Chapter 1

Beyond negativity: Motivational relevance as cause of attentional bias to positive stimuli

Julia Vogt, Yasmene Bajandouh, Umkalthoom Alzubaidi
School of Psychology and Clinical Language Sciences, Reading, University of Reading, United Kingdom

Introduction

Imagine that you arrive at a party and you enter a room full of people: Who will attract your attention? The person smiling at you or someone who looks upset and angry? And now, imagine that you approach the buffet: Which food will grab your attention? The chocolate cake that you love or a healthier but less loved option such as the vegetables? These scenarios illustrate the phenomenon of attentional bias. Research on attentional bias to emotional information has been a focus of attention research for about 30 years (MacLeod, Mathews, & Tata, 1986; Yiend, 2010).

Attention is a mechanism that allows observers to focus on a subset of possible sensory inputs (Luck & Vecera, 2002). In almost any given situation, people are surrounded by so much information that it is not possible to process all available information—such as at the party where you cannot pay attention to everybody and everything. Additionally, not all information is relevant to the ongoing behavior of an individual. Attention describes the processes and mechanisms that determine how sensory input, perceptual objects, trains of thought, or courses of action are selected from an array of concurrent possible stimuli, objects, thoughts, and actions (Talsma, Senkowski, Soto-Faraco, & Woldorff, 2010).

Various fields of psychology and neuroscience have studied attentional bias to emotional information, including vision (neuro)science, clinical, or social psychology. In this chapter, we define attentional bias as increased allocation of attention to information that often occurs automatically, which means quick, efficient, unintentional, and/or uncontrollable (Moors & De Houwer, 2006). Much research on attentional bias has illustrated that negative and particularly threatening stimuli such as angry faces (Kuhn, Pickering, & Cole, 2016) evoke attentional bias especially when observers are high in state or trait anxiety

Cognitive Biases in Health and Psychiatric Disorders: Neurophysiological Foundations
https://doi.org/10.1016/B978-0-12-816660-4.00001-5

(Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van IJzendoorn, 2007; see also Chapter 2). However, positive stimuli attract attention as well (Pool, Brosch, Delplanque, & Sander, 2016), and smiling faces are faster detected than angry faces (Becker, Anderson, Mortensen, Neufeld, & Neel, 2011) (Fig. 1). Like the findings on the negativity bias, attention to positive information is enhanced or dependent on the observer's current state or her personality. For instance, optimists (Kress, Bristle, & Aue, 2018; Segerstrom, 2001) display a positivity bias as well as observers who have positive thoughts activated on their mind (Smith et al., 2006; but see Van Dessel & Vogt, 2012).

In the present chapter, we will discuss theories and evidence investigating when and why positive information such as the smiling person or a chocolate cake will grab attention. Specifically, we will highlight recent work that emphasizes how temporary goals can not only induce but also override attentional bias. We will proceed to discuss how attentional bias to positive stimuli can be measured and which brain regions and psychophysiological responses are associated with attention to positive input. While attention to positive events has been highlighted as characteristic of healthy populations, we will also discuss why it can be problematic; for instance, obesity seems to be related to an attentional bias to high-caloric but tasty food. We will finish the chapter by highlighting limitations and suggestions for future research.

Main theories of attention to positive information

Most theories of attentional bias assume that the bias originates in the relevance of information in people's environment. For instance, threatening events could represent potential dangers to survival, whereas beautiful people might offer possibilities for reproduction (Lang, Bradley, & Cuthbert, 1997; Neuberg, Kenrick, Maner, & Schaller, 2004). However, existing theories diverge in what they mean by relevance and in what kind of relevance they consider necessary for a stimulus to possess to be capable of attracting attention automatically. In what follows, we will identify three classes of theories proposing that positive events cause attentional bias because they are relevant. First, a wide range of theories assume that attentional bias to emotional events originates in the evolutionary relevance of these events, that is, because they were relevant during

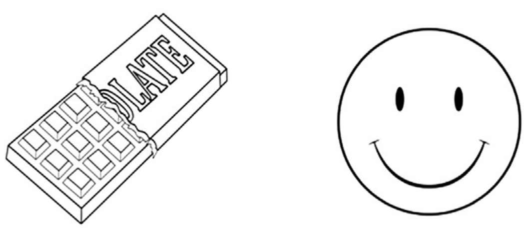

FIG. 1 Examples of positive stimuli that evoke attentional bias.

the evolution of the human species to the survival or reproduction motive. A second set of theories assume that also stimuli that acquired positive valence via learning processes during the lifetime of the observer will attract attention. A third set of theories propose that the bias is driven by the current goals of the individual and positive (or any) information will attract attention when it is relevant to an active need or goal of the observer.

Phylogenetic relevance

Evolutionary accounts are well-known for suggesting that only threats to survival that were present during the evolution of the human species such as angry facial expressions (Kuhn et al., 2016) or dangerous animals like snakes and spiders (Lipp & Derakshan, 2005) will evoke attentional bias (Öhman & Mineka, 2001). According to these theories, attentional bias to emotional information evolved in the evolution because it was highly adaptive to become aware of these stimuli. Consequently, the bias is assumed to be hard-wired by now (LeDoux, 1996). Some of these accounts argue that biologically relevant negative and threatening stimuli will receive attentional priority because the fast detection of these events was more critical for survival than the detection of positive stimuli (Aarts & Dijksterhuis, 2003; Pratto & John, 1991). Moreover, Öhman and Mineka (2001; but see Pessoa & Adolphs, 2010) suggested that biologically relevant stimuli are more automatic and robust in biasing attention than other events.

According to other authors (Lang et al., 1997; Neuberg et al., 2004), a system that only responds to negative events would be maladaptive because functional behavior also requires responding to stimuli that offer positive consequences. These theories suggest that the automatic allocation of attention is guided by three primary motivations: survival, sexual needs, and hunger. Indeed, attention is automatically directed to biologically relevant positive stimuli that correspond to the reproduction motive such as erotica (Most, Smith, Cooter, Levy, & Zald, 2007; Sennwald et al., 2016) and nonerotic images of beautiful people (Maner et al., 2003). Further, infant faces displaying perceptual features of the baby schema such as large eyes and rounded cheeks evoke an attentional bias (Brosch, Sander, & Scherer, 2007). This can be interpreted as evidence that vulnerable offspring grabs attention to ensure successful caretaking. Finally, hungry participants, compared with satiated participants, show a stronger attentional bias to food-related stimuli (Tapper, Pothos, & Lawrence, 2010). The latter findings suggest that attentional bias to motivationally relevant events is sensitive to context and reflects changes in the strength of a need or motivation. We will come back to this observation in the third section of this review of major theories.

