical agents (Bartholow et al. 2012), control becomes impotent. One thus gains a deeper understanding of cognitive control when appreciating some of the emotional ingredients that go into it. Such an understanding would not come into relief by labeling all phenomena as cognitive, as has been in fashion lately. In fact, Pessoa does an admirable job rebalancing the neural picture, though perhaps at the cost of blurring some crucial, heuristically useful distinctions.

Restoring the balance. In conclusion, the target article offers a useful framework showing how cognition and emotion work together in the brain, clarifies imprecise understandings of such terms as "low-road," or "emotional brain," and highlights the role of emotion in supposedly cognitive functions. In our commentary, we offered some insights from psychology that support thinking about emotion and cognition as slightly different beasts, and some fascinating phenomena that illustrate their struggle. Curiously, in psychology, we currently have a problem of gratuitous and imperialistic cognitivism. For example, a recent analysis of the theorized process variables in the 2011 volume of the primary journal of social psychology (JPSP Sections I and II) found that cognitive explanatory variables were invoked almost 2.5 times as often as emotional explanatory variables, with emotion process variables accounting for less than 23% of all phenomena (Inzlicht et al. 2013). Given the view that emotion pervades most, if not all, of social life (Zajonc 2000), the finding that emotion was invoked as a process variable in less than 25% of all papers should raise concerns. According to some views, which assume that any transformation of input is cognition (e.g., Lazarus 1984), there is now a "primacy of cognition," with the distinctiveness of emotion being practically dismissed, reduced completely to cognition by some writers (e.g. Duncan & Barrett 2007). As such, the target article and the excellent book bring a welcome "balance to the force," without reestablishing naïve dichotomies. We hope that our commentary can inspire some additional appreciation of how emotion, motivation, and cognition interplay and sometimes separate in the mind and behavior.

Author's Response

The cognitive-emotional amalgam

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Abstract: In the précis to *The Cognitive-Emotional Brain*, I summarize a framework for understanding the organization of cognition and emotion in the brain. Here, I address six major themes that emerged in the commentaries: (1) emotional perception and automaticity; (2) the status of cognition and emotion: together or separate? (3) evolutionary implications for the understanding of emotion and cognition; (4) the diverse forms of cognitive-emotional integration; (5) dual process theories; and (6) functional diversity of brain regions/networks and cognitive ontologies. The central argument is, again, that cognition and emotion are so highly interactive, and indeed integrated, that these two elements blend into a new amalgam.

R1. Affective perception

The commentaries by **LoBue**, **Todd & Thompson**, **Greening & Mather**, and **Vuilleumier** discuss concepts related to affective perception, including the perennial question of automaticity.

The Cognitive-Emotional Brain (Pessoa 2013) specifies multiple mechanisms for affective modulation of visual processing. **LoBue** also suggests that the field should investigate "multiple pathways" that imbue emotion-laden stimuli with their properties. A particularly compelling aspect of her work is that she seeks to devise experiments that can unravel diverse sources of bias for emotionally valenced stimuli, including both bottom-up-like and top-down-like contributions.

Despite the "pluralistic" account of affective vision in the book (Ch. 2–4 and 7), it missed an important component. **Todd & Thompson** corrected this omission by describing the contributions of the locus coeruleus to "affect-biased attention," as recently developed in the "biased attention via norepinephrine" (BANE) model (Markovic et al. 2014). Their point is important for a more general reason, too. The goal of describing *multiple* mechanisms of affective attention was to highlight that the field needs to move past the idea of "single structures" or even "single circuits." The omission of an important mechanism demonstrates that the list is far from complete; it is likely that several additional mechanisms play important roles in affective vision, too.

Vuilleumier, a major contributor to our understanding of emotional perception, argues that it is time to move past general questions like "Is emotional perception automatic?" to specific, testable mechanistic questions, and that the proposals we offered remain too abstract. Although it is true that more mechanistic accounts are important for the field to advance further (for an exampleof a formal model, see Grossberg et al. 2014), at this point of model development, my goal was to describe a general ("abstract") framework that, if persuasive to others, would lend itself to further refinement. Somewhat ambitiously, the situation is analogous to the description of the biased competition model (Desimone & Duncan 1995), which had to await a few years before more mechanistic notions of competition based on receptive fields were developed based on subsequent empirical data (Luck et al. 1997; Reynolds et al. 1999).

Greening & Mather discuss their *arousal-biased competition* model (Mather & Sutherland 2011). The model describes how arousing stimuli enhance perceptual processing of other *neutral* stimuli. It thus clearly covers territory not addressed by the *dual competition* model (Ch. 7). But one of the original goals of my proposal was to describe how competition takes place when items have affective and/or motivational significance, including situations that may involve both negative and positive items (Fig. R1). This is something that is not addressed by the arousal-biased completion model. For example, in a recent study, we investigated the interactions between reward and threat on brain and behavior during a visual discrimination task (Hu et al. 2013). Reward was manipulated by linking

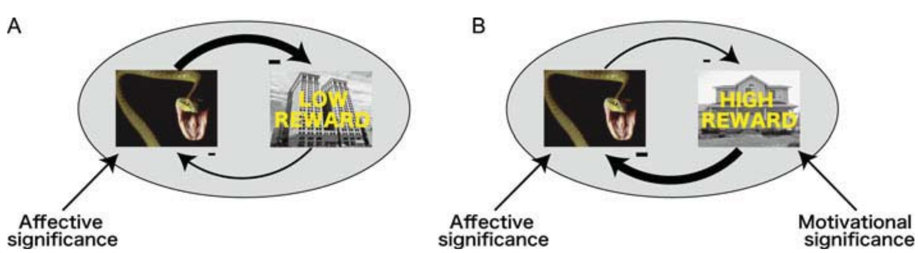

Figure R1. The dual competition model. Visual competition incorporates both affective and motivational factors, such that perception will reflect the interplay of multiple "forces" that sculpt it. In the hypothetical examples here, both a negative-image distractor and a reward-associated target influence perception. (A) Emotional images interfere with perception when the target item is positive but relatively weak. (B) In contrast, when the target item is associated with high reward, it wins the competition and in this way may reduce (or even eliminate) the deleterious impact of the negative image.