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Affective influence on judgments and decisions: Moving towards core mechanisms

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Abstract (120 words)

This article reviews psychological accounts of affective influence on judgments and decisions and argues that these accounts can be enriched by insights from biopsychology. We show how biopsychological research helps (i) reveal the sources of values and feelings (ii) predict when affect will influence attentional, perceptual, memorial, and decision processes, and (iii) identify precise mechanisms underlying the interaction between affective and cognitive systems. We also propose a specific biopsychological model of affective priming phenomena and show how this model deals with data that are hard to explain with purely psychological accounts. We conclude that a multi-level biopsychological perspective will ultimately provide a more constrained and plausible foundation for understanding psychological processes underlying affect, judgment, and decision.

How do affect and emotion influence cognition, judgment and decision? This question is intensively investigated by psychologists and neuroscientists. Yet, there is little crosstalk between the two literatures. In this article, we aim to show how current psychological accounts of affective influence can be enriched by adopting a biopsychological framework grounded in research from affective neuroscience. The paper is organized as follows. We start with some conceptual clarifications. Next, we briefly review the dominant psychological accounts of affective influence. Then, we propose a more biopsychological framework for thinking about affective influence. We illustrate its value with several studies from our and related labs, focusing especially on the affective influences on decision making and the mechanisms underlying affective priming.

1. Some conceptual clarifications

Researchers studying affective influence use a variety of terms and it is useful to briefly clarify their meaning. Arousal typically refers to a hedonically undifferentiated state of general activation (i.e., non-specific arousal), but is also used to refer to the activation dimension of emotion, ranging from low to high. Valence refers to the hedonic dimension of a state, ranging from positive to negative. Mood refers to a low-intensity, diffuse, and relatively long-lasting state that is primarily differentiated on valence (e.g. feeling good or feeling bad). Affect can function as an umbrella term for all states, but typically refers to states that are primarily differentiated on valence and arousal. Emotion is also used as an umbrella term, but often refers to an intense and relatively brief state with qualitatively differentiated phenomenology (e.g., within negative states, one can differentiate between fear, anger, sadness, and disgust).

It is also worthwhile to clarify the distinction between emotional stimuli, emotional states, and different components of an emotional response. Affective influence on decision-

making has typically been proposed to involve a sequence of events, starting with the perception of the emotional stimulus, through some underlying affective state, and terminating with behavior. However, note that in many cases only some parts of the sequence might be “emotional” and that the specific nature of “emotion” may vary in different parts of the sequence. Thus, a stimulus might be “emotional” in the sense of being semantically related to emotion, but not elicit any real “hot” response (e.g., seeing the word “love” may or may not induce an emotional reaction). Further, if an emotional reaction is induced, it may not carry the same quality as that associated with the stimulus (e.g., seeing an angry face may not induce anger, but rather fear, or a generalized negative state).¹

Finally, when an emotional state occurs, it is important to consider which components are present and causally responsible for emotion’s impact on subsequent behavior. Researchers generally agree that emotional states include several components. The cognitive component refers to changes in perceptual, attentional, and semantic aspects of emotion (e.g., attentional biases, primed appraisals). The behavioral component refers to activated motor programs and action tendencies (e.g., prepared reflexes, changed facial or postural expressions). The physiological components refers to underlying changes in emotion-relevant bodily and brain-responses (e.g., hormonal or cardiovascular state, activation of subcortical circuitry). Finally, the experiential component refers to the subjective feeling, or the phenomenal aspect of emotion. Theories of affective influence on decision differ in which components are deemed crucial for affective influence (e.g., cognitive, behavioral, or experiential).

2. Psychological approaches to affective influence

We now briefly review a few dominant psychological accounts of how affect influences judgment and decision. Importantly, we do not intend to provide a comprehensive review, but

rather aim to provide a context for the subsequent discussion of our own biopsychological approach and supportive empirical work.

Dominant models of affective influence can be divided into two very general categories. The first category includes associative models (e.g., semantic memory model, and action model), which view affective influence as resulting from spreading activation, either in a memory network or in a motor network. The second category includes inferential models (e.g., affect-as-information model, affect regulation model), which view affective influence as resulting from inferences drawn from the current or anticipated presence, or absence, of an affective experience.

2.1 Associative models

2.1.2. Semantic memory models

One class of models proposes that affective states are associatively linked to related cognitive categories within a network of semantic memory (Bower, 1991; Forgas, 1995). Thus, inducing an affective state can prime categories that guide the encoding, retrieval, and use of information in judgment. Evidence for this model comes primarily from studies reporting affective influence on cognitive variables, such as attention, perception, memory, reasoning, and judgment. The most frequently reported finding in this literature is affective congruency. For example, participants in positive rather than negative moods are more likely to interpret ambiguous information in a positive way (Niedenthal, 1990), make more optimistic estimates of risk (Johnson & Tversky, 1983), and act in a more cooperative and confident manner (Forgas, in press). There is also some evidence that affect influences encoding and retrieval of memory, though this literature is not entirely consistent (Blaney, 1986).

Early versions of semantic memory models emphasized that affective influence on judgment is fairly valence-general. This conclusion was based on evidence that moods exert

rather broad priming effects across widely divergent semantic associations. For example, bad mood enhances perceived risk of fire, flood, and other accidents (Johnson & Tversky, 1983). However, later work using inductions of emotional state, rather than general mood, found some evidence for specificity. Thus, Niedenthal and Setterlund (1994) found that emotion influences perception of concepts that are specifically related to the induced emotion. In their study, happy, as opposed to sad participants, made faster lexical decisions on happiness-related words (e.g., “delight”, as opposed to “weep”), but not on general positive words (e.g., “love,” as opposed to “death”). Finally, recent research indicated that inducing an emotional state can prime “appraisals” (beliefs) that are specifically associated with the induced emotion. For example, Lerner and Keltner (2001) contrasted the judgmental impact of induced states of fear, anger, and happiness. Note that both fear and anger have negative valence, but fear is associated with an appraisal of lower certainty and control, while anger is associated with an appraisal of higher certainty, like happiness (Smith & Ellsworth, 1985). Consistent with the idea of appraisal priming, fearful participants made more pessimistic risk assessments and more risk-averse choices than both angry and happy participants, who did not differ in their estimates (Lerner & Keltner, 2001).

2.1.2. Action model

In contrast to the semantic memory model, which focuses on spreading activation within a person’s conceptual network, action models emphasize priming within a perception-action network (Dijksterhuis & Bargh, 2001; see also an “impulsive” model by Strack & Deutsch, 2004). In one of the first studies exploring the impact of stimulus valence on motor behavior, Solarz (1960) asked participants to move cards with words that were mounted on a movable stage either towards or away from themselves. Participants responded faster with the pulling

(approach) movement to positive than to negative words, and faster with the pushing (avoidant) movement to negative than to positive words (see also Chen & Bargh, 1999).

