within formalized cognitive architectures. Pioneering artificial intelligence and cognitive science researcher Alan Newell, argued (e.g., 1973; 1990) that psychological science would benefit by moving beyond mere verbal (qualitative) hypotheses, such as simple dichotomies (e.g., nature vs. nurture), toward formalized (quantitative) hypotheses. Additionally, he suggested that one path toward a unified theory of mind is by developing cognitive architectures. A number of cognitive architectures have been developed, such as Soar (Newell 1990), EPIC (Meyer & Kieras 1997) and ACT-R (Anderson & Lebiere 1998; see Langley et al. 2008 for a review of different architectures). Take ACT-R, for example (see Anderson 2007 for details). This model incorporates decades of research to describe a full range of cognitive processes, from perception to action, and can provide fine-grained predications about reaction times, neuroimaging measurements, eye-tracking data, as well as behavioral responses. In our view, it is quite stunning that, thus far, there have been relatively few attempts to incorporate affective components into architectural models of cognition and behavior. For the purpose of this commentary, the most noteworthy aspect of cognitive architectures relates to understanding and hypothesizing about interactions between different perceptual, motor, and cognitive components that naturally arise while modeling behavioral tasks. Within Pessoa's book and elsewhere (e.g., McGaugh 2000), affective aspects of behavior such as stress, motivation, and arousal have been shown to modulate cognitive processes such as attention and memory, and we believe that developing these affective components within cognitive architectures can afford researchers the ability to precisely define how and where these types of interactions may take place within a human system. Additionally, when one or more aspects of cognition are qualified based on an affective state and a possible system-wide chain of interactions occurs, cognitive architectures may be the best tool for dealing with the high level of complexity.

How can affective components be implemented within cognitive architectures? The approach that several authors have called for or begun working with is to define how affective states might modulate the underlying cognitive processes (e.g., attention, working memory) within the architecture (e.g., Belavkin 2001; Cochran et al. 2006; Dancy et al. 2013; Hudlicka 2004; Ritter et al. 2007; see also Gunzelmann et al. 2009 for similar work related to fatigue). This can translate to adjusting certain parameters within existing architectures. For example, Cochran et al. (2006) provide a relatively simple demonstration of this approach, in which they model the effect of one aspect of emotion (arousal) within one cognitive module of ACT-R (declarative memory). Cochran et al. (2006) point out that the standard ACT-R model is not able to predict the results of the classic study by Kleinsmith and Kaplan (1964), which found that study of high emotional arousal stimuli led to short-term forgetting and long-term remembering compared with low emotional arousal stimuli. To implement this impact of arousal on memory within ACT-R, Cochran et al. (2006) redefined and expanded certain parameters (specifically, within the declarative memory module) to produce a pattern similar to the behavioral data. Similarly, in another paper, Ritter et al. (2007) developed a model within ACT-R to predict performance on a serial subtraction task, in which certain cognitive mechanisms within the architecture (e.g., attention, working memory) were modified to represent the impact of stress. Much more, we suspect that it would be worthwhile to explore how the findings and theories presented within Pessoa's book can be modeled within cognitive architectures in similar ways.

Many cognitive architectures (ACT-R in particular) not only attempt to model the processes underlying human behavior, but they also incorporate neuroimaging findings to develop a brain-like system of structures and processes (e.g., Anderson 2007; Just & Varma 2007). Indeed, within ACT-R different cognitive modules are associated with certain brain structures. Because of this design approach, (1) neuropsychological findings can be used to guide and constrain model development, and (2) neuroimaging data (such as fMRI) can be used in conjunction with behavioral measurements to help validate models (e.g., Borst & Anderson 2014). Because ACT-R provides latency information for different cognitive processes (e.g., visually encoding a stimulus, retrieving information from memory, producing a motor response), this pattern of activity can be translated into predictions for neuroimaging data in correspondence with the brain areas associated with the different cognitive modules. We suspect that this facet of cognitive architectures may be especially compelling for the development of affective components because, as Pessoa describes, certain brain structures (such as the amygdala) are associated with a variety of processes. These types of neuropsychological research findings can be taken into account when exploring how affective aspects might modulate particular processes within an architecture.

