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Applications of the dot probe task in attentional bias research in eating disorders: A review

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Recent years have seen an increasing interest in the cognitive approach to eating disorders, which postulates that patients selectively attend to information associated with eating, body shape, and body weight. The unreliability of self-report measures in eating disorders due to strong denial of illness gave rise to experimental studies inspired by research into anxiety disorders involving attentional bias, with the prevalent method being a modified color-naming Stroop task. Unfortunately, that tool was shown to exhibit many limitations, especially in terms of attentional bias measurement. Thus, researchers started to seek alternative methods of evaluating attention in persons with eating disorders. Along with the Stroop test and the Posner paradigm, one of the most frequently used methods is the dot probe task. This paper presents the dot probe protocol as well as the rationale underpinning its use, including its advantages and drawbacks. Furthermore, a modification of the task is proposed to enable the assessment of all components of attentional bias in patients with eating disorders. The paper also discusses practical implications of the modification for the treatment of these patients. For several years now there has been an increasingly widespread use of so-called attentional training employing, amongst others, the dot probe task, which may be modified for the purpose of reducing or eliminating of attentional biases in patients with eating disorders. Unfortunately, due to the absence of studies providing a reliable account of all types of attentional bias in eating disorders, this field of research lags considerably behind anxiety research and does not enable therapeutic applications.

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Introduction

The issue of treatment of eating disorders, such as anorexia nervosa and bulimia nervosa, continues to be very contentious. Recent years have seen a surge of interest in the cognitive approach, in which patients evaluate themselves almost exclusively in terms of their body shape, weight, eating habits, and their ability to control them. Jones, Leung, and Harris (2007) argue that these are "essentially cognitive disorders in which the main cognitive disturbance is manifested in a characteristic set of attitudes and values concerning body weight and shape" (Jones et al., 2007, p. 157). One of the cognitive processes that may perpetuate these disorders is selective attention. According to cognitive theories of eating disorders, patients selectively attend to material related to eating and body appearance (Vitousek & Hollon, 1990; see also Johansson, 2006; Dobson & Dozois, 2004). In this field, the most promising avenues are experimental studies into selective attention, including attentional bias, as in the case of patients with eating disorders self-report instruments are unreliable due to the fact that such patients tend to deliberately distort their responses (Faunce, 2002). Therefore, studies in this field are increasingly often conducted using information processing paradigms incorporating stimuli related to food, body shape, and weight (Ainsworth, Waller, & Kennedy, 2002).

Attentional bias or attentional biases?

According to Quimet, Gawronski, and Dozois (2009), many studies have shown that attention cannot be treated as a uniform, one-dimensional construct (see also Posner, 1980), while Koster and colleagues (2006) have observed that the exact nature of attentional biases remains elusive (see also Fox et al., 2001). In particular, the specific components of attentional bias associated with threat-related stimuli are still the subject of ongoing debate (Bannerman, Milders, & Sahraie, 2010). It should be emphasized that while attentional bias linked to positive stimuli is noteworthy, it is negative stimuli that are particularly "attention grabbing" (Fox, Russo, & Dutton, 2002, p. 376; see also Pratto & John, 1991, p. 380; Morgan, Rees, & Curran, 2008, p. 1331). According to Cisler and Koster (2010), the components of attentional bias refer to its measurable characteristics (what attentional bias "looks like"). In the case of threat-related attentional bias, these authors distinguish several components, which may also be termed "phases" (Ouimet et al., 2009, p. 461) or "mental operations" (Koster et al., 2006, p. 636). The first one is facilitated attention to threat, which is the relative facility or speed with which attention is drawn toward a threat. This represents attentional orienting toward threat, and so threatening stimuli are detected faster than non-threatening ones. The second component of attentional bias is difficulty in disengaging attention away from threat, which is the degree to which a threat-related stimulus captures, attention, preventing the reorientation of attention towards a different location. Consequently, it is more difficult to disengage attention from a threatening stimulus than from a neutral one. The third component is attentional avoidance of threat, which causes attention to be preferentially allocated towards locations other than the location of a threatening stimulus (Cisler & Koster, 2010). As can be seen, researching attentional bias is non-trivial as a distinction must be made between the three components. Thus, studies of persons with eating disorders should make it possible to reveal the nature of the attentional bias of those patients upon presentation of relevant (i.e., eating-related) stimuli.

Is the Stroop test the right method of measuring attentional bias in eating disordered patients?

The paradigm most frequently used in attentional bias research involving eating disordered patients is the Stroop task (1935). The original version of the task consisted of presenting neutral words in different color inks written on large cards, often with several words per card (Faunce, 2002). Participants were first requested to name the color of the words and then read the words irrespective of their color. This task was later revised to include color words (e.g., red and green) written in either the corresponding color, e.g., the word “red” printed in red (congruent trials) or other competing colors, e.g., the word “green” printed in blue (incongruent trials) (Wells & Matthews, 1994; Dobson & Dozois, 2004; Johansson, 2006; Bar-Haim et al., 2007). In this version, the participants are required to ignore the meaning of the words and to name the color of each stimulus as quickly as possible (Ainsworth et al., 2002; Cisler, Bacon, & Williams, 2009; Faunce, 2002; Johansson, 2006; Cisler & Koster, 2010). Many studies have found that subjects take significantly longer to color-name the words presented in incongruent trials than in congruent ones (Wells & Matthews, 1994; Johansson, 2006). This difference is attributed to the interference effect, which is calculated as the total time taken to name the words written in incongruent colors divided by the total time for the words written in congruent ones (Dobson & Dozois, 2004).

The discovery that performance on the classical Stroop task depends on the meaning of stimuli enabled researchers to modify that task for testing information processing in emotional disorders (Ainsworth et al., 2002; Johansson, 2006; Cisler et al., 2009; see also Faunce, 2002). Modifications of the original Stroop test were developed in the 1980s and are popularly known as "emotional Stroop tasks" (Wells & Matthews, 1994; Krejtz & Sędek, 2001; Lee & Shafran, 2004; Bar-Haim et al., 2007; Asanowicz & Wolski, 2007). The new versions were meant to evaluate attentional bias in emotional disorders, such as anxiety and depression (Lee & Shafran, 2004), as well as in other psychiatric conditions, e.g., eating disorders. (Dobson & Dozois, 2004). Two new types of trials were proposed: emotional and control ones (Johansson, 2006; see also Cisler et al., 2009; Cisler & Koster, 2010; Szymura, 2007). In emotional trials, researchers manipulated the content (Dobson & Dozois, 2004) and the valence of stimuli employed (Bar-Haim et al., 2007), making the meaning of the presented words relevant to the specific concerns of the patients arising from their emotional disorder. Similarly to the classical Stroop task, in modified clinical versions of the test the subjects were asked to name the color of words linked to their psychopathology; for instance a person with arachnophobia was asked to name the color of the word "cobweb." Also in the 1980s, special versions of the Stroop test were developed to test patients with eating disorders; these are known as the "Food Stroop" (Ben-Tovim et al., 1989) and the "Body Stroop" (Channon, Hemsley, & deSilva, 1988) and include words related to food and body shape. In control trials the meaning of the presented words was neutral with respect to valence (see also Dobson & Dozois, 2004).

Although tests employing the Stroop task have shown that individuals with eating disorders tend to name the colors of words related to food and body more slowly (e.g. Faunce, 2002; Dobson & Dozois, 2004; Johansson, 2006), some researchers (e.g. Lee & Shafran, 2004) have also emphasized that this task is poorly suited for measuring attentional bias as such. First of all, it is unclear what mechanisms are responsible for the results obtained in the Stroop test. Despite the very high number of tests using the classic Stroop task, it has not been conclusively determined whether the effect is caused by differences in the relative speed of processing color vs. language (Klein, 1964), the automaticity of language use (e.g., Logan, 1980), the perceptual encoding of appropriate stimulus attributes (Dyer, 1973), or the interference related to the unequal strengths of competing processing pathways (Cohen, Dunbar, & McClelland, 1990; see also Dobson & Dozois, 2004). It is not even certain whether Williams, Mathews, and MacLeod (1996) were right in claiming that Stroop interference is indicative of attention being automatically directed toward a given type of information, e.g. related to eating, which makes the test inadequate for studying attentional bias.

Due to the numerous concerns as to the legitimacy of the Stroop task for the measurement of attentional bias, researchers started to seek other methods of exploring the relationship between attention and psychopathology (Lee & Shafran, 2004), especially in terms of assessing attentional bias (Lee & Shafran, 2008). One of the predominant objectives was to design tests that would provide more consistent results concerning threat-related attentional biases. Thus, new information processing paradigms (Shafran et al., 2007) were developed largely in response to the methodological shortcomings of the Stroop task (Shafran et al., 2007; Lee & Shafran, 2008). The most prominent of them are the Posner paradigm (Cisler et al., 2009) and the dot probe task (Ainsworth et al., 2002; Cisler et al., 2009; Cisler & Koster, 2010), which represent significant advances in the approach to attentional bias research. These modifications show an interesting evolution of methods in the quest for a tool that would be best suited for evaluating attentional bias.

While a detailed description of the Posner paradigm is beyond the scope of this paper, it should be noted that in its most widely used variant, employed by Fox and colleagues (2001), a single word (threatening or neutral) is presented on the right or left side of the screen. Immediately following the word, a target is displayed. In validly cued, or test, trials (Hoppitt & Mackintosh, 2009; Fox et al., 2002) the cue and target appear at the same location, while in invalidly cued, or control, trials (Hoppitt and Mackintosh, 2009; Fox et al., 2002) they appear in different locations (Fox et al., 2001; see also Jaśkowski, 2009). This paradigm enables evaluation of attentional engagement as measured by the subjects' responses (expressed as reaction times, RTs) to valid targets and attentional disengagement as measured by their responses to invalid targets (Derakshan, Eysenck, & Myers, 2007). It is believed that faster RTs to targets on valid trials reflect attentional capture by the cue, whereas slower RTs on invalid trials indicate difficulty in disengaging attention from the cue (Bannerman et al., 2010). If the subjects respond faster only on valid trials, following negative cues as compared to valid trials containing neutral stimuli, it may be assumed that bias is linked to attention being attracted and captured by negative information. In turn, if the subjects' responses are slower in invalid trials following negative words as compared to responses on invalid trials following neutral words, this suggests that they have a problem with disengaging attention from a negative stimulus (Amir et al., 2003; Derakshan et al., 2007; Hoppitt & Mackintosh, 2009; Cisler et al., 2009; Klumpp & Amir, 2009, Bannerman et al., 2010; see also Fox, 2002; Cisler & Koster, 2010). Attentional disengagement from threat is manifested by the additional time the subject takes to respond to invalid threatening trials as compared to invalid neutral trials (Klumpp & Amir, 2009). A major criticism of the Posner trial has been voiced by Klumpp and Amir (2009), who argue that this task essentially does not measure the degree to which attention is attracted by a given stimulus, which means that it is not sensitive to vigilance effects, because trials display only one stimulus so that there is no competition for attentional resources (see also Fox et al., 2002). This implies that the Posner test can be used only for invalid trials, where the target appears in the location previously not occupied by the stimulus (Fox et al., 2002). Therefore, it is perhaps fortunate that this test has not been used for patients with eating disorders, as the results would be just as non-informative as in the case of the Stroop task.

The dot probe task

As mentioned above, researchers of attentional bias (e.g., Cisler et al., 2009; Cisler & Koster, 2010) distinguish three components of attention: vigilance/facilitated attention towards relevant cues, cue avoidance, and difficulty in disengagement from cues. In this context, the dot probe task has been shown to measure more components of attentional bias than the Stroop test, which at best records vigilance to relevant cues. This task is a modification of the Posner paradigm (1980) proposed by MacLeod, Mathews, and Tata (1986), and is particularly well-suited for testing anxiety. Differences between the dot probe and the Posner tasks include the fact that the former simultaneously presents two stimuli, which are personally relevant or threatening, while in the Posner task it is not always the case (see also Faunce, 2002; Lee & Shafran, 2004; Mogg & Bradley, 2005; Bar-Haim et al., 2007, Asanowicz & Wolski, 2007; Shafran et al., 2007; Lee & Shafran, 2008; Cisler & Koster, 2010). The dot probe task is considered by many researchers a methodologically stronger test of attentional bias than the Stroop color naming task (Placanica, Faunce, & Job, 2002; see also Lee & Shafran, 2004; Mogg & Bradley, 1998), and it is also deemed to be a superior and more direct test of allocation of attention and attentional bias (Rieger et al., 1998; Mogg & Bradley, 1998; see also Faunce, 2002).

A study of patients with anxiety disorders (MacLeod et al., 1986) showed that this procedure is sensitive to attentional biases (Rieger et al., 1998) and can determine whether the subject’s attention is directed towards or away from a given class of stimulus words. This is achieved by forcing the subjects to simultaneously process two distinct stimuli rather than different attributes of one stimulus, as in the Stroop task. Due to the fact that in this task a pair of stimuli, such as words, are presented separately, reaction times to the probes that replace them (one at a time) show whether the subject's attention is preferentially directed towards or away from the stimuli.

The dot probe task protocol and rationale

In the dot probe task, subjects are seated in front of a computer screen with their chins securely positioned on a chin rest. They are asked to stare at a fixation cross at the center of the screen (the cross was absent in the original version of the task), and then a pair of stimuli (words, facial expressions, or pictures) are displayed simultaneously near the fixation cross, approx. 5 cm apart (one above and the other below it, or one to the left and the other to the right) for a certain amount of time, which is usually 500 ms (Cisler et al., 2009). Subsequently, a neutral item known as a probe (e.g., a dot, asterisk, or letter) is presented at the location of one of the stimuli. Participants are requested to indicate the location of the probe (i.e., signal whether the probe has replaced the top, bottom, left, or right stimulus) using either a keyboard (pressing two differently colored buttons) or a special response box with two buttons, also differently colored. Latency is measured automatically by the computer (MacLeod et al., 1986; Rieger et al., 1998; Aisnworth et al., 2002; Fox et al., 2002; Asanowicz & Wolski, 2007; Frewen et al., 2008; Cisler et al., 2009; Klumpp & Amir, 2009; Ouimet et al., 2009; Bannerman et al., 2010; Cisler & Koster, 2010).