Although findings like these may suggest a relatively direct link between valence and movement, the relationship between affect and motor activation is more complicated (Niedenthal, Barsalou, Winkielman, Ric, & Krauth Grubber, 2005). For example, in a similar paradigm, Wentura et al. (2000) asked participants to respond to positive and negative words by either reaching out their hand to press a button, or by withdrawing their hand from the button. Note that in this case pressing the button required an extension movement, away from the body, and withdrawing required a flexion movement, towards the body. However, participants pressed the button faster for positive than for negative stimuli, but withdrew their hand faster for negative than positive stimuli. This finding suggests that there is no simple connection between positive/negative valence and flexion/extension (pull/push) movements. Instead, the connection depends upon participants' understanding of what the movement "means" in terms of the relation between the stimulus and the participant. Further, Markman and Brendl (2005) recently demonstrated that the relation to "physical body" is not critical, but rather the relation to the more abstract representation of the "self". Specifically, they found that positive valence facilitates any motor action (push or pull) that brings the stimulus closer to the self, even when the self is represented as participants' name on a screen.

2.2. Inferential models

Neither semantic memory nor action priming accounts assign special status to the experiential, "felt" component of emotion. Further, these models assume that affective influence operates via fairly automatic, context-free, knowledge activation processes. In contrast, inferential models (affect-as-information, and affect regulation) emphasize the experiential "felt"

component of affect and allow for a more strategic and flexible use of affect in guiding judgments and decisions.

2.2.1. Affect as information

The affect-as-information model (AIM) proposes that a person often forms a judgment of a target by asking herself “How do I feel about it?” and then uses her current feeling as a shortcut to judgment. However, in doing so, the individual may mistake (mis-attribute) her feeling due to a pre-existing state for a reaction due to the target, unless she questions the source of the feeling (Schwarz & Clore, 2003). The AIM is supported by findings that affect-congruency effects are often eliminated when subjects are given an alternative explanation for the presence of their feelings, thus undermining their diagnostic value for judgment (without presumably reducing semantic accessibility). For example, a classic study showed that the affectively congruent influence of good vs. bad weather on life satisfaction judgments is eliminated when participants are subtly reminded of the surrounding weather conditions (Schwarz & Clore, 1983). Similarly, although arousal induced by some previous context (e.g., exercise, scary bridge, caffeine) can influence judgments ranging from attractiveness to aggressiveness, this influence can disappear when participants are alerted to the actual source of arousal (Martin, Harlow, & Strack, 1992).

2.2.2. Affect regulation

Affect regulation models propose that affective influence on decision occurs because people perform actions to manage (i.e., maintain, change, or remove) their emotional experience (for reviews, see Andrade, in press; Baumeister et al., under review, Erber & Markunas, in press). These accounts suggest that people manage their emotions (sometimes automatically, sometimes for strategic reasons) in order to (i) restore a previous emotional state, (ii) get into an

emotional state that maximizes performance, or (iii) make their emotional state congruent with situational demands.

In the domain of mood, the regulation idea was explored by Erber, Wegner, and Theriault (1996). These authors first made participants happy or sad and then told them to expect they would be working on an unrelated task either alone or with another participant. Next, participants were asked to indicate their preference for a set of newspaper stories, identified by their headlines as uplifting, depressing, or neutral. Participants who expected to work alone showed the standard mood-congruency pattern -- happy participants chose cheerful stories while sad participants chose depressing ones. However, participants who expected to work with a stranger showed the opposite preference -- happy participants chose depressing stories while sad participants chose cheerful ones, presumably reflecting an attempt to neutralize their mood before a novel social interaction. In the domain of emotion, the regulation idea was explored by Raghunathan and Pham (1999). These authors hypothesized that sadness may occasionally promote active seeking of reward, while fear would motivate the need to reduce uncertainty of a situation. Consistent with these ideas, inducing sadness resulted in high risk/high reward choices, while inducing fear led to low-risk/low reward choices.

3. Psychobiological underpinning of affective influence

The psychological accounts of affective influence shed light on a variety of findings in the literature. However, they cannot explain a number of major findings and do not make many predictions that easily fall out of more biopsychological models. In what follows, we demonstrate how biopsychological considerations lead to more complete answers to several central questions, including (i) where do values and feelings come from? (ii) how does affect influence attention, perception, memory, and decision?, and (iii) how is cognition integrated with

emotion? To further illustrate the value of biopsychological perspective, we also discuss in more detail how affective neuroscience can enrich our understanding of affective priming. The next few sections refer to several brain structures underlying affective influence (see Figure 1 for approximate locations). Because our description of these structures and their many roles in affect and cognition is necessarily simplified, we invite readers to additionally consult more comprehensive physiological reviews (e.g., Berridge, 2003; Phelps, 2005).

3.1. Where do values and feelings come from?

The psychological models, especially the associative model, assume that “values” and “feelings” basically reflect the number and extremity of cognitively accessible positive and negative attributes. If biological factors are considered, they are typically thought of as contributing to ‘non-specific’ arousal that acquires value only when it is interpreted in the light of semantically activated concepts (Schachter & Singer, 1962). In contrast, affective neuroscience encourages investigators to ask about neural coding of “value” and the neural basis of feelings. This framing can lead to interesting and novel insights, as we discuss next.

3.1.1. Representation of rewarding outcomes and experiences

The neural representation of reward is a highly debated topic, but there is good evidence that at least some aspects of reward are represented by nuclei rich in dopamine and opioid neurotransmitters that lie near the bottom of the front of the brain, in the area called the basal forebrain. One of those nuclei, the nucleus accumbens (NAcc) became subject of intense research attention, long after Olds and Milner (1954) discovered that a rat with an electrode implanted near the NAcc would work vigorously to self-administer stimulation to the point of exhaustion, and to the exclusion of all other activities (e.g., eating, drinking, sex, and sleep). Subsequent research in humans and other animals indicated that many of these studies

supporting self-stimulation involved the neurotransmitter dopamine, either housing the bodies of dopamine neurons (i.e., deep in the midbrain), or their projection areas (i.e., to subcortical areas like the NAcc and cortical areas like the prefrontal cortex) (Falck & Hillarp, 1959). Subsequent work demonstrated that brain microinjections of drug droplets that activate opioid receptors in the accumbens caused increased ‘liking’ for sweetness in rats (Pecina & Berridge, 2000). In humans, dopamine release in the ventral striatum caused by amphetamine injection correlates with self-reported positive arousal (e.g., euphoria), but not with negative arousal (e.g., fear) (Drevets et al., 2001; Mawlawi et al., 2001; Volkow et al., 1999).

