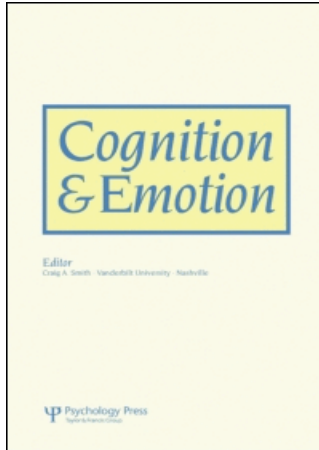


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Affect is a form of cognition: A neurobiological analysis

Seth Duncan ^a; Lisa Feldman Barrett ^a

^a Boston College, Chestnut Hill, MA, USA

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Affect is a form of cognition: A neurobiological analysis

Seth Duncan and Lisa Feldman Barrett

Boston College, Chestnut Hill, MA, USA

In this paper, we suggest that affect meets the traditional definition of “cognition” such that the affect–cognition distinction is phenomenological, rather than ontological. We review how the affect–cognition distinction is not respected in the human brain, and discuss the neural mechanisms by which affect influences sensory processing. As a result of this sensory modulation, affect performs several basic “cognitive” functions. Affect appears to be necessary for normal conscious experience, language fluency, and memory. Finally, we suggest that understanding the differences between affect and cognition will require systematic study of how the phenomenological distinction characterising the two comes about, and why such a distinction is functional.

Scholars have long assumed that cognition and affect are separable (and often opposing) mental processes (Aristotle, 1991; Plato, 1992). Modern psychological science no longer views them as opposing forces within the human mind, but continues to be grounded by the assumption that “thinking” (e.g., sensing and categorising an object, or deliberating on an object) is a fundamentally different sort of psychological activity than “affecting” (i.e., constructing a state to represent how the object affects you). Many psychologists believe that cognition and affect interact (cf. Storbeck & Clore, 2007 this issue). Cognitions might trigger affective feelings or behaviours, and affect might influence cognitive processes like memory and attention but the two are considered to be separate in some real and fundamental way (what philosophers would call “ontologically” distinct). The purpose of this special issue is to discuss the distinctiveness of affect and cognition, and in this paper we question whether the boundary between the two is given by nature, or whether it is a phenomenological distinction that

Correspondence should be addressed to: Lisa Feldman Barrett, Department of Psychology, Boston College, Chestnut Hill, MA 02467, USA. E-mail: barretli@bc.edu

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can, at times, be functional. The psychologist's fallacy, Dewey (1894) wrote, "is to confuse the standpoint of the observer and explainer with that of the fact observed" (p. 555; see also James, 1890/1950, p. 196). There is a risk, he explains, of confusing functional distinctions with ontological ones. We might not go as far as to call the distinction between affect and cognition a fallacy, but it may be the case that the distinction between the two is rooted in function rather than in nature.

In his formative book on cognitive psychology, Neisser wrote, "The term 'cognition' refers to all processes by which . . . sensory input is transformed, reduced, elaborated, stored, recovered, and used" (Neisser, 1967, p. 4). Following Neisser, we suggest that affect is a form of cognition. Neisser's definition of cognition was purposefully broad, and the field has moved beyond this broad definition. Even the distinction between sensation and cognition has been called into question, given the emerging evidence that that perceptual and conceptual processing have substantial overlap (Barsalou, in press; Barsalou, Simmons, Barbey, & Wilson, 2003b). In this paper, we focus on the idea that affect makes important contributions to both sensory and cognitive processing. Since all objects and events have somatovisceral consequences, cognitive and sensory experiences are necessarily affectively infused to some degree. There is no such thing as a "non-affective thought". Affect plays a role in perception and cognition, even when people cannot feel its influence.

We begin by offering a precise definition of affect, following which we pose the question of whether an affect–cognition distinction is respected by the human brain. We answer this question by outlining the neural reference space for what is traditionally called affective processing and then focus on accumulating findings that increasingly blur the affect–cognition boundary. Specifically, we discuss how affect modulates bottom-up contributions to sensory processing in both direct and indirect ways. We then suggest the consequences of this modulation for consciousness, language, and memory. In the end, we conclude that the affect–cognition divide is grounded in phenomenology, and offer some thoughts on how this phenomenological distinction arises.

CORE AFFECT

The word "affect" is generally used to refer to any state that represents how an object or situation impacts a person. The term "core affect" has been recently introduced to refer to a basic, psychologically primitive state that can be described by two psychological properties: hedonic valence (pleasure/displeasure) and arousal (activation/sleepy). Core affect has been characterised as the constant stream of transient alterations in an organism's

neurophysiological and somatovisceral state that represent its immediate relationship to the flow of changing events (Barrett, 2006; Russell, 2003; Russell & Barrett, 1999); in a sense, core affect is a neurophysiologic barometer of the individual's relationship to an environment at a given point in time. To the extent that an object or event changes a person's "internal milieu" it can be said to have affective meaning—these changes are what we mean when we say that a person has an affective reaction to an object or stimulus. They are the means by which information about the external world is translated into an internal code or representations (Barnard, Duke, Byrne, & Davidson, 2007 this issue; Damasio, 1999; Nauta, 1971; Ongur & Price, 2000).

Core affect functions as "core knowledge" (see Spelke, 2000, on "core knowledge"), the hardwiring for which is present at birth (Bridges, 1932; Emde, Gaensbauer, & Harmon, 1976; Spitz, 1965; Sroufe, 1979) and is homologous in other mammalian species (Cardinal, Parkinson, Hall, & Everitt, 2002; Rolls, 1999; Schneirla, 1959). Core affect is universal to all humans (Mesquita, 2003; Russell, 1983; Scherer, 1997; Wierzbicka, 1992), is evident in all instrument-based measures of emotion (see Barrett, 2006, for a review), and forms the "core" of emotion experience (Barrett, 2006; Barrett, Mesquita, Ochsner, & Gross, 2007; Russell, 2003). Core affect (i.e., the neurophysiological state) is available to consciousness, and is experienced as feeling pleasant or unpleasant (valence) and to a lesser extent as activated or deactivated (arousal; see Russell & Barrett, 1999, for a review). If core affect is a neurophysiologic barometer that sums up the individual's relationship to the environment at a given point in time, then self-reported feelings are the barometer readings. Feelings of core affect provide a common metric for comparing qualitatively different events (Cabanac, 2002). As we discuss later, core affect is a precondition for first-person experiences of the world, and forms the core of conscious experience (Edelman & Tononi, 2000; Searle, 1992, 2004; Titchener, 1909; Wundt, 1897).

