

Anxiety-linked Attentional Bias and its Modification: Illustrating the Importance of
Distinguishing Processes and Procedures in Experimental Psychopathology Research

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This work was supported by Australian Research Council Grants DP140104448 and DP140103713, and by a grant from the Romanian National Authority for Scientific Research, CNCS–UEFISCDI, project number PNII-ID-PCCE-2011-2-0045.

Abstract

In this review of research concerning anxiety-linked attentional bias, we seek to illustrate a general principle that we contend applies across the breadth of experimental psychopathology. Specifically, we highlight how maintenance of a clear distinction between process and procedure serves to enhance the advancement of knowledge and understanding, while failure to maintain this distinction can foster confusion and misconception. We show how such clear differentiation had permitted the continuous refinement of assessment procedures, in ways that have led to growing confidence in the existence of the putative attentional bias process of interest, and also increasing understanding of its nature. In contrast, we show how a failure to consistently differentiate between process and procedure has contributed to confusion concerning whether or not attentional bias modification reliably alters anxiety vulnerability and dysfunction. As we demonstrate, such confusion can be avoided by distinguishing the process of attentional bias modification from the procedures that have been employed with the intention of evoking this target process. Such an approach reveals that procedures adopted with the intention of eliciting the attentional bias modification process do not always do so, but that successful evocation of the attentional bias modification process quite reliably alters anxiety symptomatology. We consider some of the specific implications for future research concerning attentional bias modification, while also pointing to the broader implications for experimental psychopathology research in general.

The discipline of clinical psychology has carved a distinctive position within the health sciences through its long-standing commitment to productively fusing science and practice. Embracing the scientist practitioner approach has ensured that theoretical progress within this discipline has been guided by the goal of illuminating the mechanisms that underpin psychological dysfunction, while intervention approaches have been soundly based on the resulting knowledge of candidate causal mechanisms. In consequence, the efficacy of these interventions (or lack thereof) has, in turn, further informed theoretical understanding. While the power of this fusion is undeniable, and is well-evidenced by the extraordinary growth in both the scale and impact of clinical psychology across the half century since the concept of the scientist practitioner was first collectively embraced by the discipline at the Boulder Conference in 1949, this growth has steadily broadened the subject matter of clinical psychology. In an era when journals are now becoming increasingly specialized, there are grounds for concern that an ill-considered approach to the segmentation of this broad content across clinical psychology journals could threaten the integrity of the vital connection between basic research designed to illuminate the dysfunctional processes that give rise to psychopathology, and applied research designed to develop and evaluate candidate clinical interventions procedures that may attenuate psychopathology. Such disconnect is not an inevitable consequence of journal specialization, but instead depends upon the precise manner in which journals impose divisions on the field. Thus, for example, journals that specialize in particular forms of psychological dysfunction can readily sustain a breadth of coverage that preserves a strong connection between the fundamental investigation of basic processes that give rise to clinically-pertinent symptoms, and applied research that evaluates the therapeutic impact of intervention procedures designed to evoke a change process that may alleviate these symptoms. However, when specialization leads to supposed clinical psychology journals defining as beyond their scope of interest research designed to illuminate such basic processes, to focus instead only on studies that

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evaluate the outcomes of intended therapeutic procedures, then this threatens the bond between fundamental science and applied practice upon which our discipline is built.

Behavior Research and Therapy (BRAT) is to be commended for having resisted the temptation to specialize in this simplistic and potentially damaging manner. For over 50 years BRAT has served, instead, to progressively strengthen the bridge between basic science and therapeutic practice, amply delivering on the promise originally voiced by Hans Eysenck in his editorial to the first issue, assuring that “contributions will stress equally the application of existing knowledge to psychiatric and social problems, experimental research into fundamental questions arising from attempts to relate theory to maladaptive behavior, and high level theoretical attempts to lay more secure foundations for experimental studies” (Eysenck, 1963, p. 1). This invaluable legacy is now passing into the care of a new Editor, and editorial team, whose outstanding research careers vividly demonstrate the power of tightly integrating the experimental study of basic mechanisms with practice-oriented outcome evaluation research. We are delighted to contribute the present review of our own research field to mark this important occasion. While the content of our review will focus on work concerning the involvement of attentional bias in anxiety vulnerability and dysfunction, we hope that it demonstrates how laboratory research, motivated by the goal of illuminating basic mechanisms that plausibly contribute to clinically-pertinent phenomenon, can serve to establish a firm foundation for field-based research evaluating the therapeutic impact of interventions intended to alleviate clinical dysfunction by targeting these mechanisms for change. In this review we place special emphasis on the critical importance of maintaining a clear distinction, in experimental psychopathology research, between the psychological processes of interest and the procedures adopted by psychologists in their efforts to assess or to influence these processes. If this distinction becomes blurred, then theoretical understanding can be adversely affected, and the advancement of therapeutic practice is likely to be compromised.

The Importance of Distinguishing Process from Procedure in Experimental Psychopathology Research

Experimental psychopathology researchers seek to understand and modify the processes that underpin psychopathology, and achieving these twin objectives requires that they must develop and deploy effective procedures. *Processes* must not be confused with *procedures*. Processes represent psychological operations, while procedures are sets of actions taken by the investigator, most often with the goal of measuring or manipulating processes. It is appropriate to distinguish two subsets of processes that commonly are of relevance to the experimental psychopathologist, each of which is related to a distinctive subset of procedures. One such subset concerns the psychological processes that operate to produce and/or maintain the dysfunctional symptomatology of interest, which will here be labeled “*pathological processes*”. The other subset concerns the change processes that operate to modify psychological functioning, perhaps with attendant consequences for dysfunctional symptomatology. We will label these “*change processes*”. While these two subsets of processes, distinguished in the top row of Figure 1, operate within the psychological system, each is aligned with a certain type of procedure adopted by clinical psychologists with an interest in that particular subset of processes, as shown in the bottom row of Figure 1. Researchers with a primary interest in advancing knowledge and understanding of the pathological processes that underpin psychological dysfunction commonly engage in the development and refinement of procedures intended to measure the candidate pathological processes putatively implicated in the production of core maladaptive symptoms. We label these “*pathological process assessment procedures*” in Figure 1. In contrast, researchers with a primary interest in directly attenuating psychopathology develop and deploy procedures intended to evoke the specific change process that they anticipate will yield therapeutic benefits. In Figure 1 we label such procedures “*intended change process evocation procedures*”, and novel candidate interventions belong to this category of procedure.