Ontogenetic relevance

The preceding section discussed how both negative and positive stimuli of phylogenetic relevance attract attention. In this section, we will review theories suggesting that attentional bias is not limited to phylogenetically relevant events. Specifically, events that acquired negative or positive valence during the lifetime of an observer also appear to evoke attentional bias (Le Pelley, Mitchell, Beesley, George, & Wills, 2016). For instance, knives are comparable to phylogenetic threats in their capacity to evoke attentional bias in adults but not in children (Blanchette, 2006; LoBue, 2010; see also discussion in Chapter 2). Such modern threats were not present until quite late in the history of the human species. Therefore, the appraisal of relevance for such stimuli cannot be caused by a mechanism responding to inborn relevance but must be caused by a mechanism that responds to the learned relevance or valence of such stimuli.

In an early demonstration of this effect, stimuli associated with positive attitudes for participants (e.g., a bike) were faster detected than stimuli that evoked neutral evaluations (Roskos-Ewoldsen & Fazio, 1992). Roskos-Ewoldsen and Fazio (1992) argued that attitudes, that is, positive or negative evaluations, have an orienting value. Consequently, they attract an observer's attention to make them aware of stimuli that they like or dislike. Participants display attentional bias toward various stimuli that are associated with learned positive attitudes such as their partner (Dewitte, De Houwer, Koster, & Buysse, 2007) or stimuli related to a cherished hobbies like birds for bird lovers (Dalgleish, 1995) or exercise-related words for people who enjoy physical activity (Calitri, Lowe, Eves, & Bennett, 2009). Finally, many accounts attribute attentional bias to drugs in addictions to the learned liking of the drug (Franken, 2003; Mogg, Bradley, Field, & De Houwer, 2003).

In recent years, various studies have shown how positive stimuli evoke an attentional bias even when their valence was only learned in the experimental session. For instance, when participants learn that a certain stimulus feature is related to winning money in an experiment, this feature grabs attention even after it stopped being associated with reward (Le Pelley et al., 2016; Raymond & O'Brien, 2009).

Current relevance

Some studies have suggested that positive stimuli or any stimuli will only attract attention when they are currently relevant to an active goal of the individual (Gronau, Cohen, & Ben-Shakhar, 2003; Lichtenstein-Vidne, Henik, & Safadi, 2012; Vogt, Koster, & De Houwer, 2017). For instance, recent evidence suggests that drug-related cues bias attention in addicts but only when they pursue a goal of finding drug-related cues in a visual display (Brown, Duka, & Forster, 2018). Goal theories assume that goals are knowledge structures that represent desired end states and that goal pursuit is characterized by the heightened accessibility of these structures (Moskowitz, 2002). For instance, when the goal is to search for drug-related cues, the representation of drug-related cues will be highly accessible. According to these theories, the heightened accessibility of goal-relevant events in long-term or working memory will guide attention automatically to stimuli in the environment that match the goal representation. Importantly, the goal representation often includes positive stimuli and means that are instrumental for goal pursuit such as food when hungry. Therefore, goal theories would suggest that positive information attracts attention when it is relevant to goal pursuit.

Indeed, means that are instrumental to active goals evoke attentional bias that are automatic in the sense of unintended or fast (Vogt, De Hower, Moors, Van Damme, & Crombez, 2010; Wieber & Sassenberg, 2006). For instance, automatic attention to goal-relevant events emerges even when those stimuli are presented only briefly or when attention to goal-relevant events in the attention task is irrelevant for goal achievement (Lichtenstein-Vidne et al., 2012; Vogt et al., 2010). Further, goal-driven attention reflects the instrumentality of attended information for goal achievement. For instance, when the goal is to win as many tokens as possible, stimuli relevant to winning a high number of tokens attract attention over stimuli that are relevant to winning a low number of tokens (Vogt, De Houwer, & Crombez, 2011). Likewise, attention is not allocated to goal-related but goal-irrelevant information (e.g., "boat" when "ship" is goal relevant) indicating that the effect reflects relevance for goal pursuit rather than mere cognitive associations (Vogt, De Houwer, & Moors, 2011). Similarly, these studies suggest that goal-driven attention serves as a goal shielding mechanism by preventing attention to competing goals and other highly salient events (Vogt, Houwer, Crombez, & Van Damme, 2013).

Importantly, these theories can explain why stimuli relevant to the survival and reproduction motive only attract attention when they also match an observer's current concern (Gronau et al., 2003; Vogt et al., 2017). For instance, attentional bias to beautiful people is strongest in individuals looking for a partner and absent when the goal of being faithful to their current partner is activated in individuals who are in a monogamous relationship (Maner, Gailliot, & Miller, 2009). Relatedly, people are inattentive to tasty but high-caloric food when dieting goals are activated (Papies, Stroebe, & Aarts, 2008). Further, people attend to goal-relevant stimuli when goals are not fulfilled but not after completing (Moskowitz, 2002) or giving up on the goal. For instance, women who approached the childbearing deadline and wished to have a baby showed an increased attentional bias to baby pictures; in contrast, women who just passed the deadline and had given up their baby wish did not show this bias (Light & Isaacowitz, 2006).

Based on these findings, researchers have suggested that emotion regulation goals could induce or prevent attention to emotional information. For instance, attention to positive events and away from negative events might reflect a person's attempt to feel good or to suppress negative feelings. Indeed, attention to positive events has been linked to the desire to feel good (Segerstrom, 2001; Xing & Isaacowitz, 2006). Relatedly, suppressing negative feelings caused attentional avoidance of negative images but only when positive distractors are present (Vogt & De Houwer, 2014). However, at other times, aversive events might grab attention when the dominant emotion regulation goal indicates to fight the source of an emotional state. Supporting the latter assumption, we found that people attend to aversive situations when mastering those situations is possible (Vogt et al., 2017). Crucially, in this case, people also attend spontaneously to positive stimuli that allow them to alleviate the aversive situation directly. For example, they attend to stimuli such as water and soap when experiencing disgust (Vogt, Lozo, Koster, & De Houwer, 2011).