People experience core affective feelings as phenomenologically distinct from thoughts and memories, but, as we discuss in the next section, the circuitry that implements core affect serves as a core feature of cognitive processing in the human brain. By virtue of its broad, distributed connectivity, this circuitry modulates sensory processes both directly (via direct projections to sensory cortex) and indirectly (via projections to the thalamus and brainstem). Through this modulation, core affect plays a crucial role in all levels of cognitive processing, determining what people are conscious of, how they use and understand language, and what content is encoded and retrieved in memory.

THE BASIC CIRCUITRY OF CORE AFFECT

One way to address the question of whether cognition and affect are separable processes is to see if these psychological categories are respected by the human brain. The traditional view, depicted in Figure 1, and rooted in the works of Papez (1937) and MacLean (1949), and recently reinforced by LeDoux (1996), is that affect is cognitively impenetrable and implemented or entailed in subcortical regions of the brain (for a discussion see Barrett, Ochsner, & Gross, 2006). A simplified version of this traditional view is that negative and positive affect are computed in the amygdala and nucleus accumbens, respectively, both of which receive sensory input from thalamic nuclei and sensory cortex, and both of which send output to the brainstem. Cognitive processes are thought to regulate affective processing after the fact via inhibitory projections from the prefrontal cortex to these subcortical areas. Accordingly, the assumption has been that the brain respects the cognitive–affective divide.

Our review of the neuroanatomical and neuroimaging literature reveals, however, that no brain areas can be designated specifically as “cognitive” or “affective”. Although it is the case that subcortical regions are regulated by prefrontal cortical regions, this state of affairs does not inevitably translate into the conclusion that cognitive parts of the brain regulate affective parts of the brain. Instead, it appears that affect is instantiated by a widely distributed, functional network that includes both subcortical regions (typically called “affective”) and anterior frontal regions (traditionally called “cognitive”). As a result, parts of the brain that have traditionally

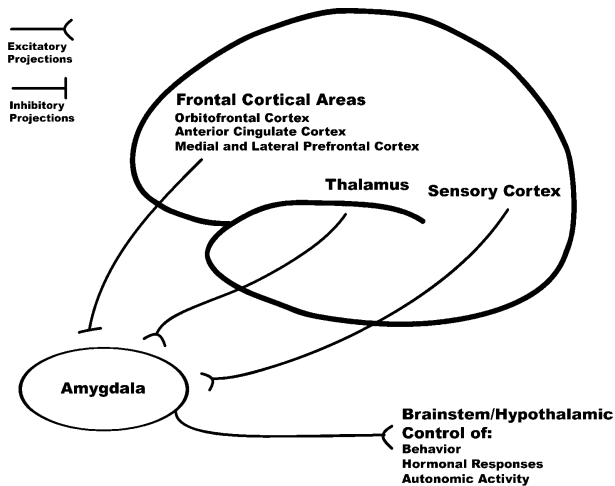


Figure 1. A simplified version of the traditional view of the cognition/emotion distinction within the brain (adapted from LeDoux, 1996).

been called “cognitive” participate in instantiating an affective state, not merely regulating that state after it has been established. Furthermore, the parts of the brain that have traditionally been called “affective” participate in cognitive processes. The so-called “affective” brain areas (e.g., the amygdala and brainstem) participate in sensory processing and contribute to consciousness in a manner that meets most definitions of “cognition”.

Affect is widely distributed throughout the brain

Core affect serves the primary function of translating sensory information from the external environment into an internal, meaningful representation that can be used to safely navigate the world. Widely distributed circuitry accomplishes this function, by binding sensory and somatovisceral information to create a valenced, mental representation of external objects (e.g., facial behaviours, foods, etc.). The function of this circuitry is to link sensory information about a stimulus with a representation of how the stimulus affects the person’s internal (somatovisceral) state (Barbas, Saha, Rempel-Clower, & Ghashghaei, 2003; Ghashghaei & Barbas, 2002; Kringelbach & Rolls, 2004; Ongur, Ferry, & Price, 2003; Ongur & Price, 2000). This circuitry involves areas of the brain that are traditionally considered to be “affective” (e.g., amygdala and ventral striatum), along with anterior portions of the cortex that have traditionally been considered cognitive, including the lateral orbitofrontal cortex (OFC), the medial OFC, often called the ventromedial prefrontal cortex (vmPFC), and anterior cingulate cortex (ACC; see Figure 2). As we discuss here, these anterior cortical areas do not appear to simply regulate the amygdala, but rather they appear integral to computing the value of an object and guiding visceral and motor responses accordingly.

Although the details remain to be specified, the available evidence suggests that neural representations of sensory information about a stimulus and its somatovisceral impact are entailed by two related functional circuits that make up a ventral system for core affect (see Carmichael & Price, 1996; Elliott, Friston, & Dolan, 2000; Ongur & Price, 2000, for reviews). The first functional circuit involves connections between the basolateral complex (BL) of the amygdala (which, along with other amygdalar nuclei directs the organism to learn more about a stimulus so as to better determine its predictive value for well-being and survival; Davis & Whalen, 2001; Kim, Somerville, Johnstone, Alexander, & Whalen, 2003; Whalen, 1998) and the central and lateral aspects of the OFC, which are necessary to a flexible, experience- or context-dependent representation of an object’s value (Dolan & Morris, 2000; Elliott et al., 2000; Kringelbach, 2005; Kringelbach & Rolls, 2004). Both the BL and lateral OFC (including the closely related anterior insula) have robust connections with cortical representations of every