One of the most interesting emerging discoveries from affective neuroscience is the remarkable similarity with which the brain codes different types of rewards. Specifically, fMRI studies on humans suggest that the accumbens and related areas activate not only in response to drug cues, but also to cues for other rewarding stimuli, including tasty foods and drinks (O’Doherty et al., 2002), and pictures of desirable social or sexual partners (Knutson and Cooper, 2005). Even more interesting, these regions might even be involved in representing rewarding aspects of social interactions, suggesting that perhaps the brain transforms socially constructed rewards into the same “common currency” as “natural rewards”. Thus, the NAcc and related structures activate during anticipation of monetary gain (Knutson et al., 2001), to signals of cooperation in prisoner’s dilemma games (Rilling et al, 2001), and even prior to exacting “altruistic punishment”, as when a person punishes a transgressor against her group in spite of personal costs (De Quervain et al., 2004).

If positive expected value is somehow coded by activity in these “reward regions,” then investigators should be able to predict participants’ choice behavior based on activation in these regions. This idea was recently explored by Kuhnen and Knutson (2005) who hypothesized that

an increase in gain anticipation would promote risky choices, whereas an increase in loss anticipation would instead promote riskless choices. Accordingly, using a financial trading task in combination with fMRI, they found that anticipatory NAcc activation preceded switches to a risk-seeking strategy (i.e., choosing stocks rather than bonds), whereas anterior insula preceded switches in the opposite direction to a risk-avoidant strategy (i.e., choosing bonds rather than stocks) (Kuhnen & Knutson, 2005). Thus, evidence is beginning to suggest that anticipatory NAcc activation may modulate subsequent behavior in ways that promote gain-seeking.

Finally, recent evidence suggests that putative reward regions might be involved in the influence of affect on memory. In an fMRI experiment, Adcock et al. showed subjects cues for high (\$5.00) or low (\$0.10) rewards followed by a delay and then outdoor scenes that they were instructed to memorize for the cued amount. At a memory test one day later, subjects correctly remembered more high value scenes. Analysis of fMRI data revealed that enhanced encoding was preceded by coactivation of NAcc, ventral tegmental area, and hippocampus (a region implicated in memorization) before subjects saw the high-value scenes (Adcock et al., 2006). Thus, NAcc activation predicted that subjects would be more likely to remember upcoming scenes, even before the subject had seen them. Note that this finding cannot be predicted from purely psychological accounts that do not consider the neural connectivity between the reward and memory systems.

3.1.2. Representation of aversive outcomes and experiences

Research in affective neuroscience has also contributed to our understanding of aversive outcomes and experiences, and their role in attention, perception, memory, and judgment. Traditionally, this research focused on two regions of the brain, the amygdala and the insula, although those regions are also involved in coding of non-aversive experiences.

3.1.2.1 Amygdala

The amygdala is an almond-shaped structure located in the medial temporal lobe, just anterior to the hippocampus. The amygdala is richly and reciprocally connected to several cortical areas involved in cognitive and affective processing, as well as subcortical areas involved in physiological regulation (sympathetic and parasympathetic control of cardiovascular activity, respiration, hormone levels, muscular responses, etc). As a result, the amygdala is involved in many important affective phenomena, including affective modulation of attention, perception, and memory.

Research on the amygdala contributed to better understanding of the ‘attention-grabbing’ power of affective stimuli – a challenging issue for purely psychological accounts. One example comes from the phenomenon of attentional blink, in which detection of a first target temporarily impairs detection of a second target. Normally, attentional blink is reduced for important affective stimuli, but this reduction is eliminated after amygdala damage, suggesting that this subcortical structure encodes salient affective information (Anderson & Phelps, 2001).

Research on the amygdala also led to better understanding of how people can perceive affective stimuli even under minimal exposure conditions (Atkinson & Adolphs, 2005). Note that this possibility has been debated for years in psychology, but did not receive a satisfying answer until the emergence of affective neuroscience (Zajonc, 2000). However, there are now many studies documenting amygdala response even in the absence of conscious recognition of the stimulus, such as when fearful or angry facial expressions are presented subliminally (Whalen et al., 1998), under conditions of binocular rivalry (Williams et al., 2004), or with anger expressions presented to a patient’s “blind field” (Morris, DeGelder, Weiskrantz, & Dolan, 2001; Morris, Öhman, & Dolan, 1999).²

Similarly, there is now a very large literature suggesting that affective memory benefits from the amygdala's contribution. In the amygdala, neurons can rapidly adjust their activity to reflect both positive and negative value of an external stimulus, which predicts how quickly monkeys learn to respond to a stimulus (Paton et al., 2006). Patients with amygdala damage (but intact hippocampus) are impaired on acquisition of conditioned fear responses, as measured by skin conductance, but relatively unimpaired on declarative memory (Bechara et al., 1995). Such patients also do not show the typical memory advantage for emotionally-arousing stimuli, such as taboo words (Anderson & Phelps, 2002). Again, these neural findings severely challenge purely associative models of affective memory that assume little difference in processing of cognitive and affective content (Phelps, 2005).

Finally, and somewhat surprisingly, some research suggests that amygdala may not always be necessary for the subjective experience of emotion. Specifically, patients with amygdala damage show little, if any, impairment in the magnitude and frequency of self-reported positive or negative affect (Anderson & Phelps, 2002). This interesting finding highlights a possible dissociation between the mechanisms by which salient emotional stimuli influence attention, perception and memory, for which the amygdala plays an essential role, and the mechanisms underlying subjective experience, which may require additional recruitment of cortical circuits, as discussed below. If further confirmed, this observation would be especially challenging for the psychological models proposing that conscious feelings, and inferences from these feelings, play a primary causal role in the impact of affect on judgment and decision.³

3.1.2.2. The insula.

The insula typically comprise five gyri that are covered by cortex bordering anterior to the orbitofrontal cortex, superior to the prefrontal and parietal cortices, and posterior to the

temporal cortex (Augustine, 1996). The insula maintain bidirectional connections with subcortical structures, such as the amygdala and all cortical structures, especially the orbitofrontal cortex, the parietal cortex, and the anterior cingulate. Research suggests that the insula might be particularly involved in reactions to aversive stimuli and representation of aversive experiences, especially those related to fear and anxiety. Thus, functional neuroimaging studies have linked insular cortex to processing of supraliminal expressions of fear (Morris et al 1998) and disgust (Phillips et al 1998), anticipation of electric shocks (Chua et al 1999), sad mood (Liotti et al 2000), aversive Pavlovian conditioning (Buchel et al 1998), perceptual awareness of threat (Critchley et al 2000) and penalty-related activation (Elliott et al 2000).

