Emotion and Attention: When the Heart's Eye Guides the Mind's Eye

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The dichotomy between "cold" cognition and "hot" emotion is deeply rooted in our understanding of the human mind. Traditional research in cognitive science often ignores the role of emotion when pursuing an information processing model. Recently, however, research has supported the critical role of emotion in many cognitive processes, including attention, memory, and decision-making. The interaction between attention and emotion is especially important in the adaptive sense because the ability to quickly respond to meaningful stimuli is essential for survival. The current review uses the distinction between top-down (goal-directed) and bottom-up (stimulus-driven) attention to investigate the relationship between emotion and attention. In particular, this review focuses on the relationship among visual selective attention and affective states, individual differences of emotional processing, and neural bases for the interaction between emotion and attention. Converging evidence shows that emotion can prioritize stimuli in the environment and that attention plays a role in controlling emotional processing.

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1. Introduction

Adaptive behavior requires a rapid selection and evaluation of relevant stimuli. Clearly, there is an evolutionary advantage to a species that can

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quickly and accurately detect and respond to a threat in the environment. If an animal waits too long to identify an object before taking action, the chances of survival are reduced. The function of emotion is to quickly indicate the importance of an event. In fact, emotion is primarily defined by its relevance to a goal (Smith & Lazarus, 1990). Stimuli or events are considered emotional when they have a potential impact on promoting or hindering the goals of an individual. Using information available in the environment, an individual must prioritize the incidents that affect his or her objectives. The role of emotion is to attach "importance markers" to an event (Lang, Bradley, & Cuthbert, 1997; Öhman, Flykt, & Esteves, 2001) before higher-order cognitive system processes the event via emotional significance.

Until recently, emotion and cognition have primarily been studied in isolation, as the 'cold' cognition and 'warm' emotion are considered to be separate processes. However, this approach ignores the fact that selective attention in the natural environment is most often driven by motivation and is regulated by the emotional significance of stimuli (Lang, Bradley, & Cuthbert, 1997). Attention is drawn to emotionally significant stimuli and individuals pay attention to stimuli that are congruent with their current affective states. Critically, affective states not only influence what people attend to, but also how people attend to the world.

One well-known theory suggests that affective states influence the scope of attentional distribution. For instance, research shows that positive affect broadens attention, while negative affect narrows attentional focus (Easterbrook, 1959). The relationship between affective states and attention can be understood using functional and adaptive perspectives of emotions (Damasio, 1994). Many negative emotions are associated with specific action tendencies. Under stress, we tend to focus narrowly. For example, we tend to attack when angry and withdraw when afraid. Conversely, positive emotions are not particularly associated with specific action tendencies. Instead, they broaden cognitive scope and are associated with flexible action routines. In the field of positive psychology, the broaden-and-build theory of positive emotions suggests that positive emotions are adaptive over the long-run by broadening thought-action repertoire and building a variety of personal resources (Fredrickson, 2004).

2. Affective States and Attention

Much evidence shows that emotional stimuli attract attention as compared to neutral stimuli. However, this effect is modulated by various factors such as the type of stimuli (Öhman, 2010; Vuilleumier & Schwartz, 2001), the level of involvement in the ongoing cognitive task (Pessoa, Padmala, Morland, 2005; Schwartz et al., 2005), and individual differences of traits (Mogg & Bradley, 1998). Previous research found that faces expressing negative facial emotions guide visual search more efficiently than faces expressing happy or neutral emotions (Eastwood, Smilek, & Merikle, 2001; Hahn, Carlson, Singer, & Gronlund, 2006, Vuilleumier & Schwartz, 2001). For instance, Eastwood, Smilek, and Merikle (2001) found that searching for an angry face among neutral distracters yielded a shallower search slope than searching for a happy face among neutral distracters.