The methodological rationale underpinning this measure of attention allocation (Fox et al., 2002) is that that the subjects' reaction time will vary between trials partly as a function of the stimulus on which they first focus their attention (Frewen et al., 2008). It is expected that the subjects will detect more quickly those probes that are displayed in the same spatial locations as the stimuli they focused on as opposed to locations they did not focus on (Posner, Snyder, & Davidson, 1980; Navon & Margalit, 1983; Faunce, 2002; Lee & Shafran, 2004; Mogg & Bradley, 2005; Frewen et al., 2008; Shafran et al., 2007; Lee & Shafran, 2008) because of the additional time it takes for the subject to shift his or her attention toward the location of the probe in the latter case (Frewen et al., 2008). In other words, response latency to the probe will be reduced when it appears in an attended rather than unattended region of the computer screen (Mogg & Bradley, 2005). It is thought that reaction times to the probe are faster if at the time of probe display the subject's attention is already allocated to the location of the probe (Koster et al., 2004). For instance, if the subject's attention was initially oriented towards a negative word (i.e., the subject exhibits a negative attentional bias), the reaction time should be shorter if the probe appears in the region where that word was displayed. On the other hand, if the subject's attention was oriented away from the negative word, then the reaction time should be shorter if the probe is displayed in the location previously occupied by a positive word (Bar-Haim et al., 2006; Bar-Haim et al., 2007; Hoppit & Mackintosh, 2009).

In the "emotional" variant of the task, subjects are presented with a pair of words that differ in their emotional valence (threatening vs. neutral, or positive vs. negative), usually for 100–1250 ms (MacLeod et al., 1986; Mogg & Bradley, 2005; see also Asanowicz & Wolski, 2007; Frewen et al., 2008, Ouimet et al., 2009). Later versions of the dot probe task included masked exposure conditions with word pairs presented for 14 ms. It should be noted that over time the range of stimuli was expanded to include schematic facial expressions (e.g., Bradley et al., 1999; see also Mogg & Bradley, 2005) and pictures (Asanowicz & Wolski, 2007; Frewen et al., 2008; see also Shafran et al., 2008). Researchers typically use two types of stimuli – neutral and threat-related (Fox et al., 2001; Bar-Haim et al., 2007, Derakshan et al., 2007, Klumpp & Amir, 2009; see also Koster et al., 2004; Lee & Shafran, 2004; Szymura, 2007).

Attentional biases are diagnosed based on differences in reaction times towards probes replacing threatening and neutral stimuli in congruent and incongruent trials, respectively (Cisler et al., 2009; Cisler & Koster, 2010). Shorter RTs in congruent trials show that the individual had attended to the location where the probe was displayed (suggesting vigilance to threat), whereas longer RTs in incongruent trials indicate that he or she detected the probe by shifting attention to a previously unattended location (suggesting difficulty with attentional disengagement from threat). In turn, shorter RTs in incongruent trials than in congruent ones indicate that the individual avoids threatening stimuli. This interpretation was corroborated by reports that probe detection latencies are correlated with eye shifts between the two regions of the computer screen (Bradley, Mogg, & Millar, 2000; see also Ouimet et al., 2009) (Figure 1).

Advantages of the dot probe task

Thanks to the fact that participants performing the dot probe task respond to a neutral probe, latency is not affected by any emotional reaction to that probe or some general arousal. An additional advantage of this paradigm is the ability to manipulate the time interval between the presentation of the stimulus pair and the probe (i.e., stimulus onset asynchrony, SOA, also known as the Inter-Stimulus Interval, ISI), which allows for exploring the time course of attentional allocation (Bar-Haim et al., 2007). When exposure time is very short, then attentional orientation towards or away from a threat is probably unconscious, while in the case of longer exposure times this orientation may be linked to conscious processing. The dot probe task is also advantageous in that it enables measurement of whether attention is preferentially directed toward certain stimuli or perhaps the stimuli are avoided (Placanica et al., 2002).

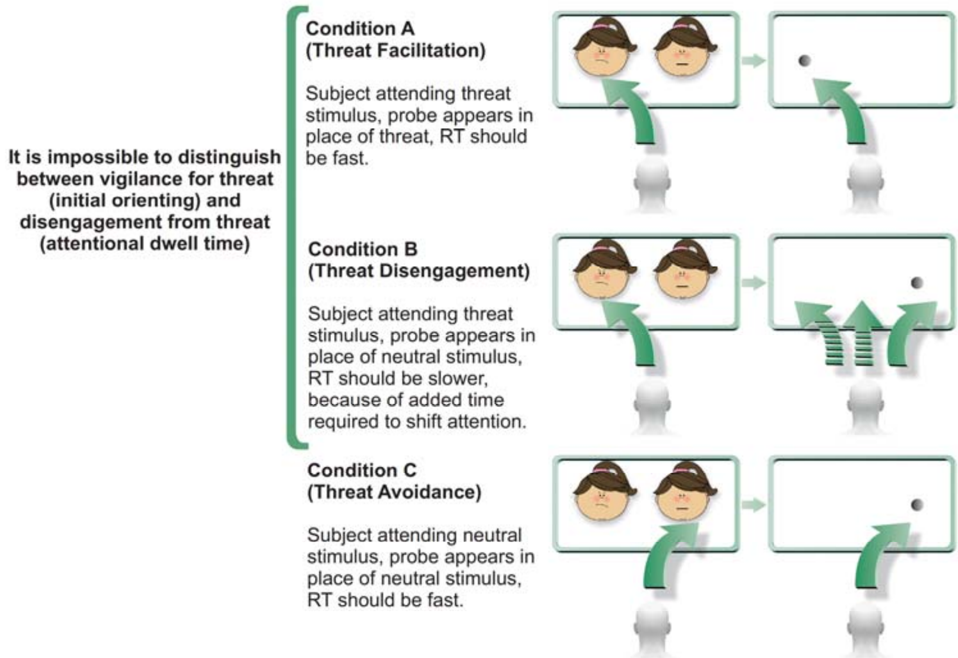

Figure 1. Three components of attentional bias and their testing with the dot probe task (based on Frewen et al., 2008, with the publisher's permission).

Reservations as to what kind of attentional bias(es) the dot probe task actually measures

Despite the fact that some studies using the Stroop test on non-clinical and clinical groups, and especially on anxious individuals (e.g. Bradley et al., 1998; see also MacLeod et al., 1986), showed the procedure to be sensitive to attentional biases (MacLeod et al., 1986; Rieger et al., 1998), other studies have called this into question (Koster et al., 2004). The original interpretations of the patterns obtained with the dot probe task have been challenged (Fox et al., 2002; see also Klumpp & Amir, 2009). These concerns have not been allayed even by the study of Bradley and colleagues (2000), who reported that subjects exhibiting eye movements towards threatening faces also responded faster to probes that replaced those faces as compared to non-threatening faces. According to Bradley et al. (2000), these results seem to confirm that anxious individuals (in contrast to non-anxious ones) are characterized by attentional vigilance to threat faces (see also Klumpp & Amir, 2009).

However, their argument has been criticized on three main grounds.

First criticism

First, it has been observed that in dot-probe trials where the probe is displayed at the location of a threat-related stimulus, short reaction times (positive attentional bias manifested as the difference in RTs between congruent and incongruent trials, e.g. Bar-Haim et al., 2007) may be linked to either vigilance to threat or difficulty in disengaging attention from it (Bar-Haim et al., 2007; see also Koster et al., 2004). The Posner paradigm appears to be better suited for investigation of the disengagement mechanism: since a threat-related or neutral stimulus is displayed briefly in one of two possible locations followed by a probe in one location, slower responses on invalidly cued trials are interpreted as difficulty in disengagement from threat (Fox et al., 2002; Koster et al. 2004; Bar-Haim et al., 2007). Even though according to Bar-Haim et al. (2007) the task was intended to determine the relative proportion of two components of attention, namely engagement and disengagement, it actually only identifies disengagement and is not sensitive to vigilance effects, because only one stimulus precedes the probe on each trial and there is no competition for attentional resources (Fox et al., 2002; Bar-Haim et al., 2007; Klumpp & Amir, 2009). Thus, it may be concluded that while the dot probe task does detect the presence of attentional biases, it cannot determine the specific type of bias observed (Cisler et al., 2009), and in particular it cannot distinguish between vigilance and difficulty in disengagement from threat (Koster et al., 2004).

In response to the limitations of the dot probe task and the Posner paradigm, Koster et al. (2004) proposed a modification of the dot probe task observing that the previous versions of the dot probe task lacked a neutral baseline (neutral-neutral stimuli) with which to compare the reaction times of congruent and incongruent trials. In the original version of the test, RTs were compared only between the latter two types of trials. However, if a baseline were used, RTs on congruent and incongruent trials could be compared with it to check for vigilance to threat and difficulty in attentional disengagement from threat, respectively (Cisler et al., 2009; Cisler & Koster, 2010; see also Shane & Peterson, 2007; Cisler et al., 2009; Klumpp & Amir, 2009). Koster et al. (2004) proposed two methods of analyzing data obtained in tests using the modified dot probe task: a comparison of RTs on congruent and incongruent trials and a comparison of RTs between trials displaying two neutral stimuli and those displaying one neutral and one threatening stimulus. The first analysis determines whether subjects engage with the threatening stimulus (subtraction of RTs on congruent trials from those on incongruent trials gives a positive bias score) or avoid that stimulus (subtraction of RTs on congruent trials from those on incongruent trials gives a negative bias score). The other analysis shows whether a positive attentional bias score reflects vigilance to threat or difficulty in disengagement from threat. Vigilance should yield shorter RTs on congruent trials than on neutral-neutral baseline trials (the difference obtained by subtracting RTs on baseline trials from those on congruent trials should be negative), while difficulty in disengagement from threat should result in longer reaction times on incongruent trials than on baseline trials (the difference obtained by subtracting reaction times on baseline trials from reaction times on incongruent trials should be positive). In the latter case, the longer reaction times on incongruent trials result from the additional time needed to shift attention from a threatening location to a neutral one (Koster et al., 2004; see also Koster et al., 2006) (Figure 2).

Results from studies employing the modified dot probe task have shown that RTs on trials containing a pair of neutral stimuli do not differ from RTs on congruent trials, which suggests that threat-related stimuli do not lead to attentional facilitation. In turn, RTs on neutral-neutral trials are shorter than on incongruent trials, which corroborates difficulty in attentional disengagement from threat (Koster et al., 2004; Koster et al., 2006).

Second criticism

Secondly, it seems that response latencies in the dot probe task provide only a snapshot of the distribution of subjects' attention, with faster responses to probes displayed in the attended location relative to the unattended location (Cooper & Langton, 2006, p. 1322; see also Koster et al., 2004; Mogg & Bradley, 2005; Bar-Haim et al., 2006, 2007; Posner et al., 1980; Navon & Margalit, 1983).

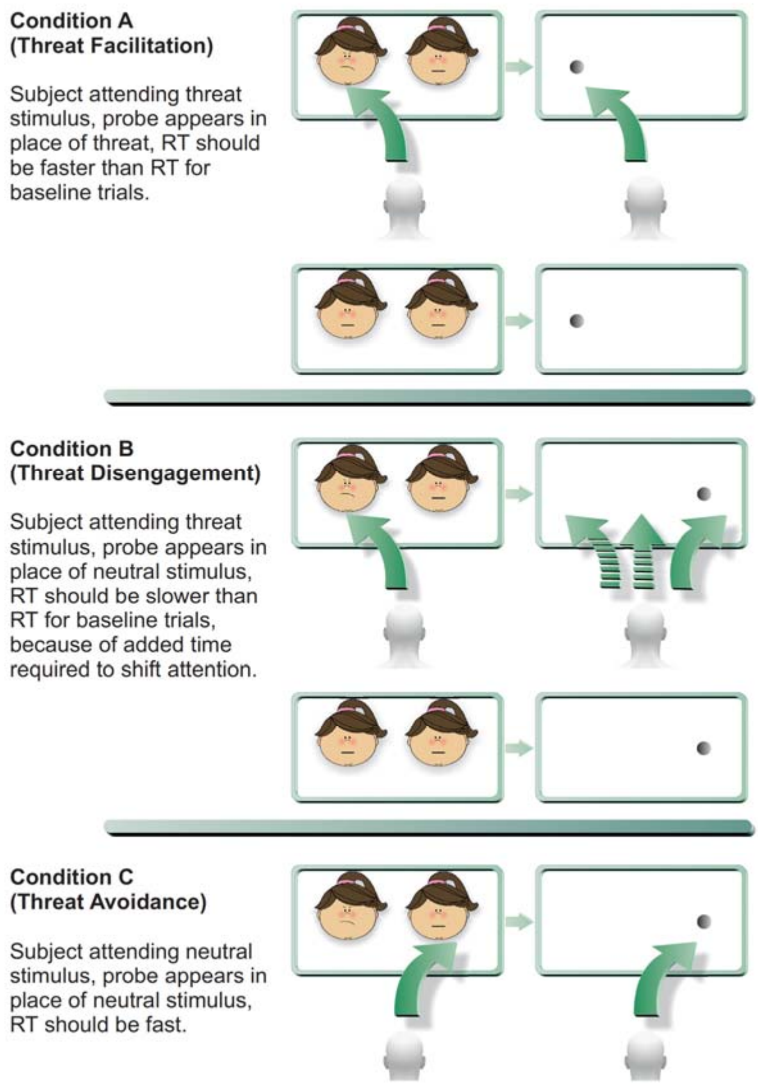

Figure 2. Modification of the dot probe task.

The problem may be elucidated by studying the components of attentional bias using variable stimulus presentation durations (different time intervals between the presentation of a pair of stimuli and a probe, also known as stimulus onset asynchrony). Ouimet et al. (2009; see also Fox et al., 2001) discuss the temporal characteristics of attentional components; according to them attentional orienting occurs at <30 ms, engagement at

30–500 ms, disengagement at 500–1000 ms, and avoidance at >1000 ms. Koster et al. (2004) note that attentional orientation can be studied at <200 ms (e.g., in the dot probe task pictures should not be displayed for more than 200 ms). Calvo and Avero (2005) emphasize that the nature of attentional bias changes over time in the case of processing of emotional pictures. Indeed, research has revealed that a specific component of the observed attentional bias may be the function of exposure time, or stimulus onset asynchrony (this parameter makes it possible to elucidate the time course of attentional allocation, Bar Haim et al., 2007).