There is, perhaps, no better way to conclude this short commentary than by turning to one of the conceptual founders of integrative approaches to behavior and cognition. In many ways, Pessoa's book echoes Newell's (1990) argument that, "A single system (mind) produces all aspects of behavior. It is one mind that minds them all. Even if the mind has parts, modules, components, or whatever, they all mesh together to produce behavior.… If a theory covers only one part or component, it flirts with trouble from the start" (p. 17). In short, Pessoa contends that, given the high level of overlap between aspects of cognition and emotion, the two should not be considered separately. We agree with this and believe that the ideal research approach for pursuing this integration of theories includes cognitive architectures.

Neuropsychology still needs to model organismic processes "from within"

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Abstract: Four issues are discussed: (1) differences between cognition and emotion; (2) affect, emotion, and motivation differentials, including a neuropsychological model of motivation; (3) mental attention (working memory) as a resource neither affective nor cognitive, but applicable to both; and (4) explication of neuropsychological scheme units, which have neuronal circuits as functional infrastructure, thus helping to clarify the semantics of functional connectivity.

Pessoa's *The Cognitive-Emotional Brain* (2013) is important because it attempts to clarify in broad detail neuroscience relations among cognition, emotion, and motivation. Pessoa sees these constructs as intertwined in the brain networks but does not make apparent how cognition, emotion, and motivation *functionally* complement each other as different modes of processing.

A number of important issues remain unanswered. Do Pessoa's multiple waves and dual competition models (pp. 70–72, and Chapter 7 of his book) imply that performance is *overdetermined* – as Freud would have said – by many actively self-propelling, often connected brain processes? How are external "contexts" and related internal processes expressed in the brain?

Are they "passive" representations or *coordinated sets* of here-and-now-activated multiple circuits (heretofore called *schemes*)? A better neuropsychology should examine these and other topics, adopting a processing attitude "from within" – a perspective called *metasubjective* to contrast it to an external observers' perspective (Pascual-Leone 2013). We illustrate this point by discussing four issues.

The first issue addresses subjective differences between emotion and cognition. Contrary to Pessoa's belief (p. 4 of his book), capturing functional differences between psychology constructs is essential to understand their expression in the brain. Cognition assigns a *truth value* to experience – that is, asserting whether (present, past, or future) experiences are *true* or valid vis-à-vis *future outcomes*. In contrast, emotion processes assign a *vital value*, evaluating the importance of experience in situations for one's life and living (done by *specific*, positive or negative, affect systems – love, mastery-seeking, guilt, joy, fear, etc.). These two sorts of value (truth vs. vital) complement one another and are *compatible but not interchangeable*. Because they are compatible, *some* circuits or networks carry both sorts of value together: fully and simultaneously *cognitive and affective*, as Pessoa claims. Some researchers call these sorts of hybrid processes *emotions* (Damasio 1999; 2010; Greenberg 2002), restricting the terms *feeling*, affect, *affective* (versus cognitive) to processes where vital value *predominates*. As Panksepp and Biven (2012) have reemphasized, *primary* "pure" *affects* have innate-instinctual (evolutionary) roots, each with a distinct sort of affective "flavor" – roots whose number is estimated as high as seven or nine primary affects (positive or negative). The existence of these innate roots is a major argument for differentiating between affects and emotions, because the latter always embody *situation-bound* cognitions that cannot be innate.