Interestingly, there is also evidence that somatosensory cortices and the insula might be crucial to generate conscious emotional experiences, particularly aversive ones. Harkening back to the writings of William James (1884), one proposed mechanism for this involves building a model of the current bodily state, including the hormonal, muscular, and visceral milieu (Damasio, 1999). Specifically, an internal representation of a “visceral homunculus” may be maintained in the posterior insula bilaterally, which primarily projects to the right anterior insula (Craig, 2003). Activation of this circuitry has consistently been associated with aversive bodily sensations, including noxious heat or cold stimuli (Becerra et al., 1999; Tracey et al., 2000) and pain (Ploghaus et al 2001; Sawamoto et al 2000). Consistent with the idea of a visceral basis of emotion experience, neuroimaging studies show that recall of emotional memories is associated with extensive activation of the insula and somatosensory cortex (Damasio et al., 2000), whereas damage to these regions is associated with reduction in the intensity of affective feelings (Craig; 2003; Critchley, 2005). However, the present literature has not yet clarified whether insular activation is more related to the arousal or valence component of emotional

experience.

Assuming that insular activation correlates with negative valence, activation of this region should predict subsequent behavior. This implication was explored by Paulus et al. (2003) in a decision-making game. They found that activity in the right insular cortex was greater during risky gambles (Paulus et al., 2003), and that insular activation correlated with later risk aversion, as well as with trait measures of negative arousal. These findings were extended by Kuhnen and Knutson (2005), who found that insular activation preceded switches to risk averse strategies in an investment task. Together, these findings suggest that insular activation (particularly on the right) may play a critical role for the processing of aversive emotions during decision-making.

3.2. Integration and regulation of emotion and cognition

Affective neuroscience also leads to new insights on how affect gets integrated into cognitive processing and how cognition can regulate affect. Most of the research in this area has focused on the role of the prefrontal cortex, especially orbitofrontal, ventromedial, and lateral areas.

3.2.1 Orbitofrontal cortex.

Orbitofrontal cortex (OFC) is the bottom third portion of prefrontal cortex, situated just above the eyes. OFC is hypothesized to play a role in one of the most fundamental aspects of affect-cognition interactions -- linking cognitive representation of a stimulus with the representation of its corresponding value. The OFC may play an important role in this process, as suggested by selective firing of OFC neurons in monkeys to stimuli associated with rewards or punishments (Rolls, 1999). A subset of these neurons is highly flexible in their coding properties, changing their firing rate when the reward properties of a stimulus change (e.g., when

a stimulus that previously predicted food delivery no longer does so). Further, some OFC neurons only fire to motivationally relevant stimuli. For example, neurons that fire during presentation of a particular food (e.g., a banana) when the animal is hungry, no longer fire in the presence of that food after the animal is satiated (Rolls, 1999).

3.2.2. Ventromedial prefrontal cortex.

A more circumscribed, ventral section of the medial prefrontal cortex (vmPFC) has been hypothesized to play a unique role in the ability to incorporate emotional factors into decisions (Damasio, 1999). For instance, Bechara and colleagues (1997) compared performance of controls and vmPFC-lesioned patients on a money gambling task in which an initially attractive option was later associated with occasional but substantial losses. The vmPFC patients chose the risky option more frequently and ultimately made less money, presumably due to their inability to process loss-related somatic feedback.

Interestingly, given the right task, vmPFC patients can also make more profit-maximizing decisions (Shiv et al., 2005). Specifically, in a myopic loss aversion task, typical participants show excessive caution about choosing risky, though profitable options (Gneezy & Potters, 1997). In this task, participants start with an endowment (e.g., \$20), and decide on each subsequent round to either invest \$1 or to advance to the next round without investing. If the participant decides to invest, they have a 50% chance of losing their \$1, or a 50% chance of winning an additional \$1.50. Thus, from a profit-maximizing perspective, it is better to invest than to pass (expected value = \$1.25 vs. \$1). However, typical participants often fail to invest, and particularly if they have lost money on the previous trial – consistent with the notion of loss aversion. Using the myopic loss aversion paradigm, Shiv et al. (2005) showed that compared to

healthy controls, vmPFC patients invested more frequently and ultimately made more money, presumably because the absence of negative feedback reduced their risk aversion.

Finally, fMRI studies have repeatedly implicated medial PFC in processing financial gain outcomes, with increases in mPFC activation when the outcome is better than expected and decreases when outcome is worse than expected (Knutson et al., 2003). This finding, which recently has been verified with electrophysiology (Oya et al., 2005), highlights that understanding how value (affect) and expectation (cognition) is incorporated in the decision requires consideration of both psychological and biological factors.

3.2.3. Lateral prefrontal cortex. Affective neuroscience is also beginning to investigate a possible role of lateral PFC in strategic control of emotion. Such control could involve descending projections from the dorsolateral PFC to the medial and orbital PFC, which then project to the amygdala and to the accumbens (Phan, Wager, Taylor, & Liberzon, 2002; Davidson, Jackson, & Kalin, 2000). Thus, recent research reported lateral PFC activation during tasks in which subjects were asked to increase or decrease their affective reactions to negative pictures (Ochsner & Gross, 2004; Schaefer et al., 2002).

3. Mechanisms of affective priming: Psychological and biopsychological account

One specific demonstration of how affective neuroscience elucidates affective influence phenomena involves “affective priming” – the impact of preceding affective stimuli on responses to subsequent neutral stimuli. One robust examples of this phenomenon is the affect congruent influence of emotional facial expressions on subsequent judgments (Murphy & Zajonc, 1993; Niedenthal, 1990). Importantly, such affective priming can be obtained with actual behavior. For example, in a study by Winkielman, Berridge, and Wilbarger (2005) participants subliminally exposed to happy, as opposed to angry, faces poured and drank more of a pleasant

drink and also rated the drink as more desirable and financially valuable afterwards. This study also revealed two additional important findings. First, the priming effects depended on motivation, such that thirsty participants showed the greatest increases in pouring, consumption and ratings after exposure to happy faces. Second, changes in behavior and ratings were not accompanied by conscious changes in mood. Recently, we also obtained similar results with even more complex subsequent decisions, such as choices between risky gambles (Trujillo, Knutson, Paulus, & Winkielman, under review). These findings indicated that participants were more likely to choose a risky option after exposure to positive (happy) versus negative expressions (anger, fear, or disgust). Once again, the influence of facial expressions on risky gambles did not depend on changes in participants' conscious experience.