Third criticism

Third, Klumpp and Amir (2009) suggest that if a pair of stimuli is displayed for a longer period of time, more than one shift of attention between them may occur. In their objections to the adopted dot probe methodology, Asanowicz and Wolski (2007) argue that at a SOA of 500 ms subjects' reaction times do not reflect the initial orienting toward affective stimulation, because the processes of attentional disengagement, shift, and engagement with a new object proceed much faster, and their direction and strength may change within that time (see also Posner, 1994). Therefore, it seems that at a SOA of 500 ms the dot probe task does not record processes linked to attentional orientation; instead emotional information is processed more thoroughly, due to which disengagement from the stimulus and response to the probe require more time. According to Asanowicz and Wolski (2007), 500 ms is long enough to reorient attention twice; following initial engagement with the emotional stimulus, attention may be shifted to a neutral stimulus. Consequently, while a very short display of affective stimuli triggers an automatic orientation reaction leading to attentional engagement, a longer exposure (500 ms) to affective stimuli does not reflect the processes of attentional orientation, but rather the costs of emotional information processing by the attentional control mechanism. Thus, only very short SOAs afford an insight in the process of initial attentional shifts, which proceed faster than the control processes.

Holas and Brzezicka (2009) argue that anxiety affects preattentive processing and causes heightened detection of threat-related stimuli. In anxious individuals, attention is initially "stuck" to the stimulus (attentional component associated with engagement), which may result in difficulties in disengagement, most often observed at SOAs of 150 to 600 ms. Anxious individuals often avoid looking at threatening stimuli at longer exposure times. This effect has been found in studies tracking eye movements at SOAs of 1500 to 3000 ms. Also Cooper and Langton (2006) report that 500 ms is sufficient time to enable more than one shift in covert attention (i.e., attending to a stimulus without shifting the subject's gaze towards it). Similarly, according to Holas and Brzezicka (2009), 500 ms of stimulus display is sufficient for several attentional shifts between different locations. This is corroborated by Wells and Matthews (1994), who conclude that a SOA of 500 ms or more provides enough time for a strategic shift of attention. Cooper and Langton (2006) note that following 100 ms of face stimulus presentation, the subject's attention is preferentially directed towards the location of threatening faces, while at 500 ms that effect is absent. Furthermore, Fox et al. (2001) and Fox et al. (2002) observe that since in the probe-detection task stimuli are presented in the central visual field, both locations on the screen (top/bottom or right/left) are task relevant, and display time is relatively long (500 ms), attention may be directed to different locations and the subjects may have a tendency to dwell on threat-related stimuli once they have been detected. If this is indeed the case, the traditional probe detection task (with a presentation time of 500 ms) cannot be used to determine whether the threatening stimulus draws attention or rather holds attention once detected (Fox et al., 2001, p. 682). In other words, it is impossible to differentiate between initial vigilance to threat and difficulty in disengagement from it (see Koster et al., 2004; Bar-Haim et al., 2007; Klumpp & Amir, 2009).

In their recent study, Derakshan et al. (2007) investigated the time course of processing emotional information in repressors using the dot probe task and the Posner paradigm. According to these authors, manipulation of stimulus exposure duration enables investigation of the time course of attentional bias, including automatic vigilance to threat upon short exposure times and conscious vigilance towards threat and/or avoidance of threat when exposure times are long. Davidson (1998) described such research efforts as affective chronometry, or "the temporal dynamics of affective responding" (p. 310). It should be noted that while measuring changes in attentional bias over time requires variation in stimulus exposure times, in practice it is difficult to use more than two or three exposure durations (e.g., 100 and 500 ms), without making the task excessively long and fatiguing for participants. Alternatively, one can assess the direction and latency of eye movements in response to emotional stimuli (Mogg & Bradley, 2005). It should be noted here that many researchers have used the eye-tracking paradigm in patients with eating disorders and analogue conditions, obtaining some conflicting results.

As far as body-related stimuli are concerned, while certain patients (especially those with low BMI) exhibited greater attentional engagement with body shape than healthy controls (Blechert et al., 2009; Pinhas et al., 2014), but other experiments failed to produce evidence for such attentional bias (Horndasch et al., 2012, a study of children). Similarly inconclusive results have been obtained for subclinical groups. In this case, inconsistency may be attributed to differences between study groups. Some of the studies in question reported that patients directed increased attention towards their own unattractive body parts (in eating symptomatic participants) (Jansen, Nederkoorn, & Mulkens, 2005; see also Roefs et al., 2008), whereas others indicated avoidance of those stimuli (participants high in body dissatisfaction) (Janelle et al., 2009). Yet another study of overweight subjects (Warschburger et al., 2015) gave the opposite result reporting greater attentional engagement with attractive vs. unattractive regions of one's body. In turn, experiments with stimuli such as pictures of specific body parts (hips and upper legs) and fat body words have consistently revealed vigilance towards those stimuli in subclinical samples in participants with high scores on the Drive-for-Thinness subscale of the Eating Disorder Inventory (EDI) (Garner, 1991) and in weight-dissatisfied individuals (Hewig et al., 2008; Gao et al., 2011, respectively). Furthermore, Cho, Kwak, and Lee (2013) found that healthy participants with high levels of avoidance coping exhibited greater attention towards slim body shapes than subjects with low levels of avoidance coping, especially after exposure to oversized body pictures.

Regarding food stimuli, researchers using the eye-tracking paradigm obtained mixed results, similarly to the case of body stimuli. Giel and co-workers (2011a) failed to produce evidence for greater attentional engagement with food cues in eating-disordered patients. In subclinical groups, the findings have not been conclusive either, as some researchers reported vigilance towards low calorie foods and decreased vigilance towards high calorie foods in overweight participants (Graham et al., 2011), while others found fixation on both high-calorie and low-calorie food items in individuals with nonclinical BED (Popien et al., 2015). According to Werthmann and colleagues (2013a), who studied high and low chocolate cravers, the former group was characterized by a longer initial gaze on chocolate and reduced total dwell time for chocolate stimuli than high cravers. Furthermore, the same research team (2013b) found that normal-weight high-restrained and low-restrained eaters showed attentional biases for food stimuli in comparison to control stimuli, regardless of restraint status. Finally, Folkvord and colleagues (2015) reported that children with a higher gaze duration and faster latency of initial fixation for food cues ate more of the advertised snacks. Undoubtedly, research using the eye-tracking paradigm should be continued because the obtained results, albeit mixed, are very interesting and may provide valuable insights, especially if applied in conjunction with the dot probe task. So far, several studies of this type have been conducted (i.e., Castellanos et al., 2009; Nijs et al., 2010; Werthmann et al., 2011, 2014; Doolan et al.; 2014) (see Table 2). They are discussed at length in the following section on dot probe task research.

Results of dot probe studies with a focus on eating disordered individuals in the context of attentional bias research

The dot probe task was initially used to study populations with anxiety disorders, including Generalized Anxiety Disorder (GAD) (MacLeod et al., 1986) with the findings consistently indicating preferential processing of information linked to potentially threatening stimuli (MacLeod et al., 1986; see also Koster et al., 2004; Asanowicz & Wolski, 2007; Ouimet et al., 2009). It has been found that individuals with anxiety disorders, including GAD, respond faster to probes replacing threat-related stimuli than to those replacing neutral stimuli, even upon subliminal stimulus display. Their reaction times are also shorter than those of individuals in the control group, which seems to prove that persons with anxiety disorders exhibit attentional vigilance for threat (Macleod et al., 1986; Lee & Shafran, 2004; see also Fox et al., 2001; Koster et al., 2004; Szymura, 2007). This is true both for words (e.g., MacLeod et al., 1986; Mogg & Bradley, 2005; Fox et al. 2002) and faces (Bradley et al., 1999; see also Cisler et al., 2009; Cisler & Koster, 2010). It appears that individuals with stronger anxiety tend to select a subsequent source of data taking into consideration the previous threatening stimulus to make sure it does not recur in their selected attentional "window" (Szymura, 2007). The dot probe task has also been used for investigating attentional bias in other anxiety disorders, such as: panic disorder, arachnophobia, and blood-injury phobia (e.g., Wenzel & Holt, 1999; see also Ainsworth et al., 2002) and have usually reported attentional bias toward threat. Moreover, this paradigm has been used in patients with depression (e.g., Platt, Murphy, & Lau, 2015), alcohol dependence (e.g., Sinclair et al., 2016), complicated grief (e.g., Bullock & Bonanno, 2013), psychopathy (e.g., Edalati, Walsh, & Kosson, 2016), insomnia (Spiegelhalder et al., 2010), chronic pain (e.g., Asmundson, Wright, & Hadjistavropoulos, 2005), and asthma (e.g., Fritzsche et al., 2010), as well as in repressors (e.g., Derakshan et al., 2007). Recent years have seen numerous studies using the dot probe task in patients with eating disorders.

This paper reviews the literature concerning attentional bias in eating disorders and analogue conditions, with a particular focus on tests using the dot probe paradigm. Even though this work sets out to characterize a part of the dot probe paradigm rather than offer a systematic overview, relevant studies where sought based on PRISMA recommendations (Moher et al., 2009). Key search terms ("eating disorders", "anorexia nervosa", "bulimia nervosa", "eating", "body shape", "weight", "attention bias", "attentional bias", "information processing", "dot probe task") were used to query the online databases EBSCOhost, Google, PubMed, and ScienceDirect. No limits were set on publication date. In terms of the participants, the inclusion criterion was a diagnosis of clinical or subclinical eating disorder or analogue condition (e.g., obesity, restrained eating); however to obtain a fuller understanding of attentional bias with respect to the health–illness continuum, this review also covered studies involving healthy individuals exposed to experimental manipulation (e.g. fasted vs. fed exposure to eating-, body shape-, and weight-related cues). There was no limit on the age or sex of participants. Initially, 186 papers (168 original articles and 18 reviews) were identified based on the above criteria. Subsequently, the eligibility of studies was evaluated in a two-step process. First of all, taking into consideration the multitude of diverse research results, original studies which did not employ the dot probe task (n=116) were excluded for the sake of clarity of meta-analysis. Ultimately, the original studies included in qualitative synthesis were: 27 articles describing applications of the dot probe task in eating disorders and analogue conditions, 16 works using combined measures in eating disorders and analogue conditions, and 11 papers on applications of attentional bias modification training (ABMT) based on the dot probe task in obese and healthy samples (ABMT was not applied in eating disorders in any of the studies). Second, the present meta-analysis included all of the identified 18 review articles, even if they did not discuss the one-dot probe paradigm, as their rejection would have implied discarding information on some of the most critical developments in attentional bias research in eating disorders and analogue conditions.

Thus to the best of the present author's knowledge, 27 original studies employing the dot probe task on patients with eating disorders (11) and analogue conditions (16) have been published to date (Table 1, appendices).

A brief presentation of the results is given below, complete with a critical discussion pointing to similarities and differences between them.

Several studies on patients with eating disorders have consistently reported attentional bias towards words reflecting a large physique (Rieger et al., 1998), negative eating stimuli (i.e., images depicting high-calorie foods) (Shafran et al., 2007, studies 1 and 2) and negative body shape stimuli (i.e., images reflecting thin models) (Shafran et al., 2007, study 2).

However, those results were not reproduced when the standard inter-stimulus interval (ISI) of 500 ms was changed to 2,000 ms (Lee & Shafran, 2008). Other findings included attentional avoidance of words reflecting a thin physique (which constituted positive body shape stimuli from the perspective of eating disordered individuals) (Rieger et al., 1998) and positive eating stimuli (i.e., images reflecting low-calorie foods) (Shafran et al., 2007). In contrast to the above, in the study of Blechert, Ansorge, and Tuschen-Caffier (2010) anorexic patients exhibited attentional bias towards self-photos (i.e., thin body cues).

In terms of stimuli unrelated to eating disorders, Cardi and colleagues (2013) found that patients with those disorders exhibited attentional bias towards rejecting faces, difficulty disengaging attention from them, and attentional avoidance of accepting faces. In another study, Cardi and colleagues (2014) identified vigilance towards dominant and submissive faces both in eating disordered patients and in individuals recovered from an eating disorder. Hughes-Scalise and Connell (2014) reported attentional bias towards angry faces in eating disordered teens; importantly, in participants with high attentional bias towards angry faces maladaptive parental response to sadness predicted seriousness of the eating disorder. Finally, the study by Schober and colleagues (2014) showed no evidence for a differential attentional bias towards threatening words in patients with anorexia nervosa as compared to healthy controls.

A considerable body of research using the dot probe task has also focused on the outcomes of eating disorder treatments. One study (Shafran et al., 2008, study 2) indicated a decrease in attentional biases for positive and negative eating stimuli following treatment (20 weeks of Cognitive-Behavioral Therapy, CBT). Furthermore, Kim et al. (2014a) reported reduction in vigilance towards eating-related stimuli and negative shape stimuli in anorexic patients treated with oxytocin. Moreover, Kim and colleagues (2014b) found that patients exhibited changed attentional bias for angry faces following oxytocin administration (avoidance of angry faces was replaced with vigilance towards them).

Of particular importance are studies of overweight and obese samples because, although they may not be assigned to any particular group of eating-disordered patients (except for binge eating disorder, BED), they are very close to them in terms of body dissatisfaction, increased anxiety, and excessive attempts at weight control (e.g. Day, Ternouth, & Collier, 2009). Three studies on overweight and/or obese patients were found to use the dot probe task. Loeber et al. (2012) reported that food stimuli did not modulate attention allocation either in obese or in healthy participants at a very early stage of information processing. Very different results were obtained in the other two studies. First, the group of obese participants examined by Kemps, Tiggemann, and Hollitt (2014, study 1) revealed faster RTs to high calorie food than animal words. Second, Oh and Taylor (2013) showed that attentional bias to chocolate images could trigger uncontrolled consumption both in overweight/obese individuals and normal chocolate eaters.