Neural networks differ relatively, *not absolutely*, on the sort of value they carry (truth/cognitive vs. vital/affective), often modulated by tasks/situations. We talk of cognition when the pragmatically *predominant* value is concerned with truth (e.g., lateral/dorsal prefrontal areas, lateral parietal). It is similarly useful to talk of affective or emotional when vital value dominates (e.g., periaqueductal gray area, anterior insula, orbitofrontal, medial prefrontal, posterior medial cortex). Affect and cognition, as complementary modes of processing, are in continuous *dialectical interrelation* (Pascual-Leone 2012; 2014; see Pessoa, p. 249) at the service of goal-directed activity: *activation of one mode tends to inhibit the other, although they are jointly needed to fully analyze external or mental experience*. Indeed, as Pessoa's data show, when affect/emotion and pure cognition modes occur together *within the same task*, negative-affect activation may increase the use of mental-attentional effort as a result of the implicit executive-processing demand created by need to control the negative affect. Hence, truth value characterizes cognition and vital value affect; emotion involves coexistence of both values.

The second issue concerns organismic functional distinction among affect, emotion, and motivation. Affect and motivation are related, but they differ markedly (Pascual-Leone & Johnson 2004). Pessoa equates motivation with external reward (p. 135). However, a view "from within" the subject (i.e., metasubjective) shows it differently. Motivation has three conjoint characteristics: (a) *Affective motivation* is an implicit *conative* (i.e., purpose-seeking, quasi-volitional) *tendency* to convert conscious or unconscious *affective goals* into conscious or unconscious *cognitive goals;* (b) the *strength* or energy (magnitude of activation) *of this tendency is high;* (c) well-learned, purely cognitive schemes tend to apply, because schemes are self-propelling (Piaget's *assimilation tendency* – with its *intrinsic cognitive-motivation strength*). Cognitive goals are dispositions to do something that is known, or believed, to be congruent with one's affective goals. Affective goals are dispositions towards the future that seek certain vital outcomes or consequences (escape with fear, approach with love, attack with anger, etc.).

There is reason to believe that anterior and posterior cingulate gyri, albeit different, are interconnected sites where motivation emerges (e.g., Beckman et al. 2009; Cromheeke & Mueller 2014; Pessoa, p. 237; Small et al. 2003; Torta et al. 2013). However, the network enabling affective motivation is much more complex. Without attempting a final formulation, our hypothesis is as follows (connections described here are often bidirectional, enabling loops). Once an instinctual-affect reaction in the midbrain occurs (perhaps in hypothalamus and periaqueductal gray area; Panksepp & Biven 2012), activation may spread to anterior insula (which may dynamically express organismic, interoceptive needs and costs) and to orbitofrontal cortex (which expresses current vital sensorial values, or external priorities, of the organism), among others. Then amygdala, one of the most connected context-and-situation sensitive sites for affect/emotion, synthesizes an *affective criterion of relevance* (Sander et al. 2003); it provides an implicit, current ranking of affective-organismic priorities for vigilance and attention. Hence, relative to appropriate threshold and in comparison to a baseline/control condition, low or nil activation of amygdala means low or nil *affective* relevance (*although a purely cognitive relevance of goals* – Piaget's assimilation tendency – *might still exist*). Finally, we propose that affective/emotion information is transferred to anterior and posterior cingulate (ACC and PCC), where context-sensitive conversion of (here-and-now dominant) affective goals into cognitive goals takes place, to spread elsewhere (e.g., posterior medial cortex).

ACC can also be activated, expressing *schemes' assimilation tendency*, in complex cognitive tasks with very low affective relevance and no amygdala participation. Perhaps ACC differs from PCC in that the former is more engaged in high affect or in cognitive conflict/*misleading* situations; whereas the latter is active in less affective and less complex cognitive (*facilitating*) situations. We believe that motivational choices can occur in cognitively simple situations with little participation of cingulate gyrus; however, in more complex cognitive situations, cingulate cortex will be needed. Hence, emotions are not pure affects but combine truth values (cognition) with vital values. Motivation may have intervened in the emergence of emotions via (a) and (b) – see the beginning of this issue-section. Once overlearned, emotions are strengthened as a result of (c).