Traditional psychological models have difficulty in fully explaining affective priming. For instance, the affect-as-information view proposes that affective priming involves a misattribution of a conscious affective experience induced by a subliminal prime to a neutral target (Schwarz, 1990). However, our work showed that subliminal affective primes do not change conscious mood (Winkielman et al., 2005). Further, unlike the many misattribution studies (Schwarz & Clore, 1988), participants continue to show subliminal affective priming effects even when invited to attribute their emotional reaction to an alternative source, such as background music or "hidden pictures" (Winkielman, Zajonc, & Schwarz, 1997). The associative semantic memory model proposes that affective priming is just a type of semantic priming with participants interpreting neutral targets in light of affective concepts activated by the prime (Forgas, 1990). This model can explain the absence of conscious feelings. However, it cannot explain why priming effects are easily obtained with pictures of emotional faces or emotional scenes, but are hard to elicit with valence and intensity matched affective words

(Winkielman & Gogolushko, under review). Similarly, the associative model cannot explain why priming with non-affective attributes of the face, like gender and age, fails to produce comparable effects as those seen with emotional expressions (Murphy & Zajonc, 1993). Finally, the associative model cannot explain why affective priming generalizes to behavioral measures, but not to participants' ratings of their own mood, nor can the model explain why motivational state amplifies the impact of affective primes (Winkielman et al., 2005).

Given the inability of traditional psychological models to account for affective priming, we have recently offered a model that incorporates considerations from affective neuroscience (Winkielman et al., 2005). Specifically, we propose that salient emotional stimuli, such as facial expressions (but not words), activate subcortical circuits, such as the amygdala or NAcc. This can occur either when salient stimuli are presented subliminally (Whalen et al., 1998) or supraliminally, and even when participants' attention is not focused on the emotional content of the stimuli (Critchley et al., 2000). These subcortical circuits project to other subcortical regions involved in processing incentives (Berridge, 2003) and to prefrontal cortex, involved in representation of expected value and probability (Knutson & Wimmer, in press). Thus, an emotionally expressive face activates the amygdala or NAcc, which then alters the readiness of regions involved in perception and behavior to respond to subsequent incentive stimuli (e.g., a novel beverage or risky gamble). Finally, as discussed earlier, while these neural events may eventually be important for conscious experience, they also have the potential to operate independently from conscious experience (Anderson & Phelps, 2002). Thanks to their connectivity with brain regions implicated in perception, attention, memory and motor preparation, these subcortical regions have the capacity to push an organism toward or away from stimuli, even without the mediation of reflective insight or emotional feeling.

Importantly, these biopsychological considerations generate interesting predictions about when affective stimuli should influence subsequent behavior and feeling. For example, the degree to which an affective stimulus, or a task, activates the neural incentive system should predict its influence on subsequent incentive-related processing and behaviors, and how individual and motivational differences will modify the observed effects.

4. Conclusion

In this paper, we argued that dominant psychological models of affective influence on judgment and decisions (including the major associative and inferential models) cannot capture and predict many phenomena that are more gracefully accommodated by biopsychological models. We illustrated this point by showing that biopsychological models shed light on how values and feelings arise, and how they subsequently influence perception, attention, memory, judgment, and choice. Of course, existing psychological models of affective influence are not inherently deficient. In fact, we strongly believe the primary relevance of affective neuroscience hangs on its ability to inform the psychological level of explanation. However, as we have tried to demonstrate, the psychological models can only partially capture variables that are relevant to the phenomena they are trying to explain, and they sometimes hold untenable assumptions in light of biopsychological findings. Finally, many functional algorithms may lead to the same software implementation, but it is now necessary to “crack open” the hardware to determine which algorithm is instantiated. For all these reasons, the time is ripe for pairing psychological research on affective influence with affective neuroscience. We hope that the current overview provides a step towards that goal.

References

- Adams, R. B., Gordon, H. L., Baird, A. A., Ambady, N. & Kleck, R. E. (2003). Effects of gaze on amygdala sensitivity to anger and fear faces. Science, 300, 1536.
- Adcock, R. A., Thangavel, A., Whitfield-Gabrieli, S., Knutson, B., & Gabrieli, J. D. E. (2006). Reward-motivated learning: Mesolimbic activation precedes memory formation. Neuron, 50.
- Adolphs, R., Gosselin, F., Buchanan, T.W., Schyns, P., Tranel, D., & Damasio, A.R. (2005). A mechanism explaining impaired fear recognition in amygdala damage. Nature, 433, 68-72.
- Adolphs, R., Tranel, D., Damasio, H. & Damasio, A. (1994). Impaired recognition of emotion in facial expressions following bilateral damage to the human amygdala. Nature, 372, 669–672.
- Anderson, A.K. & Phelps, E.A. (2001). Lesions of the human amygdala impair enhanced perception of emotionally salient events. Nature, 411, 305-309.
- Anderson, A.K. & Phelps, E.A. (2002). Is the human amygdala critical for the subjective experience of emotion? Evidence of intact dispositional affect in patients with lesions of the amygdala. Journal of Cognitive Neuroscience, 14, 709-20.
- Andrade, E.B. (2005). Behavioral consequences of affect: Combining evaluative and regulatory mechanisms. Journal of Consumer Research, 32, 355-362.
- Atkinson, A.P. & Adolphs, R. (2005). Visual emotion perception: Mechanisms and processes. In Feldman-Barrett, L., Niedenthal, P., & Winkielman, P. Emotion and Consciousness. Guilford Press. New York.
- Augustine, J. R. (1996). Circuitry and functional aspects of the insular lobes in primates

- including humans. Brain Res Rev, 2, 229-294.
- Baumeister, R. F. Vohs, K.D., De Wall, N. F., Zhang, L., (under review), Does Emotion Cause Behavior, or Vice Versa? Toward a Dual Process Theory of Emotion, Affect, and Behavior. Manuscript under review.
- Becerra, L.R., Breiter, H.C., Stojanovic, M., Fishman, S., Edwards, A., Comite, A.R., Gonzalez, R.G., Borsook, D. (1999). Human brain activation under controlled thermal stimulation and habituation to noxious heat: an fMRI study. Magn. Reson. Med. 41, 1044–1057.
- Bechara A, Tranel D, Damasio H, Adolphs R, Rockland C, Damasio A (1995) Double dissociation of conditioning and declarative knowledge relative to the amygdala and hippocampus in humans. Science, 267, 115–1118.
- Bechara, A., Damasio, H., Tranel, D., Damasio, A. R. (1997). Deciding advantageously before knowing the advantageous strategy. Science, 275, 1293-1295.
- Berridge, K.C. (2003). Comparing the emotional brain of humans and other animals. In Handbook of Affective Sciences, R.J. Davidson, H.H. Goldsmith, & K. Scherer (Eds.), pp. 25-51, Oxford University Press.
- Blaney, P.H., (1986). Affect and memory: a review. Psychological Bulletin, 99, 229– 246.
- Bower, G. H. (1991). Mood congruity of social judgments. In J. P. Forgas (Ed.), Emotion and social judgments (pp. 31–54). Oxford: Pergamon Press.
- Buchel, C., Morris, J., Dolan, R.J., Friston, K.J., 1998. Brain systems mediating aversive conditioning: an event-related fMRI study. Neuron, 20, 947–957.
- Cacioppo, J. T., Berntson, G. G. (1999). The affect system: architecture and operating characteristics. Current Direction in Psychological Science, 18, 133-137.