Research conducted on a variety of subclinical and healthy samples provides a very interesting, albeit sometimes contradictory, body of evidence, with discrepancies being probably attributable to differences between the subclinical groups. Some studies have confirmed that problematic food-related beliefs and behaviors are associated with attentional biases towards food cues. For instance, Placanica et al. (2002) reported that high EDI-2 scorers exhibit greater attentional bias towards low-calorie food as compared to low EDI-2 scorers, and greater attentional bias towards low-calorie food when nonfasted as compared to fasted. Brignell and colleagues (2009) found that high-external eating was associated with greater attentional bias for food cues. In another study (Hou et al., 2011), attentional bias towards food pictures was positively correlated with external eating. In subjects with high food neophobia Maratos and Staples (2015) identified greater vigilance towards unfamiliar fruit and vegetable stimuli than in those with low food neophobia. Furthermore, in participants with high hunger Mogg and colleagues (1998) detected attentional bias for food-related stimuli, but only if those stimuli were presented for a longer time (500 ms). Other noteworthy results come from two studies reporting attentional bias for food cues. First, Papies, Stroebe, and Aarts (2008) found that in restrained eaters pre-exposure to food cues elicited an attentional bias towards palatable food words. Second, Shank and colleagues (2015) identified a positive correlation between attentional bias towards highly palatable food and BMI in children with loss of control eating.

Importantly, another group of studies did not reveal differences between subclinical individuals and healthy participants in terms of attentional biases. Glauert et al. (2010) reported that healthy participants exhibited vigilance towards thin bodies for an ISI of both 500 ms and 150 ms and irrespective of whether stimuli (images of thin and fat female bodies) were less or more extreme. In turn, Wilson and Wallis (2013, study 3) did not identify any effect of restrained eating and/or mood on attention processing. Very surprisingly, healthy participants examined by Freijy, Mullan, and Sharpe (2014) revealed attentional bias towards high-calorie pictures, away from high-calorie words, towards low-calorie words, and away from low-calorie pictures.

Finally, one should take note of experimental manipulations in healthy samples. Smith and Rieger (2010) did not detect increased attention towards negative shape/weight words in participants in the body dissatisfaction condition versus negative mood and neutral conditions, but participants in the negative mood condition exhibited increased attention towards negative shape/weight words relative to the body dissatisfaction condition. Similarly, in a study by Hepworth and colleagues (2010) negative mood increased attentional bias for food pictures in healthy participants. In turn, di Pellegrino, Magarelli, and Mengarelli (2011) reported that attentional bias for food eaten decreased from pre- to post-satiety, along with the subjective pleasantness of that food.

In summary, despite certain inconsistency in the reported results, most studies of patients with eating disorders indicated vigilance towards stimuli related to those disorders (e.g., Shafran et al., 2007). Investigations using stimuli unrelated to the disorders (faces) were less consistent: some authors reported vigilance to those stimuli (e.g., Cardi et al., 2013), while others did not find differences between eating disordered patients and healthy controls (e.g., Schober et al., 2014). Nevertheless, it is noteworthy that attentional bias patterns changed after treatment (CBT or oxytocin), resulting in reduced vigilance towards eating-related stimuli (e.g., Shafran et al., 2008, study 2; Kim et al., 2014a).

Studies using the dot probe task in subclinical and healthy samples revealed considerable discrepancies in attentional biases for cues related to eating disorders. While some authors reported vigilance to these stimuli (e.g., Brignell et al., 2009), others did not identify any attentional biases in this respect (Loeber et al., 2012) or did not detect differences between subclinical and healthy participants (e.g., Werthmann et al., 2013b).

Finally, only three studies (i.e. Mogg et al., 1998; Lee & Shafran, 2008; Glauert et al., 2010), explored the relationship between ISI and attentional bias, so further research in this area is needed.

Of note are also studies employing the dot probe task and other paradigms. To the best of the present author's knowledge, sixteen papers on the subject have been published to date, including one on eating disordered patients and fifteen on subclinical and healthy samples (Table 2, appendices).

The only such study involving patients with eating disorders was conducted by Chamberlain and co-authors (2012), who examined subjects with BED before and after treatment. Although they proved that GSK1521498 (a selective mu-opioid receptor antagonist) at 5 mg/day significantly reduced attentional bias for food pictures (dot probe task) versus placebo at longer stimulus duration (2000 ms), the treatment had no effect on the Stroop task.

Similarly as in the case of studies using exclusively the dot probe paradigm, one should separately analyze reports on overweight and obese samples. To the best of the present author's knowledge, to date 7 studies of this type have been carried out. A study using the eye-tracking paradigm (Castellanos et al., 2009) reported increased gaze duration for food compared to non-food images in the fasted condition both in obese and healthy participants, but no attentional bias was found for cues related to an eating disorder on the dot probe task. Nijs and co-authors (2010), who investigated both obese/overweight and healthy participants, identified enhanced automatic orientation towards food cues in hungry versus satiated participants, and in overweight/obese versus normal-weight individuals, but only on the dot probe task. Furthermore, in the same study Nijs and co-authors (2010) observed increased intentional allocation of attention to food pictures in hunger versus satiety, but only using event-related potentials (ERP). At the same time, they did not find differences between obese and healthy participants in eye-tracking data. Werthmann et al. (2011) obtained statistically significant results only for experiments involving the eye-tracking paradigm, but not the dot probe task. In overweight (versus healthy) participants they detected more frequent initial gazing towards food pictures, accompanied by subsequent reduced maintenance of attention on those pictures. Furthermore, according to Werthmann and colleagues (2011) craving was related to initial orientation towards food. Doolan et al. (2014), who employed both the dot probe task and the eye-tracking paradigm, obtained statistically significant results only for the latter: both overweight/obese participants and healthy participants showed greater attentional bias towards high-energy-density (vs. low-energy-density) food images regardless of hunger condition. A study of both obese and healthy participants by García-García et al. (2013) reported higher reaction times both for food and rewarding non-food stimuli (dot probe task) and decreased activation of the bilateral occipital lobe, lateral prefrontal cortex, medial prefrontal cortex, precentral gyrus, paracingulate gyrus, anterior cingulate gyrus, precuneous/posterior cingulate cortex, and lateral occipital cortex (functional magnetic resonance imaging MRI). One should also mention works which did not identify any statistically significant effects. In a study of obese and overweight patients, low- and high-restrained eaters and healthy participants, Ahern and colleagues (2010) did not find any differences in attentional bias for food-related images on the dot probe task or in approach tendencies elicited by food images on the stimulus-response compatibility task. Nathan et al. (2012), who examined overweight/obese participants using the Stroop task and the dot probe task, did not report any effects of the D3 receptor antagonist GSK598809 on attentional bias.

Interestingly, many studies involving subclinical and healthy groups, combining the dot probe task with other paradigms identified attentional bias for stimuli related to an eating disorder using one of the measures, but not the other. For instance, Boon, Vogelzang, and Jansen (2000) did not find any attentional bias for food and weight/shape stimuli on the dot probe task, but identified such bias towards food stimuli on the word recognition task. In turn, in a dot probe task study carried out by Johansson, Ghaderi, and Andersson (2004) individuals high in responsiveness to external food cues exhibited avoidance of food words, while those low in responsiveness revealed vigilance towards food words; at the same time no attentional bias was detected for food or body words on the Stroop task. Calitri and colleagues (2010) did not find any effects of cognitive bias (as measured by the dot probe task) on weight change over a one-year period, but reported that cognitive bias (as measured by the Stroop task) towards unhealthy foods predicted an increase in BMI whereas cognitive bias towards healthy foods was associated with a BMI decrease.

Only one study reported statistically significant results for all (in this case - two) paradigms used. In the study employing the dot probe task and the eye-tracking paradigm in healthy participants, Werthmann and co-workers (2014) found that self-reported emotional eating did not account for changes in attention allocation for food or food intake and that in participants in neutral condition attention, maintenance on food cues was significantly related to increased intake in contrast to the sad mood condition.

Some other studies used the dot probe task in conjunction with paradigms designed to examine inhibitory control. Loeber and colleagues (2013), who used the dot probe task and a go/no-go task, identified an influence of self-reported hunger on behavioral response inhibition. Interesting results were reported by Kakoschke, Kemps, and Tiggemann (2015), who applied three tools: the dot probe task, an approach-avoidance task, and a food-specific go/no-go task. They found that in healthy participants neither attentional nor approach bias alone made a significant contribution to food intake (dot probe task, approach-avoidance task). On the other hand, they detected a significant effect of the interaction between approach bias (approach-avoidance task) and inhibitory control (food-specific go/no-go task) on unhealthy snack food intake. Participants who showed a strong approach bias combined with low inhibitory control consumed the most snack food. While Lattimore and Mead (2015) obtained interesting results with the dot probe task, such as slower disengagement from pictorial food stimuli (for 2000 ms duration) in high-impulsive participants and faster detection of pictorial food cues (for 500 ms duration) in low-impulsive participants, differences on the go/no-go task were not statistically significant. Pothos et al. (2009), who used the Stroop task, the dot probe task, a recognition task, and the extrinsic affective Simon task, found that correlations between the various cognitive measures were weak and evident only in certain subsets of the population sample, as defined by gender and emotional-, restrained- and external-eating characteristics of healthy participants.

In summary, the use of the dot probe task in conjunction with other paradigms has led to mixed results. Some studies employing that research pattern (e.g., Castellanos, 2009) reported statistically significant results for one of the tests only, while others (e.g., Nathan et al., 2012) did not obtain any significant findings whatsoever. Only a few studies (i.e., García-García et al., 2013; Werthmann et al., 2014) yielded statistically significant results on all the measures applied. Studies focused on inhibitory control were also inconclusive (e.g., Lattimore & Mead, 2015). Hence, the question arises as to what is actually measured by those tools, especially in light of the seminal work by Pothos and co-authors (2009), which revealed poor correlations between the various tests (Stroop task, dot probe task, recognition task, extrinsic affective Simon task). Perhaps the best solution would be to use only one methodologically sound measure of attentional bias?

Despite the above-mentioned difficulties, one should carefully consider systematic reviews and meta-analyses focused on the results of attentional bias tests in eating disorders and analogue conditions. To the best knowledge of the present author, eighteen papers of this kind have been published to date, thirteen of which included results from patients with eating disorders (Table 3, appendices).

Most reviews of works involving patients with eating disorders (beside other groups) were devoted to analysis of results produced by different paradigms. Exceptions were reported in five papers. Aspen, Darcy, and Lock (2013) and Renwick, Campbell, and Schmidt (2013a) analyzed four and twelve dot probe task studies, respectively. The conclusions were that patients with eating disorders exhibited attentional bias towards negative eating disorder-related stimuli (greater for negative eating-related than shape-related stimuli) and away from positive eating disorder-related stimuli (Aspen et al., 2013; Renwick et al., 2013a). Second, these patients were characterized by attentional bias towards rejecting faces and disengagement from accepting faces (Renwick et al., 2013a). Two papers were devoted to studies using the Stroop task only (Dobson & Dozois, 2004; Johansson, Ghaderi, & Andersson, 2005). According to Dobson and Dozois (2004), who reviewed 26 papers, patients with anorexia nervosa are characterized by attentional bias for body/weight stimuli, while patients with bulimia nervosa additionally exhibit attentional biases for food and neutral stimuli. In another work analyzing 27 studies, Johansson and colleagues (2005) came to the conclusion that patients with anorexia nervosa exhibit greater Stroop interference for food than for body words while bulimic patients are characterized by moderate Stroop interference for body and food words. Finally, Zhu et al. (2012) offered a meta-analysis of 17 studies using fMRI in patients with anorexia nervosa and found that negative emotional arousal was related to cognitive processing bias of food and body stimuli.

Additionally, in their review covering 31 studies employing the dot probe task and the Stroop task Lee and Shafran (2004) suggested that eating disordered patients exhibit greater Stroop interference for food and shape words than healthy controls. Moreover patients with anorexia nervosa reveal Stroop interference for food, body, and size words and vigilance towards positive emotional words. On the other hand, patients with bulimia nervosa are characterized by Stroop interference for food, shape, weight, body and ego threat words and avoidance of positive emotional words. Generally, findings for anorexia nervosa seem to be more consistent than for bulimia nervosa.

The other twelve publications analyzed studies using multiple paradigms (see Table 3, appendices), leading to the following conclusions. First, patients with anorexia nervosa and bulimia nervosa exhibit attentional bias for disorder-relevant (food, body shape, and body weight) words, but results across various studies are inconsistent (Duchesne et al., 2004, meta-analysis of 19 papers). Second, those patients reveal hypervigilance towards high calorie food pictures and avoidance of low-calorie food images; in addition anorexic patients are characterized by greater Stroop interference than bulimic patients (Brooks et al., 2011, meta-analysis of 43 studies). In their review of 15 works, Giel and colleagues (2011b) argued that they consistently prove attentional bias for food pictures in patients with eating disorders. In turn, Oldershaw and co-authors (2011), who reviewed 13 studies, concluded that attentional bias towards food, shape, and weight stimuli extends to emotional stimuli and patients with eating disorders exhibit greater attentional bias towards social threat words than healthy controls. Attentional bias towards threat appears to be most specific to anorexia nervosa, while threat avoidance is linked to bulimia nervosa. Having analyzed 66 studies, Lydecker (2013) proposed that patients with eating disorders are susceptible to an interference effect of eating-disorder relevant words and identified certain associations between attention and core eating disorder symptomatology. Werthmann, Jansen, and Roefs (2015), who reviewed 30 reports, observed inconsistent results for eating-disordered patients in comparison to non-clinical groups and no significant differences in attentional bias for food cues between restrained eaters and unrestrained ones. In one of the latest meta-analyses, involving 21 studies, Wolz and colleagues (2015) found a consistent attentional bias towards food pictures vs. neutral pictures for patients and control groups, while group comparisons between individuals with abnormal eating and healthy eating participants were inconsistent.