[Insert Figure 1 here]

Meaningful progress in the field of experimental psychopathology depends critically upon maintaining a firm understanding of the vitally important relationship between the four elements identified in Figure 1, which must not be confused. To illustrate the need to keep a clear distinction between procedure and process, consider first the leftmost column of Figure 1. Recognition that understanding is compromised by failure to differentiate between the processes that researchers seek to assess, and the procedures adopted with the aim of assessing these processes, is evidenced by the frequency with which contemporary investigators continue to lampoon the early claim that intelligence is whatever intelligence tests measure (Boring, 1923). It is now widely accepted that the data resulting from assessment procedures, intended to measure candidate processes, are not themselves the process of interest. It is because of this recognition that investigators must always seek to identify the limitations of existing assessment procedures, and to continuously refine them. In consequence, our assessment procedures become progressively more powerful, and their capacity to assess increasingly precise aspects of processing permits the development and evaluation of ever more specific hypotheses concerning the nature of putative pathological processes thought to underpin dysfunctional symptoms. In our review of the attentional bias literature we will endeavor to illustrate this interplay, by showing how the refinement of assessment procedures designed to measure anxiety-linked attentional bias, and the advancement of understanding concerning the specific nature of these attentional processes, have progressed hand in hand to illuminate the patterns of attentional selectivity that characterize heightened anxiety vulnerability and dysfunction..

The type of experimental psychopathology research associated with the left column of Figure 1 serves, through the development and deployment of sensitive assessment procedures such as questionnaire protocols, cognitive experimental tasks and psychophysiological measurement of fear responses to conditioned stimuli, to illuminate the putative pathological processes that represent promising therapeutic targets, such as impoverishment of self-efficacy, biased information processing, and maladaptive acquisition of conditioned associations. In contrast, the delivery of therapeutic benefits relies on work associated with the right column of this figure. This type of

experimental psychopathology research instead involves the development and deployment of procedures intended to evoke target change processes, such as programs intended to evoke the enhancement of self-efficacy, the modification of biased information processing, and the extinction of conditioned associations, and the determination of whether the evocation of such change processes serves to attenuate the dysfunctional symptoms of interest. Once again, maintaining a firm distinction between process and procedure is of paramount importance if we are to draw clear and appropriate conclusions from this research. The implications of observing that symptom alleviation does or does not result from the delivery of a procedure intended to evoke a target change process are quite different, depending upon whether this procedure did or did not successfully this target change process. Consequently, failure to distinguish between the intended change process evocation procedure, and the change process itself, must ultimately result in confusion. This confusion may go unnoticed when such procedures reliably elicit the intended change process, and symptom alleviation reliably ensues. However, when inconsistencies begin to emerge across studies, then the failure to distinguish procedure from process will lead to confusion concerning the implications of such inconsistencies.

Only by sustaining a firm distinction between processes and procedures can clarity be maintained concerning the important relationship between these two intimately linked elements of experimental psychopathology research. In the next section, we illustrate this relationship when reviewing laboratory-based work designed to evaluate the hypothesis that elevated anxiety vulnerability and dysfunction are characterized by an attentional bias towards threat. As will be seen, recognition that intended assessment procedures may not always effectively measure the candidate pathological process of interest has made a significant positive contribution to the growth of this research, driving the progressive refinement of assessment procedures in ways that have enabled them to measure increasingly precise aspects of anxiety-linked attentional selectivity. We then will proceed to review work that has sought to evaluate whether anxiety vulnerability and dysfunction can be altered by evoking change in attentional selectivity. Here it will be seen that a common failure

to maintain a firm distinction between the intended change evocation procedure and the target change process itself, together with a lack of clarity concerning the relationship between procedure and process, has led to growing confusion and misguided conclusions.

The Measurement of Anxiety-Linked Attentional Bias: Maintaining Clarity Concerning the Relationship between the Putative Pathological Process and Intended Assessment Procedures

Across all scientific disciplines, compelling theory plays a pivotal role in driving the advancement of knowledge and understanding. While theory can be simple or complex, it must always provide a plausible *explanation* for the phenomenon of interest. Within the discipline of clinical psychology, where phenomena of interest concern patterns of dysfunctional psychological symptomatology, theories describe candidate psychological processes that plausibly could give rise to this type of symptomatology. Such theoretical development represents the component of our discipline indicated by the upper left cell of Figure 1. But the putative pathological processes delineated by such theoretical work may, or may not, genuinely operate. The worth of a scientific theory to the clinical practitioner depends, first and foremost, on its validity, which can be evaluated only through the development and iterative refinement of procedures intended to assess the processes implicated by this theory. Such work represents the component of our discipline indicated by the lower left cell of Figure 1. Although its capacity to determine the veracity of clinically relevant theories lends such work major real-world relevance, this type of research is commonly carried out within the controlled laboratory setting. Typically, the procedures initially developed to assess the putative pathological process will have limitations that are progressively overcome through subsequent procedural refinement. In turn, as assessment procedures grow more sophisticated, it becomes possible to distinguish and directly evaluate progressively more precise theoretical ideas concerning the specific nature of these pathological processes. Each of these key points, concerning the intimate relationship between the development of theoretical ideas concerning putative pathological processes, and the refinement of procedures designed for the purpose of assessing these

processes, can readily be illustrated with reference to the field of anxiety-linked attentional bias research.

Theoretical rationale motivating anxiety-linked attentional bias research

The origins of this field can be traced to the quite simple theoretical idea that elevated disposition to frequently experience intense and/or dysfunctional anxiety may potentially be explained by a tendency to selectively allocate attention to more threatening elements of the environment. This idea first gained traction in the 1980s, and quickly became incorporated into many influential models of anxiety vulnerability and dysfunction (e.g., Beck, Green, & Emery; 1985; Bower, 1981; Rapee & Heimberg, 1997; Williams et al., 1988). Logically, it is reasonable to suppose that such an attentional bias to threat would lead individuals to experience anxiety with disproportionate frequency and severity, and so this putative pathological process satisfies the requirement of providing a candidate explanation for the dysfunction symptoms of interest.

The potential explanatory power of this theoretical position cannot, however, suffice to determine its veracity. Instead, this has required the development of procedures intended to objectively assess, under controlled laboratory conditions, the patterns of attentional selectivity exhibited by people who differ in terms of anxiety symptomatology. Each such assessment procedure has tested the validity of some particular experimental prediction generated by the proposal that anxiety is characterized by an attentional bias towards threatening information. Commonly, when support has been obtained, critics have noted ways in which the observed effects could have arisen without the operation of this putative attentional bias. This has driven the development of amended assessment procedures, designed to assess the putative attentional bias in ways that preclude such alternative accounts. Consequently, across time, these procedures have become progressively more sophisticated, increasing confidence in the conclusions drawn and permitting assessment of more precise aspects of anxiety-linked attentional selectivity.

