Further Readings

Dehaene, S., & L. Naccache (2001). Towards a cognitive neuroscience of consciousness: Basic evidence and a workspace framework. *Cognition, 79,* 1–37.

Koch, C., & Tsuchiya, N. (2006). Attention and consciousness: Two distinct brain processes. *Trends in Cognitive Science, 11,* 16–22.

Lamme, V. A. F. (2003). Why visual attention and awareness are different. *Trends in Cognitive Science, 7,* 12–18.

Levin, D. T., & Simons, D. J. (1997). Failure to detect changes to attended objects in motion pictures. *Psychonomic Bulletin and Review, 4*(4), 501–506.

Mack, A., & Rock, I. (1998). *Inattentional blindness.* Cambridge: MIT Press.

Moore, C. M., & Egeth, H. (1997). Perception without attention: Evidence of grouping under conditions of inattention. *Journal of Experimental Psychology: Human Perception and Performance, 23,* 339–352.

Neisser, U., & Becklen, R. (1975). Selective looking: Attending to visually specified events. *Cognitive Psychology, 7,* 480–494.

Posner, M. I. (1994). Attention: The mechanisms of consciousness. *Proceedings of the National Academy of Sciences USA, 91,* 7398–7403.

Reddy, L., Reddy, L., & Koch, C. (2006). Face identification in the near-absence of focal attention. *Vision Research, 46,* 2336–2343.

Simons, D. J., & Rensink, R. A. (2005). Change blindness: Past, present, and future. *Trends in Cognitive Science, 9,* 16–20.

Wright, W. (2006). Visual stuff and active vision. *Philosophical Psychology, 19,* 129–149.

Attention and Emotion

Daily life presents such a bombardment of information that people would be overloaded without some means of prioritizing what they process. Attention and emotion systems both contribute to such prioritization. Emotions, for example, provide rapid, efficient means for identifying high-priority aspects of the environment, and attention mechanisms allow people to select manageable subsets from an otherwise overwhelming influx of information. Although these two systems influence each other, studies of attention within the traditional perception literature have often overlooked the role of emotion, examining instead how attention operates on various perceptual features. But the world is not characterized solely by assemblages of colors, angles, and motions; the objects, people, and events around us resonate with emotional meaning, so it is crucial to understand how attention and emotion interact. This entry describes emotional stimuli and varieties of attention, preattentive biases, rapid orienting versus delayed disengagement, emotional stimuli and mechanisms supporting awareness, asymmetry of attention-emotion interactions, and reciprocal influences.

Emotional Stimuli and Varieties of Attention

Attention refers to a family of mechanisms that—although they converge in the service of stimulus selection—differ from each other in important ways; orienting of attention to spatial locations is not the same as selectively attending to some features of a stimulus while ignoring other features, and neither of these processes is necessarily identical with the attention mechanisms involved in bringing information to awareness. Although evidence does suggest dissociations between these types of attention, each of them appears to be strongly influenced by emotion; emotional information seems to "capture" and hold various aspects of attention more robustly than does non-emotional information. For example, when it comes to attending to some features of a stimulus over others, *emotional Stroop* experiments have shown how difficult it is for people to ignore emotional aspects of a stimulus even when such aspects are task-irrelevant. In a typical version of this task, participants try to name as quickly as they can the colors in which words or monochrome pictures appear (or are printed). Frequently, they are slower to do so when the words and pictures happen to have strong emotional significance, suggesting that people had difficulty tuning out the task-irrelevant emotional information to focus only on the relevant color information.

A large portion of research on attention-emotion interactions has focused on the orienting of spatial attention. One procedure commonly used to tap into spatial orienting is the *dot-probe* task, where pairs of words or faces are typically presented on a computer screen and are followed quickly by a dot at one of the word/face locations;

participants are required to respond as soon as they detect the dot, and they tend to be faster when it appears at the former location of an emotional word or face than of a neutral one, suggesting that attention had already oriented to the emotional stimulus at that location (similar effects have been found even when people were not aware of the emotional stimulus). Similarly, in a *cueing* task—another measure of spatial orienting of attention—participants make speeded responses to targets, which could appear at one of at least two locations. On some trials, a cue appears before the target at one of the potential target locations, but the location of the cue does not predict the actual location of the subsequent target. In standard, non-emotional versions of this task, people tend to be slower to respond to the target when it appears away from the cue (an "invalid" cue) than when it appears at the same location as the cue (a "valid" cue), indicating that they had reflexively oriented to the cue despite knowing that doing so would not aid their performance. In emotional versions of this task, the cues themselves can be emotional or neutral stimuli (e.g., words or faces), and when they are emotional, their effects on spatial orienting are amplified. Notably, the emotional Stroop, the dot-probe, and various cueing experiments have revealed general biases to attend to emotional stimuli and have shown that such biases tend to be stronger among clinical and highly anxious individuals.