To the best of the present author's knowledge, five meta-analyses did not involve patients with eating disorders. Nijs and Franken (2012), who reviewed seven papers, identified a specific pattern of attention to food stimuli in the group of overweight/obese participants. Doolan and colleagues (2015), who analyzed eight papers, claimed that in obese participants there is a positive correlation between reaction time bias scores and food craving scores and in overweight/obese participants there is increased gaze direction bias to food images as compared with healthy controls. In turn, Hendrikse et al. (2015) reported that only four out of nineteen studies supported the notion of enhanced reactivity to food stimuli overweight/obese individuals. Asmaro and Liotti (2014), who reviewed 33 papers devoted to fMRI and event-related potentials (ERP), reported that stimuli related to high-calorie food activated brain areas involved in reward processing, which were similar to those activated in substance users viewing drug-related stimuli. Finally, of special note is the review by Pool and co-authors (2016), which incorporated data from 243 reports, of which 58 employed the dot probe task. While no studies involving participants with eating disorders or analogue conditions were analyzed, some investigations did use food-related stimuli. The review suggested the occurrence of attentional biases towards positive stimuli as opposed to neutral ones.

Summing up the review results, it should be stressed that their conclusions are quite divergent. These discrepancies may be partially attributed to differences in the number of studies analyzed (from 4 to 66, except for Pool et al., 2016). Meta-analyses involving patients with eating disorders consistently showed the presence of attentional bias towards negative eating disorder-related stimuli (i.e., Duchesne et al., 2004; Lee & Shafran, 2004; Giel et al., 2011b; Aspen et al., 2013; Lydecker, 2013; Renwick et al., 2013a; see also Brooks et al., 2011) and away from positive eating disorder-related stimuli (i.e., Aspen et al., 2013; Lydecker, 2013; Renwick et al., 2013a; see also Brooks et al., 2011). However, there are considerable discrepancies between the results of meta-analyses in terms of the type of stimuli. While according to Dobson and Dozois (2004) patients with anorexia nervosa exhibit an attentional bias for body/weight stimuli and those with bulimia nervosa additionally reveal attentional biases for food cues, Johansson and colleagues (2005) concluded that patients with anorexia nervosa are characterized by greater attentional bias (Stroop interference) for food than for body words. Moreover, Oldershaw and colleagues (2011) suggested that attentional bias towards food, shape, and weight stimuli extends to emotional stimuli and patients with eating disorders exhibit greater attentional bias towards social threat words than healthy controls. Importantly, Lydecker (2013) observed associations between attention and core eating disorder symptomatology. Unfortunately, Werthmann and colleagues (2015) reported inconsistent results for eating-disorder patients in comparison to non-clinical groups. Also some other researchers (i.e., Wolz et al, 2015) found that attentional biases towards food pictures occur both in patients with eating disorders and in healthy controls; moreover, group comparisons between individuals with abnormal eating and healthy eating participants were inconsistent. Meta-analyses which did not involve patients with eating disorders suggested a specific pattern of attention to food stimuli in the group of overweight/obese participants (Nijs & Franken, 2012), which is vigilance to food images (linked to food craving scores) (Doolan et al., 2015), while Hendrikse and colleagues (2015) reported that some studies confirmed attentional bias to these stimuli in overweight/obese individuals. Very promising are meta-analyses of studies using psychophysiological measures (Zhu et al., 2012; Asmaro and Liotti, 2014), which corroborate reports from meta-analyses on experimental tasks evaluating attentional bias.

Attentional Bias Modification Treatment as an interesting treatment option for patients with eating disorders

As the efficacy of existing treatments for patients with eating disorders, including CBT, has been found unsatisfactory (e.g., Zipfel et al. 2014), efforts have been undertaken to develop novel, more effective therapy options. Several interesting methods have been designed on the basis of the cognitive approach to eating disorders.

For several years now, intensive studies have been under way on neurocognitive deficits in the executive function involving a set of neuropsychological processes primarily centered in prefrontal regions and governing higher-level, goal-directed behavior. The existing body of research suggests that impairments in this function, particularly in the domains of set-shifting (e.g., Tchanturia et al., 2011), central coherence (e.g., Lopez et al. 2009), inhibitory control (e.g., Wu et al., 2013), and working memory (e.g., Svaldi, Brand, & Tuschen-Caffier, 2010) are related to the development and maintenance of disordered eating behavior. These observations formed the basis for developing neurocognitive training known as cognitive remediation therapy (CRT) (e.g., Tchanturia, 2014) consisting of cognitive flexibility training, inhibitory control training, and working memory training. CRT shows initial promise for improving executive function, though more research is needed to establish whether these programs result in symptom reduction or greater responsiveness to conventional behavioral treatment (Juarascio et al., 2015).

Another interesting treatment option for patients with eating disorders is Attentional Bias Modification Treatment (ABMT). Although Bar-Haim (2010), who initiated work on the program, used the initialism ABM (attentional bias modification), this work has adopted ABMT for the sake of clarity, following the practice of Renwick et al. (2013a) and Renwick, Campbell, and Schmidt (2013b). ABMT is a novel method of treating anxiety disorders that arose from contemporary cognitive theories of anxiety and from experimental studies concerning threat-related attentional biases in anxiety disorders (Bar-Haim, 2010). In the ABMT protocol using the dot probe task, the location of the target probes is manipulated to increase the proportion of trials with targets appearing at the location of the intended training bias. For example, in attentional training aimed to induce attentional bias away from threat and towards neutral stimuli, targets would appear more frequently at the location of the neutral stimulus rather than threat. Researchers assume that a bias away from threat is gradually induced with the systematic repetition of trials, typically hundreds of times (Bar-Haim, 2010; see Figure 3).

Indeed, ABMT is a promising method for the treatment of anxiety disorders. Many researchers have shown that it leads to considerable reduction in anxiety symptoms, remission, and continued beneficial treatment effects for at least four months following the treatment course (Mathews & MacLeod, 2002; see also MacLeod et al., 2002; Shafran et al., 2008; Amir et al., 2009; Schmidt et al., 2009; Hoppitt & Mackintosh, 2009, see also Lopes, Viacava, & Bizarro, 2015).

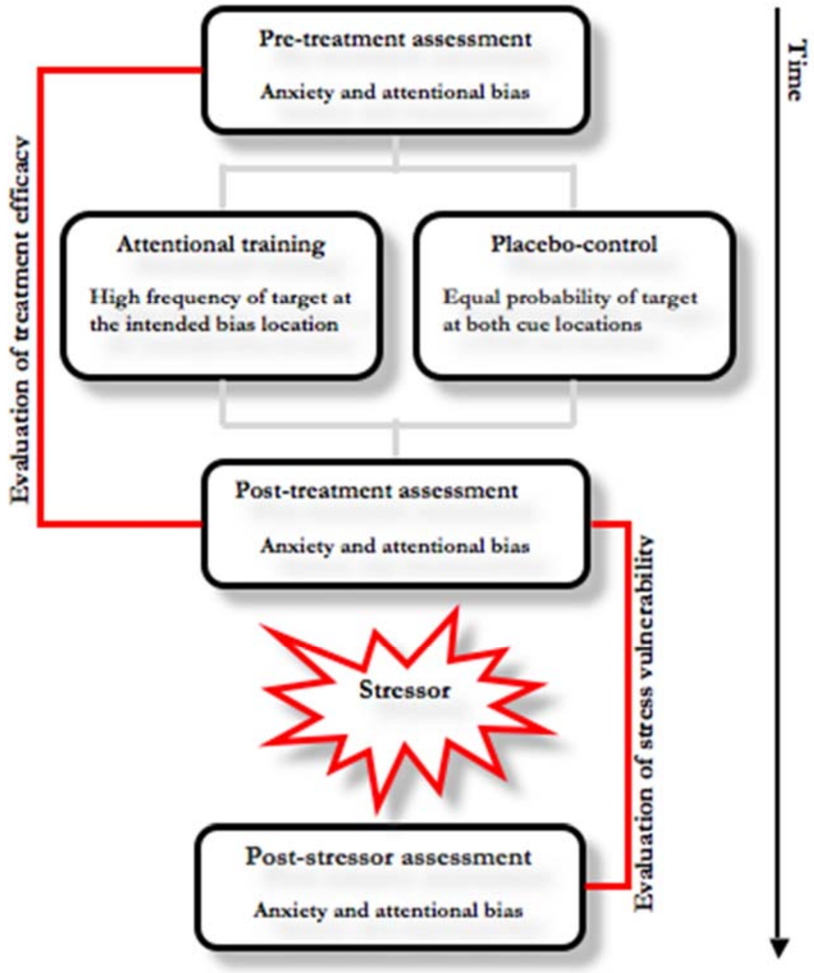

Figure 3. Schematic of attentional bias modification study evaluating treatment efficacy and stress vulnerability (source: Bar-Haim, 2010, p. 861, with the publisher's permission).

Since anxiety is considered to play a major role in the development and maintenance of eating disorders, ABMT should be widely used in patients suffering from such disorders (Renwick et al., 2013a, b). Until several years ago, when very few papers on attentional bias in eating disorders were available, it may be said to have prevented the application of the dot probe task in the treatment of eating disorders. However, recent years have seen a proliferation of studies using the dot probe task in individuals with eating disorders and analogue conditions (Tables: 1, 2, see also table 3). To the best of the present author's knowledge, a total of ten reports have been published on ABMT effectiveness. Only two of them involved patients with clinical eating disorders (anorexia nervosa and binge eating disorder – Cardi et al., 2015 and Boutelle et al., 2016, respectively), while the others were conducted on individuals with subclinical eating conditions and healthy subjects (Table 4, appendices).

Although the last group of studies should be regarded as preliminary, they indicate that such interventions are effective: attentional bias for food increased in the "attend" group and decreased in the "avoid" group (Boutelle et al., 2014, 2016; Kakoschke, Kemps, & Tiggemann, 2014; Kemps, Tiggemann, & Hollitt, 2014 study 2; Kemps et al., 2014; Kemps, Tiggemann, & Elford, 2015; Kemps, Tiggemann, & Hollitt, 2016). Moreover, participants who are trained to attend to negative shape/weight-related stimuli are more likely to develop body dissatisfaction and more prone to dietary restraint when exposed to a body image challenge as compared with participants trained to attend to positive stimuli (Smith & Rieger, 2006, 2009). Additionally, Cardi and co-authors (2015) found that in patients with AN this type of training led to a moderate increase in attention to positive faces, accompanied by both lower levels of anxiety and higher self-compassion in response to a judgmental video clip.

Admittedly, it is far from obvious whether ABMT results could be generalized to real-life contexts, but this question may be addressed using an approach similar to CBT and CRT, in which the abilities acquired by the patient are practiced in real life as behavioral experiments (Tchanturia & Hambrook, 2010). In the case of ABMT such experiments would provide an opportunity to implicitly retrain early attention orientating which happens outside conscious control. However, it should be remembered that this route of translating newly acquired skills into everyday situations may be more difficult than in the case of the other two treatment methods, which rely on the individual's ability to utilize effortful attention control strategies. Nevertheless, behavioral experiments involving ABMT can be conducted, and are indeed necessary.

Designing attentional training for eating disordered patients requires thorough investigation of the time course of attentional allocation in this group. For this purpose, it is necessary to develop a novel modification of the dot probe task to distinguish between all three components of attention. Results obtained with such a tool should enable a comprehensive description of the temporal aspects of attention in patients with eating disorders and development of an appropriate training protocol with a view to alleviating their conditions. It remains to be established whether ABMT can be used as a stand-alone treatment or whether it will be more effective when used as adjunct to more traditional psychological interventions.

Summary

For many years now researchers have endeavored to determine the etiology of eating disorders and discover how they are maintained. Recently, an increasing focus has been directed to the cognitive approach, including selective attention. There is robust evidence that eating disordered individuals display an attentional bias for eating disorder-salient stimuli. Scholars have at their disposal a wide array of measures which have been successfully deployed in studies on fear. The attentional bias test most frequently used on patients with eating disorders is the Stroop test, which is unfortunately fraught with some shortcomings and it is debatable whether it actually measures attentional bias or distraction. One of the most promising measures of attentional bias, which is increasingly often used in eating disorder research, is the dot probe task. Again, the popularly used version of this tool has a number of shortcomings; for instance, the obtained results do not permit a distinction between the various components of attention (i.e., vigilance to relevant stimuli vs. difficulty disengaging attention from those stimuli). The modification introduced by Koster and colleagues (2004) is particularly promising as it solves the problem by means of baseline trials (with both stimuli being neutral). On the one hand, meta-analyses concerning the dot probe task in patients with eating disorders and analogue conditions indicate that this task needs to be methodologically perfected (it sometimes leads to inconclusive results). On the other hand, the rapidly increasing numbers of studies in this area make it possible to attain a more comprehensive view of attentional bias in this group of patients. In recent years, it has been suggested that the dot probe task could be used as a tool for training attentional bias in eating disordered patients (e.g., Renwick 2013a,b). Some researchers (e.g., Kemps et al., 2016) have already successfully undertaken such efforts (albeit only on subclinical groups). Indeed, this type of attention training has been found to result in very good outcomes. It should be emphasized that the use of such an intervention in eating disorders, whether as a stand-alone treatment or as an adjunct to the standard therapy, offers promising prospects to the patients as long as the training is designed to include all components of attentional bias.

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APPENDICES

Table 1. Attention bias in eating disorders and analogue conditions – dot probe task studies

Reference	Subjects*	N	Stimuli	Main findings
Studies in clinical samples				
Rieger et al. (1998)	ED: -AN -BN RES	 16 17 32	Stimulus words reflecting a thin, a large physique and positively or negatively valenced emotion words	ED: -Trend attentional bias towards words reflecting a large physique, -Attentional bias away from words reflecting a thin physique. AN: -Trend attentional bias towards words reflecting a large physique. BN: -Trend attentional bias away from words reflecting a thin physique. RES: -No attentional bias.
Shafran et al. (2007) Study 1	ED: -AN -BN -EDNOS Anxious HC: -Low -Moderate -High shape concerns	 3 6 14 19 31 21 23	Food, shape pictures (positive, neutral and negative), weight pictures (all neutral) and control pictures (positive, neutral, negative)	ED: -Attentional bias towards negative eating stimuli and neutral weight stimuli, -Avoidance of positive eating stimuli, -No attentional bias for shape stimuli and neutral eating stimuli, -Greater attentional bias for positive eating stimuli than in all comparison groups, -Greater attentional bias for negative eating stimuli than in anxious, moderate and low shape concern controls, -No attention bias for positive, negative and neutral shape stimuli across groups, -Greater attention bias for neutral weight stimuli than in all comparison groups.
Shafran et al. (2007) Study 2	ED: -AN -BN -EDNOS (BED) -EDNOS (other) HC	 5 27 6 44 44	Food, shape pictures (positive, neutral and negative), weight pictures (all neutral) and control pictures (positive, neutral, negative)	ED: -Attentional bias towards negative eating stimuli, negative and neutral shape stimuli and neutral weight stimuli, -Attentional bias away from positive eating stimuli, -Greater attentional bias for positive and negative eating stimuli than for HC, -Greater attentional bias for negative shape stimuli than for HC, -Greater attentional bias for weight stimuli than for HC. ED and HC: -No differences in attentional bias for positive or neutral shape stimuli.