The third issue concerns mental attention as a neutral brain resource, neither cognitive nor affective. Pessoa formulates the concept of a "performance-resource function" in general terms to characterize any kind of task activity (Pessoa 2013, p. 249). Nonetheless, relations of affect with *mental attention* (mental effort, working memory), and the relation of each to low (simple) cognition versus complex cognition, are unclear in the book. To effectively employ the construct of a performance-resource function, the "resources" must be properly and explicitly defined, which Pessoa does not do. Like most neuroscientists and experimental psychologists, he speaks of resources in plural, but likely means *mental/endogenous attention* – usually construed as working memory (Pascual-Leone & Johnson 2005). Clear definitions are needed of *automatic-perceptual attention* versus *mental/endogenous attention* (Arsalidou et al. 2010; 2013) and other brain resources – such as a neoGestaltist *internal-field* "simplicity" *factor* (possibly lateral inhibition in the brain) and an *overdetermination principle* – which together would permit *dynamic syntheses* in problem-solving acts. Clarity in these organismic constructs makes easier *process/task analyses* in neuropsychology (Pascual-Leone 2005; Pascual-Leone et al. 2009; Pascual-Leone & Johnson 2005; 2011). From this perspective, mental/endogenous attention appears expressed in the brain as a neutral resource (i.e., neither affective nor cognitive, albeit applicable to both).

The fourth issue addresses *overdetermination* of outcomes of brain processing, as a result of codetermination by many active, often connected, processes (cognitive and affective). Brain's connectivity spreads activation within cofunctional and often coactivated neuronal lines – along circuits/pathways that *necessarily* express certain semantic-pragmatic probabilistic invariances that give psychological meaning to the circuits. We say *necessarily*, because (given the anatomy and constraints on processing imposed by experience) pathways are activated and evolve in congruence with organismic and situational constraints. Thus , cofunctional and often coactivated neuronal circuits become unitized (coordinated) under these internal and external constraints, to characterize sorts of action (and change) in new situations. These coordinated functional invariances expressed in circuits are called *schemes* by Piaget and others (Arbib et al. 1998; Pascual-Leone & Johnson 2005; 2011). *Schemes* are unitized circuits or networks, embodying probabilistic *constraints/resistances* of (past, present, future) reality to the subject's actions or representations. They can be seen as self-propelling *systems that coordinate three distinct sorts of component,* all in dynamic/dialectical interaction: (a) a *releasing component* that contains *conditions* predicating features/templates that signal probable applicability of the scheme in question; (b) an *effecting component* that stipulates or carries cognitive, affective, or emotive *effects* of this scheme; effects whose application probabilistically brings results, often in a simultaneous or sequentially organized manner; and (c) a *functional component* that formulates the *gist* or overall functional description of the scheme: its practical importance and potential contribution to activities. In a very real sense, neural circuits are functional infrastructure of the scheme units formulated by constructivist psychological research.

As an illustration of how to apply the scheme construct to interpret brain circuits or networks, consider the connected (cognitive and affective) circuits that embody face recognition in humans (e.g., Arsalidou et al. 2011; Tsao & Livingstone 2008). Face perception and recognition use various brain areas, of which I mention seven of them, from (a) to (f): (a) occipital "face" area in the inferior occipital gyrus (a misnomer, because it analyzes intricate perceptual patterns, not only faces), which extracts figurative constituents (eyes, mouth, nose, etc.); (b) the fusiform "face" area, in the fusiform gyrus, that synthesizes meaningful figurative constituents into organized relational wholes (a face, flower, house, hands, etc.) as distinct perceptual totalities; (c) a site in the superior temporal sulcus (STS); and (d) the posterior middle temporal visual cortex (V5/MT – involved in visual motion awareness) – we note that in the latter two sites, temporally structured patterns of exploration are organized, leading to cognitive appraisal of distal objects such as a face and its meaningful mobile constituents, including gaze direction. (e) A more deeply cognitive interpretation of the complex object (e.g., the dynamic face) may require other areas such as left inferior frontal cortex (BA 47) and the occipito-temporal junction. (f) When emotion-affective relevance such as familiarity is involved, face recognition uses the amygdala. Both right and left hemispheres may participate in this processing, but the right hemisphere may be more involved in ordinary (*automatic*) face recognition.