- Chen, S., & Bargh, J. A. (1999). Consequences of automatic evaluation: Immediate behavior predispositions to approach or avoid the stimulus. Personality and Social Psychology Bulletin, 25, 215-224.
- Chua, P., Krams, M., Toni, I., Passingham, R., Dolan, R., 1999. A functional anatomy of anticipatory anxiety. NeuroImage 9, 563–571.
- Craig, A. D. (2003). Interoception: the sense of the physiological condition of the body. Current Opinion in Neurobiology, 13, 500-505.
- Critchley H.D. (2005). Neural mechanisms of autonomic, affective, and cognitive integration, Journal of Comparative Neurology, 493, 54-166.
- Critchley, H., Daly, E., Phillips, M., Brammer, M., Bullmore, E., Williams, S., Van Amelsvoort, T., Robertson, D., David, A., & Murphy, D. (2000). Explicit and implicit neural mechanisms for processing of social information from facial expressions: A functional magnetic resonance imaging study. Human Brain Mapping, 9, 93-105.
- Damasio, A. R. (1999). The feeling of what happens: body and emotion in the making of consciousness. New York: Harcourt Brace.
- Damasio, A. R., Grabowski, T. J., Bechara, A., Damasio, H., Ponto, L. L., Parvizi, J., & Hichwa, R. D. (2000). Subcortical and cortical brain activity during the feeling of self-generated emotions. Nature Neuroscience, 3, 1049-1056.
- Davidson, R. J., Jackson, D. C., & Kalin, N. H. (2000). Emotion, plasticity context, and regulation: Perspectives from affective neuroscience. Psychological Bulletin, 126, 890–909.
- de Quervain, D., J.-F., Fischbacher, U., Treyer, V., Schellhammer, M., Schnyder, U., Buck, A., & Fehr, E. (2004). The neural basis of altruistic punishment. Science, 305, 1254-1258.

- Dijksterhuis, A., & Bargh, J. A. (2001). The perception-behavior expressway: Automatic effects of social perception on social behavior. In M. P. Zanna (Ed.), *Advances in experimental social psychology*, Vol. 33 (pp. 1–40). San Diego: Academic.
- Drevets, W. C., Gautier, C., Price, J. C., Kupfer, D. J., Kinahan, P. E., Grace, A. A., et al. (2001). Amphetamine-induced dopamine release in human ventral striatum correlates with euphoria. *Biological Psychiatry*, 49, 81-96.
- Elliott, R., Friston, K. J., & Dolan, R. J. (2000). Dissociable neural responses in human reward systems. *Journal of Neuroscience*, 20, 6159-6165.
- Ellsworth, P.C., & Scherer, K. R. (2003). Appraisal processes in emotion. In R.J. Davidson, K. R. Scherer, H. H. Goldstein. *Handbook of affective sciences*. New York: Oxford University Press.
- Erber, R. & Markunas, S. (in press). Managing affective states. In Forgas, J.P. (Eds.). *Hearts and minds: Affective influences on social thinking and behavior*. Philadelphia, PA.: Psychology Press.
- Erber, R., Wegner, D.M., & Theriault, N. (1996). On being cool and collected: Mood regulation in anticipation of social interaction. *Journal of Personality and Social Psychology*, 70, 757-766.
- Falck, B., & Hillarp, N. A. (1959). On the cellular localization of catechol amines in the brain. *Acta Anatomica*, 38, 277-279.
- Forgas, J.P. (1995). Mood and judgment: The Affect Infusion Model (AIM). *Psychological Bulletin*, 117, 39-66.

- Forgas, J. (in press). Affective influences on interpersonal behavior: Towards understanding the role of affect in everyday interactions. In Forgas, J.P. (Eds.). Hearts and minds: Affective influences on social thinking and behavior. Philadelphia, PA.: Psychology Press.
- Gneezy, U. & Potters, J. (1997). An experiment on risk taking and evaluation periods. Quarterly Journal of Economics, 112, 631–645.
- Hamm, A. O., Schupp, H. T., Weike, A. I. (2003) Motivational organization of emotions: autonomic changes, cortical responses, and reflex modulation. In R.J. Davidson, K.R.Scherer, H.H.Goldstein. Handbook of affective sciences. New York: Oxford University Press.
- James, W. (1884). What is an Emotion? Mind, 9, 188-205.
- Johnson, E. J., & Tversky, A. (1983). Affect, generalization, and the perception of risk. Journal of Personality and Social Psychology, 45, 20-31.
- Knutson, B., Adams, C.M., Fong, G.W., & Hommer, D. (2001). Anticipation of increasing monetary reward selectively recruits nucleus accumbens. Journal of Neuroscience, 21, 1-5.
- Knutson, B., Fong, G. W., Bennett, S. M., Adams, C. S., & Hommer, D. (2003). A region of mesial prefrontal cortex tracks monetarily rewarding outcomes: Characterization with rapid event-related FMRI. NeuroImage, 18, 263-272.
- Knutson B, Wimmer GE (in press). Reward: Neural circuitry for social valuation. Social Neuroscience: Bridging biological and psychological explanations of social behavior, Harmon-Jones E, and Winkielman P (Eds). New York NY, Guilford.
- Kuhnen, C. M., & Knutson, B. (2005). The neural basis of financial risk-taking. Neuron, 47, 620-628.

- Lang, P. J. (1995). The emotion probe: studies of motivation and attention. American Psychologist, 50 (5), 372-385.
- LeDoux, J. (1996). The emotional brain: The mysterious underpinnings of emotional life. New York: Simon & Schuster.
- Lerner, J. S., & Keltner, D. (2001). Fear, anger, and risk. Journal of Personality and Social Psychology, 81, 146-159.
- Liotti, M., Mayberg, H.S., Brannan, S.K., McGinnis, S., Jerabek, P., Fox, P.T., 2000. Differential limbic–cortical correlates of sadness and anxiety in healthy subjects: implications for affective disorders. Biological Psychiatry 48, 30–42.
- Markman, A. B., & Brendl, C.M. (2005). Constraining theories of embodied cognition, Psychological Science, 16, 6-10.
- Martin, L. L., Harlow, T. F., & Strack, F. (1992). The role of bodily sensations in the evaluation of social events. Personality and Social Psychology Bulletin, 18, 412–419.
- Mawlawi, O., Martinez, D., Slifstein, M., Broft, A., Chatterjee, R., Hwang, D., et al. (2001). Imaging human mesolimbic dopamine transmission with positron emission tomography: I. Accuracy and precision of D2 receptor parametr measurements in ventral striatum. Journal of Cerebral Blood Flow and Metabolism, 21, 1034-1057.
- Morris, J.S., Friston, K.J., Beuchel, C., Frith, C.D., Young, A.W., Calder, A.J., Dolan, R.J., (1998). A neuromodulatory role for the human amygdala in processing emotional facial expressions. Brain, 121, 47–57.
- Morris, J.S., DeGelder, B., Weiskrantz, L. & Dolan, R.J. (2001). Differential extrageniculostriate and amygdala responses to presentation of emotional faces in a cortically blind field. Brain, 124, 1241-1252.