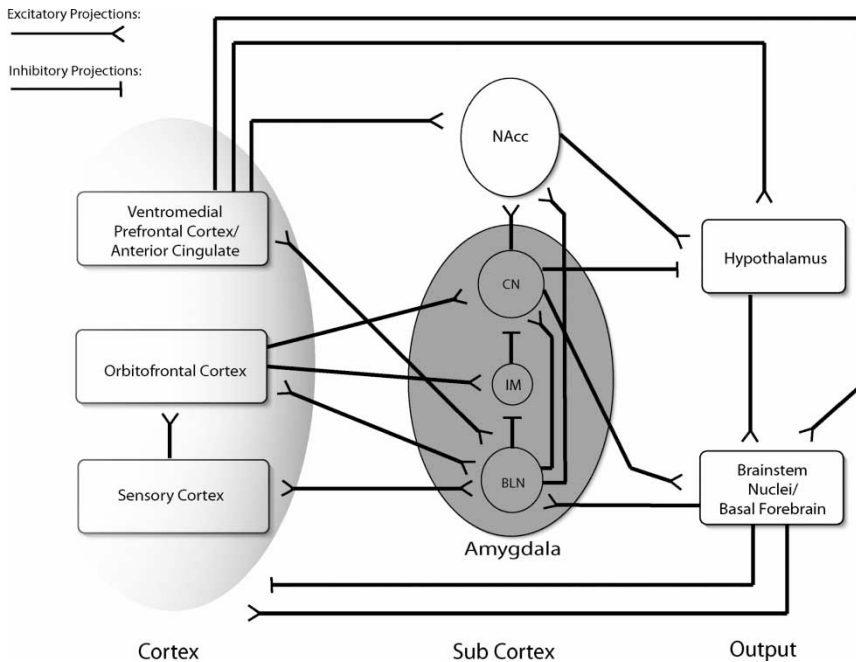


Figure 2. The widely distributed network of neural regions involved in computing a core affective state. These regions include subcortical areas typically considered to be “affective” (e.g., the amygdala and nucleus accumbens), as well as portions of the cortex that are typically considered “cognitive”, e.g., the ventromedial prefrontal cortex/anterior cingulate and orbitofrontal cortex (adapted from Barbas et al., 2003).

sensory modality and have strong reciprocal connections (Ghashghaei & Barbas, 2002; Kringelbach & Rolls, 2004; McDonald, 1998; Stefanacci & Amaral, 2002), so that they form a functional circuit that integrates sensory (including visceral) information. This information is needed to establish (at least initially) a value-based representation of an object that includes both external sensory features of the object, along with its impact on the homeostatic state of the body (Craig, 2002). One recent formulation argues that the BL complex formulates the predictive value of a stimulus, whereas the OFC participates in generating a response based on that prediction (Holland & Gallagher, 1999).

The second circuit, entailing a neural representation that guides visceromotor control, involves reciprocal connections between the vmPFC, including the closely related subgenual anterior cingulate cortex (ACC), and the amygdala. Together, these areas modulate the visceromotor (i.e., autonomic, chemical, and behavioural) responses that are part of the value-based representations of an object (Koski & Paus, 2000; Ongur &

Price, 2000). The vmPFC, in particular, may help to link sensory representations of stimuli and their associated visceromotor (i.e., core affective) outcomes and provides an “affective working memory” whose contents inform choices and judgments contingent upon an assessment of affective value (as computed by the BL and lateral OFC). This conclusion fits with the finding that vmPFC is important for altering simple stimulus-reinforcer associations via extinction (Milad et al., 2005; Phelps, Delgado, Nearing, & LeDoux, 2004; Quirk, Russo, Barron, & Lebron, 2000) or reversal learning (Fellows & Farah, 2003) and is preferentially activated by somatovisceral or interoceptive information (Hurliman, Nagode, & Pardo, 2005) more generally. The representations encoded in vmPFC may also be useful for decisions based on intuitions and feelings rather than on explicit rules (Goel & Dolan, 2003; Shamay-Tsoory, Tomer, Berger, Goldsher, & Aharon-Peretz, 2005), including guesses and familiarity-based discriminations (Elliott et al., 2000; Elliott, Rees, & Dolan, 1999; Schnider, Treyer, & Buck, 2000; Schnyer, Nicholls, & Verfaellie, 2005).

Conventional wisdom says that frontal areas regulate emotion, meaning that they offer a mechanism for control of the amygdala. Accumulating evidence, however, indicates that they are crucial components of a system that binds sensory information from inside the body with sensory information from outside the body. In doing so, the OFC and vmPFC (and adjacent ACC) guide appropriate responses to external objects. That is not to say that these frontal areas do not perform cognitive functions. These areas are heteromodal association areas and function to integrate sensory information from different sources. The main point of this paper, however, is that these areas (via the amygdala) project back to sensory cortices, influencing sensory processing in a fundamental way. The iterative nature of this process makes it difficult to derive simple cause and effect relationships between sensory and affective processing, although we will focus on one direction: how core affect influences how information about external objects is processed in the first place.

The cognitive functions of core affect

The amygdala’s role in sensory processing has been clearly worked out, and so we focus our review on the amygdala for illustrative purposes. The amygdala modulates sensory processing in three ways. First, the amygdala can indirectly influence sensory processing through a top-down form of attention involving the dorsolateral prefrontal cortex (via connections with the OFC) in a goal-directed way (cf. Ochsner & Gross, 2005). Second, the amygdala can directly enhance stimulus-driven sensory processing via strong reciprocal connections with unimodal sensory areas, such as ventral visual cortex. Third, the amygdala engages in a bottom-up form of attention

modulation, entraining all sensory cortical areas to select between competing sensory representations. In the next sections, we discuss the psychological consequences of these last two circuits. We are primarily interested in the latter two because they direct sensory processing based on the state of the organism.