Table 1. *Continued*

Reference	Subjects*	N	Stimuli	Main findings
Lee and Shafran (2008)	ED: -AN -BN -EDNOS Anxious HC: -Low -Moderate -High shape concerns	 3 6 14 19 31 21 23	Food, shape pictures (positive, neutral and negative), weight pictures (all neutral) and control pictures (positive, neutral, negative)	ED: -Attentional bias towards negative eating stimuli, negative and neutral shape stimuli and neutral weight stimuli when Inter-Stimulus Interval (ISI)=500 ms, -Attentional bias away from positive eating stimuli when ISI=500 ms, -Attentional bias towards neutral weight stimuli when ISI=2,000 ms.
Shafran et al. (2008) Study 1	ED: -AN -BN -EDNOS (BED) -EDNOS (other) HC	 5 27 6 44 44	Food, shape pictures (positive, neutral and negative), weight pictures (all neutral) and control pictures (positive, neutral, negative)	ED: -Attentional bias towards negative eating stimuli, negative and neutral shape stimuli and neutral weight stimuli, -Attentional bias away from positive eating stimuli, -Greater attention bias for positive and negative eating stimuli than for HC, -Greater attention bias for negative shape stimuli than for HC, -Greater attention bias for weight stimuli than for HC. ED and HC: -No differences in attentional bias for positive or neutral shape stimuli.
Shafran et al. (2008) Study 2	ED (before and after 20 weeks of CBT): -BN -EDNOS (BED) -EDNOS (other) ED-Waiting List Controls	 13 6 12 24	Food, shape pictures (positive, neutral and negative), weight pictures (all neutral) and control pictures (positive, neutral, negative)	ED: -Decrease in attentional biases for positive and negative eating stimuli following treatment, -Decrease in attentional bias for weight stimuli following treatment.
Blechert, Ansorge, and Tuschen-Caffier (2010)	ED: -AN -BN HC	 19 18 21	Self and other body photos	AN: -Attentional bias towards self-photo. BN: -Nonsignificant attentional bias towards other photos. HC: -No attentional bias.

Table 1. ***Continued***

Reference	Subjects*	N	Stimuli	Main findings
Cardi et al. (2013)	ED: -AN -BN ANRec BNRec HC	 29 17 13 9 50	Faces expressing rejection and acceptance, neutral faces	ED: -Attentional bias towards rejecting faces, -Difficulty disengaging attention from rejecting faces, -Sustained attentional avoidance of accepting faces, -No significant differences between AN and BN. ANRec and BNRec: -Similar pattern to ED: no significant differences between ANRec and BNRec. HC: -Attentional bias towards accepting faces, -Difficulty disengaging attention from accepting faces, -Sustained attentional avoidance of rejecting faces. ED and HC: -Attentional bias towards rejection was correlated with adverse childhood experiences.
Cardi et al. (2014)	ED EDRec HC	46 22 50	Grey-scale pictures of neutral faces and social rank stimuli, i.e. dominant and submissive faces of different people (males and females)	ED and EDRec: -Vigilance towards dominant and submissive faces. HC: -Attentional disengagement from dominant and submissive faces, -Vigilance towards neutral faces.
Hughes-Scalise, and Connell (2014)	ED <18 ChP <18	25 25	Emotional faces: happy, sad and angry	ED: -Attentional bias towards angry faces moderated the relationship between parental response to sadness and teen ED status: for teens with high attentional bias towards angry faces, maladaptive parental response to sadness predicted seriousness of ED status versus chronic pain status.
Kim et al. (2014a)	AN (the oxytocin condition and the placebo condition) HC (the oxytocin condition and the placebo condition)	31 33	Food, weight, and shape images	AN: -Reductions in vigilance towards eating-related stimuli and towards negative shape stimuli under the influence of oxytocin. HC: -No changes.

Table 1. ***Continued***

Reference	Subjects*	N	Stimuli	Main findings
Kim et al. (2014b)	AN (the oxytocin condition and the placebo condition) HC (the oxytocin condition and the placebo condition)	31 33	Social faces representing anger, disgust, and happiness	AN: -Avoidance of angry faces under the placebo condition, -Changed attentional bias for angry faces after administration of oxytocin (avoidance of angry faces before the administration of oxytocin and vigilance towards angry faces after the administration of oxytocin). AN and HC: -Attentional bias towards disgust faces under the placebo condition, -Reductions in attentional bias towards disgust faces under the oxytocin condition, -No attentional bias for happy/smiling faces under either the placebo or oxytocin conditions. HC: -Vigilance towards angry faces under the placebo condition, -Reduced vigilance towards angry faces after administration of oxytocin.
Schober et al. (2014)	AN: -AN-R -AN-BP -EDNOS-AN HC	 20 17 12 44	Threatening words (denoting negative emotional states, physical illness or death, catastrophe/trauma/victimization) and control words	AN: -No evidence for a differential attentional bias for threatening words as compared to HC.
Studies in overweight and obese samples				
Loeber et al. (2012)	OB: -Females -Males HW: -Females -Males	 13 7 13 7	Food words and control words	Food stimuli did not modulate attention allocation in a very early stage of information processing.
Oh and Taylor (2013)	OW/OB regular chocolate eaters: -after 24 h abstinence -after ≥1 week abstinence during Lent Normal chocolate eaters	 21 17 20	Chocolate and control images	-Attentional bias to chocolate images can trigger uncontrolled consumption, - Lower vigilance towards chocolate images after exercise than after the rest, -Similar effect for normal chocolate eaters and OW/OB, -Similar effects after restraint for eating chocolate for 1day and 1week.
Kemps, Tiggeman, and Hollitt (2014) Study 1	OB HW	58 58	Food (high and low calorie) words and neutral, control (animal) words	OB: -Faster RT for high calorie food words than for animal words. HW: -No attentional bias.

Table 1. *Continued*

Reference	Subjects*	N	Stimuli	Main findings
Studies in subclinical and healthy samples				
Mogg et al. (1998)	HP (low and high hunger): -Females -Males	 16 16	Food-related words and control, transport-related words	HP (low hunger): -No attentional bias for brief (14 ms) and longer (500 ms) duration food-related stimuli. HP (high hunger): -Attentional bias for food-related stimuli when presented for longer duration only (500 ms).
Placanica, Faunce, and Soames Job (2002)	HP (fasted and nonfasted): -Low EDI-2 scorers -High EDI-2 scorers	 19 19	High-calorie food, low-calorie food, negative shape/weight, positive shape/weight and control, household-related and transport-related words	High and low EDI-2 scorers: -No vigilance towards negative and positive shape/weight stimuli. Low EDI-2 scorers: -Greater attentional bias towards high-calorie foods when fasted compared with nonfasted. High EDI-2 scorers: -Greater attentional bias towards low-calorie food compared with low EDI-2 scorers, -Greater attentional bias towards low-calorie food when nonfasted compared with fasted.
Papies, Stroebe, and Aarts (2008) Study 1	HP (RES and uRES): -Females -Males	 79 25	Food words, palatable food words and control words	RES and uRES: -No selective attention for control words. RES: -The pre-exposure to food cues elicited an attentional bias for palatable food, -Higher hedonic ratings of palatable food were associated with increased selective attention for these food items. uRES -No shifts in selective attention.
Papies, Stroebe, and Aarts (2008) Study 2	HP (RES and uRES): -Females -Males	 98 40	Food words, palatable food words and control words	The results of Study 1 were replicated. Additional results RES: -Attentional bias for palatable food did not emerge when they were exposed to subliminally presented diet words after the pre-exposure to food cues.

Table 1. *Continued*

Reference	Subjects*	N	Stimuli	Main findings
Brignell et al. (2009)	HP: -Females -Males -Low external eaters -High external eaters	 44 11 24 19	Food and control stimuli pictures	High-external eating was associated with a greater attentional bias for food cues, as well as with a bias to evaluate them more positively.
Glauert et al. (2010) Study 1	HP	50	Images of thin and fat female bodies (extreme stimuli)	-Vigilance towards thin bodies when ISI=500 ms, -This attentional bias existed regardless of how dissatisfied women were with their bodies.
Glauert et al. (2010) Study 2	HP	50	Images of thin and fat female bodies (extreme stimuli)	-Vigilance towards thin bodies when ISI=150 ms, -This attentional bias existed regardless of how dissatisfied women were with their bodies.
Glauert et al. (2010) Study 3	HP	50	Images of thin and fat female bodies (less extreme stimuli)	-Vigilance towards thin bodies when ISI=150 ms, - Attentional bias was significantly negatively correlated with both body dissatisfaction and BMI, -The significant correlation between attentional bias and body dissatisfaction was eliminated when BMI was controlled, -The significant correlation between BMI and attentional bias was eliminated when body dissatisfaction was controlled.
Hepworth et al. (2010)	HP: -The negative mood condition -The neutral condition	 40 40	Food and control pictures	-Negative mood increased both attentional bias for food pictures and subjective appetite, -Attentional bias and subjective appetite were positively inter-correlated, -Attentional bias was associated with external and restrained eating.
Smith and Rieger (2010)	HP (the body dissatisfaction condition, the negative mood condition, and the neutral condition)	54	Negative shape/weight words, control words	HP in the body dissatisfaction condition: -No increase in attention towards negative shape/weight words compared with the negative mood and neutral conditions. HP in the negative mood condition: -Increase in attention towards negative shape/weight words relative to the body dissatisfaction condition.
di Pellegrino, Magarelli, and Mengarelli (2011)	HP (before satiation and after satiation)	26	Food and control pictures	-Attentional bias for food eaten decreased from pre- to post-satiety, along with the subjective pleasantness for that food, -Subjective pleasantness and attentional bias for the food not eaten did not show any such decrease.

Table 1. ***Continued***

Reference	Subjects*	N	Stimuli	Main findings
Hou et al. (2011)	HP (with high or low external eating scores): -Females -Males	 29 13	Food and control stimuli pictures	-Attentional bias towards food cues correlated positively with external eating, -Attentional bias for food cues was positively related to trait impulsivity, -Attentional bias for food cues remained related to attention impulsivity after controlling for external eating.
Wilson and Wallis (2013) Study 1	HP: -LRES -HRES	 31 29	Food and control pictures	-No evidence of attentional orientation or disengagement, -Slight attentional avoidance of food-related pictures.
Wilson and Wallis (2013) Study 2	HP: -LRES -HRES	 31 29	Food and control pictures (based on ratings)	No evidence of attentional bias.
Wilson and Wallis (2013) Study 3	HP: -Negative mood -Neutral mood	 38 39	Food and control pictures (based on additional ratings)	-No evidence of attentional bias, -No effect of restrained eating and/or mood on attention processing.
Freijy, Mullan, and Sharpe (2014)	HP	99	Word and pictorial food (high-calorie and low-calorie) stimuli	-No main effects for stimuli type (pictures vs words) or calorific value (high vs low), -Attentional bias towards high-calorie pictures, -Attentional bias away from high-calorie words, -Attentional bias towards low-calorie words, -Attentional bias away from low-calorie pictures.
Maratos and Staples (2015)	HP with food neophobia, <18: -Females -Males	 35 35	Photographs of familiar and unfamiliar fruits and vegetables	HP with food neophobia: -Vigilance towards unfamiliar fruit and vegetable stimuli, -Willingness to try the food stimuli was inversely correlated with vigilance towards unfamiliar fruits/vegetables. HP with high food neophobia: -Greater vigilance towards unfamiliar fruit and vegetable stimuli than for HP with low food neophobia.
Shank et al. (2015)	HP <18: -With loss of control eating -Without loss of control eating	 47 29	Pictures of high palatable foods, low palatable foods and neutral, household objects	HP with and without loss of control eating: -No differences in sustained attentional bias and this component of attentional bias was unrelated to body weight. HP with loss of control eating: -Attentional bias towards high palatable foods was positively associated with BMI.

* Studies mostly involved females; hence, the studies where males were included besides females are marked accordingly: Females, Males.
* Abbreviations: ED, diagnosis of an eating disorder; AN, diagnosis of anorexia nervosa; BN, diagnosis of bulimia nervosa; RES, restrained eaters; uRES, unrestrained eaters; EDNOS, diagnosis of eating disorder not otherwise specified; HC, healthy controls; BED, binge eating disorder; CBT, cognitive behavioral therapy; ANRec, recovered from anorexia nervosa; BNRec, recovered from bulimia nervosa; EDRec, recovered from an eating disorder; <18, under 18 years of age, ChP, diagnosis of chronic pain, AN-R,

anorexia nervosa, restricting subtype; AN-BP Anorexia nervosa binge eating/purging type; EDNOS-AN, diagnosis of eating disorder not otherwise specified, anorexia nervosa type; OB, obese participants; HW, healthy weight participants; OW, overweight participants; HP, healthy participants; EDI-2, Eating Disorder Inventory-2; HRES, high-restrained eaters; LRES, low-restrained eaters.