- Morris, J. S., Öhman, A., & Dolan, R. J. (1999). A subcortical pathway to the right amygdala mediating "unseen" fear. Proceedings of the National Academy of Sciences, 96, 1680-1685.
- Murphy, S.T., & Zajonc, R.B. (1993). Affect, cognition, and awareness: Affective priming with optimal and suboptimal stimulus exposures. Journal of Personality and Social Psychology, 64, 723-739.
- Niedenthal, P.M. (1990). Implicit perception of affective information. Journal of Experimental Social Psychology, 26, 505-527.
- Niedenthal, P. M., Barsalou, L., Winkielman, P., Krauth-Gruber, S., & Ric, F. (2005). Embodiment in attitudes, social perception, and emotion. Personality and Social Psychology Review, 9, 184-211.
- Niedenthal, P.M., & Setterlund, M.B. (1994). Emotion congruence in perception. Personality and Social Psychology Bulletin, 20, 401-411.
- Ochsner, K. N., Bunge, S. A., Gross, J. J., & Gabrieli, J. D. E. (2002). Rethinking feelings: An fMRI study of the cognitive regulation of emotion. Journal of Cognitive Neuroscience, 14, 1215-1299.
- O'Doherty J., Deichmann, R., Critchley H.D., & Dolan R.J. (2002). Neural responses during anticipation of a primary taste reward. Neuron, 33, 815-26.
- Ohman , A. Hamm, A., & Hugdahl, K., (2000) Cognition and the autonomic nervous system. In J.T. Cacioppo, L.G. Tassinary, & G.G. Berntson (Eds.), Handbook of psychophysiology (2nd ed.), pp. 533-575. Cambridge: New York.

- Olds, J., & Milner, P. (1954). Positive reinforcement produced by electrical stimulation of septal area and other regions of rat brain. Journal of Comparative and Physiological Psychology, 47, 419-427.
- Oya H, Adolphs R, Kawasaki H, Bechara A, Damasio A, Howard MA 3rd. (2005) Electrophysiological correlates of reward prediction error recorded in the human prefrontal cortex. *Proc Natl Acad Sci U S A*, 102, 8351-8356.
- Paton, J.J., Belova, M.A., Morrison, S.E., and Salzman, C.D. (2006). The primate amygdala represents the positive and negative value of visual stimuli during learning. Nature, 439, 865–870.
- Paulus, M. P., Rogalsky, C., Simmons, A., Feinstein, J. S., Stein, M. B. (2003). Increased activation in the right insula during risk-taking decision making is related to harm avoidance and neuroticism. Neuroimage, 19, 1439-1448.
- Pecina, S., & Berridge, K. C. (2000). Opioid eating site in accumbens shell mediates food intake and hedonic ‘liking’: Map based on microinjection Fos plumes. Brain Research, 863, 71–86.
- Phan K.L, Wagner T, Taylor S.F., Liberzon, I. (2002). Functional neuroanatomy of emotion: a meta-analysis of emotion activation studies in PET and fMRI. Neuroimage 16, 331–348.
- Phelps, E.A. (2005). The Interaction of Emotion and Cognition: Insights from Studies of the Human Amygdala. In Feldman-Barrett, L., Niedenthal, P., & Winkielman, P. Emotion and Consciousness. Guilford Press. New York.
- Phillips, M.L., Young, A.W., Scott, S.K., Calder, A.J., Andrew, C., Giampietro, V., Williams, S.C., Bullmore, E.T., Brammer, M., Gray, J.A., 1998. Neural responses to facial and vocal expressions of fear and disgust. *Proc. R. Soc. Lond. B. Biol. Sci.* 265, 1809–1817.

- Ploghaus, A., Narain, C., Beckmann, C.F., Clare, S., Bantick, S., Wise, R., Matthews, P.M., Rawlins, J.N., Tracey, I., 2001. Exacerbation of pain by anxiety is associated with activity in a hippocampal network. *J. Neurosci.* 21, 9896–9903.
- Raghunathan, R., & Pham, M. T. (1999). All negative moods are not equal: motivational influences of anxiety and sadness on decision making. Organizational Behavior and Human Decision Processes, 79, 56-77.
- Rolls, E. T. (1999). The brain and emotion. Oxford: Oxford University Press.
- Sawamoto, N., Honda, M., Okada, T., Hanakawa, T., Kanda, M., Fukuyama, H., Konishi, J., Shibasaki, H., (2000). Expectation of pain enhances responses to nonpainful somatosensory stimulation in the anterior cingulate cortex and parietal operculum/posterior insula: an event-related functional magnetic resonance imaging study. *J. Neurosci.* 20, 7438–7445.
- Schachter, S., & Singer, J. E. (1962). Cognitive, social, and physiological determinants of emotional state. Psychological Review, 69, 379-399.
- Schaefer, S. M., Jackson, D. C., Davidson, R. J., Aguirre, G. K., Kimberg, D. Y., Thompson-Schill, S. L. (2002). Modulation of amygdalar activity by the conscious regulation of negative emotion. *Journal of Cognitive Neuroscience*, 14, 913-921.
- Schwarz, N. (1990). Feeling as information: Informational and motivational functions of affective states. In E.T. Higgins & R.M. Sorrentino (Eds.), *Handbook of motivation and cognition* (pp. 527-561). New York: Guilford Press .
- Schwarz, N., & Clore, G.L. (1983). Mood, misattribution, and judgments of well-being: Informative and directive functions of affective states. Journal of Personality and Social Psychology, 45, 513-523.