The amygdala directly modulates sensory processing. In this section, we focus our discussion on the manner in which the amygdala directly modulates visual processing, because the connectivity between the ventral stream and amygdala is well documented in primates. The amygdala, particularly the basal nucleus, influences visual processing in a very direct manner by modulating the intensity of neural firing in all portions of the ventral visual stream, from association visual cortex to primary visual cortex (Amaral, Behnia, & Kelly, 2003; Amaral & Price, 1984; Freese & Amaral, 2005). Here, we will review evidence to suggest that, through extensive feedback projections, the amygdala facilitates associative connections between affective value and basic visual features of the environment, even in V1. We also review evidence that the amygdala enhances the visual awareness of objects that have been deemed to have affective value (e.g., facial behaviours that depict emotions such as fear) by modulating activity in the more anterior aspects of the ventral stream. Given the amygdala's extensive connectivity to all sensory cortices, however, we expect that this discussion would hold true for the affective impact on other sensory modalities as well.

The amygdala appears to be important for developing associations between affective value and primitive features of the visual world. The primary visual cortex (V1) receives strong, excitatory projections from the basal nucleus of the amygdala. These excitatory neurons from the amygdala project to spiny, pyramidal cells in V1, which are commonly involved in associative learning (Freese & Amaral, 2006). Neuroimaging studies have reported increased activation around the V1/V2 boundary in response to affectively evocative (compared to neutral) stimuli (Moll et al., 2002). More specific evidence for affective modulation of V1 activity comes from a study using event-related potentials (ERPs) to classically conditioned images. Black and white gratings (CS+) previously paired with affectively evocative images (i.e., IAPS images) elicited higher amplitude ERPs recorded over primary visual cortex than did gratings (CS-) not paired with images (Stolarova, Keil, & Moratti, 2006). The increased CS+ event-related potential amplitude over V1 occurs roughly 50 ms post-stimulus onset, well before information could reach core affective circuitry and forward back to V1. As a result, we conjecture that, over time, this V1 activity becomes amygdala independent, suggesting that associative, affective

learning occurs, not only in the amygdala, but in sensory cortex as well. As the activity in V1 eventually gains independence, the distinction between affective and non-affective processing in the brain becomes further blurred.

Correlational findings also support the conjecture that the amygdala modulates the extent of visual processing. Neuroimaging studies consistently demonstrate that aversive images produce greater activity (than do neutral images) in the amygdala and throughout the entire visual cortex (e.g., Breiter et al., 1996; Lane, Chua, & Dolan, 1999; Lang et al., 1998; Moll et al., 2002; Morris et al., 1998; Taylor, Liberzon, & Koeppe, 2000). This enhanced activity in the visual cortex appears to be related to enhanced awareness of objects. Objective awareness of valenced stimuli (i.e., greater perceptual sensitivity in signal-detection tasks, even when participants report no conscious awareness of the stimulus) is associated with increased amygdala activation, and the absence of objective awareness is associated with no increase in amygdala activation over baseline levels (Pessoa, Jappe, Sturman, & Ungerleider, 2006). Furthermore, increased amygdala activation co-occurs with increased activation in fusiform gyrus (FG; a portion of the brain involved in complex object recognition that is activated when objects reach visual awareness; Bar et al., 2001; Tong, Nakayama, Vaughan, & Kanwisher, 1998), but only when people are objectively aware of the stimuli (i.e., faces) presented to them (Pessoa et al., 2006).¹ Greater amygdala and FG co-activation is observed when participants are instructed to attend to faces as opposed to a concurrent distractor (e.g., houses; Anderson, Chistoff, Panitz, De Rosa, & Gabrieli, 2003; Pessoa, McKenna, Gutierrez, & Ungerleider, 2002; Vuilleumier, Armony, Driver, & Dolan, 2001); in binocular rivalry studies where a house is presented to one eye, and a facial depiction presented to the other, FG activity increases in the hemisphere corresponding to the dominant visual field (i.e., the eye whose sensory input reaches conscious awareness; Williams, Morris, McGlone, Abbott, & Mattingley, 2004). These correlational findings are consistent with neuropsychological evidence that patients with amygdala lesions show a decreased FG response

¹ Based upon neuroanatomical studies of rodents, it is typically assumed that the ability to detect a valenced stimulus under the threshold of awareness is mediated by the projections from the thalamus to the amygdala (i.e., the "low-road"; LeDoux, 1996). It has been argued, however, that the "low road" is impoverished in primates (for reviews, see Pessoa & Ungerleider, 2004; Rolls, 2000). It is possible that objective awareness of valenced stimuli is mediated by activity in the ventral stream that is directed by the amygdala. Subliminal presentations of valenced stimuli might be associated with increased activation in the amygdala and ventral visual stream, but such activation may not be sufficient (i.e., too few neurons fire, or neurons do not fire for a sufficient duration) for the neural activation to reach the threshold of conscious awareness. The degree of conscious awareness for a valenced stimulus is most likely modulated by the degree of activity in the ventral stream, such that conscious and non-conscious perceptions of valenced stimuli involve the same circuitry (rather than by two different circuits).

to facial depictions of fear (Vuilleumier, Richardson, Armony, Driver, & Dolan, 2004).

Preliminary evidence from our own lab suggests that affective experience can lead to the same enhanced awareness of objects that is associated with increased amygdala and FG activation. Using the signal-detection approach employed by Pessoa and colleagues (Pessoa et al., 2006), we have found that individuals who characterise themselves as introverted (and who report decreased levels of positive affect; Lucas & Baird, 2004) demonstrate greater perceptual sensitivity to briefly presented (16 ms) faces depicting fear than those who are lower in introversion (Duncan & Barrett, unpublished data). Taken together, these findings suggest the intriguing hypothesis that what people literally see in the world around them may in part be determined by their core affective state.