Development of assessment procedures capable of detecting presence of anxiety-linked attentional bias

An early procedure employed with the intention of assessing anxiety-linked attentional bias presented threat-related and neutral words under degraded exposure conditions, that made their identification difficult, and required participants to explicitly identify these words. It was reasoned that an anxiety-linked attentional bias to threat should selectively enhance the identification of the threat-related items. Such an effect has indeed been observed. For example, Parkinson and Rachman (1981) demonstrated that when mothers who were experiencing heightened anxiety, because their children were undergoing a surgical procedure, were instructed to report the identity of auditory words embedded in white noise, they reported threat-related words more accurately than neutral words. This was not the case for less anxious control participants. While such findings are consistent with the operation of an anxiety-linked attentional bias to threat, it was subsequently pointed out that Parkinson and Rachman's finding could readily be explained without the need to implicate such an attentional process (e.g., MacLeod, Mathews, & Tata, 1986). A plausible alternative account of this observed effect is that, under these degraded presentation conditions, all participants guessed the identity of the many words that they imperfectly heard, and the more anxious participants simply favored more threatening guesses. The consequence of such an anxiety-linked guessing bias would be to increase the accurate reporting of words that were threat-related, while reducing reporting accuracy for words that were not. Hence, it became necessary to refine assessment procedures, such that this type of guessing bias would not give rise to the pattern of effects predicted by the operation of an anxiety-linked attentional bias to threat.

In consequence, researchers came to favor the use of interference paradigms. These do not require participants to report the emotional stimuli of interest, but instead infer attentional bias towards threat information by measuring the degree to which such information disrupts performance on a central task. Thus, in this type of assessment procedure threat-related and neutral stimuli are presented as distractors while participants perform an emotionally neutral central task. It is reasoned

that, if dispositionally anxious participants' attention is selectively drawn towards threatening information, then for these anxious participants performance on the central task will be disproportionately impaired by the presence of threat-related, as opposed to emotionally neutral, distractors. Across a variety of interference procedures, such effects have been repeatedly observed. Thus, for example, when participants high and low in anxious disposition perform the central task of quickly pressing a button in response to a visual cue, while endeavoring to ignore emotional words presented auditorily, their responding is slowed when these auditory words are threat-related rather than neutral in content (Mathews & MacLeod, 1986). Similarly, when participants who differ in anxious disposition perform a flanker task, in which they must discriminate the identity of a neutral central stimuli while ignoring distractor stimuli that simultaneously appear above and below this central screen location, then higher levels of anxiety vulnerability have been shown to be characterized by disproportionate slowing on trials that present threat-related distractor stimuli (Fenske & Eastwood, 2003). By far the most common interference procedure employed for the intended purpose of assessing the putative process of anxiety-linked attentional bias is the approach that has become known as the emotional Stroop task (Mathews & MacLeod, 1985). Here, participants perform the central task of naming the ink color in which words are presented, and the distracting information is word content, which participants endeavor to ignore. It has repeatedly been observed that individuals with heightened levels of anxiety vulnerability are disproportionately slow to color name emotionally-threatening words, relative to neutral words, consistent with the operation of an anxiety-linked attentional bias (c.f., Williams, Mathews, & MacLeod, 1996). Across a range of interference procedures, this disproportionate slowing in the presence of threat-related distractor information has been observed both in high trait anxious individuals (e.g., Fox, 1993; MacLeod & Rutherford, 1992; Mogg, Kentish, & Bradley, 1993), and in clinically anxious participants, including those with diagnoses of generalized anxiety disorder (e.g., Golombok, Stavrou, Bonn, Mogg, Critchlow, & Rust, 1991; Mathews & MacLeod, 1985; Martin, Williams, & Clark, 1991), panic disorder (Ehlers, Margraf, Davies, & Roth, 1988; McNally, Amir, Louro, Lukach, Riemann, &

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Calamari, 1994), post-traumatic stress disorder (Thrasher, Dalgleish, & Yule, 1993; Bryant & Harvey, 1995), social anxiety disorder (Hope, Rapee, Heimberg, & Dombeck, 1990; Spector, Pecknold, & Libman, 2003; Mattia, Heimberg, & Hope, 1993), and obsessive compulsive disorder (Lavy, van Oppen, & van den Hout, 1994).

However, it is important to maintain a clear separation between the findings obtained using interference procedures, and the putative anxiety-linked attentional bias process that such procedures have been intended to assess. As critics of this type of assessment procedure have noted, this observed pattern of findings could arise for reasons that need not implicate an anxiety-linked attentional bias to threat. For example, some critics have pointed out that an anxiety-linked attentional bias *away from* threat could increase the probability of more dispositionally anxious participants moving attention off the computer screen on trials that display threat-related stimuli, resulting in the observed pattern of selective response slowing conventionally offered as evidence of anxiety-linked attentional vigilance for threat (e.g., Lavy & van den Hout, 1994). A broader concern voiced by critics of interference procedures is that any tendency for dispositionally anxious participants to display general response freezing in the presence of threatening information would perfectly mimic the pattern of effects expected to result from the putative anxiety-linked attentional bias process (e.g., Wilson & MacLeod, 2007). Once again, these identified limitation drove procedural refinement, to satisfy the resulting need for an assessment procedure approach that could index the putative process of interest in ways that would preclude the alternative possible accounts permitted by interference procedures.

Probe based assessment procedures were developed in response to this need. The attentional probe approach involves simultaneously presenting, on a computer screen, two stimuli that differ in emotional tone, and requiring participants to discriminate small visual probes that can appear either in the locus where the threat-related or neutral stimuli have just been presented. Selective attentional orientation towards threat-related information is revealed by speeding to discriminate the former probes relative to the latter. This measure of attentional bias to threat is unaffected by any anxiety-

linked general slowing of responding in the presence of threat, because a single threat-related stimulus is present on every trial. Moreover, the pattern of findings now predicted by an anxiety-linked attentional bias towards threat could not result from anxiety-linked attentional avoidance of displays that include threat information. Hence, confidence in the validity of the hypothesis that elevated susceptibility to anxiety is characterised by an attentional bias towards threatening information has been strengthened by the much replicated finding, using this assessment procedure, that heightened anxiety vulnerability and dysfunction are associated with disproportionate speeding to discriminate probes that appear in the locus of threat-related information, relative to probes that appear in the locus of neutral information (c.f., Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van Ijzendoorn, 2007). Such findings have been reported not only using emotional words as stimulus materials (e.g., Tata, Leibowitz, Prunty, Cameron, & Pickering, 1996), but also using emotional images, including emotionally-expressive faces (e.g., Gilboa-Schechtman, Foa, & Amir, 1999), and pictures of emotional scenes (e.g., Grafton & MacLeod, 2014). Once again, these effects have been observed both in high trait anxious individuals (e.g., Bradley, Mogg, & Lee, 1997; Broadbent & Broadbent, 1988; MacLeod & Mathews, 1988), and also in clinically anxious participants, for example, with diagnoses of generalized anxiety disorder (e.g., Bradley, Mogg, White, Groom, & Bono, 1999; Mogg & Bradley, 2005; Mogg, Mathews, & Eysenck, 1992), social anxiety disorder (Asmundson & Stein, 1994; Musa, Lepine, Clark, Mansell, & Ehlers, 2003), post-traumatic stress disorder (Bryant & Harvey, 1997), panic disorder (Beck, Stanley, Averill, Baldwin, & Deagle, 1992; Kroeze & van den Hout, 2000), and obsessive compulsive disorder (Tata et al., 1996).