In addition, whether the visual stimuli are symbolic (e.g., written words, signs, or schematic drawings) or non-symbolic can also make a difference in terms of the attentional capture. For example, fear-related pictures can strongly attract automatic attention even when the stimuli are presented outside individuals' awareness (Morris, Öhman, & Dolan, 1999). However, emotional words can interfere with emotional Stroop or affective lexical decision task only when they are especially intense (Mackay et al., 2004). Studies using schematic faces consisting of simple line drawings (Fenske & Eastwood, 2003; Hahn et al., 2006) generally report angry face superiority effect in capturing attention. However, in addition to emotional differences, the perceptual factor of the schematic face was found to contribute to the attentional bias (Horstmann & Bauland, 2006).

The link between affective states and cognitive scope has been observed using a variety of measures, including visual perception and categorization. Researchers hypothesized that positive affect may result in the relaxation of attentional selection, thus increasing the breadth of spatial attention (Rowe, Hirsh, & Anderson, 2007). Because selective attention is associated with the inhibitory filtering of task irrelevant distraction (Friedman & Miyake, 2004), increased attentional breadth is reflected by a decreased capacity to inhibit processing of spatial adjacent irrelevant information. For instance, using the global-local perception task (Navon, 1977), researchers observed that individuals tend to perceive stimuli globally when they are happy, and locally when they are sad. The role of attentional breadth is not limited to spatial distribution of attention. For example, research has shown that individuals in positive mood tend to make associations between words that are remotely related (Fredrickson & Branigan, 2005; Rowe, Hirsh, & Anderson, 2007).

One explanation proposes that negative affect signals the presence of a problem, and thus triggers a narrow focus and more detailed bottom-up processing in an attempt to resolve the perceived problem. In contrast, positive affects signals a safe and benign environment, and thus triggers a broad focus and more relational, top-down processing (Huntsinger, 2013). According to the 'level-of-focus' hypothesis (Gasper & Clore, 2002), happy mood may lead individuals to focus at a global, abstract, or general level. On the other hand, sad mood signals that something is problematic and causes individuals to shift their focus to more local, specific and detail-level of thought.

A broader theoretical framework that supports the relationship between affective states and attention can be found in the 'affect-as-information' hypothesis (Schwarz & Clore, 1983). According to this view, affective cues of mood and emotion influence judgment by providing information about the value of whatever comes to mind. However, the relationship between affect and attentional scope is somewhat flexible. Affective states can simply give value to what is accessible at the moment. That is, positive affect can act as a green light or a go signal that facilitates the use of accessible perceptual inclination, whereas negative affect can act as a red light or a stop signal (Huntsinger, 2013). Thus, the idea that people in happy mood focus broadly and those in sad mood focus narrowly can be explained by the dominant tendency of global bias (Fiske & Taylor, 2008). Recent studies also suggest that motivational intensity plays an important role in controlling attentional scope regardless of the positivity or negativity of affects (Gable & Harmon-Jones, 2010). It has been shown that positive affect with high motivational intensity (i.e., desire for a dessert) narrows attentional scope, but positive affect with low motivational intensity (i.e., joy after watching a movie) broadens attentional scope (Carver & Harmon-Jones, 2009; Gable & Harmon-Jones, 2008).

3. Top-down and Bottom-up Attention to Emotional Stimuli

According to the biased competition model of attention, stimuli in the environment compete for processing resources and the role of attention is to guide the direction of the competition (Desimone, 1988). Top-down or voluntary attention focuses on events or stimuli based on individual goals. This process is conscious and requires individuals' controlled processing. On the other hand, bottom-up or stimulus-driven attention disrupts ongoing tasks and rapidly drives towards the perceptually salient stimuli. Bottom-up attention is automatic, unconscious, and efficient. It allows for the processing of biologically significant events, even if they occur outside individuals' current interest.