Table 2. Attention bias in eating disorders and analogue conditions - results of studies that used combined paradigms (the dot probe task and other paradigms)

Reference	Subjects*	N	Measure of attention	Stimuli	Main findings
Studies in clinical samples					
Chamberlain, at al. (2012)	BED before and after therapy (with a mu opioid receptor antagonist GSK1521498 - 2 or 5 mg per day) or placebo condition. -Female -Male	 35 28	Stroop task, dot probe task	-Palatable, non-palatable and neutral, control words (Stroop task), -Food and non-food words (dot probe task).	BED: -GSK1521498 – 5 mg/day significantly reduced attentional bias for food pictures versus placebo (dot probe task), -The effect on attentional bias was limited to the longer stimulus duration condition (2000 ms), -No effects of treatment on Stroop task.
Studies in overweight and obese samples					
Castellanos et al. (2009)	OB (fasted and fed conditions) HW (fasted and fed conditions)	18 18	Dot probe task, eye-tracking paradigm	Food and non-food images	OB and HW: -Increased gaze duration for food compared to non-food images in the fasted condition (eye-tracking paradigm). OB: -Increased attention to food images in the fed condition, -Preferential orienting towards food images at the onset of each image (eye-tracking paradigm). HW: -Similar gaze duration for food and non-food images in the fed condition (eye-tracking paradigm).
Ahern et al. (2010)	OW, OB, HW, LRES, HRES	63	Dot probe task, stimulus-response compatibility task	Food and control pictures	LRES and HRES: -No differences in attentional bias for food-related images (dot probe task), -No differences in approach tendencies elicited by food images (stimulus-response compatibility task).

Table 2. ***Continued***

Reference	Subjects*	N	Measure of attention	Stimuli	Main findings
Nijs et al. (2010)	OW/OB (hungry and satiated) HW (hungry and satiated)	26 40	Dot probe task, eye-tracking paradigm, P300 event-related potentials (ERP)	Food and control pictures	OW/OB and HW: -No differences between groups or conditions in the eye-tracking data (eye-tracking paradigm), -No differences between groups or conditions in maintained attention (dot probe task), -Enhanced automatic orientation towards food cues in hungry versus satiated, and in overweight/obese versus normal-weight individuals (dot probe task). HW: -The intentional allocation of attention to food pictures was enhanced in hunger versus satiety (P300 ERP).
Werthmann et al. (2011)	OW/OB HW	22 29	Dot probe task, eye-tracking paradigm	Palatable high-fat food, musical instruments, office and traffic pictures	OW: -An approach-avoidance pattern of attention towards high-fat food (eye-tracking paradigm), -Initial gaze towards food pictures more often than in HW, but subsequently reduced maintenance of attention on these pictures (eye-tracking paradigm), -Craving was related to initial orientation towards food (eye-tracking paradigm).
Nathan et al. (2012)	OW/OB (LRES and HRES) (before and after administration of D3 receptor antagonist GSK598809 175 mg/day or placebo)	26	Stroop task, dot probe task	Food images and control images	OW/OB: -No effect of the D3 receptor antagonist GSK598809 on attentional bias (Stroop task, dot probe task). LRES: -Significant attentional bias towards food cues in both tasks under placebo, and this was attenuated by GSK598809. HRES: -No attentional bias to food cues following either placebo or GSK598809.
García-García et. al. (2013)	OW/OB HW	15 19	Dot probe task, functional Magnetic Resonance Imaging	High and low calorie food pictures, control and rewarding non-food pictures	OB and HW: -Both higher reaction times for food and rewarding non-food stimuli (dot probe task). OB: -Decreased activation in bilateral activation of occipital lobe, lateral prefrontal cortex, medial prefrontal cortex, precentral gyrus, paracingulate gyrus and anterior cingulate gyrus, precuneous, posterior cingulate cortex and lateral occipital cortex (fMRI).

Table 2. *Continued*

Reference	Subjects*	N	Measure of attention	Stimuli	Main findings
Doolan et al. (2014)	OW/OB (fasted and nonfasted): -Females -Males HW (fasted and fed conditions): -Females -Males	 12 14 12 14	Dot probe task, eye-tracking paradigm	High-energy-density food images, low-energy-density food images	OW/OB and HC: -Greater attentional bias towards high-energy-density food images compared to low-energy-density food images regardless of hunger condition (eye-tracking paradigm). OW/OB – males: -Greater maintained attention towards high-energy-density food images when compared with HC (eye-tracking paradigm).
Studies in subclinical and healthy samples					
Boon, Vogelzang, and Jansen (2000)	HP: -RES -uRES	 29 30	Dot probe task, word recognition task	Food-, weight/shape-related and control: home-related and office-related words	HP: -No attentional bias for food and weight/shape stimuli (dot probe task), -Attentional bias towards food stimuli (word recognition task).
Johansson, Ghaderi, and Andersson (2004)	HP (individuals high and low in responsiveness to external food cues)	43	Stroop task, dot probe task	Food-, body-weight-, and shape-related words, control words	HP: Individuals high in responsiveness to external food cues: -Avoidance of food words (dot probe task). Individuals low in responsiveness to external food cues: -Vigilance towards food words (dot probe task). Individuals high and low in responsiveness to external food cues: -No significant differences in attentional bias for body words on the dot probe task or for food or body words on the Stroop task.
Pothos et al. (2009)	HP	25	Stroop task, dot probe task, a recognition task, extrinsic affective Simon task	Healthy foods, unhealthy foods, and control (office) words	The relation between the cognitive measures was weak and evident only in certain subsets of the population sample, as defined by gender and emotional-, restrained- and external-eating characteristics of HP.
Calitri et al. (2010)	HP	102	Stroop task, dot probe task	Healthy and unhealthy food words, control, office words	-No effects of cognitive bias (measured by dot probe task) on weight change over a 1-year period, -Cognitive bias (measured by Stroop task) to unhealthy foods predicted an increase in BMI whereas cognitive bias to healthy foods was associated with a decrease in BMI, -Cognitive biases appear to predict behavior change.
Loeber et al. (2013)	HP	48	Dot probe task, go/no-go task	Food and control words (Go/No-Go Task), food and control pictures (Dot Probe Task)	HP: -The influence of self-reported hunger on behavioral response inhibition (go/no-go task), -The blood glucose level was associated with an attentional bias towards food-associated cues (dot probe task).

Table 2. ***Continued***

Reference	Subjects*	N	Measure of attention	Stimuli	Main findings
Werthmann et al. (2014)	HP (the sad mood condition, the neutral condition)	85	Dot probe task, eye-tracking paradigm	Palatable high-fat food, musical instruments, office and traffic pictures	HP: -Self-reported emotional eating did not account for changes in attention allocation for food or food intake. HP in the neutral condition: -Attention maintenance on food cues was significantly related to increased intake in contrast to the sad mood condition.
Kakoschke, Kemps, and Tiggemann (2015)	HP	146	Dot probe task, approach-avoidance task; food-specific go/no-go task	Food and animal pictures	HP: -Neither attentional nor approach bias alone made a significant contribution to food intake (dot probe task, approach-avoidance task), -A significant effect of interaction between approach bias (approach-avoidance task) and inhibitory control (food-specific go/no-go task) on unhealthy snack food intake, -Participants who showed a strong approach bias combined with low inhibitory control consumed the most snack food.
Lattimore and Mead (2015)	HP (high-impulsive and low-impulsive individuals	50	Dot probe task, stop-signal task	Food and control stimuli	High-impulsive participants: -Slowed disengagement (longer RTs for 2000 ms duration) of pictorial food stimuli compared to low-impulsive participants (dot probe task). Low-impulsive participants: -Speeded detection of pictorial food cues (for 500 ms duration) compared to high-impulsive participants (dot probe task).

* Studies mostly involved females; hence, the studies where males were included besides females are marked accordingly: Females, Males.
* Abbreviations: BED, binge eating disorder; GSK1521498, a selective mu-opioid receptor antagonist; OB, obese participants; HW, healthy weight participants; OW, overweight participants; LRES, low-restrained eaters; HRES, high-restrained eaters; HP, healthy participants; RES, restrained eaters; uRES; unrestrained eaters.

Table 3. Attentional bias in eating disorders and analogue conditions - systematic reviews and meta-analyses

Study	No. of studies	Study groups	N	Measure of attention*	Stimuli	Main findings
Dobson and Dozois (2004)	26	AN BN ANRec BNRec LDFT HDFT Dieters RES uRES TMJ HC HP<18	211 509 23 11 22 37 100 64 61 45 461 120	Stroop task (n=26)	Body/weight, food words, neutral words	BN: -Attentional biases for body/weight, food, and neutral stimuli. AN: -Attentional bias for body/weight stimuli. Dieters and RES: -No attentional bias.
Duchesne et al. (2004)	19	AN BN EDNOS OB NC	210 399 10 51 622	Encoding test (n=1), free recall test (n=1), dot probe task (n=1), Stroop task (n=16), cued recall test (n=1), vocabulary (WAIS-R) (n=1), word completion test (n=1)	Eating, weight, body shape and body size words, control words	AN, BN: -Attentional bias for disorder-relevant words, but results across various studies are inconsistent. OB under eating restriction: -Attentional bias for eating and body size words. BN: -Decrease in the attentional bias for eating, weight and body-shape words after treatment. EDNOS: -Attentional bias for weight and body shape words. HC with restrictive attitudes: -Attentional bias for eating words. HC with high eating restriction: -Attentional bias for eating, weight and body-shape words.

Table 3. *Continued*

Study	No. of studies	Study groups	N	Measure of attention*	Stimuli	Main findings
Lee and Shafran (2004)	31	ED AN BN ANRec BNRec LDFT HDFT Dieters RES uRES obRES NED HC	20 306 525 23 11 37 29 24 65 76 45 19 873	Stroop task (n=27), dot probe task (n=4)	Eating, food, body shape/weight, positive and negative emotional, social threat and control words, body shape images	ED: -Greater Stroop interference for food and shape words than in the HC, -Avoidance of positive words. AN: -Stroop interference for food, body and size words and vigilance towards positive words. BN: -Stroop interference for food, shape, weight, body and ego threat words and avoidance of positive words, -Discrepancies between different studies, -Findings for AN are more consistent than for BN.
Johansson, Ghaderi, and Andersson (2005) (see also Johansson, 2006, the same metaanalysis).	27	ED (separated into AN and BN) NED HC	759 244 589	Stroop task (n=27)	Body, food and control words	AN: -Greater Stroop interference for food than for body words. BN: -Moderate Stroop interference for body and food words. ED, NED and HC: -Significant differences between ED and NED/HC in response latency. NED and HC: -No differences between NED and HC in response latency.
Brooks et al. (2011)	43	ED AN BN ANRec BNRec RES uRES HC	262 355 253 23 11 437 607 1076	Stroop task (n=27), dot probe task (n=3), distracter task (n=2), memory task (n=5), verbalising task (n=2), cue reactivity (n=3), perception estimation (n=1)	Food stimuli and control stimuli – images and words	ED: -Hypervigilance towards high calorie food pictures, -Avoidance of low-calorie food images, -High calorie food words distract attention. AN: -Greater Stroop interference than in the BN. RES: -No attentional bias for food stimuli.

Table 3. *Continued*

Study	No. of studies	Study groups	N	Measure of attention*	Stimuli	Main findings
Giel et al. (2011b)	15	ED AN BN EDNOS ANRec RES Anxiety Disorders HC	272 127 99 7 9 11 38 480	Functional Magnetic Resonance Imaging (FMRI) (n = 3), psychophysiological measures (e.g. electroencephalography, EEG and electromyography, EMG) (n=4), behavioural measures (e.g. dot-probe task) (n = 8)	Food, shape, face, emotional and neutral images	ED: -Sensory disengagement and higher emotional involvement (fMRI), -Experience food as less pleasurable (self-reported data and facial EMG), -Attentional bias for food pictures (dot probe task).
Oldershaw et al. (2011) (Construct 1: social-affective values and responses)	13	ED AN BN ANRec Depression and/or anxiety disorder Obsessive–compulsive disorder HC	83 339 132 35 21 16 464	Dot probe task (n = 1), Stroop task (n=2), conditional associative task (n = 2), recall task (n = 3), startle reflex (n=1), visual search task (n=2), anagram solving (n = 1), fast response decision task (n=1)	Shape, weight, food, emotional, social threat, appetitive and control words, auditory emotional specific to AN and neutral stimuli, food, emotional and facial images	-Attentional bias towards food, shape and weight stimuli extends to emotional stimuli, -Attentional bias towards threat appears most specific to AN, -Threat avoidance is more strongly associated with BN than with AN, -Greater attentional bias towards social threat words for ED than for HC.
Nijs and Franken (2012)	7	OB OW/OB Long-term successful WLM NW	72 63 15 167	Dot probe task (n=4), Stroop task (n=2), eye-tracking paradigm (n=4), event-related potentials (n=2)	High and low calorie foods pictures, high-fat food pictures, high calorie sweet foods pictures and high calorie savoury foods pictures, non-food pictures, high and low foods words, non-food words	OW/OB: -Specific (different from NW) pattern of attention to food stimuli, -After an enhanced initial automatic orientation of attention to high-calorie stimuli, tendency to strategic attentional disengagement from these stimuli.
Zhu et al.. (2012)	17	AN HC	248 241	Functional Magnetic Resonance Imagining (fMRI) (n=17)	Food, body, emotional and neutral stimuli (oral and visual)	AN: Although no robust brain activation has been found in response to emotional stimuli, emotion-related neural networks are involved in the processing of food and body stimuli. Negative emotional arousal is related to cognitive processing bias of food and body stimuli.

Table 3. *Continued*

Study	No. of studies	Study groups	N	Measure of attention*	Stimuli	Main findings
Aspen, Darcy, and Lock (2013)	4	ED HC	117 226	Dot probe task (n=4)	Words related to thin and large physique, positively and negatively valenced emotion words, pictures related to eating, body shape, and body weight	ED: -Attentional bias towards negative stimuli (greater bias for negative eating-related stimuli than for negative shape-related stimuli) and away from positive stimuli (greater bias for positive eating-related stimuli than for positive shape-related stimuli).
Lydecker (2013)	66	ED AN BN EDNOS OB ANRec BNRec Symptomatic dieters Healthy dieters RES obRES Fasting Nonfasting Weight dissatisfied Weight satisfied LDFT HDFT Psychiatric patients Depressed Anxiety disorder TMJ HC HP<18	236 482 844 30 72 58 11 12 83 104 45 58 59 20 20 37 29 19 12 19 45 1630 120	Stroop task (n=49), dot probe task (n=9), eye-tracking paradigm (n=8)	Eating, food, body shape and weight words, forbidden and unforbidden foods words, positive body words, self-directed ego threat words, threatening words (soociotropy threat words, autonomy threat words, discomfort anxiety threat words, ego-others threat words, ego-self threat words), emotional words, body shape (figures) and neutral images, self-photo, other-photo, thin figure, normal figure and fat figure images, endomorph, ectomorph, mesomorph figures, images of attractive men and women, higher and lower BMI images	ED: -Susceptibility to an interference effect of eating-disorder relevant words, -Initial, automatic attentional bias for eating disorder-relevant stimuli, -Associations between attention and core eating disorder symptomatology.