Identifying the limitations of attentional bias assessment procedures that may compromise their capacity to measure the putative process of interest, and the resulting development of enhanced procedures that overcome these limitations, properly should remain a consistent priority for experimental psychopathologists working in this field. Even the best available procedures will always have shortcomings, and so continuous improvement is both viable and desirable.

Consequently, we should heed concerns that some widely used variants of the probe assessment procedure have limited reliability (e.g., Schmukle, 2005; Waechter, Nelson, Wright, Hyatt, Oakman, 2014), and we must continue to improve attentional bias assessment procedures. Certainty that the hypothesized process of attentional bias to threat serves to differentiate people with heightened dispositional anxiety, from their less anxious counterparts, has steadily increased as the range of novel assessment procedures providing evidence of this process has continued to expand. Such evidence now comes from a wide diversity of assessment procedures. Some studies have used visual search procedures to confirm that dispositionally anxious individuals are disproportionately speeded to find threat-related targets within search matrices (e.g., Gilboa-Schechtman, Foa, & Amir, 1999). Others have employed ERP based procedures and/or startle measures to confirm the presence of effects consistent with the operation of this anxiety-linked attentional bias (e.g., Bar-Haim, Lamy, & Glickman, 2005; Li, Li, Luo, 2005). A good number of studies have used eye movement procedures to demonstrate that participants with heightened anxiety vulnerability demonstrate a bias in gaze that favours the locus of threat-related information (e.g., Buckner, Maner, & Schmidt, 2010; Gamble & Rapee, 2010; Weiser, Pauli, Weyers, Alpers, & Muhlberger, 2009). Across this expanding range of assessment procedures, it has remained the case that the findings support the operation of this putative attentional process both in high trait anxious members of the general populations (e.g., Weiser et al., 2009; Schofield, Johnson, Inhoff, & Coles, 2012; Rinck, Reinecke, Ellwart, Heuer, & Becker, 2005), and also in clinical cohorts with a wide variety of anxiety disorders (e.g., Gamble & Rapee, 2010; Mogg, Millar, & Bradley, 2000; Pflugshaupt et al., 2007). Thus, the progressive development of new procedures designed to assess the putative process of attentional bias to threat, theoretically implicated as a candidate explanation for elevated anxiety vulnerability and dysfunction, has led to a degree of converging support that now permits the confident conclusion that such an attentional bias does indeed characterize such vulnerability and dysfunction (c.f., Bar-Haim et al., 2007; Dudeney, Sharpe, & Hunt, 2015; Yiend, 2010).

Refinement of assessment procedures to illuminate nature of anxiety-linked attentional bias

The progressive refinement of assessment procedures has permitted more than growing confidence in the veracity of the hypothesis that such a biased attentional process operates in anxious individuals. Additionally, the advancement of assessment procedures has enabled investigators to more precisely delineate the specific nature of this anxiety-linked process. Each step along this pathway to increasing precision has involved the identification of some theoretical distinction concerning the hypothetical nature of the pathological attentional process that may give rise to problematic anxiety, followed by the refinement of existing assessment procedures in ways that enable them to determine the validity of the differing predictions generated by these theoretical alternatives. Thus, for example, one early theoretical distinction concerned whether anxiety-linked attentional bias reflects increased attentional vigilance for threat information in particular, or for emotional information in general. This distinction between alternative accounts of the putative process involved in anxiety-linked attentional bias led some investigators to include positive information in their assessment procedures, and well as neutral information and threat information. Such procedural refinement enhanced understanding of the pathological process of interest, by demonstrating that heightened vulnerability to anxiety is characterised not by an attentional bias to all emotional information in general, but only to threatening information (Rutherford, MacLeod, & Campbell, 2004). Another theoretical distinction, also pertaining the informational breadth of this biased process, concerns whether anxiety-linked attentional bias favors all threatening information equally, or disproportionately favors threatening information that is more personally relevant. This conceptual distinction led investigators to refine assessment procedures by including threat-related information that differed in terms of its personal relevance to participants. In turn, this procedural refinement led to increased understanding concerning the putative pathological process of interest, by demonstrating that anxiety-linked attentional bias is commonly more pronounced for threatening information that is high in personal relevance (e.g., MacLeod & Rutherford, 1992).

There are many other examples of this intimate reciprocal relationship between the advancement of theoretical understanding, concerning the putative dysfunction attentional process that underpins heightened susceptibility to anxiety, and advances to the procedures adopted to assess anxiety-linked attentional processing. Thus, investigators have conceptually distinguished the theoretical possibilities that such bias may reflect selectivity in automatic attentional processing, that operates prior to conscious awareness of emotional stimuli, or may instead reflect selectivity in controlled attentional processing, that operates only subsequent to the conscious registration of this emotional information (e.g., McNally, 1995; Williams, Watts, MacLeod, & Mathews, 1997). This has led to refinement of assessment procedures, such that the emotional information has been presented either under visual masking conditions that preclude conscious awareness of its content, or under exposure conditions that permit such awareness. The observation that the patterns of effects predicted by the operation of anxiety-linked attentional bias remain evident, when awareness of stimulus content is precluded, has lent support to the idea that this bias reflects selectivity in automatic attentional processing (e.g., Mogg, Bradley, & Hallowell, 1994; Mogg, Bradley, & Williams, 1995).

Another theoretical distinction concerning the anxiety-linked attentional bias process pertains to whether this involves increased attentional engagement with threat-related information, or impaired attentional disengagement from such information (e.g., Fox, Russo, & Dutton, 2002; Amir, Elias, Klumpp, & Przeworski, 2003). Again, the conceptual differentiation between these putative attentional processes has driven the refinement of assessment procedures, motivated by the objective of rendering these procedures capable of independently measuring the alternative candidate processes. Early procedural innovations introduced for this purpose were comprised by certain limitations (e.g., Amir et al., 2003; Fox et al., 2002; Koster, Crombez, Verschuere, & De Houwer, 2004; Koster, Crombez, Verschuere, Van Damme, & Wiersema, 2006), and critical appraisal of these limitations has led to progressive procedural enhancement. This has culminated in the emergence of procedures capable of sensitively differentiating these two components of attentional processing

(e.g., Clarke, MacLeod, & Guastella, 2012; Grafton & MacLeod, 2014; Mogg, Holmes, Garner, & Bradley, 2008). For example, a recent variant of the probe approach, designed for this purpose, anchors initial attention in one or other of two screen loci prior to stimulus pair onset, then presents differentially valenced stimuli either proximally to or distally from the locus of current attention. This enables separate assessment of the degree to which attention is more firmly held by proximal threat stimuli relative to neutral stimuli, indexing disengagement bias, and the degree to which attention is more strongly drawn to distal threat stimuli relative to neutral stimuli, indexing engagement bias (e.g., Grafton & MacLeod, 2014; Grafton & MacLeod, in press; Rudaizky, Basanovic, & MacLeod, 2013). This assessment procedure has revealed that elevated trait anxiety is characterized by both forms of attentional bias, and also has shown that these bias subtypes are independent of one another, with variation in each bias subtype accounting for independent variance in trait anxiety (Rudaizky et al., 2013). Moreover, adoption of this refined assessment procedure has revealed that some subsets of clinically relevant symptomatology are specifically associated with only one subtype of attentional bias. Thus, for example, we now know that heightened rumination is characterised specifically by impaired attentional disengagement from emotionally negative information, and not by increased attentional engagement with such information (e.g., Grafton, Southworth, Watkins, & MacLeod, 2016; Southworth, Grafton, MacLeod, & Watkins, 2016).