The distinction between top-down and bottom-up forms of attentional guidance is prominent in visual search literature (Wolfe, 1998; Yantis, 1998). An example of bottom-up attention is the involuntary orienting to a target on the basis of local salience of display characteristics (e.g., red target letter among gray distractor letters). In top-down processing, visual search is driven by the observers' knowledge and goals rather than the attributes of the display (e.g., using the car color to search where the car was parked). Several experimental paradigms have been used in visual search literature to investigate the interaction between top-down and bottom-up processing. One of the most commonly used experimental paradigms uses simultaneous presentation of a target and task-irrelevant distractors and measures the efficiency of visual search for the target. Increased reaction times (RT) and error rates in the presence of distractors are attributed to the influence of bottom-up forms of attention competing with the goal-directed attention towards the target (Desimone & Duncan, 1995). Many studies utilize oculomotor behaviors to investigate the interaction between top-down and bottom-up attention. For instance, when a salient distractor (e.g., unique color or abrupt onset) appears with a pre-defined target, saccadic eye movements are drawn to distractors away from the target, indicating bottom-up attention (Irwin, Colcombe, Kramer, & Hahn, 2000; Theeuwes, Kramer, Hahn, Irwin, & Zelinsky, 1999). These experimental paradigms have used emotionally neutral stimuli, but the characteristics of stimuli that attract bottom-up attention are particularly relevant to biological significance. For instance, the sudden appearance of a new object can indicate a threatening incident of the environment.

Research has shown that emotional stimuli attract automatic attention and interfere with the ongoing task (Carretié, 2014; Müller, Andersen & Keil, 2008). Research has demonstrated the effects of emotion on capturing attention by employing concurrent but distinct target distractor paradigm (de Fockert, Rees, Frith & Lavie, 2004), emotional dot probe task (MacLeod & Mathews, 1988), affective cue-target paradigm (Fox, Russo & Dutton, 2002), backward masking paradigm (Morris, Öhman, & Dolan, 1999), and affective attentional blink paradigm (Anderson & Phelps, 2001). For instance, Öhman and colleagues utilized fear-relevant stimuli (snakes or spider) and fear-irrelevant stimuli (flowers and mushrooms) in the discrepant target search paradigm (Öhman, Flykt, & Esteves, 2001). In a typical attention requiring visual search task, search time increases as the number of items in the display increases. However, with highly arousing stimuli, visual search is unaffected by the number of distractors. These results indicate that the emotional stimuli can attract automatic attention. In fact, much research has reported the negativity bias as an anger superiority effect (Hansen & Hansen, 1988). However, it is debatable whether superiority of negative stimuli in capturing attention is exclusively due to their valence. In order to better understand the relationship between emotion and attention, researchers proposed two theoretically orthogonal affective dimensions, from negative to positive valence, and from calming to stimulating arousal (Lang, Greenwald, Bradley, & Hamm, 1993). The consequence of a negative event is more dramatic than a positive event, and thus more arousing than positive event (Ekman, 1992).

Automatic attention to emotional stimuli can vary based on individual differences. For instance, studies suggested that older adults are more biased against negative affect (Carstensen, 1992; Mroczek, 2001). Mather and Carstensen (2003) showed that older adults were slower at responding to locations previously occupied by emotionally negative faces, indicating better inhibition of negative information than younger adults. This positivity bias by older adults was explained using the socioemotional selectivity theory (Carstensen, 1992), which argues that the priority changes of older adults lead better emotional regulations. These results showing better inhibition of negative information in older age may not be consistent with previous studies suggesting an age-related inhibitory deficit (Hasher & Zacks, 1988). However, age-related inhibitory deficits were selective, not unitary (Kramer, Humphrey, Larish, Logan, & Strayer, 1994). Thus, it is plausible to hypothesize a special status for threat stimuli regarding inhibitory processing of older adults.

Personality and other individual difference traits are also linked to differences in automatic attention to emotional stimuli. Derryberry and Reed (1994) reported that in a spatial attention task, extraverts were slower to shift attention away from a location associated with reward, whereas introverts were slower to attend away from a location associated with punishment. In addition, Fox et al. (2002) showed that anxious individuals had difficulty in inhibiting emotionally negative stimuli, as demonstrated by delayed disengagement from angry facial expressions. Other studies also found that anxious individuals show attentional bias toward emotionally negative stimuli (Eysenck & Calvo, 1992; Mogg & Bradley, 1998).