Not only do the anatomical and experimental evidence implicate the amygdala in sensory processing, but mood disorders, which are associated with amygdala hyperactivity, also involve sensory dysfunction. As discussed earlier, core affect involves a binding of sensory and somatovisceral information. In mood disorders this binding may be functionally compromised, resulting in hyperactive responses in the amygdala and visual cortex to affective stimuli. Serotonergic neurons that originate in the raphe nucleus project to the amygdala (Azmitia & Gannon, 1986; Bauman & Amaral, 2005; Brown, Crane, & Goldman, 1979; Sadikot & Parent, 1990) and inhibit its activity (Rainnie, 2003). An amygdala disinhibition effect is seen in depressed individuals because they have decreased levels of synaptic serotonin. As a result, individuals who suffer from depression have greater activation in the amygdala at rest than do non-clinical controls (Abercrombie et al., 1998; Drevets, Videen, MacLeod, Haller, & Raichle, 1992). The psychological consequence of this enhanced amygdala activation is that depressed and anxious individuals will be overly sensitive to valenced sensory information. Anxious and depressed individuals have greater amygdala activity in response to masked fearful faces than healthy controls (Sheline et al., 2001), and exhibit sustained amygdala responses to negative words (Siegle, Steinhauer, Thase, Stenger, & Carter, 2002). Along with an increase in amygdala activation in response to negative visual stimuli among depressed individuals there is an increase in activity throughout the ventral visual stream (Davidson, Irwin, Anderle, & Kalin, 2003), which increases the likelihood that the stimulus reaches awareness. Administering SSRIs (which increase the levels of synaptic serotonin) can decrease amygdala responses to faces depicting fear (Sheline et al., 2001) and aversive images (Davidson et al., 2003) to normal levels. Disrupted core affective circuitry, then, can have dramatic effects on sensory processing.

The amygdala indirectly modulates sensory processing by influencing bottom-up forms of attention. The circuitry that computes core affect plays an integral role in regulating sensory processing throughout the brain via its projections to the brainstem and basal forebrain, two parts of the brain that are necessary for consciousness. This modulation can occur in two ways (cf. Edelman & Tononi, 2000). First, brainstem and basal forebrain nuclei modulate the connections between thalamus and cortex (cortico-thalamic circuits) that are partly responsible for forming and selecting the groups of neurons that fire in synchrony (called neuronal assemblies) to form conscious percepts (the things people are aware of seeing). Brainstem and basal forebrain areas accomplish this modulation by projecting to two nuclei in the thalamus: the intralaminar nucleus and the reticular nucleus. The intralaminar nucleus controls cortical activity via strong recursive (or re-entrant) projections from thalamus to cortex. The reticular nucleus regulates activity within the thalamus, which in turn controls the degree of sensory transmission to cortex. Second, brainstem and basal forebrain nuclei have diffuse, unidirectional afferent projections throughout the cortical mantle, acting as a “leaky garden hose” (Edelman, 2004, p. 25) that controls the degree of neuronal firing.² Core affective circuitry (e.g., amygdala, vmPFC, and ventral striatum) offers the only path by which sensory information from the outside world reaches the brainstem and basal forebrain (Mesulam, 2000). In these ways, areas involved with establishing a core affective state can indirectly constrain ongoing processing throughout the rest of the cortex, selecting for neuronal assemblies that maximise reward or minimise threat, thereby influencing which contents are experienced in the moment, and which are more likely to be stored in long-term memory (Edelman, 2004; Edelman & Tononi, 2000).

There are important psychological and phenomenological consequences arising from core affective circuitry’s indirect modulation of cortical activity via brainstem and basal forebrain nuclei. First, core affective circuitry helps to select the information that reaches conscious awareness by directing the formation and maintenance of the neuronal assemblies that underlie conscious experience. Therefore, along with more deliberate top-down forms of attention (from lateral prefrontal areas) and bottom-up forms of stimulation from the sensory world, core affect helps to orchestrate the

² For example, cholinergic projections from basal forebrain augment neural responses to motivationally relevant sensory events, and enhance their storage in long-term memory; noradrenergic innervations from locus coeruleus increase the signal-to-noise ratio and precision of neuronal firing to such events; dopaminergic projections from substantia nigra and ventral tegmental area mark the salience of an event and gate access to voluntary motor outputs; and serotonergic projections from the rostral raphe nucleus reduce distractibility and gate the processing of motivationally relevant sensory cues (Mesulam, 2000; Parvizi & Damasio, 2001).

binding of sensory information into a single, unified conscious field. Second, via multiple iterations of processing, the external sensory information that drives brainstem and basal forebrain activity becomes processed with and bound to somatovisceral information. As a result, conscious percepts of the external world are intrinsically infused with affective content. The idea that affect is a basic property of consciousness is not new (Titchener, 1909; Wundt, 1897) and it continues to be incorporated into contemporary perspectives, including Damasio's somatic marker hypothesis (Damasio, 1999), Edelman's theory of neural Darwinism (Edelman, 1987; Edelman & Tononi, 2000), Searle's theory of consciousness (Searle, 2004), and Humphrey's theory of conscious sensation (Humphrey, 2006). As we discuss below, core affect is a necessary component of normal conscious experience.

The fact that core affect intrinsically drives the neuronal circuitry that selects and instantiates conscious content leaves open the possibility that disruptions in consciousness may occur when there are extreme disturbances of core affect. First, it is possible to speculate that intense or disrupted core affect could lead to a "psychotic break", or disintegration of the unified conscious field where sensory information from separate modalities no longer seem integrated. This form of dysfunction in consciousness is most commonly associated with schizophrenia, but can also be observed in severe instances of major depressive episodes. Schizophrenia is often associated with abnormalities in the anatomy of core affective circuitry, particularly reduced amygdala volume (Pinkham, Penn, Perkins, & Lieberman, 2003; Wright et al., 2000). In cases of intense or disrupted core affect, core affective circuitry may relax its control over cortico-thalamic processing, leading to disorganised, fractured perception (Tononi & Edelman, 2000). On average schizophrenia is not associated with disruptions in affective experience (Kring & Germans, 2004; Kring & Werner, 2004), but it is still possible that certain endophenotypes may show an association between disorganised perception and disordered core affect. It is also possible that disorganised perception might result from large or unexpected changes in a person's core affective state even when pervasive negative affect is not a tonic feature of the disorder.