Arousal as cause of attentional bias to phylogenetic and ontogenetic relevant events

Some researchers have suggested that attentional bias might be caused by high levels of arousal that characterizes most of the stimuli described earlier (Schimmack, 2005; Vogt, De Houwer, Koster, Van Damme, & Crombez, 2008). This would explain why attentional biases to phylogenetic and ontogenetic events are comparable without assuming multiple mechanisms underlying the bias. Similarly, emotion theories conceptualize arousal as an indicator of relevant events that should be selected by attentional processes for further processing (Lang et al., 1997). Indeed, various studies have found that high levels of arousal attract attention independent of valence (Schimmack, 2005; Vogt et al., 2008) or that it enhances the bias to positive stimuli (Pool et al., 2016). Future research is still needed to see whether goal-relevant events evoke high levels of arousal that could underlie the bias to goal-relevant events.

Methods

In this section, we will review some of the most prominent paradigms that have been used to measure attentional bias to positive information. It is important to note that attention is not regarded as a unitary concept, but as an umbrella concept for a variety of processes (Luck & Vecera, 2002). For instance, some attentional processes refer to the selection of stimuli, which means how attention is focused on information or how people become consciously aware of it. Other processes explain how attention inhibits irrelevant stimuli and whether some stimuli cannot be ignored.

Cueing paradigms

Exogenous spatial cueing paradigm

Cueing paradigms are useful for measuring attentional orienting to peripheral cues (Posner, 1980; Vogt et al., 2008). In a spatial cueing paradigm, participants are asked to detect visual targets presented at two locations on the screen. The target is preceded by a visual cue at the same location (validly cued trials) or opposite location (invalidly cued trials). Valid cues typically lead to response time benefits (due to engagement of attention at the validly cued location), whereas invalid cues lead to response time costs (due to delayed disengagement of attention from the invalidly cued location), a difference referred to as cue validity effect. Emotional cues lead to a larger cue validity effect than neutral cues and to both enhanced engagement and impaired disengagement, which implies that they engage and hold attention (Fox, Russo, Bowles, & Dutton, 2001; but see Mogg, Holmes, Garner, & Bradley, 2008).

Dot probe paradigm

The dot-probe paradigm is like the cueing paradigm but presents two cues simultaneously at two different spatial locations on the screen (Dodd & Porter, 2010; Johnson, 2009) (Fig. 2). It does therefore not allow to differentiate between attentional engagement and disengagement (but see Koster, Crombez, Van Damme, Verschuere, & De Houwer, 2004). In contrast, it is useful to measure whether a stimulus attracts attention to its location in competition with other stimuli that might be a more realistic reflection of real environments and thus capture the true function of attention (Desimone & Duncan, 1995).

Emotional Stroop paradigm

The emotional Stroop paradigm has been used to measure attentional interference by positive stimuli (Gantiva, Araujo, Aragão, & Hewitt, 2018). In this task, participants must name the color of words or images (Fig. 2). The emotional Stroop effect describes the finding that it takes longer to name emotional than neutral stimuli (Williams, Mathews, & MacLeod, 1996). The effect reflects the capacity of a stimulus to interfere with a participant's main task and to impair inhibition of task-irrelevant inputs. However, results in such tasks might reflect differences situated at the response stage (e.g., emotional stimuli interrupt the response selection mechanism and slow down motor responses) rather than differences in the allocation of attention (i.e., attention is directed toward stimuli; see Algom, Chajut, & Lev, 2004).

Emotional flanker paradigm

The (emotional) Flanker paradigm is another paradigm used to capture interference during selective attention (Horstmann, Borgstedt, & Heumann, 2006).

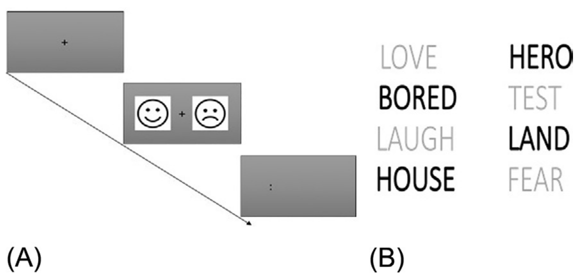

FIG. 2 Schematic overviews of dot-probe task (A) and emotional Stroop task (B).

In the emotional variant of the paradigm, participants must indicate the valence of a target stimulus while trying to ignore flanking distracters. In relation to the target stimulus, flankers may be congruent (flankers are of the same valence), incongruent (flankers are of opposite valence), or neutral (flankers are of neutral valence; Fenske & Eastwood, 2003; Horstmann et al., 2006). Participants cannot completely ignore the flankers resulting in slower responses on incongruent trials (interference effect) and faster responses on congruent trials (facilitation effect) (Horstmann et al., 2006).

Visual search

In a visual search task, participants search for a discrepant target within a varying number of stimuli, for instance, a happy face among angry faces (see Fig. 3; Hickey, Chelazzi, & Theeuwes, 2010). Search time is measured. By varying the number of distractors, researchers can investigate whether a stimulus "pops out," which indicates that search is independent of set size. Pop out suggests that a stimulus attracts attention fast and in a very efficient way without that observers must scan all stimuli to find the target. The visual search paradigm is therefore best suited to measure attentional capture.

Brain regions involved in the emergence of the Bias

Traditionally, the limbic system has been characterized as the emotional brain (e.g., LeDoux, 1996). More precisely, the amygdala has been considered as the structure that is responsible for the fast and preferred processing of emotional and especially negative and threatening events (see also Chapter 2). Dominant theories assumed for a long time that sensory modalities project information