Table 3. *Continued*

Study	No. of studies	Study groups	N	Measure of attention*	Stimuli	Main findings
Renwick, Campbell, and Schmidt (2013a)	12	AN BN EDNOS ANRec BNRec High EDI-2 Low EDI-2 RES uRES Anxious With low shape concerns With moderate shape concerns With high shape concerns HC	129 131 146 13 9 19 19 29 30 38 62 42 46 267	Dot probe task (n=12)	Positive, negative, neutral eating shape and weight images, high-calorie food, low-calorie food, negative and positive shape/weight words, self and other body images, rejecting, accepting and neutral facial images, negative emotional words (social threat, physical illness, death and catastrophe/trauma/victimi-sation), control images (animals, transport words, home-related and office-related words)	ED: -Attentional bias towards negative eating, neutral weight, negative and neutral shape stimuli, -Attentional bias away from positive eating stimuli; greater bias for these stimuli than in HC, -Attentional bias towards rejecting faces and disengagement from accepting faces, -Trend attentional bias towards positive emotion stimuli (AN), -No difference in attentional bias to negative emotional words compared with HC, -Trend attentional bias away from positive emotion stimuli (BN). HC: -In participants with high hunger attentional bias towards food stimuli when presented for longer duration only, -Greater attentional bias to high-calorie foods when fasted compared with nonfasted and greater attentional bias to low-calorie food when nonfasted compared with fasted, -Greater attentional bias to low-calorie food in participants with high EDI-2 scores compared with participants with low EDI-2 scores.
Asmaro and Liotti (2014)	33	RES uRES Emotional eaters Non-emotional eaters Chocolate cravers Non-cravers HP HP<18	45 49 10 11 22 20 484 190	Electroencephalography (EEG)/Event-related potentials (ERP) (n=10), functional Magnetic Resonance Imaging (fMRI) (n=23)	High-caloric food and chocolate cues (images, words, odors)	Stimuli related to high-calorie food activate brain areas involved in reward processing, similar to those activated when substance users view drug stimuli.

Table 3. ***Continued***

Study	No. of studies	Study groups	N	Measure of attention*	Stimuli	Main findings
Doolan et al. (2015)	8	OB OW/OB WLM HC with high BMI HC with low BMI NW	72 148 15 15 21 146	Stroop task (n=2), eye-tracking paradigm (n=4), dot probe task (n=5)	Food and non-food images, high and low energy dense food words, control words, pictures related to high calorie sweet foods, high calorie savoury foods, and low calorie foods	OB: -Positive correlation between reaction time bias scores and food craving scores. OW/OB: -Increased gaze direction bias to food images as compared with the HC, -Positive correlation between BMI and reaction times to food images high in fat and/or sugar. OB and HC: -Increased gaze direction and duration to food images for all participants when hungry, maintained in OB females when fed, -Increased gaze duration and direction to high dense food images compared with low dense food images. Weight loss maintainers: -Slower reaction times to high energy dense words than in HC or OB participants. HC: -Faster visual probe task reaction times in 500 ms trials to food images as compared with the OW/OB, -Increased direction bias to high dense sweet food images in HC with low BMI as compared with HC with high BMI.
Hendrikse et al. (2015)	19	OB OW OW/OB HW + OW + OB WLM UW/HW HW	301 3 41 102 15 21 368	Dot probe task (7), Stroop task (n=3), presentation of food pair pictures – passive (n=1), randomised-blocked passive picture presentation/viewing (n=6), one-back visual recognition task (n=1), food attention network test (n=1)	High calorie and low calorie food words and pictures, high calorie sweet and savoury foods pictures, appetizing and non-appetizing food pictures, neutral non-food pictures, scenery, car, geometric shapes, objects, office items, pictures, rewarding pictures, “pleasant” positive valenced pictures, neutral (utensil) items pictures, animal words, negative emotion words, neutral “glass of water” pictures, neutral words	-Only four studies support the notion of enhanced reactivity to food stimuli in OW and OB, -This support was observed primarily (3 from 4 studies) in studies that employed psychophysiological techniques (i.e. eye-tracking paradigm, functional Magnetic Resonance Imagining).

Table 3. ***Continued***

Study	No. of studies	Study groups	N	Measure of attention*	Stimuli	Main findings
Werthmann, Jansen, and Roefs (2015)	30	AN BN EDNOS OB OW/OB OW/OB BED OW/OB <18 RES uRES RES-AN-like patients Anxious With low shape concerns With moderate shape concerns With high shape concerns HC HW HP (students)	71 55 64 18 242 27 29 263 288 88 19 31 21 23 217 403 460	Dot probe task (n=16), Stroop task (n=4), free viewing task (n=4), visual search task (n=4), clarification task (n=1), spatial cueing task (n=3), eye -tracking paradigm (n=1), event-related potentials (ERP) (n=1), flanker task (n=2), rapid serial visual presentation task (n=1), anti-saccade task (n=1)	High calorie and low calorie food cues (words and pictures), healthy and unhealthy food words and pictures, high calorie savoury food pictures, high calorie sweet food pictures, palatable high calorie food pictures and words, bland low calorie food pictures, pictures connected to food with high added fat, food with high added sugar, food with low natural sugar, food with low natural fat, "positive eating", "negative eating", "neutral eating" pictures, high-fat food pictures, low-fat food pictures, weight/shape words, appetising food, non-appetising food pictures, high-fat cake pictures, chocolate and non-chocolate pictures, non-food cues, e.g. shoes (words and pictures)	-Conflicting evidence for an increased attention bias for high calorie food in OW and OB in comparison with HW, -Inconsistent results for eating-disorder patients in comparison to non-clinical groups, -No differences in an attention bias for food cues between RES and uRES, -Food-related attentional biases in HW and RES.

Table 3. ***Continued***

Study	No. of studies	Study groups	N	Measure of attention*	Stimuli	Main findings
Wolz et al. (2015)	21	AN BN BED OB OW/OB Chocolate cravers Non-cravers Successful dieters Non dieting subjects Low external eaters High external eaters Low emotional eating style High emotional eating style RES uRES UW HC HP HP<18 NW	48 22 22 102 26 14 12 18 24 24 25 20 25 39 41 16 97 73 64 177	Event-related potentials (ERP) (n=21), Stroop task (n=2), dot probe task (n=1), eye-tracking paradigm (n=1). go/no-go paradigm (n=1), oddball paradigm (n=4)	High- and low-calorie food pictures, emotional and neutral pictures, food and non-food images and words, images of chocolate, bland and uncooked foods, chairs, images of landscapes and faces	-Consistent attentional bias towards food pictures compared to neutral pictures for patient and control groups, -Group comparisons between individuals with abnormal eating and healthy eating participants were more inconsistent. OB: -Early attention engagement to food is followed by relative disengagement, -Loss of control eating, as well as external and emotional eating, are associated with a sustained maintenance of attention towards high-caloric food.
Pool et al. (2016)	243	HP	9120	Dot probe task (n=58), free viewing task (n=24), rapid visual serial presentation task (n=24), spatial cuing task (n=24), Stroop task (n=35), visual search task (n=51), other adaptations of these tasks (n=27)	Positively valenced stimuli: Baby/child; erotic/attractive; food; general mixed; money; self-relevant; smiling face and neutral stimuli (illustrations, photos, words)	-Attentional biases towards positive stimuli when compared with neutral stimuli, -This effect is larger during early than later stages of attentional processing, this means that emotional stimuli are processed rapidly and independently of voluntary processes, -This effect is significantly larger for positive stimuli that are relevant to the current concerns of the observer.

*For the sake of clarity, full names of the measures of attention were included. The gender of participants was not specified, similarly as in other overviews of meta-analyses (e.g., Renwick, Campbell, & Schmidt, 2013a), since more than 90% of the studies involved females.

*Abbreviations: AN, diagnosis of anorexia nervosa; BN, diagnosis of bulimia nervosa; ANRec, recovered from anorexia nervosa; BNRec, recovered from bulimia nervosa; LDFT, Low scores on the Drive-for-Thinness subscale of the EDI; HDFT, High scores on the Drive-for-Thinness subscale of the EDI; RES, restrained eaters; uRES; unrestrained eaters; TMJ, temporomandibular joint disorders; HC, healthy controls; HP, healthy participans; <18, under 18 years of age; EDNOS, diagnosis of eating disorder not otherwise specified, OB, obese participants; NC, normal controls; ED, diagnosis of an eating disorder; obRES, obese restrained eaters; NED, non-eating-disordered nevertheless over-concerned with eating and body weight; OW, overweight participants; WLM, Weight Loss Maintainters; NW, normal weight participants; BMI, Body Mass Index; EDI-2, Eating Disorder Inventory-2; HW, healthy weight participants; BED, binge eating disorder; UW, underweight participants.

Table 4. Attentional bias in eating disorders and analogue conditions: Results of attentional bias modification studies (only those based on the dot probe task) involving clinical, subclinical, and healthy samples

Reference	Subjects*	N	Stimuli	Main findings
Studies in clinical samples				
Cardi et al. (2015)	AN	28	Positive, negative and neutral faces	At baseline patients displayed an attention bias towards negative faces. At the end of intervention there was a medium sized increase in attention to positive faces There were also lower levels of anxiety and higher levels of self-compassion in response to a judgemental video clip.
Boutelle et al. (2016)	BED (OW and OB)	9	Food words and neutral words	-Beneficial changes in attentional bias, -Decrease in weight, eating disorder symptoms, binge eating, loss of control and responsivity to food in the environment, -The majority of these effects were sustained at 3-month follow-up.
Studies in overweight and obese samples				
Boutelle et al. (2014)	OW/OB <18 (females – 44.8%, males 55.2%) (the "avoid food" group and control group)	24	Food words and non-food words	The "avoid group": -Beneficial outcome of the training as compared to the control group for attentional bias, -Decreased number of calories consumed. Control group: -Attentional bias for food, -Upward food intake trend.
Kemps, Tiggeman, and Hollitt (2014) Study 2	OB (the "attend" group, the "avoid" group) before and after the induction of an attentional bias towards or away from food words)	96	Food pictures and neutral, control pictures	OB: Attentional bias for food increased in the "attend" group, and decreased in the "avoid" group.

Table 4. *Continued*

Reference	Subjects*	N	Stimuli	Main findings
Kemps, Tiggeman, and Hollitt (2016)	OW and OB	104	Food pictures	OW and OB: -Attentional bias for food increased in the "attend" group and decreased in the "avoid" group. These retraining effects were maintained at 24 h and one-week follow-up, and extended to new food pictures, -Participants in the "avoid" group also produced relatively fewer food words on the word stem task than those in the "attend" group.
Studies in healthy samples				
Smith and Rieger (2006)	HP (before and after the induction of an attentional bias toward shape/weight-related information)	70	Negative shape/weight-related words, negatively valenced emotion words, neutral, control words	HP: Participants who are trained to attend to negative shape/weight-related stimuli will be more vulnerable to the development of body dissatisfaction when exposed to a body image challenge compared with participants who are trained to attend to either neutral stimuli or negative emotion stimuli.
Smith and Rieger (2009)	HP (before and after the induction of an attentional bias toward shape/weight-related information)	98	Negative shape/weight words, positive shape/weight words, negative (high calorie) food words, positive (low calorie) food words or neutral, control words	HP: Participants who are trained to attend to negative shape/weight-related stimuli will be more vulnerable to the development of body dissatisfaction and will be more prone to dietary restraint when exposed to a body image challenge compared with participants who are trained to attend to positive shape/weight-related stimuli.
Kakoschke, Kemps, and Tiggeman (2014)	HP (the "attend healthy food" group and the "avoid healthy food" group)	146	Healthy food and unhealthy food pictures	HP: Participants trained to attend to healthy food cues demonstrated an increased attentional bias for such cues and ate relatively more of the healthy than unhealthy snacks compared to the "attend unhealthy food" group.
Kemps et al. (2014) Study 1	HP (the "attend chocolate" group and the "avoid chocolate" group)	110	Chocolate and non-chocolate pictures	HP: -Attentional bias for chocolate cues increased in the "attend chocolate" group, and decreased in the "avoid chocolate" group, -Participants in the "avoid chocolate" group ate significantly less of the chocolate muffin than those in the "attend chocolate" group, by contrast, blueberry muffin consumption did not differ between the two training conditions, -Attentional retraining also affected chocolate craving.
Kemps et al. (2014) Study 2	HP (the "attend chocolate" group and the "avoid chocolate" group)	88	Chocolate and non-chocolate pictures	HP: -Training effects from the first experiment generalized to novel, previously unseen chocolate pictures, -Participants in the "avoid chocolate" group ate significantly less of the chocolate muffin than those in the "attend chocolate" group, by contrast, blueberry muffin consumption did not differ between the two training conditions, -Additionally, the "attend chocolate" group reported stronger chocolate cravings following training, whereas the "avoid chocolate" group reported less intense cravings.

Table 4. ***Continued***

Reference	Subjects*	N	Stimuli	Main findings
Kemps, Tiggeman, and Elford (2015)	HP (the “attend chocolate” group and the “avoid chocolate” group)	149	Chocolate and non-chocolate pictures	HP: -Attentional bias for chocolate cues increased in the “attend chocolate” group, and decreased in the “avoid chocolate” group after training, -Participants in the “avoid chocolate” group also ate disproportionately less of a chocolate food product than participants in the “attend chocolate” group, -The observed re-training effects were maintained 24 h later and also one week later.

* Studies mostly involved females; hence, the studies where males were included besides females are marked accordingly: Females, Males.
* Abbreviations: AN, anorexia nervosa; BED, binge eating disorder; OW, overweight participants; OB, obese participants; HP, healthy participants.