Even more recently, it has been recognised that anxiety-linked attentional selectivity potentially could reflect either a bias in the low-level setting of attentional goals (reflecting the elevated probability of the cognitive system adopting the goal of attending towards rather than away from threat), or a bias in the execution of these attentional goals (reflecting superior execution the former attentional goal relative to the latter). By appropriately modifying the probe-based assessment procedure, such that the attentional goal either was or was not constrained by the task configuration, Basanovic & MacLeod (2016) were able to demonstrate that anxiety-linked attentional bias towards threat was exclusively restricted to the condition that required attentional goal setting by participants. This finding suggests that elevated anxious disposition is characterized by selectivity in attentional

goal setting, rather than in attentional goal execution. All these examples, and many more that space does not permit us to cover, serve to emphasize the same important point. Specifically, the measures resulting from any procedure intended to assess a putative psychological process, potentially involved in the generation of dysfunctional symptomatology, must never be misconstrued as *being* the process of interest. Thus, for example, the exaggerated threat interference effect shown by anxious participants in the emotional Stroop task is not itself anxiety-linked attentional bias, but rather is a pattern of task performance that may or may not result from anxiety-linked attentional bias. Because every existing assessment procedure can and should be improved upon, an unwavering allegiance to one specific assessment protocol will ultimately prove to be counterproductive. Rather, the commitment to most effectively illuminating the putative process of interest will best be served by a readiness to creatively amend existing procedures in order to steadily improve their capacity to more sensitively assess this putative process. These progressively more refined assessment procedures, developed through such continuous improvement, will enable the assessment of increasingly more precise aspects of this psychological process.

The basic experimental research reviewed above, involving the development and progressive refinement of assessment procedures, has immediate applied value. The resulting knowledge that anxiety vulnerability and dysfunction is robustly characterised by this hallmark process of attentional bias to threat, and the provision of procedures with a demonstrated capacity to sensitively measure this process, can enable the enhancement of clinical assessment. For example, it has been demonstrated that measures of automatic attentional bias to threat predict the intensity of later dysphoric responses to subsequent stress substantially better than do the type of self-report measures of anxiety vulnerability more commonly favored by clinical assessors (MacLeod & Hagan, 1992). Furthermore, a number of investigators have observed that the delivery of conventional cognitive behaviour therapy serves to reduce attentional bias to threat in anxiety patients (c.f., Tobon, Ouimet, & Dozois, 2011), with greater therapeutic gains being evidenced by those who exhibit the greatest reduction in such attentional bias (e.g., Legerstee et al., 2010; Lundh & Ost, 2001). Among other

interesting implications, this finding suggests the possibility that measures of attentional bias may have the capacity to index clinical improvement in ways that could reduce the demand and expectancy effects associated with self-report measures.

Most important of all, by confirming the existence of anxiety-linked attentional bias to threat, this basic experimental research lends weight to the plausibility of those clinical models that causally implicate this process of attentional bias in the production of heightened anxiety vulnerability and/or dysfunction. If attentional bias to threat functionally contributes to such problematic symptomatology, as proposed by these models, it follows that effectively attenuating this attentional bias should result in therapeutic improvement for these individuals. But assessment-based research cannot serve to determine whether this attentional bias does causally contribute to the elevated tendency to experience anxious symptomatology. In order to empirically evaluate the important hypothesis that attentional bias to threat plays this causal role, it is necessary to empirically determine whether the direct evocation of a change process, that involves the modification of attentional bias, serves to alter anxiety vulnerability and dysfunction. Resolving this theoretical issue was the original motivation for the line of experimental work that has become known as attentional bias modification (ABM) research. As will be seen, early support for this causal hypothesis has led to the subsequent expansion of this field, which now also includes a significant body of clinical outcome research. As we will illustrate in the following review of this developing field, careful interpretation of the resulting findings can reveal whether or not the successful evocation of this target change process, involving modification of attentional bias, does therapeutically attenuate anxiety vulnerability and dysfunction, as predicted by the motivating theoretical accounts. However, as we also will point out, the failure to consistently distinguish the target change *process* of attentional bias modification from the *procedures* that have been employed with the intention of evoking this change process, has hampered such careful interpretation of the findings, in ways that have led to some misleading conclusions.

The Modification of Anxiety-Linked Attentional Bias: Maintaining Clarity Concerning the Relationship between the Target Change Process and Intended Change Evocation Procedures

In shifting to consider experimental psychopathology research that has sought to evaluate the therapeutic impact of potentially beneficial change processes, through the use of procedures developed with the aim of evoking these change processes, we move onto the type of work represented by the right column of Figure 1. A great deal of clinical psychology research is of this nature. Across the breadth of such work, the candidate change processes that clinical researchers may seek to evoke vary widely, for example including processes involving belief change, processes involving change in learned associations, and processes involving change in activity levels. Likewise, the procedures that are deployed with the intended purpose of evoking these target change processes also differ greatly, with examples including belief challenging procedures, exposure plus response prevention procedures, and media-based health promotion procedures. But in all cases, it is essential to ensure that there is no confusion between the target change process itself, and the procedure developed with the aim of evoking this change process, as such confusion is likely to compromise interpretation of findings.

To illustrate this important point, let us suppose that a clinical study is motivated by the hypothesis that invoking a change process involving the modification of activity levels could attenuate depression symptoms. Let us also suppose that the investigators have developed a media-based promotion procedure, intended to evoke this target change process. Finally, let us suppose that this media-based promotion procedure does not consistently attenuate depression levels. Clearly, this observation cannot permit the conclusion that the *process* of activity level modification exerts no reliable therapeutic impact on depression symptoms. An alternative possibility is that the media-based promotion procedure does not reliably evoke this target change process of activity level modification, which would have effectively attenuated depression had it been successfully evoked. The implications of these two alternative possibilities are strikingly different. The latter interpretation encourages the development of procedural refinements to better elicit the target change process of

activity level modification, whereas the former instead discourages any further efforts to alleviate depression by changing activity level. Hence, determining the basis of inconsistent findings, and correctly identifying the implications of the observed inconsistency, requires that we maintain a clear distinction between the target change process, and the procedure intended to evoke this change process, and that we fully appreciate the relationship between the two.