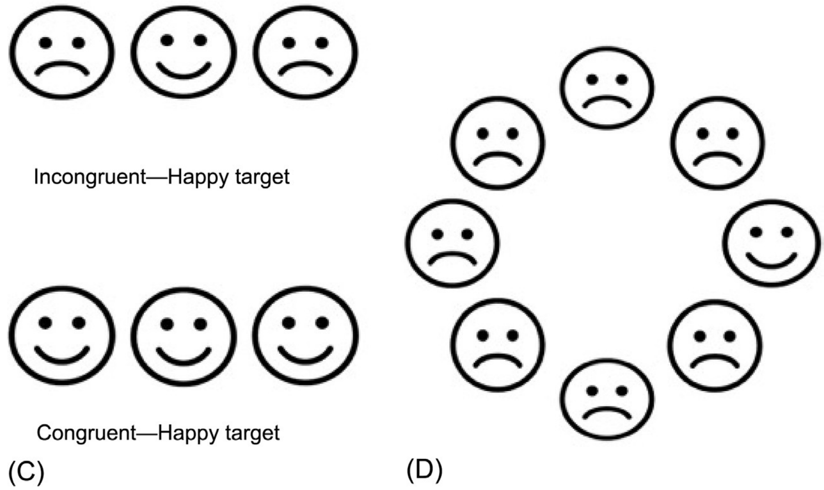

FIG. 3 Schematic overviews of flanker task (C) and visual search task (D).

on emotional input to the amygdala via subcortical thalmo-amygdala pathways and visual cortices (Tamietto & de Gelder, 2010). Indeed, those with amygdala lesions show impaired emotion processing (Vuilleumier, Richardson, Armony, Driver, & Dolan, 2004).

However, recent evidence suggests that attentional bias to positive stimuli emerges as early as attentional bias to negative events. For instance, negative and positive stimuli evoke increased P1 amplitudes that reflect enhanced perceptual processing in the visual cortex (Brosch, Sander, Pourtois, & Scherer, 2008). This is in line with evidence showing that the amygdala reacts to relevant stimuli in general (Fitzgerald, Angstadt, Jelsone, Nathan, & Phan, 2006). Further, various networks and pathways in the brain are involved in attention allocation to positive events (Pessoa & Adolphs, 2010; Vuillemier & Huang, 2009). For instance, striate and occipitotemporal extrastriate regions have been associated with attentional bias to babies (Brosch et al., 2008) and with value-driven attentional capture (Anderson, Laurent, & Yantis, 2014).

Areas related to the processing of reward and to the control of actions, thoughts, and attention are also associated with attentional bias to positive information (see Kress & Aue, 2017, for an overview). For instance, activity in the anterior cingulate cortex (ACC) is associated with the magnitude of attentional bias to reward in visual search (Hickey et al., 2010). Models of drug addiction propose that attentional bias to substance related cues is a consequence of a dopaminergic activity in the dorsal anterior cingulate cortex (dACC) and dorsolateral prefrontal cortex (DLPFC) that raises the salience of those cues (Franken, 2003). For instance, smokers in a placebo condition displayed attentional bias and showed elevated brain activation in the dACC and the right dorsolateral prefrontal cortex (r-DLPFC) in response to smoking cues. By contrast, those who were given a dopamine antagonist (haloperidol) did not demonstrate enhanced brain activation in these regions or an attentional bias (Luijten et al., 2012). Finally, attentional bias to food in hungry observers is related to stronger functional coupling between the posterior parietal cortex and the posterior cingulate cortex (Mohanty, Gitelman, Small, & Mesulam, 2008).

In sum, a variety of brain regions and networks are correlated with attentional bias to positive events. Recent studies have therefore argued that the amygdala appears to coordinate cortical networks and pathways like the prefrontal and visual cortices that convey and modulate information on the significance of the identified emotional stimulus to effectively recruit adaptive responses (Pessoa & Adolphs, 2010). This implies that the brain areas responsible for processing and responding to the emotional value of events (e.g., amygdala, orbitofrontal cortex (OFC), superior colliculus, and pulvinar) interact with brain regions such as the PFC and ACC that coordinate processes like decision-making and the control of attention, thoughts, and actions (Brown & Braver, 2005; Pourtois, Schettino, & Vuilleumier, 2012). Consequently, top-down processes such as goals may influence reactions to emotional events (Vuilleumier & Huang, 2009).

Somatovisceral responses related to the Bias

Various somatovisceral responses have been associated with attentional bias to positive input. For instance, attentional biases toward smoking-related stimuli in smokers are strongly associated with enhanced activity in the zygomaticus facial muscles that are responsible for raising the corners of the mouth upward enabling the face to smile (Waters et al., 2003). However, heart rate and skin conductance responses (SCRs) did not increase in response to the smoking cues. The findings suggest that attentional bias in addiction is a reaction to positive attitudes toward and liking of the drug.

Inconsistent with the Waters et al.'s (2003) findings, other studies suggest that attentional bias to positive information is linked to increases in SCRs that result from enhanced sweat gland secretions. The production of SCRs is associated with an increased activation of the right medial PFC (Critchley, Melmed, Featherstone, Mathias, & Dolan, 2002). Heightened SCRs indicate heightened arousal independent of valence. They occur in response to both negative and positive events of motivational relevance, which means to stimuli that should be avoided or approached. For instance, a recent study (Gantiva et al., 2018) compared behavioral and physiological responses in an emotional Stroop task between dysphoric and nondysphoric participants. Nondysphoric participants showed an enhanced attentional bias and SCRs toward positive stimuli, whereas participants with dysphoria demonstrated increased attentional bias in response to negative stimuli; the latter also displayed heart rate deceleration that is associated with sustained attention. Relatedly, alcoholics showed larger SCRs and lower heart rate acceleration to alcohol words (Stormark, Laberg, Nordby, & Hugdahl, 2000). In sum, visceral responses that reflect not only liking but also motivational responses such as wanting to approach or avoid stimuli appear to be involved in attentional bias to positive stimuli.

Finally, effective cardiac vagal tone regulation that predicts the ability to rapidly alter the cardiac autonomic reactivity has been associated with increased PFC reactivity and improved control of attention and emotional regulation, including adaptive attentional responses to positive stimuli (Porges, 1992; Thayer & Lane, 2000). Supporting this notion, faster and higher relapse rates in alcohol-dependent patients were related to increased attentional bias and elevated high frequency heart rate variability in response to alcohol-related cues (Garland, Franken, & Howard, 2012). In sum, various somatovisceral reactions are associated with (dys)functional attentional bias to both pleasant and unpleasant stimuli, and with mechanisms that allow to control the bias.

Similarities and differences between healthy and clinical populations

Attention to positive stimuli is significantly lowered or absent in many affective disorders. For instance, depressed individuals show an absence of attentional capture by stimuli that are associated with reward (Anderson, Leal, Hall, Yassa, & Yantis, 2014). Impaired attention to positive information also characterizes people that are only at risk for depression. For instance, female adolescents who are more vulnerable to the development of depression orient attention away from positive stimuli after a negative mood induction (Joormann, Talbot, & Gotlib, 2007). In contrast, healthy samples show attentional bias toward positive information that seems to serve adaptive emotion regulation. Indeed, when participants were instructed to attend to positive stimuli after a stress induction, they reported to be less frustrated than participants who were instructed to attend to negative images (Johnson, 2009).