In a second form of disrupted consciousness, affective value is applied to objects and events indiscriminately, leading to delusions, or the belief that otherwise neutral objects have significant affective importance or value for well-being. In a recent study by Holt and colleagues (Holt et al., 2006b), schizophrenia patients suffering from delusions were more likely to rate neutral words as unpleasant and were slower to correctly classify neutral words as neutral than were non-delusional schizophrenia patients and healthy controls. Delusions seem to occur when the connections between core affective circuitry and sensory cortices become deregulated and overly active, infusing a persons' sensory experience with an unrealistically strong

affective meaning. Delusional patients with schizophrenia, for example, have greater amygdala responses to neutral faces than do non-delusional patients (Holt et al., 2006a).

If delusions are the misattribution of affective value to neutral objects and events, Capgras syndrome can be thought of as an anti-delusion: the inability to attribute affective value to objects when doing so is necessary for normal conscious experience. In Capgras syndrome, the affective meaning in sensory experience is lost due to compromised connections between the amygdala and the inferior temporal cortex (a brain region involved in recognising facial identity; Ellis & Young, 1990; Hirstein & Ramachandran, 1997). As a result, patients suffering from Capgras syndrome do not experience a sense of familiarity when seeing friends and family and believe that impostors have replaced those individuals. Patients with Capgras also do not show an increased skin conductance response that is typically seen when people view familiar faces (Ellis, Young, Quayle, & de Pauw, 1997).

In the third form of disrupted consciousness, the integration of internal and external sensory information is compromised, leading to hallucinations that are often seen in schizophrenia, as well as severe forms of depression and bipolar disorder. Hallucinations are thought to result from an increase in burst-like processing in the thalamus, which inhibits the relay of external sensory information to the rest of the cortex (Behrendt, 2006). As a result, conscious percepts are based primarily on cortical activity not being driven by the external world. Again, given the architecture of the circuitry involved, it is possible to speculate that disruptions in core affect may be in part responsible for this schism between what is going on outside in the external world and what neural assemblies are being formed inside the person's head. Hallucinations can be seen as an extreme form of naïve realism, where the contribution of internal information drastically outweighs the contribution of external sensory information in forming a conscious percept.

CORE AFFECT AS A DIMENSION OF PSYCHOLOGICAL MEANING

Because core affect modulates sensory processing, any psychological process that draws on sensory information will have an affective quality to it. As a result, core affect influences forms of cognitive activity that are traditionally considered distinct from emotion. Perhaps the most discussed example of affect's role in cognition comes from the literature on decision making (e.g., Bechara, 2004; Janis & Mann, 1977; Kahneman & Tversky, 1979), but there is also evidence for affect's contribution to normal consciousness, language and memory. As we discuss here, core affect makes external information from the world personally relevant to people, providing them

with a first-person experience of the world, a fluency with language so that they can describe those experiences, and enhances how those experiences are encoded for future use.

Core affect is a precondition for first-person experiences of the world

Perception without an affective component lacks the first-person, subjective quality that is the hallmark of conscious awareness of external sensory information. Blindsight patients offer a particularly clear illustration of perception without affect. Blindsight is a condition caused by lesions in primary visual cortex (V1), leading patients to report complete lack of vision even when they are able to detect the movement, orientation, and colour of objects at above chance levels (Weiskrantz, 1986, 1987). People with blindsight have objective awareness of the world in the absence of subjective awareness. Even with massively impoverished vision, they can detect and act upon visual features of objects at better than chance levels, but they have no conscious experience of those objects. In signal-detection terms, their sensitivity to visual information is above chance, but they have a conservative threshold for reporting the presence of an object (i.e., their response bias is to report no visual awareness for the object; Weiskrantz, 2001). For example, blindsight patients often report that they “know” an object is present, but that they definitely cannot “see” it (Weiskrantz, 1991).

We propose that core affect, through direct and indirect projections to striate cortex, provides individuals with the subjective sense of certainty comes with consciously seeing an object. “Seeing” an object can be equated with perception that has an “about me” quality to it, meaning that the perception is personally relevant in some basic way (probably achieved via the binding of somatovisceral information with sensory information from the external world that occurs in the evaluation circuit involving the OFC and amygdala). In the absence of core affective modulation, a person will remain uncertain of whether or not they consciously experience an object. In fact, Humphrey (2006) calls blindsight “affectless vision” (p. 67). For blindsight patients, who seem to have perception without an affective dimension,³ seeing is similar to a third-person experience of an object: the person knows that the object is there (as if they were told by someone else), but they do not experience themselves as having seen it.

³ We are not claiming that sensory input is inaccessible to core affective circuitry in blindsight patients. Sensory information could still cause changes in core affective experience, helping blindsight patients to make affect-based discriminations in their environment such as categorising facial configurations depicting fear—as observed by de Gelder and colleagues (de Gelder, Morris, & Dolan, 2005). Our discussion focuses on the output from core affective circuitry to sensory cortex.

Humphrey and colleagues (Ackroyd, Humphrey, & Warrington, 1974) have reported on a patient with an unusual form of blindsight, HD, whose experience speaks to the importance of affect in conscious awareness. Functionally blind from the age of 3, HD had cataracts removed from her eyes at the age of 27, with the presumption that this operation would restore her sight. Indeed, HD had some functional increase in her vision after the operation—she could successfully navigate her world by avoiding obstacles (e.g., curbs on the street), and could point towards and even grasp objects without prompting or instruction. She did not, however, report any conscious visual awareness of these objects. It seems that her vision lacked the affective quality and subjectivity of normal conscious vision. Presumably, the connectivity between core affective circuitry and visual cortex had no opportunity to develop normally in the absence of experience. Eventually, HD returned to wearing dark glasses, since perception without affective quality was more disturbing than no vision at all. Although this is just a single case study, it makes a compelling case for the idea that core affect is a necessary precondition for normal conscious experience.