In the following sections we will review work that has sought to determine whether eliciting a change process in attentional bias to threat serves to influence anxiety vulnerability and dysfunction, as predicted by the hypothesis that such attentional bias causally contributes to such anxiety. We will refer to this target change process as the attentional bias modification (ABM) process. In order to evaluate whether the eliciting the ABM process serves to influence anxiety, early researchers sought to develop procedures that they hoped would have the capacity to evoke this ABM process. Some of these early procedures were more successful than others in doing so ABM process, and so have become widely used in subsequent research, though new procedures continue to be developed with the objective of more effectively evoking the ABM process. As will be seen, early laboratory work provided compelling evidence that the successful evocation of the ABM process can alter anxiety reactivity to stress. This laid the foundation for field-based research work, designed to evaluate whether evoking the ABM process can deliver real-world therapeutic benefits to clinically anxious individuals.

Encouraging initial findings from this field-based research, revealing therapeutic benefits of the ABM process when evoked by procedures delivered in the clinic or clinical laboratory setting, has since led to increasingly ambitious designs, involving the delivery of such procedures in differing ways and across differing settings. The therapeutic outcomes of studies employing these more diverse procedures intended to evoke the ABM process have become more variable. Unfortunately, the interpretation of such variability has been compromised by failure to maintain a clear distinction between process and procedure. As we review this field of research, we also to show how clearly

differentiating process from procedure enables the understanding of inconsistencies that otherwise would be difficult to interpret.

Development of procedures capable of evoking the ABM process

Our own early efforts to develop procedures that may prove capable of evoking the ABM process began in the 1990s, and have been reviewed elsewhere by Mathews & MacLeod (2002). These intended change evocation procedures involved exposing participants to amended variants of tasks that had previously been employed to assess anxiety-linked attentional bias. The amended protocols involved introducing a contingency into the original task, that it was anticipated may drive the intended process of change in attentional bias. For any given protocol, this contingency could be configured in a manner designed to reduce attention to threat (*avoid-threat contingency condition*), or in a manner designed to increase attention to threat (*attend-threat contingency condition*). Alternatively, the contingency could be removed from the protocol, such that neither attentional change was encouraged (*control condition*). We commonly delivered these protocols in single sessions within the laboratory, giving alternative conditions to differing subsets of participants, and evaluating the capacity of these procedures to evoke the target ABM process by assessing whether these subgroups came to differ in attentional bias to threat as intended. For this purpose, conventional attentional bias assessment procedures were employed. These always included novel stimulus materials, not encountered by participants during the intended ABM evocation procedure, in order to ensure that any observed difference between the subgroups reflected the generalized modification of attentional bias to threat. In our early work, many of our candidate procedures did not prove capable of eliciting the ABM process as intended.

For example, such an early attempt reported by Mathews & MacLeod (2002) involved adapting the emotional Stroop task to create a color naming protocol intended to modify, rather than measure, attentional bias to threat. This involved introducing a contingency between the required

response, and the emotional tone of the colored word. When this protocol was configured in the avoid-threat contingency condition, participants were cued to make a color naming response on trials presenting a threat word, and cued to make a grammatical judgment response on trials presenting a neutral word (thereby requiring them to repeatedly move attention away from threat word meanings and towards neutral word meanings). When the protocol was configured in the attend threat contingency condition, this contingency was reversed. Following extended exposure to several hundred trials of this procedure, attentional bias to threat was measured using the conventional assessment version of the emotional Stroop procedure. Unfortunately, this revealed no evidence that the subgroups of participants who received this procedure in each of the two contingency conditions came to differ in their attentional bias to threat, when this was assessed using new stimulus words. Subsequent versions of this color naming protocol that employed expressive faces as emotional stimuli, and introduced contingencies intended to induce differential attention to either affective (expression) or non-affective (age) dimensions of these faces as a function of their emotional valence, prove equally ineffective in evoking the intended ABM process. These early unsuccessful studies demonstrate an important point that has become no less valid over time. Specifically, neither the fact that a procedure is intended to evoke the process of ABM, nor the plausibility that it might potentially do so, permits the conclusion that it does evoke this target change process. Rather, the claim that ABM is elicited by any procedure, and resulting conclusions concerning the impact of the ABM process on anxiety, requires empirical verification that the ABM process is successfully evoked as intended.

Our efforts met with greater success when we sought to adapt the attentional probe task to create a probe protocol intended to modify, rather than measure, attentional bias to threat. In the assessment version of this approach, probes are presented equally often in the location of the threat member, and the neutral member, of each stimulus pair. However, in the protocol developed with the objective of evoking the ABM process, we introduced a contingency between the position of the probe and the position of the threatening word member. When this protocol is configured in the

avoid-threat contingency condition, then probes always appear in the screen locus distal from the threat member of stimulus pairs. The protocol can also be configured in the attend-threat contingency condition, by presenting all probes in the vicinity of the members of stimulus pairs, or the contingency between probe position and threat stimulus position can simply be removed, to yield a control condition. As reported by Mathews & MacLeod (2002), when we delivered a word version of this probe protocol within a single session laboratory procedure, exposing participants to many hundreds of trials configured in either the avoid-threat contingency condition or the attend-threat contingency condition, we found good evidence that the ABM process was successfully evoked. Specifically, using a conventional assessment version of the probe procedure, we found that the former subgroup of participants came to display significantly less attention to threat words than did the latter subgroup, and this induced difference in attentional bias was fully evident on new stimulus words not employed in the intended ABM evocation procedure. We obtained the same pattern of findings using a variant of this probe protocol that employed angry and neutral faces as the emotional stimulus pairs.

As will be seen in the forthcoming review, variants of this probe protocol have been used in the great majority of the procedures that experimental psychopathologists have subsequently employed with the intention of evoking the ABM process. But this should not be taken to mean that use of the probe protocol within such procedures is always effective in evoking ABM, or that this procedural approach cannot be improved upon. A number of other protocols also have been developed with the intention of invoking the ABM change process. For example, Dandeneau and Baldwin (2004) developed a visual search protocol for this purpose. In the assessment procedures based on the visual search approach, participants are required to find both threat and happy target images, such as angry and happy faces, in grids of distractors. In the protocol developed by Dandeneau and Baldwin, participants instead are always required to find the targets of only one specified valence. When the protocol is configured in the avoid-threat contingency condition, then participants must always find the single happy face in each grid of angry distractor faces, whereas

when configured in the no-contingency control condition, all stimuli are unemotional shapes. To verify its capacity to elicit the ABM process, Dandeneau and Baldwin exposed participants to a laboratory procedure that delivered over a hundred trials of this visual search protocol, configured in either the avoid-threat contingency condition or the control condition. A conventional assessment version of the emotional Stroop procedure confirmed that participants who received the former condition came to show less attention to threat than did those who received the latter condition, verifying evocation of the ABM process. Similar verification has been obtained in later studies that have confirmed this attentional change process using the attentional probe assessment procedure (Dandeneau & Baldwin, 2009; Dandeneau, Baldwin, Baccus, Sakellaropoulo, & Pruessner, 2007).