Interestingly, the capacity to attend to positive or negative stimuli appears to be related to genetic variations. A study by Fox, Ridgewell, and Ashwin (2009) examined attention allocation to negative and positive events and its relation to allelic variations in the promotor region of the serotonin transporter gene (5-HTTLPR). Those with S (short) allele score higher on measures of neuroticism (Lesch et al., 1996). Interestingly, individuals homozygous for an S allele showed increased vigilance toward threatening and negative stimuli, whereas those with an L (long) allele oriented attention toward positive stimuli and shifted away from the negative stimuli. This suggests that serotonin transporter allelic variation that impacts the neuroendocrine system underlies (mal)adaptive emotional processing including attentional bias.

However, attention to positive stimuli is not inevitably adaptive (Dodd & Porter, 2010). For instance, attentional bias toward sexual stimuli has been observed in females who had *low* sexual functioning compared with females who possessed high sexual functioning (Beard & Amir, 2010). This suggests that sexual dysfunctions lead to an oversensitivity toward relevant sexual contents.

Dysfunctional bias also characterizes obesity and addictions (Garland et al., 2012; Luijten et al., 2012; Stormark et al., 2000; Waters et al., 2003). For example, both healthy and obese participants direct their gaze toward food-related cues compared with nonfood cues when hungry; however, when satiated, obese participants continued to divert their gaze toward food-related cues in contrast to healthy participants who shifted their gaze away from food-related stimuli (Castellanos et al., 2009). Attentional bias to food found in those with heightened weight-to-height ratio also predicts future weight gain (Yokum, Ng, & Stice, 2011).

Similar results have been obtained in addiction. Increases in subjective motivational states such as substance craving are associated with increases in attention allocation to substance related cues that, in turn, are supposed to enhance craving (Franken, 2003). For instance, Field and Eastwood (2005) trained heavy drinkers either to attend or to avoid attending to images of alcohol. To this end, participants were presented with pairs of alcohol and neutral images in a dot-probe task. In the attend alcohol condition, the probes almost always appeared in the location of the alcohol images whereas in the avoid-alcohol condition the probes were in the location of the neutral images. The participants in the attend alcohol condition showed increased alcohol-related attentional bias compared with their baseline scores, whereas those in the avoid-alcohol condition showed reductions in attentional bias following training. Increases in attentional bias in the alcohol attend group were strongly associated with increases in subjective craving and alcohol consumption as measured by a taste evaluation task. In comparison, those in the avoid-alcohol group did not show any differences in both attentional bias and subjective craving measured at baseline and after training. Subsequently, the avoid-alcohol group consumed significantly less alcohol than the attend alcohol group. This study suggests a causal role of attentional bias in craving and the development of addictions.

In sum, both healthy and clinical samples attend to positive stimuli. Whereas healthy samples seem to attend to positive stimuli when it supports adaptive emotion regulation, attention to positive stimuli in clinical samples seems to characterize dysfunctional processes such as craving (Field et al., 2016; Shechner & Bar-Haim, 2016). However, anxious individuals allocate attention to positive events relevant to a current goal even in the presence of threatening information (Vogt et al., 2013). Making positive events goal relevant thus seems to be a tool to induce attentional bias to positive information even in clinical samples.

Limitations and future directions

Though various studies have shown that positive stimuli attract attention, several questions remain unsolved. For instance, it is unclear whether all kinds of positive stimuli evoke attentional bias in similar ways, for example, whether they differ in their capacity to capture or hold attention. Additionally, it remains to be clarified to what extent the bias varies depending on individual differences. We hope that future studies will compare a variety of stimuli in the same experimental design while also measuring individual differences and testing clinical populations. Further, combining behavioral measures with neuroscientific and psychophysiological methods will help to understand which mechanism(s) underlie the bias.

Importantly, highlighting the role of contextual factors will allow the field to shift the research focus from asking whether positive stimuli bias attention automatically to why and when people attend to them. Attention to positive stimuli varies not only across individuals but also across situations. For instance, dieters or addicts attend to high-caloric food or drugs when craving but are inattentive to them when goals to abstain are activated (Field et al., 2016; Papies et al., 2008). We hope that future research will continue to study how contextual factors such as temporary goals or expectations (Kress & Aue, 2017) prevent and induce (dys)functional attentional bias to positive information.

Taking context into account will also help to clarify under which circumstances attention to positive stimuli is adaptive. For instance, attention to positive stimuli might be adaptive when it serves, for instance, an emotion regulation goal. In contrast, if it enhances craving or turns people blind to relevant negative information such as error feedback or signs of real threat, it will be maladaptive. We believe that combining attentional measures with behavioral outcomes or indicators of relevant regulatory processes will allow researchers to gain insight into when attention to positive information is (dys)functional. Importantly, if attentional bias is context dependent, then attempts to train observers to acquire an attentional bias toward or away from positive stimuli must take relevant contextual factors into account. Only then will these trainings be efficiently transferrable to relevant real-life situations. For instance, it might be necessary to train people to attend toward (or away from) positive stimuli in response to the specific situation that usually evokes a dysfunctional attentional bias (cf. Salemink, Woud, Roos, Wiers, & Lindgren, 2019).

Summary

The present chapter outlined when and why positive information attracts attention in both healthy and clinical samples, how attention can be measured, and which neuroscientific and psychophysiological measures reflect it. We suggested that attention to positive stimuli is highly context dependent with temporary goals and subsequent top-down processes being one factor that not only causes but also erases attention to positive information. Ultimately, this line of work can help to improve the prevention and treatment of psychiatric disorders, for instance, by better tailoring attentional trainings with respect to individualistic eliciting (i.e., contextual) factors.

References

Aarts, H., & Dijksterhuis, A. (2003). On wildebeests and humans: The preferential detection of negative stimuli. *Psychological Science*, *14*, 14–18.

Algom, D., Chajut, E., & Lev, S. (2004). A rational look at the emotional Stroop phenomenon: A generic slowdown, not a Stroop effect. *Journal of Experimental Psychology: General*, *133*, 323–338.