4. Neural Mechanisms Underlying Emotion and Attention

LeDoux (1998) suggested that threatening stimuli rapidly access the amygdala through a "quick and dirty" analysis via a simple subcortical network rather than a complete visual analysis in the cortical network. Converging data from neuroscience and psychology have confirmed that the amygdala plays a special role in emotion processing, selective attention, and their interaction. For instance, individuals with bilateral amygdala damage show an impaired social judgment based on facial expressions, particularly those expressing threat-related emotions (Adolphs, Tranel, & Damasio, 1998). Vuilleumier and Schwartz (2001) also showed an enhanced amygdala response to negative faces, as compared with neutral faces, also when they were distractors (attention to houses). Other studies also show the importance of amygdala in emotional processing, demonstrating that this region responds to reward-related information as well as threatening information (Holland & Gallagher, 1999).

Whereas the amygdala can have bottom-up effects on processing emotional information, main subdivisions of the prefrontal cortex, the dorsolateral prefrontal cortex (DLPFC) and ventromedial prefrontal cortex (VWPFC) can influence the selection of emotional information in a top-down fashion. The dorsolateral region is connected with cortical sensory and association areas (Compton, 2003; Groenewegen & Uylings, 2000), but not directly with the amygdala, and involved in maintaining the strength of selected cortical representations in working memory. The ventromedial region has reciprocal connections with the amygdala, among other regions (Groenewegen & Uylings, 2000), and thus may modulate the processing amygdala processing in a top-down manner. Previous research suggests that emotional processing can be amplified with the help of amygdala, and the representations can be sustained in working memory through the connection with the DLPFC. The VMPFC is interconnected with the amygdala and provides additional top- down guidance for selecting emotionally relevant stimuli and responses. For instance, Ochsner, Bunge, Gross, and Gabrieli (2002) showed that instructing participants to reappraise aversive stimuli decreased activity in the amygdala and increased activity in frontal regions, suggesting top-down modulation of emotional stimuli.

In addition, different processes in the visual pathway support the interaction between emotion and attention. Visual pathways from the lateral geniculate nucleus to the visual cortex consist of two functionally distinct systems, parvocellular and magnocellular visual systems. The parvocelluar system is sensitive to color and higher spatial frequencies, whereas the magnocellular system is sensitive to motion and lower spatial frequencies (DeYoe & Van Essen, 1988; Maunsell & Newsome, 1987). This difference between parvocellular and magnocellular based visual system is also observed with emotional stimuli such that dynamic negative distractors capture attention to a greater extent than static emotional events (Carretié et al., 2009). Visual search tasks employing non-emotional stimuli show that distractors based on the parvocellular visual systems (i.e., color changes) are not capable of capturing attention in the automatic sense (Irwin, Colcombe, Kramer & Hahn, 2000; Theeuwes, 1995). On the other hand, distractors based on the magnocelluar system (i.e., movement, sudden onset) attract attention in an automatic manner (Theeuwes, Kramer, Hahn, Irwin, & Zelinsky, 1999). Dynamically changing non-emotional stimuli are detected more easily and more quickly than static stimuli, and an advantage of motion over other physical features, such as luminance or color, for capturing attention has been demonstrated (Franconeri & Simons, 2003).

5. Conclusion

While the dichotomy of emotion and cognition is deeply rooted in our understanding of the human mind, separating cognition and emotion is an inappropriate approach. From an evolutionary point of view, automatic attention is a valuable and low-cost tool for survival, monitoring the environment and rapidly responding to meaningful events. Researchers have suggested that the first-step in the process is finding emotional relevance and the more elaborated process is focusing attention based on the emotional relevance. Robinson (1998) proposed that pre-attentive processes categorize the valence and urgency of the situation, and prepare the body for rapid action. Fear and anxiety, in comparison to emotions such as sadness and love, are related to urgency and thus require immediate attention. Thus, a thorough understanding of the attention mechanism should include an understanding of how emotional relevance is detected, selected, and controlled. The current review illustrates studies that investigate the relationship between emotion and attention. The interaction between emotion and attention emphasizes the importance of the biological and social contexts that gives emotional value in guiding selective attention.

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