- Schwarz, N., & Clore, G.L. (2003). Mood as information: 20 years later. Psychological Inquiry, 14, 294-301.
- Shiv, B., Loewenstein, G., Bechara, A., Damasio, H. and Damasio, A.R. (2005). Investment behavior and the dark side of emotion. Psychological Science, 16, 435-439.
- Smith, C. A., & Ellsworth, P. C. (1985). Patterns of cognitive appraisal in emotion. Journal of Personality and Social Psychology, 48, 813-838.
- Solarz, A.K. (1960). Latency of instrumental responses as a function of compatibility with the meaning of eliciting verbal signs. Journal of Experimental Psychology, 59, 239-245.
- Strack, F., & Deutsch, R. (2004). Reflective and impulsive determinants of social behavior. Personality and Social Psychology Review, 8, 220-247
- Tracey, I., Becerra, L., Chang, I., Breiter, H., Jenkins, L., Borsook, D., Gonzalez, R.G., 2000. Noxious hot and cold stimulation produce common patterns of brain activation in humans: a functional magnetic resonance imaging study. Neurosci. Lett. 288, 159-162.
- Trujillo, J.T., Knutson, B., Paulus, M.P. & Winkielman, P. (under review) Taking gambles at face value: Effects of emotional expressions on risky decisions.
- Volkow, N. D., Wang, G., Fowler, J. S., Logan, J., Gatley, S. J., Wong, C., et al. (1999). Reinforcing effects of psychostimulants in humans are associated with increases in brain dopamine and occupancy of D2 receptors. The Journal of Pharmacology and Experimental Therapeutics, 291, 409-415.
- Wentura, D., Rothermund, K., & Bak, P. (2000). Automatic vigilance: The attention-grabbing power of behavior-related social information. Journal of Personality and Social Psychology, 78, 1024-1037.
- Whalen PJ, Kagan J, Cook RG, Davis FC, Kim H, Polis S, McLaren DG, Somerville LH,

- McLean AA, Maxwell JS, Johnstone T. (2004) Human amygdala responsivity to masked fearful eye whites. Science, 306, 2061.
- Whalen, P. J., Rauch, S. L., Etcoff, N. L., McInerney, S. C., Lee, M. B., & Jenike, M. A. (1998). Masked presentations of emotional facial expressions modulate amygdala activity without explicit knowledge. Journal of Neuroscience, 18, 411-418.
- Williams, M.A., Morris, A.P., McGlone, F., Abbott, D.F., & Mattingley, J.B. (2004). Amygdala responses to fearful and happy facial expressions under conditions of binocular suppression. Journal of Neuroscience, 24, 2898-2904.
- Winkielman, P. & Berridge, K. C. (2004). Unconscious emotion. Current Directions in Psychological Science, 13, 120-123.
- Winkielman, P., Berridge, K. C., Wilbarger, J. (2005). Unconscious affective reactions to masked happy versus angry faces influence consumption behavior and judgments of value. Personality and Social Psychology Bulletin, 1, 121-135.
- Winkielman, P. & Gogolushko, K. (under review). How does emotion influence motion? Pictures, but not words, elicit valence-congruent changes in hedonic behavior. *Manuscript under review*.
- Winkielman, P., Zajonc, R.B., & Schwarz, N. (1997). Subliminal affective priming resists attributional interventions. Cognition and Emotion, 11, 433-465.
- Zajonc, R.B. (2000). Feeling and thinking: Closing the debate over the independence of affect. In J.P. Forgas (Ed.), Feeling and thinking: The role of affect in social cognition (pp. 31–58). New York: Cambridge University Press.

Authors' Note

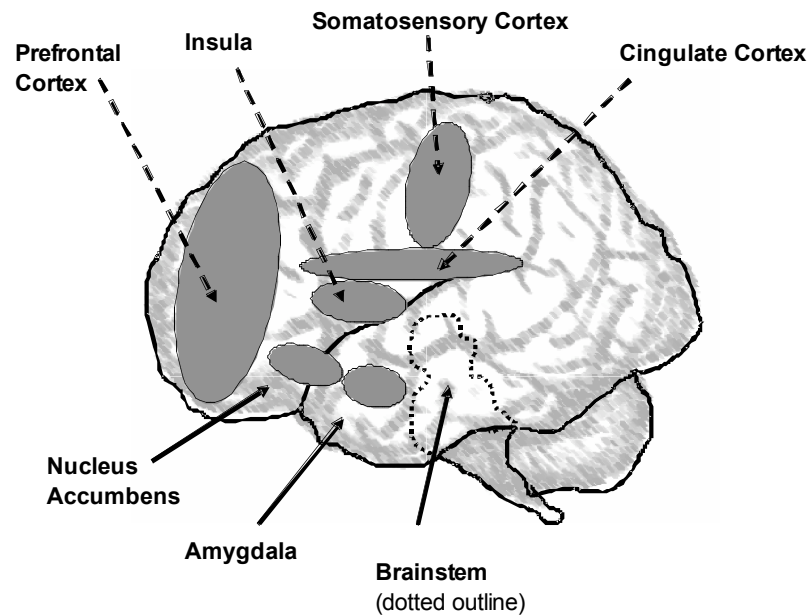
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Figure

Approximate locations of neural regions implicated in affective influence on decision-making.

Regions indicated with dashed lines are believed to play critical roles in affective experience.

The figure shows only the left side of the brain and does not indicate the depth or connectivity of any structure (see Berridge, 2003 for a detailed presentation).



Footnotes

¹ Note that the impact of an emotional stimulus is importantly determined by the amount of its processing and time available to produce a response (Scherer, 2005). With minimal processing, the stimulus may elicit only a non-specific orienting response, and perhaps non-specific mobilization, with its strength dependent on unexpectedness and importance (Ohman, Hamm, & Hugdahl, 2000). Additional stimulus processing may lead to differentiation of general valence, triggering general biphasic responses, with negative stimuli facilitating avoidance and positive stimuli facilitating approach (Cacioppo & Berntson, 1999; Hamm, Schupp, & Weike, 2003; Lang, 1995). Finally, as more features are extracted from the stimulus and the stimulus is considered in its situational context, the resulting response becomes differentiated into a specific emotional state (Ellsworth & Scherer, 2003).

² Some earlier reports have suggested that the amygdala is particularly important for processing fear-related stimuli, as indicated by the impairments of the amygdala patients in recognizing fearful facial expressions (Adolphs et al., 1994). More recent work suggests that this specificity is explained by the role that facial information from the eye region plays in fear recognition (Adolphs et al., 2005). In fact, the amygdala seems particularly important in processing of gaze information (Adams et al., 2003) and can be activated even by rudimentary eye features, such as the increases in the sclera, or the whites of the eyes (Whalen et al., 2005).

³ Conversely, some neuroscientists, who see the amygdala as the center of “emotional brain”, doubt that conscious feelings are causally important in affective influence. For example, LeDoux (1996) views feelings as a nice but ineffective ‘icing’ on an emotional cake. In contrast, we believe that feelings play an important causal role in many, though not all influence phenomena.