Anderson, B. A., Laurent, P. A., & Yantis, S. (2014). Value-driven attentional priority signals in human basal ganglia and visual cortex. *Brain Research*, *1587*, 88–96.

Anderson, B. A., Leal, S. L., Hall, M. G., Yassa, M. A., & Yantis, S. (2014). The attribution of value-based attentional priority in individuals with depressive symptoms. *Cognitive, Affective, & Behavioral Neuroscience*, *14*, 1221–1227.

Bar-Haim, Y., Lamy, D., Pergamin, L., Bakermans-Kranenburg, M. J., & van IJzendoorn, M. H. (2007). Threat-related attentional bias in anxious and nonanxious individuals: A meta-analytic study. *Psychological Bulletin*, *133*, 1–24.

Beard, C., & Amir, N. (2010). Attention bias for sexual words in females with low sexual functioning: A brief report. *US National Library of Medicine*, *36*, 216–226.

Becker, D. V., Anderson, U. S., Mortensen, C. R., Neufeld, S. L., & Neel, R. (2011). The face in the crowd effect unconfounded: Happy faces, not angry faces, are more efficiently detected in single- and multiple-target visual search tasks. *Journal of Experimental Psychology: General*, *140*, 637–659.

Blanchette, I. (2006). Snakes, spiders, guns, and syringes: How specific are evolutionary constraints on the detection of threatening stimuli? *Quarterly Journal of Experimental Psychology*, *59*, 1484–1504.

Brosch, T., Sander, D., Pourtois, G., & Scherer, K. R. (2008). Beyond fear: Rapid spatial orienting toward positive emotional stimuli. *Psychological Science*, *19*, 362–370.

Brosch, T., Sander, D., & Scherer, K. R. (2007). That baby caught my eye... Attention capture by infant faces. *Emotion*, *7*, 685–689.

Brown, J. W., & Braver, T. S. (2005). Learned predictions of error likelihood in the anterior cingulate cortex. *Science*, *307*, 1118–1121.

Brown, C. R. H., Duka, T., & Forster, S. (2018). Attentional capture by alcohol related stimuli may be activated involuntarily by top-down search goals. *Psychopharmacology*, *235*, 2087–2099.

Calitri, R., Lowe, R., Eves, F. F., & Bennett, P. (2009). Associations between visual attention, implicit and explicit attitude and behaviour for physical activity. *Psychology & Health*, *24*, 1105–1123.

Castellanos, E. H., Charboneau, E. J., Dietrich, M. S., Park, S., Bradley, B. P., Mogg, K., et al. (2009). Obese adults have visual attention bias for food cue images: Evidence for altered reward system function. *International Journal of Obesity*, *33*, 1063–1073.

Critchley, H. D., Melmed, R. N., Featherstone, E., Mathias, C. J., & Dolan, R. J. (2002). Volitional control of autonomic arousal: A functional magnetic resonance study. *NeuroImage*, *16*, 909–919.

Dalgleish, T. (1995). Performance on the emotional Stroop task in groups of anxious, expert, and control subjects: A comparison of computer and card presentation formats. *Cognition and Emotion*, *9*, 341–362.

Desimone, R., & Duncan, J. (1995). Neural mechanisms of selective visual attention. *Annual Review of Neuroscience*, *18*, 193–222.

Dewitte, M., De Houwer, J., Koster, E. H. W., & Buysse, A. (2007). What's in a name? Attachment-related attentional bias. *Emotion*, *7*, 535–545.

Dodd, H. F., & Porter, M. A. (2010). I see happy people: Attention bias towards happy but not angry facial expressions in Williams syndrome. *Cognitive Neuropsychiatry*, *15*, 549–567.

Fenske, M. J., & Eastwood, J. D. (2003). Modulation of focused attention by faces expressing emotion: Evidence from flanker tasks. *Emotion*, *3*, 327–343.

Field, M., & Eastwood, B. (2005). Experimental manipulation of attentional bias increases the motivation to drink alcohol. *Psychopharmacology*, *183*, 350–357.

Field, M., Werthmann, J., Franken, I., Hofmann, W., Hogarth, L., & Roefs, A. (2016). The role of attentional bias in obesity and addiction. *Health Psychology*, *35*, 767–780.

Fitzgerald, D. A., Angstadt, M., Jelsone, L. M., Nathan, P. J., & Phan, K. L. (2006). Beyond threat: Amygdala reactivity across multiple expressions of facial affect. *NeuroImage*, *30*, 1441–1448.

Fox, E., Ridgewell, A., & Ashwin, C. (2009). Looking on the bright side: Biased attention and the human serotonin transporter gene. *Proceedings of the Royal Society B: Biological Sciences*, *276*, 1747–1751.

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

Franken, I. H. (2003). Drug craving and addiction: Integrating psychological and neuropsychopharmacological approaches. *Progress in Neuro-Psychopharmacology & Biological Psychiatry*, *27*, 563–579.

Gantiva, C., Araujo, A., Aragão, N., & Hewitt, N. (2018). Modulation of physiological responses as indices of attentional bias in dysphoria. *International Journal of Mental Health and Addiction*, *16*, 328–338.

Garland, E. L., Franken, I. H. A., & Howard, M. O. (2012). Cue-elicited heart rate variability and attentional bias predict alcohol relapse following treatment. *Psychopharmacology*, *222*, 17–26.

Gronau, N., Cohen, A., & Ben-Shakhar, G. (2003). Dissociations of personally significant and task-relevant distractors inside and outside the focus of attention: A combined behavioral and psychophysiological study. *Journal of Experimental Psychology: General*, *132*, 512–529.

Hickey, C., Chelazzi, L., & Theeuwes, J. (2010). Reward guides vision when it's your thing: Trait reward-seeking in reward-mediated visual priming. *PLoS One*, *5*, e14087.

Horstmann, G., Borgstedt, K., & Heumann, M. (2006). Flanker effects with faces may depend on perceptual as well as emotional differences. *Emotion*, *6*, 28–39.

Johnson, D. R. (2009). Goal-directed attentional deployment to emotional faces and individual differences in emotional regulation. *Journal of Research in Personality*, *43*, 8–13.

Joormann, J., Talbot, L., & Gotlib, I. H. (2007). Biased processing of emotional information in girls at risk for depression. *Journal of Abnormal Psychology*, *116*, 135–143.