The importance of core affect in language

Core affect is not only necessary for first-person conscious experience, but it is an integral component of normal linguistic functioning as well. All words have an affective dimension of meaning. Valence (positive/negative), for example, appeared as the most stable factor in Osgood's semantic differential studies of words (Osgood, Suci, & Tannenbaum, 1957). When people rated words (particularly nouns; e.g., "tornados", "mother", "sponges", etc.) on bipolar, adjective-based Likert scales (e.g., hard–soft; slow–fast; ugly–beautiful; etc.), and these ratings were subjected to factor analysis, a valence dimension accounted for nearly 45% of the variance observed in the ratings, even across cultures (smaller "potency" and "activity" factors are also commonly found; Osgood, 1962; Osgood et al., 1957). Osgood interpreted these findings to suggest that each word and the object that the word represents has a pleasant or unpleasant connotation that is not part of the descriptive, technical definition of word. Although some philosophers have taken these findings to mean that valence represents a social, moral, or desirability-based form of evaluation (e.g., Charland, 2005; Solomon & Stone, 2002), Osgood's research suggests that people cannot use words to communicate with others without also (perhaps inadvertently) communicating affective meaning. Furthermore, there is some evidence that the relationships observed between psychological phenomena, such as personality and emotion, might be driven by connotative (as opposed to descriptive) properties (Fossum & Barrett, 2000).

Just as it is not possible to use words without communicating affective connotation, it is also not possible to understand language based on denotation alone. The affective dimension in language makes communication personal and easy to accomplish, and is an important contributor to language fluency (Altarriba & Mathis, 1997). For people who speak two languages, words with strong affective connotation presented in their first language are more likely to capture attention than words presented in their second language. In an emotional Stroop task, an interference effect (i.e., a temporal delay in speaking the colour of the printed word) indicates that attention is captured by the affective meaning of a word. In bilingual individuals, interference effects are only observed when words are presented in their native language; affectively evocative words presented in the second language are processed like neutral words (Altarriba & Mathis, 1997; Rosselli et al., 2002), where diminished interference effects are typically observed (Pratto & John, 1991; Wentura, Rothermund, & Bak, 2000).

There is also evidence that words presented in a fluent language produce greater affective responses than words spoken in a second language. Reprimands (e.g., "Shame on you") spoken in a native language, for example, elicit greater electrodermal responses than reprimands spoken in a second language (Harris, Ayçiçeği, & Gleason, 2003). Since first languages contain an affective dimension that is missing in second languages, bilingual individuals often resort to their native language when communicating their core affective states. For example, bilingual individuals feel more comfortable discussing embarrassing topics in their native language (Bond & Lai, 1986), and prefer to use their native language to swear (particularly when they want swear words to have affective weight; Dewaele, 2004). One important component of language fluency, then, is the ability to derive affective meaning from words, and to use language to communicate that meaning.

Affective meaning is a crucial dimension even in non-linguistic forms of communication. Nonhuman animals, for example, utilise a host of vocalisations to either directly or indirectly change the affect in the perceiving animal (Owren & Rendall, 1997, 2001). The basic acoustical properties of animal calls, including abrupt onsets, upward frequency sweeps, high or noisy frequency sounds, or sounds rapid amplitude fluctuations (called "squeaks", "shrieks", and "screams") directly act on the nervous system of the perceiving animal to change its core affective state (Owren & Rendall, 1997). The acoustical properties that reflect the identity of the caller (reflected in "sonants" and "gruffs") can indirectly influence the core affective state of the perceiving animal as the result of its prior experience with the caller (Owren & Rendall, 1997). Similar types of non-linguistic affectively mediated communication are also found in humans. For example, humans can use laughter to induce positive core affective states in

others (Bachorowski & Owren, 2001; Owren & Bachorowski, 2003; Smoski & Bachorowski, 2003).

Affect memory: Encoding and retrieval of experience for future use

Core affect is not only a key feature of consciousness, and necessary for communication, but it also helps determine which experiences with the world are encoded in the brain for later use. Core affect acts as a filter, giving preference to sensory information that affects the somatovisceral state of the organism, thereby helping to select which sensory information is processed more fully and therefore encoded in memory. This information is then available and used for the interpretation of incoming sensory information in the future, in what Edelman calls “the remembered present” (Edelman, 1989). In a sense, conscious experience is bootstrapped by memory (Edelman, 1989) that is directed and infused by affective content. The amygdala appears to be particularly important in this bootstrapping process. Neuroimaging studies have shown a strong correlation between amygdala activity when an object is first seen and successful recognition of the object at a later time (Cahill et al., 1996; Canli, Zhao, Brewer, Gabrieli, & Cahill, 2000; Hamman, 2001; Kensinger, Garoff-Eaton, & Schacter, 2006; Phelps, 2004). Not only does core affect enhance awareness of objects (see The amygdala directly modulates sensory processing), but it also appears to increase the quantity and vividness of memories as well (see Kensinger & Schacter, in press, for a discussion).

Core affect may not only help to determine the content of memories, but it may play a role in the confidence people place in those memories. Events that are associated with large changes in core affect are often remembered vividly, with great contextual detail, and confidence (Kensinger & Schacter, in press; Phelps, 2006). People’s memories of Challenger or Columbia space-shuttle explosions (Bohannon, 1988; Kensinger et al., 2006; Neisser & Harsch, 1992; Talarico & Rubin, 2003) or the September 11th attacks (Budson et al., 2004; Paradis, Solomon, Florer, & Thompson, 2004; Pezdek, 2003; Smith, Bibi, & Sheard, 2003) are more vivid and detailed. Controlled laboratory studies confirm that affect increases the confidence and vividness of memories. In tasks where participants were asked whether they “know” that an item is familiar (subjective report of memory with low confidence), or specifically “remember” the item (subjective report of memory with high confidence), participants reported greater confidence in remembering evocative words and images (i.e., more “remember” responses) than less evocative stimuli (Dewhurst & Parry, 2000; Kensinger & Corkin, 2003; Ochsner, 2000; Sharot & Phelps, 2004).