Hayes, Hirsch, and Mathews (2010) have developed a protocol, based on a dichotic listening approach, in which participants simultaneously hear two differing audio narratives. While at any point in time each narrative is presented to a differing ear, the two narratives frequently switch between ears. One narrative is threatening in emotional tone, while the other is neutral in emotional tone. Participants are required to shadow one of these narratives. When this protocol is configured in the avoid-threat contingency condition, participants always must shadow the neutral narrative and ignore the threatening narrative. When it is configured in the control condition, then they must shadow each valence of narratives an equal number of times. Following exposure to a laboratory procedure that delivered this protocol for around 30 minutes, a conventional assessment version of the attentional probe procedure verified that participants who completed it in the avoid-threat contingency condition came to show less attentional bias to threat than did those who completed in the neutral condition. Hence, while it has not yet been widely deployed, this dichotic listening protocol has a confirmed capacity to evoke the ABM process.

The procedures that presently are most commonly used for the intended purpose of evoking the ABM process are unlikely to be the best possible procedures. In recent years, some investigators have sought to develop novel procedures with a greater capacity to evoke the ABM process than

those that currently exist. For example, Notebaert, Clarke, Grafton, and MacLeod (2015) recently developed a protocol based on the popular children's card game snap, and compared this against the widely used probe protocol in terms of its capacity to evoke the ABM process. In this new protocol, participants are presented successive "cards" that each display pairs of faces, one showing an angry expression and one a happy expression. Participants must quickly decide whether each successive card shows the same person as the preceding card. When configured in the avoid-threat contingency condition, they must always make this judgment about the individuals who display the happy expression on each card. When configured in the attend-threat contingency condition, they must instead always make this judgment about the individuals who display the angry expression. Notebaert et al. exposed participants either to 16 games (each presenting 24 cards) of this card protocol, or to the more conventional probe protocol, both configured in either the avoid-threat contingency condition or the attend-threat contingency condition. Using a conventional probe assessment task, Notebaert et al. found this new identity matching procedure to be significantly more effective in evoking the ABM process than was the more commonly used probe procedure.

In summary, there are now a variety of procedures that have been shown in a number of studies to elicit, at least under certain circumstances, the attentional bias modification process. Not all procedures that investigators have developed for the purpose of evoking this ABM process have proven successful in doing so. It is not unlikely that some protocols may be more effective than others, and it is quite possible that a given protocol may differ in terms of its success in eliciting ABM as a function of procedural variables, such as the length, number and context of the sessions in which this protocol is delivered. Nonetheless, with the advent of procedures that can evoke the ABM process it now becomes possible to test the central tenet of models that causally implicate attentional bias to threat in the genesis and/or maintenance of anxiety vulnerability and dysfunction. Specifically, we can now investigate whether, as these accounts predict, successfully evoking the change process of attentional bias modification serves to alter anxiety vulnerability, and can therapeutically attenuate anxiety dysfunction. In reviewing findings from studies that have been

carried out to test this prediction, we divide these into two subsets. First, we consider whether anxiety vulnerability and dysfunction have been affected by procedures intended to elicit the ABM process, in studies that have confirmed the success of their procedures in evoking this target change process. We then go on to consider whether anxiety vulnerability and dysfunction have been affected by procedures intended to elicit ABM in studies that have failed to demonstrate successful evocation of the attentional bias modification process.

Is anxiety vulnerability and dysfunction attenuated by procedures that demonstrably evoke the change process of attentional bias modification?

When intended change procedures evocation procedures successfully elicit the ABM process, then they also commonly impact on anxiety vulnerability. In two early studies, MacLeod, Rutherford, Campbell, Ebsworthy, and Holker (2002) delivered a word version of the probe-based protocol intended to elicit ABM, within a single session laboratory procedure, to students who were mid-range in trait anxiety. One subgroup received this procedure configured in the avoid-threat contingency condition, while another received it in the attend-threat contingency condition. Confirmation that the procedure succeeded in eliciting the ABM change was evident from the finding that participants in former subgroup came to display reduced attentional bias threat, relative to those in the latter group, when this was measured by a standard dot probe assessment procedure using novel stimuli. These participants then were exposed to a subsequent stressor, involving a stressful anagram procedure, and the intensity of their anxiety reactions to this stressor was measured. Of critical importance, in the former participants, negative emotional reactivity to the stressor was found to be significantly attenuated compared to the latter participants. Moreover, the magnitude of the reduction in their anxiety vulnerability, as revealed by this measure of stress reactivity, was a direct function of the degree to which attentional bias to threat was reduced by the procedure employed to evoke the ABM change process. This finding, that the successful evocation of the ABM process with the laboratory serves to affect anxiety vulnerability, as assessed by

reactivity to stress, has since been repeatedly replicated, not only using this same probe-based procedure to elicit such ABM (e.g., Grafton, Mackintosh, Vujic, & MacLeod, 2013), but also when this ABM process has been successfully elicited using quite different approaches, such as the face-matching protocol developed by Notebaert et al. (2015).

Similar findings also have been obtained in children. Eldar, Ricon, and Bar-Haim (2008) recruited unselected 7- to 12-year old children and had them complete, in a single laboratory session, a pictorial version of this probe-based protocol, configured either in the avoid-threat or attend-threat condition. Successful elicitation of the ABM process again was verified by the observation that children in the former condition came to show significantly less attention to threatening information than children in the latter condition, when this was subsequently measured using the standard assessment version of this probe-based procedure. The children then were exposed to a stressor, in this case involving a demanding puzzle task, and the intensity of their anxiety responses was measured. Children in the attend-threat condition demonstrated a robust anxiety response to this stressor, which served to substantially elevate their state anxiety levels. Critically, for children in the avoid-threat condition this anxiety response was not only significantly attenuated, but was eliminated. Thus, for children as for adults, anxiety vulnerability is reduced when successful evocation of the ABM change process attenuates attentional bias to threat.

In addition to influencing emotional reactivity to general stressors, successful evocation of the ABM change process also alters the degree to which conventional worry induction procedures serve to elicit negative thought intrusions. For example, in a single session laboratory procedure Krebs, Hirsch, & Mathews (2010) exposed a cohort of students to the probe-based protocol, configured in either the attend-threat contingency condition or the avoid-threat contingency condition, before then delivering a worry induction task capable of eliciting negative thought intrusions. Participants who received the intended change evocation procedure in the avoid-threat contingency condition came to show significantly less attention to threat than did those who received it in the attend threat contingency condition, verifying that the ABM process was successfully

elicited. The former participants also showed reduced evidence of negative thought intrusions, relative to the latter participants, on the worry induction task.