Koster, E. H. W., Crombez, G., Van Damme, S., Verschuere, B., & De Houwer, J. (2004). Does imminent threat capture and hold attention? *Emotion*, *4*, 312–317.

Kress, L., & Aue, T. (2017). The link between optimism bias and attention bias: A neurocognitive perspective. *Neuroscience and Biobehavioral Reviews*, *80*, 688–702.

Kress, L., Bristle, M., & Aue, T. (2018). Seeing through rose-colored glasses: How optimistic expectancies guide visual attention. *PLoS One*, *13*, e0193311.

Kuhn, G., Pickering, A., & Cole, G. G. (2016). "Rare" emotive faces and attentional orienting. *Emotion*, *16*, 1–5.

Lang, P. J., Bradley, M. M., & Cuthbert, B. (1997). Motivated attention: Affect, activation and action. In P. J. Lang, R. F. Simons, & M. T. Balaban (Eds.), *Attention and orienting: Sensory and motivational processes* (pp. 97–135). Hillsdale, NJ: Lawrence Erlbaum Associates, Inc.

Le Pelley, M. E., Mitchell, C. J., Beesley, T., George, D. N., & Wills, A. J. (2016). Attention and associative learning in humans: An integrative review. *Psychological Bulletin*, *142*, 1111–1140.

LeDoux, J. E. (1996). *The emotional brain: The mysterious underpinnings of emotional life*. New York, NY: Simon & Schuster.

Lesch, K., Bengel, D., Heils, A., Sabol, S., Greenberg, B., Petri, S., et al. (1996). Association of anxiety-related traits with a polymorphism in the serotonin transporter gene regulatory region. *Science*, *274*, 1527–1531.

Lichtenstein-Vidne, L., Henik, A., & Safadi, Z. (2012). Task relevance modulates processing of distracting emotional stimuli. *Cognition and Emotion*, *26*, 42–52.

Light, J., & Isaacowitz, D. (2006). The effect of developmental regulation on visual attention: The example of the "biological clock". *Cognition and Emotion*, *20*, 623–645.

Lipp, O. V., & Derakshan, N. (2005). Attentional bias to pictures of fear-relevant animals in a dot probe task. *Emotion*, *5*, 365–369.

LoBue, V. (2010). What's so scary about needles and knives? Examining the role of experience in threat detection. *Cognition and Emotion*, *24*, 180–187.

Luck, S. J., & Vecera, S. P. (2002). Attention. [Series Ed.). (Volume Ed.]In Pashler, H. & Yantis, S. (Eds.), *Stevens' Handbook of Experimental Psychology: Vol. 1. Sensation and Perception*. (3rd ed.)(pp. 235–286). New York: Wiley.

Luijten, M., Veltman, D. J., Hester, R., Smits, M., Pepplinkhuizen, L., & Franken, I. H. (2012). Brain activation associated with attentional bias in smokers is modulated by a dopamine antagonist. *Neuropsychopharmacology*, *37*, 2772–2779.

MacLeod, C., Mathews, A., & Tata, P. (1986). Attentional bias in emotional disorders. *Journal of Abnormal Psychology*, *95*, 15–20.

Maner, J. K., Gailliot, M. T., & Miller, S. L. (2009). The implicit cognition of relationship maintenance: Inattention to attractive alternatives. *Journal of Experimental Social Psychology*, *45*, 174–179.

Maner, J., Kenrick, D., Becker, D., Delton, A., Hofer, B., Wilbur, C., et al. (2003). Sexually selective cognition: Beauty captures the mind of the beholder. *Journal of Personality and Social Psychology*, *85*, 1107–1120.

Mogg, K., Bradley, B. P., Field, M., & De Houwer, J. (2003). Eye movements to smoking-related pictures in smokers: Relationship between attentional biases and implicit and explicit measures of stimulus valence. *Addiction*, *98*, 825–836.

Mogg, K., Holmes, A., Garner, M., & Bradley, B. P. (2008). Effects of threat cues on attentional shifting, disengagement and response slowing in anxious individuals. *Behaviour Research and Therapy*, *46*, 656–667.

Mohanty, A., Gitelman, D. R., Small, D. M., & Mesulam, M. M. (2008). The spatial attention network interacts with limbic and monoaminergic systems to modulate motivation-induced attention shifts. *Cerebral Cortex*, *18*, 2604–2613.

Moors, A., & De Houwer, J. (2006). Automaticity: A theoretical and conceptual analysis. *Psychological Bulletin*, *132*, 297–326.

Moskowitz, G. B. (2002). Preconscious effects of temporary goals on attention. *Journal of Experimental Social Psychology*, *38*, 397–404.

Most, S. B., Smith, S. D., Cooter, A. B., Levy, B. N., & Zald, D. H. (2007). The naked truth: Positive, arousing distractors impair rapid target perception. *Cognition & Emotion*, *21*, 964–981.

Neuberg, S. L., Kenrick, D. T., Maner, J. K., & Schaller, M. (2004). From evolved motives to everyday mentation: Evolution, goals, and cognition. In J. Forgas & K. Williams (Eds.), *Social motivation: Conscious and unconscious processes* (pp. 133–152). New York: Cambridge University Press.

Öhman, A., & Mineka, S. (2001). Fears, phobias, and preparedness: Toward an evolved module of fear and fear learning. *Psychological Review*, *108*, 483–522.

Papies, E. K., Stroebe, W., & Aarts, H. (2008). The allure of forbidden food: On the role of attention in self-regulation. *Journal of Experimental Social Psychology*, *44*, 1283–1292.

Pessoa, L., & Adolphs, R. (2010). Emotion processing and the amygdala: From a "low road" to "many roads" of evaluating biological significance. *Nature Reviews Neuroscience*, *11*, 773–783.

Pool, E., Brosch, T., Delplanque, S., & Sander, D. (2016). Attentional bias for positive emotional stimuli: A meta-analytic investigation. *Psychological Bulletin*, *142*, 79–106.

Porges, S. (1992). Vagal tone: A physiologic marker of stress vulnerability. *Pediatrics*, *90*, 498–504.

Posner, M. I. (1980). Orienting of attention. *The Quarterly Journal of Experimental Psychology*, *32*, 3–25.