Pre-Attentive Biases

A number of models straddling the divide between cognitive and clinical branches of psychology have suggested that biases to prioritize emotional stimuli originate *pre-attentively,* meaning that they occur before attentional selection and are not necessarily bound by capacity-limited constraints. According to such models, pre-attentive evaluation of a stimulus's emotional significance helps direct the subsequent allocation of attention. Indeed, theorists such as J. Mark Williams, Fraser Watts, Colin MacLeod, and Andrew Mathews have suggested that high trait anxiety might be linked with a tendency to orient toward stimuli that were pre-attentively evaluated as threatening, whereas low trait anxiety might be linked with a tendency to orient away from such stimuli.

Some neurobiological evidence suggests how such a pre-attentive evaluation system might be instantiated, although such claims have also been challenged. For example, work on the amygdala—a subcortical structure strongly linked with the processing of emotional significance—has revealed direct connections with the visual system, suggesting neurobiological pathways through which emotional information could conceivably bypass many attentional circuits. Converging neuroimaging evidence has found heightened amygdala activity in response to emotional stimuli even when the stimuli were rendered unreportable through backward masking (i.e., when noisy visual patterns appearing immediately after emotional stimuli disrupted subjective awareness of such stimuli) and when attention was directed away from them to perform a secondary task. However, although such findings are provocative and have been widely influential, other work has found scant evidence of such heightened amygdala activity when the effectiveness of masking was rigorously ensured and when attention was strongly occupied by a secondary task. Additional studies have found that personality variables such as trait anxiety are linked with the degree to which attention manipulations modulate amygdala response to emotional stimuli. Such relationships may have been observed either because anxiety is linked with hyper-responsiveness to emotional stimuli or because anxiety is linked with a reduced ability to direct the focus of attention. Evidence exists to support both accounts.

Recent behavioral evidence also has led some to question whether emotional or otherwise high-priority stimuli are indeed processed independently of attention. In a study by Christine Harris and Harold Pashler, participants made speeded judgments about the relationship of two digits to each other and either an emotional word, the participant's own name, or a neutral word could appear in between the two digits. When the emotional word or one's own name was the only text alongside the digits, response times were slowed relative to when a neutral word appeared; this effect was especially large for one's own name. However, when one's name was only one of several words appearing alongside the digits, response times were no different from when no name was present. This finding suggests that rather than reflecting pre-attentive mechanisms, high-priority stimuli may

receive preferential processing only when attentional resources are readily available. Of course, as the authors noted, it is possible that different results would have emerged had stimuli been even more emotionally evocative or had participants represented a more highly anxious population.

Rapid Orienting Versus Delayed Disengagement

Related to the question of whether emotional information can be extracted pre-attentively is the question of whether biases to attend to emotional stimuli reflect faster attentional orienting to emotional stimuli in the first place (which would be consistent with pre-attentive evaluation mechanisms) or delayed disengagement from emotional stimuli already at the focus of attention. Some evidence suggests the former. For example, one study used a *visual search* task in which participants searched for a fear-relevant stimulus (a spider or snake) among non-fear-relevant stimuli (mushrooms and flowers). Typically, in a visual search task, the time it takes to detect a target within an array of items increases as the number of array items increases. However, when the target was fear-relevant, response time seemed relatively unaffected by the number of array items (an effect known as visual "pop out"), suggesting that it had been among the first of the array items to draw attention. On the other hand, attentional cueing research in which cues could be neutral or threatening stimuli has suggested that rather than preferentially drawing an initial orienting response, emotional stimuli simply "hold" processing resources once they are attended. In one cueing experiment, when cues appeared at the location of the subsequent target, participants' response times were not affected by the emotionality of the cue, suggesting that the emotional cues did not elicit faster orienting. In contrast, when cues were invalid, appearing away from the target location, emotional cues led to slower response times, suggesting that participants indeed had difficulty disengaging from them to reorient attention to the target. This evidence suggests that when it comes to spatial orienting of attention, biases to attend to emotional stimuli may be driven by tendencies to linger on—rather than initially orient to—such stimuli.