When we apply the construct of *complex scheme* (a coordinated system of multiple subordinate schemes) to processing of meaning in the face, we notice that the occipital areas may provide *conditions* (releasing component) to the complex face scheme. The fusiform gyri may provide initial perceptual-configural *effects* (effecting component) to this face scheme. These effects would in turn serve as conditions of a further elaboration: a more complex cognitive face scheme produced by STS and V5/MT, which (these areas can coordinate sequentially occurring changes) would relate face movement-and-perspective sequences to yield cognitive-expressive and emotional, not just perceptual, meanings – with contribution from amygdala and BA 47, 37 etc. The *gist* (functional component) of the complex face scheme would of course be the context-relevant salient features of this *face scheme as a functional totality*.

Consider now the *schemes' overdetermination of performance* (Pascual-Leone 1984; 2012; Pascual-Leone & Johnson 2011), a principle that expresses the *self-propelling* disposition of schemes (brain circuits) with their spreading of activation in "multiple waves." According to this principle, the full meaning of an object (e.g., face) is attained as multiple schemes with different modes and modalities of processing (located in different sites) become coactivated and rally together to *overdetermine* total meaning (the cognitive-emotional import) of the complex object in question. From this perspective, automatized and controlled processes – embodied in different cofunctional and coactivated scheme circuits – become combined and work together, as Pessoa points out, because they are part of a more *complex* (superordinate) *scheme* they have together constituted with life experience and neuroplasticity.

Pessoa offers new ideas on the neuroscience of cognition and emotion. We have added some new distinctions to neuropsychology relevant for neuroscience, which might help to improve Pessoa's theoretical framework.

When emotion and cognition do (not) work together: Delusions as emotional and executive dysfunctions

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Abstract: In this commentary, I argue that the cognitive-emotional framework put forward by Pessoa (2013) can be successfully applied to psychopathology and, in particular, to the reasoning of *delusional subjects*. More specifically, I show that the notion of *executive competition* (Ch. 7) offers a significant contribution to the idea that delusions may involve both *executive* and *emotional* dysfunctions.

The proposal Pessoa puts forward in *The Cognitive-Emotional Brain* (2013) sets out to counter the standard paradigm of labeling brain regions as either *affective* or *cognitive*, offering instead a framework that does justice to the complex interactions among different neural systems. Notably, Pessoa presents a host of empirical evidence in support of the connection between the *amygdala* – traditionally associated with fear-detection or processing of negative information – and the *prefrontal cortex* (PFC), which is thought to play a central role in cognition. In particular, amygdala and PFC seem to cooperate in a number of tasks connected to *information gathering* and *salience detection*, such as discriminating between threatening and neutral facial expressions (see also Lim et al. 2009). Here, I argue that the cognitive-emotional framework Pessoa proposes can be successfully applied to psychopathology and, in particular, to the reasoning of *delusional subjects* (DS). First, I briefly show that delusions can be characterized in terms of *executive dysfunctions* that affect the ability to detect relevance in a context. Second, I utilize Pessoa's notion of *executive competition* (Ch. 7) to offer an original explanation of the executive deficits observed in DS.

In her recent book, Bortolotti (2009) convincingly argued that the pathological character of delusions cannot derive solely from their being *irrational*. Indeed, several everyday beliefs – for example, superstitious or religious – can be regarded as completely irrational without thereby qualifying as delusional (see Bortolotti 2009, p. 259). If characterizing delusions as irrational beliefs is clearly insufficient, then Bortolotti's conclusion calls for a more detailed explanation of why DS are worthy of clinical attention. One possible solution would be to qualify delusions in terms of *executive dysfunctions*, arising from some disturbance in the ability to detect relevance (or salience) in a context. From a phenomenological perspective, the idea that delusions may involve issues with relevance detection is supported by an analysis of case reports: indeed, DS often describe a peculiar keenness, as well as the feeling of "seeing" hidden connections between things. In