Pourtois, G., Schettino, A., & Vuilleumier, P. (2012). Brain mechanisms for emotional influences on perception and attention: What is magic and what is not. *Biological Psychology*, *92*, 492–512.

Pratto, F., & John, O. P. (1991). Automatic vigilance: The attention-grabbing power of negative social information. *Journal of Personality and Social Psychology*, *61*, 380–391.

Raymond, J. E., & O'Brien, J. L. (2009). Selective visual attention and motivation: The consequences of value learning in an attentional blink task. *Psychological Science*, *20*, 981–988.

Roskos-Ewoldsen, D. R., & Fazio, R. H. (1992). On the orienting value of attitudes: Attitude accessibility as a determinant of an object's attraction of visual attention. *Journal of Personality and Social Psychology*, *63*, 198–211.

Salemink, E., Woud, M. L., Roos, M., Wiers, R., & Lindgren, K. P. (2019). Reducing alcohol-related interpretive bias in negative affect situations: Using a scenario-based cognitive Bias modification training paradigm. *Addictive Behaviors*, *88*, 106–113.

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

Segerstrom, S. C. (2001). Optimism and attentional bias for negative and positive stimuli. *Personality and Social Psychology Bulletin*, *27*, 1334–1343.

Sennwald, V., Pool, E., Brosch, T., Delplanque, S., Bianchi-Demicheli, F., & Sander, D. (2016). Emotional attention for erotic stimuli: Cognitive and brain mechanisms. *The Journal of Comparative Neurology*, *524*, 1668–1675.

Shechner, T., & Bar-Haim, Y. (2016). Threat monitoring and attention bias modification in anxiety and stress-related disorders. *Current Directions in Psychological Science*, *25*, 431–437.

Smith, N. K., Larsen, J. T., Chartrand, T. L., Cacioppo, J. T., Katafiasz, H. A., & Moran, K. E. (2006). Being bad isn't always that good: Affective context moderates the attention bias toward negative information. *Journal of Personality and Social Psychology*, *90*, 210–220.

Stormark, K. M., Laberg, J. C., Nordby, H., & Hugdahl, K. (2000). Alcoholics' selective attention to alcohol stimuli: Automated processing? *Journal of Studies on Alcohol*, *61*, 18–23.

Talsma, D., Senkowski, D., Soto-Faraco, S., & Woldorff, M. G. (2010). The multifaceted interplay between attention and multisensory integration. *Trends in Cognitive Sciences*, *14*, 400–410.

Tamietto, M., & de Gelder, B. (2010). Neural bases of the non-conscious perception of emotional signals. *Nature Reviews Neuroscience*, *11*, 697–709.

Tapper, K., Pothos, E. M., & Lawrence, A. D. (2010). Feast your eyes: Hunger and trait reward drive predict attentional bias for food cues. *Emotion*, *10*, 949–954.

Thayer, J. F., & Lane, R. D. (2000). A model of neurovisceral integration in emotion regulation and dysregulation. *Journal of Affective Disorders*, *61*, 201–216.

Van Dessel, P., & Vogt, J. (2012). When does hearing laughter draw attention to happy faces? Task relevance determines the influence of a cross-modal affective context on emotional attention. *Frontiers in Human Neuroscience*, *6*, 294.

Vogt, J., & De Houwer, J. (2014). Emotion regulation meets emotional attention: The influence of emotion suppression on emotional attention depends on the nature of the distracters. *Emotion*, *14*, 840–845.

Vogt, J., De Houwer, J., & Crombez, G. (2011). Multiple goal management starts with attention: goal prioritizing affects the allocation of spatial attention to goal relevant events. *Experimental Psychology*, *58*, 55–61.

Vogt, J., De Houwer, J., Koster, E. H. W., Van Damme, S., & Crombez, G. (2008). Allocation of spatial attention to emotional stimuli depends upon arousal and not valence. *Emotion*, *8*, 880–885.

Vogt, J., De Houwer, J., & Moors, A. (2011). Unintended allocation of spatial attention to goal relevant but not to goal related events. *Social Psychology*, *42*, 48–55.

Vogt, J., De Hower, J., Moors, A., Van Damme, S., & Crombez, G. (2010). The automatic orienting of attention to goal-relevant stimuli. *Acta Psychologica*, *134*, 61–69.

Vogt, J., Houwer, J., Crombez, G., & Van Damme, S. (2013). Competing for attentional priority: Temporary goals versus threats. *Emotion*, *13*, 587–598.

Vogt, J., Koster, E. H. W., & De Houwer, J. (2017). Safety first: Instrumentality for reaching safety determines attention allocation under threat. *Emotion*, *17*, 528–537.

Vogt, J., Lozo, L., Koster, E. H. W., & De Houwer, J. (2011). On the role of goal relevance in emotional attention: Disgust evokes early attention to cleanliness. *Cognition and Emotion*, *25*, 466–477.

Vuilleumier, P., & Huang, Y.-M. (2009). Emotional attention: Uncovering the mechanisms of affective biases in perception. *Current Directions in Psychological Science*, *18*, 148–152.

Vuilleumier, P., Richardson, M. P., Armony, J. L., Driver, J., & Dolan, R. J. (2004). Distant influences of amygdala lesion on visual cortical activation during emotional face processing. *Nature Neuroscience*, *7*, 1271–1278.

Waters, A. J., Shiffman, S., Sayette, M. A., Paty, J. A., Gwaltney, C. J., & Balabanis, M. H. (2003). Attentional bias predicts outcome in smoking cessation. *Health Psychology*, *22*, 378–387.

Wieber, F., & Sassenberg, K. (2006). I can't take my eyes off of it—attention attraction effects of implementation intentions. *Social Cognition*, *24*, 723–752.

Williams, J. M. G., Mathews, A., & MacLeod, C. (1996). The emotional Stroop task and psychopathology. *Psychological Bulletin*, *120*, 3–24.

Xing, C., & Isaacowitz, D. M. (2006). Aiming at happiness: How motivation affects attention to and memory for emotional images. *Motivation and Emotion*, *30*, 249–256.

Yiend, J. (2010). The effects of emotion on attention: A review of attentional processing of emotional information. *Cognition and Emotion*, *24*, 3–47.

Yokum, S., Ng, J., & Stice, E. (2011). Attentional bias to food images associated with elevated weight and future weight gain: An fMRI study. *Obesity*, *19*, 1775–1783.