While it is clear that affect influences what people remember and their confidence in those memories, the evidence remains mixed as to whether affect influences the accuracy of memories. Neuroimaging studies show that activity in the amygdala is associated with improved recognition of images, whereas field and behavioural studies find that people are no more accurate in remembering affect-laden autobiographical events (Neisser & Harsch, 1992; Talarico & Rubin, 2003) or images (Ochsner, 2000; Sharot & Phelps, 2004) than less evocative material. In some cases, focusing on one's own affective state during a task can even lead to source memory errors (Johnson, Nolde, & De Leonardis, 1996). Although resolving this debate is outside of the scope of this paper, Kensinger & Schacter (in press) have recently proposed that affect increases the accuracy of memory not by changing the quantity of items or aspects remembered correctly, but by influencing the quality of what is remembered (more important or central details are remembered with more detail, sometimes at the expense of non-central details). Regardless of the outcome, it is clear that affect increases the confidence and vividness of memory. Accordingly, one thing that might distinguish implicit from explicit memories is their affective component. When core affective circuitry enhances sensory processing, events are conscious and are remembered vividly and with confidence.

CONCLUSION

Although feelings seem different than thoughts, we resurrect Neisser's (1967) definition of cognition to argue that affect is a form of cognition. The circuitry that instantiates a core affective state is widely distributed throughout the brain, and includes so-called "cognitive" areas. This circuitry projects to and modulates sensory processing. Via this modulation, affect is an intrinsic part of sensory experience, not a separate cognitive function that is later performed on sensations. As a result, affect is an intrinsic property in all psychological phenomena that result from so-called "cognitive" processes (such as consciousness, language, and memory). Affect and cognition, then, are not ontologically separate, but they are, perhaps, phenomenologically distinct. This is distinction in experience, however, rather than a distinction that exists in the structure of the brain or the psychological processes that produce that experience.

In psychology, we often take distinctiveness in experience as evidence for distinctiveness in process. In appraisal theories of emotion, for example, theorists use specific contents of what is experienced as evidence for distinct cognitive processes that produce the content (e.g., the fact that people experience their goals as blocked when experiencing anger is taken as evidence for the existence of an internal cognitive mechanism for deciding

whether or not their goals are blocked). Similarly, appraisal theorists assume that in the apperception of an object, affective processing is separate from sensory processing. Arnold, for example, stated that, "to know or perceive something and to estimate its effect on us are two distinct processes, and appraisal necessarily presupposes perception" (Arnold, 1960, p. 176). Others have followed this trend, but in our view, following Dewey (1894), it may be problematic to regard the perception of an object and the affective meaning of an object as ontologically separate phenomena. Affective experiences are not sequenced, discriminable conscious events distinct from experiences that seem devoid of affect (i.e., perceptual or intellectual experiences). Any thought or action can be said to be more or less affectively infused, so that there is no ontological distinction between, say, affective and non-affective behaviours, or between "hot" and "cold" cognitions. This line of reasoning is very consistent with recent embodiment views of cognition, which argue that affective states are incorporated into the conceptual knowledge that we use to categorise objects and events in the world (Barsalou, 1999, 2002, Barsalou, Niedenthal, Barbey, & Ruppert, 2003a). How you see an object and how you feel about an object may be the same concrete experience, but their distinction is introduced in reflection upon this experience (Dewey, 1895). A phenomenological distinction might exist between thinking and feeling, but they are actually two sides of the same coin.

To understand the distinction between affect and cognition, then, is to understand the nature, causes and functions of this phenomenological distinction. We suggest that core affect can be a central or a background feature (figure or ground) of consciousness, depending on where and how attention is applied. When core affect is in the background, it functions as background feelings (Lane & Garfield, 2005) or background emotions (Damasio, 1999) that colour conscious experience in a less direct fashion, but presumably have the potential to influence behaviour implicitly (Berridge & Winkielman, 2003; Winkielman, Berridge, & Wilbarger, 2005). Backgrounded core affect is experienced as a property of the external world, rather than as the person's reaction to it. We experience some people as nice and others as mean, some foods as delicious but others as unappetising, some pictures as aesthetically pleasing and others as unpleasant or disturbing. It may be under these circumstances that core affect directly translates into a behavioural response. When core affect is backgrounded, as in the Winkielman et al. (2005) study, the contribution of core affect to sensation and cognition goes unnoticed, Thirsty participants in their study valued a fruit-flavoured beverage more (i.e., drank more, were willing to pay more) when they had been exposed to subliminal presentations of smiling compared to frowning faces, even though there was no change in self-reported affective experience. Unconscious affect, in contrast, is not experienced at all.

When brought into the foreground of consciousness, core affect will be experienced directly as pleasant or unpleasant content with some degree of arousal (e.g., “drinking juice makes me feel good), and can serve as information for making explicit judgements and decisions (Clore & Schnall, 2005; Schwarz & Clore, 1983). In addition, core affective feelings will perhaps be attributed to some situational cause, thereby forming the basis of an emotion experience (cf. Barrett, 2006; Russell, 2003; but see Frijda, 2005; Lambie & Marcel, 2002, who characterise backgrounded affect as emotion experience).

When affect is backgrounded and seen as property of the world, it has its effects on cognition in stealth. We experience a world of facts rather than feelings, and affect gives us a sense of confidence in those facts. As we have discussed throughout this paper, the validity of experience (both in conscious awareness and in memory) is rooted in core affect. Core affect provides the necessary components that gives force to beliefs and gives people a sense that what they know is correct or right. It seems plausible, then, that core affect would contribute to confidence in people’s beliefs about political topics (e.g., global warming, abortion), world view (belief in a just world) or even form the core of religious faith (a strong affective response is how you believe in something that you cannot see). Given that core affect helps to determine the contents of conscious experience, it is no surprise that the most affectively loaded topics are the ones that produce the most steadfast opinions, even in the face of contrary evidence.

The fact that thoughts and feelings are experienced as different is important, and needs to be explained, but is not, in and of itself, evidence that they are fundamentally different kinds of phenomena. Why the phenomenological boundary between affect and cognition exists remains an important, but perhaps overlooked, question in psychological science. Understanding the conditions under which people foreground or background core affect, and knowing why doing one or the other is functional, will provide us with the best answer to the question of how cognition and affect are different.

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