Emotional Stimuli and Mechanisms Affecting Awareness

Recent studies have begun to examine the impact of emotional stimuli on attention mechanisms that help drive visual awareness itself. These experiments have suggested that emotional stimuli both gain more ready access to such mechanisms and, perhaps in doing so, prevent spatially or temporally neighboring, non-emotional information from doing the same. In large part, such experiments have used what is known as the *attentional blink* task, where participants search for targets within rapid streams of stimuli (e.g., streams of alphanumeric characters in which each item appears for about 80 to 100 milliseconds [ms] before being replaced by the next). In a typical non-emotional version of this task, people often detect the first target but fail to detect the second if it follows too soon afterward. One widely influential explanation for this effect is that the attentional processes that select information for consolidation into visual awareness are relatively slow, and that failures to detect the second target stem from such processes already being engaged by the first target. Notably, when the second target happens to be an emotional word, it is less susceptible to the attentional blink, suggesting that it captures the processes necessary to support awareness (although this does not occur among patients with bilateral amygdala damage). In a similar rapid presentation task, participants searched for only a single non-emotional target, and the target could be preceded in the stream by a task-irrelevant emotional or neutral picture. When the task-irrelevant picture was emotional, participants had difficulty perceiving the subsequent target; thus, in drawing attention to themselves, emotional stimuli appear to distract or disrupt attention processes that would otherwise usher other information into awareness. Consistent with this notion, evidence suggests that emotional stimuli associated with disrupted target detection are, in themselves, better remembered than are those not associated with such disruption.

Asymmetry of Attention–Emotion Interactions

The literature on attention–emotion interactions seems to contain an asymmetry wherein

emotionally negative stimuli influence attention more than emotionally positive stimuli do. Such findings have led to suggestions of evolved mechanisms for attending specifically to threat; arguably, such mechanisms could aid one's chances of survival. However, some have argued that the observed asymmetry stems not from evolved threat-detection mechanisms, but from the fact that emotionally negative stimuli tend to be more emotionally "arousing" or intense than are emotionally positive stimuli. A few studies have attempted to control for the general emotional arousal elicited by stimuli and, in doing so, have reported that the positive–negative asymmetry largely disappears. In other words, it may be that the degree of arousal elicited by a stimulus drives attention effects more than does the evaluation of a stimulus as being positive or negative. The degree to which arousal and positive–negative evaluations respectively contribute to attention–emotion interactions is still a topic of considerable inquiry.

Reciprocal Influences

In addition to evidence suggesting that emotion influences attention, recent evidence has highlighted the bidirectional nature of this relationship, exploring ways in which attentional withdrawal from stimuli affects emotional responses to them. Jane Raymond and colleagues, for example, have found that when a visual search task requires that people ignore otherwise attractive visual distractors, participants later rate the ignored distractors as being less pleasing than visually similar items that had not been ignored. Notably, the harder a person had to try to ignore a distractor (e.g., the closer a distractor had appeared to a target), the more they affectively "devalued" it. Such findings reveal reciprocal influences between attention and emotion and carry implications for how patterns of attention allocation may foster affective preferences in daily life.

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See also Attention: Covert; Attention: Effect on Perception; Attention and Consciousness; Emotional Influences on Perception; Face Perception; Individual Differences in Perception

Further Readings

Anderson, A. K., & Phelps, E. A. (2001). Lesions of the human amygdala impair enhanced perception of emotionally salient events. *Nature, 411,* 305–309.

Arnell, K. M., Killman, K. V., & Fijavz, D. (2007). Blinded by emotion: Target misses follow attention capture by arousing distractors in RSVP. *Emotion, 7,* 465–477.

Compton, R. J. (2003). The interface between emotion and attention: A review of evidence from psychology and neuroscience. *Behavioral and Cognitive Neuroscience Reviews, 2,* 115–129.

Fenske, M. J., & Raymond, J. E. (2006). Affective influences of selective attention. *Current Directions in Psychological Science, 15,* 312–316.

Fox, E., Russo, R., Bowles, R., & Dutton, K. (2001). Do threatening stimuli draw or hold visual attention in subclinical anxiety? *Journal of Experimental Psychology: General, 130,* 681–700.

Harris, C. R., & Pashler, H. (2004). Attention and the processing of emotional words and names: Not so special after all. *Psychological Science, 15,* 171–178.

Mogg, K., & Bradley, B. P. (1998). A cognitive-motivational analysis of anxiety. *Behaviour Research and Therapy, 36,* 809–848.

Most, S. B., Chun, M. M., Widders, D. M., & Zald, D. H. (2005). Attentional rubbernecking: Cognitive control and personality in emotion-induced blindness. *Psychonomic Bulletin & Review, 12,* 654–661.

Öhman, A., Flykt, A., & Esteves, F. (2001). Emotion drives attention: Detecting the snake in the grass. *Journal of Experimental Psychology: General, 130,* 466–478.

Pessoa, L., McKenna, M., Gutierrez, E., & Ungerleider, L. G. (2002). Neural processing of emotional faces requires attention. *Proceedings of the National Academy of Sciences USA, 99,* 11458–11463.

Schimmack, U. (2005). Attentional interference effects of emotional pictures: Threat, negativity, or arousal? *Emotion, 5,* 55–66.

Attention and Medical Diagnosis

When a radiologist is presented with a medical image, be it a radiograph or the many hundreds of images generated from a computerized tomography (CT) or magnetic resonance imaging (MRI)