In the above described studies, participants were not selected on the basis of existing dysfunctional anxiety symptoms, but there is compelling evidence that successful elicitation of the ABM change process to reduce attention to threat serves to reduce such dysfunctional symptomatology. In some cases, this evidence comes from studies in which the symptom of interest has been assessed immediately following exposure to a single session of the procedure intended to evoke the ABM process. For example, Bernstein and Zvielli (2014) selected participants who already displayed elevated levels of trait anxiety, and exhibited an attentional bias towards threat. Half these participants were exposed to a novel procedure intended to evoke the ABM process, configured in the avoid-threat condition. In this procedure attentional bias to threat was continuously measured using the conventional attentional probe assessment approach, and participants received real-time feedback concerning their attentional bias, in the form of a bias index computed from a moving window of immediately prior trials. Participants in the avoid-threat condition were instructed that their objective was to perform the task in a manner that brought this index down to zero (the value representing elimination of their attentional bias to threat), while the remaining participants were given no such instruction, thereby providing a control condition. Following this procedure, it was confirmed that participants who received the procedure in the avoid-threat condition did indeed display significantly less attention to threat than did control participants, verifying that this procedure evoked the ABM process as intended. The former participants also exhibited significantly briefer anxiety elevations, in response to a subsequently presented anxiogenic video clip, than did control participants, confirming that the ABM process attenuated anxiety reactions to stress in these high trait anxious individuals.

In a similar vein, Hayes, Hirsch and Mathews (2010) have demonstrated that the successful elicitation of the ABM change process, to reduce attentional bias to threat, can attenuate worry in participants selected on the basis of existing high levels of dispositional worry. In a single laboratory

session, the investigators gave one group of such participants a word version of the probe-based procedure, configured in the avoid-threat contingency condition intended to evoke the ABM change process. A second group of matched participants instead received it in a control condition, containing no contingency designed to evoke the ABM change process. When attentional bias was then measured using a conventional probe assessment procedure, it was verified that the former participants had come to show increased attentional avoidance of threat relative to the control participants, confirming successful evocation of the ABM process. While a subsequent worry induction task invoked negative thought intrusions in control participants, this was not the case for participants in the avoid-threat contingency condition. Thus, successful evocation of the ABM process, that serves to reduce attention to threat, also attenuates the negative impact of worry in people with prior tendency to experience problematic levels of worry.

Using the visual search protocol that they developed for the purpose of evoking the ABM process, Dandeneau and Baldwin (2009) have shown that successful attenuation of attentional bias to threat can reduce the feelings of rejection experienced in social situations by people with low self-esteem. In a single laboratory procedure, one subgroup of such participants completed a version of this search protocol in an avoid-threat configuration, requiring them to search grids of expressive faces to find happy targets while ignoring angry distractors. Another subgroup instead completed a control version of the protocol, which employed no emotional stimuli and so was not intended to evoke the ABM process. A conventional probe assessment measure confirmed that participants who received the procedure in the avoid-threat condition came to display reduced attentional bias to threat compared to those who received the control condition, confirming successful evocation of the intended ABM process. These former participants also reported experiencing less intense feelings of rejection, and less thoughts concerning rejection, in response to a subsequent stressor designed to simulate social rejection.

Using single sessions of laboratory procedures delivering a variant of the probe protocol, Amir and colleagues also have demonstrated that dysfunctional symptoms associated with

subclinical manifestations of anxiety disorders are attenuated when successful evocation of the ABM process reduces attention to threat. Amir, Weber, Beard, Bomyea, and Taylor (2008) exposed participants, selected on the basis of showing subclinical social anxiety symptoms, either to a procedure in which a version of this protocol (employing angry and neutral faces as stimuli) was presented in the avoid-threat contingency condition, or in a control condition in which no contingency was present. The former condition evoked the intended ABM change process, as verified by the observation that individuals in this condition came to show significantly less attention bias to threat than did participants in the latter condition, when such bias was measured using the standard probe assessment procedure. All participants were then required to give an impromptu speech. Compared to the control participants, those who had been exposed to the avoid-threat contingency condition demonstrated attenuated attentional bias to threat, and experienced reduced anxiety responses to this speech stressor. The ABM process also appeared to deliver behavioural benefits, as these participants' speech performance was judged to be superior by blind raters.

Further evidence that successful evocation of the ABM process, to reduce attention threat in subclinical cohorts, can impact on anxiety-relevant behavioral measures comes from a study by Najmi & Amir (2010), carried out on participants with subclinical obsessive-compulsive symptoms. A single session laboratory procedure involving a verbal variant of the probe protocol (employing contamination-related threat words and neutral words as stimuli) was delivered to half these participants, configured in the avoid-threat contingency condition. The remaining participants received a control version of the task, containing no contingency configured to evoke AMB. As in the previously reported studies, the successful evocation of the ABM change process was verified by the former participants coming to show significantly less attention to threat than the control participants, when this was measured using the conventional probe assessment procedure. Participants who received the procedure in the avoid-threat contingency condition also showed significantly reduced behavioral avoidance of previously feared contaminants, compared to the control participants in a final behavioral approach task.

Across these many single session studies, it repeatedly has been observed that when the successful evocation of the ABM process serves to reduce attention to threat, then this can exert an immediate impact on anxiety vulnerability, and can attenuate dysfunctional anxiety-related symptoms of clinical relevance. In such single-session studies these symptom changes tend to be assessed using contrived laboratory stressors, leaving unanswered the question of whether such successful evocation of the ABM process can have a beneficial impact on naturalistic emotional experience outside the laboratory. To address this issue, many researchers have employed multiple sessions to deliver procedures intended to evoke the ABM change process, with aim of producing a more enduring attenuation of attentional bias to threat. The results of these studies indicate that the successful evocation of this intended ABM change process serves to reduce anxiety vulnerability and dysfunction in real-world settings.

Adopting this approach, See, MacLeod & Bridle (2009) demonstrated that successfully evoking the ABM change process to reduce attention to threat can alleviate anxiety responses to a stressful life event. These researchers employed a procedure in which the probe protocol, configured in the avoid-threat contingency condition, was delivered daily to a cohort of participants due to emigrate to commence tertiary studies overseas, across the fortnight prior to departure from their home country. An equivalent number of such participants completed the same procedure but in a control condition, that contained no contingency configured to evoke ABM. Confirmation that the ABM process was evoked as intended by the avoid-threat condition was provided by verification, using the conventional probe assessment procedure, that participants in this condition exhibited a reduction in attention bias to threat across this period, not shown by participants in the control condition. The degree to which the former participants subsequently experienced anxiety elevations in response to the stressful transition event of relocating from their home country also was significantly and substantially attenuated, relative to the control participants. Hence, evoking the ABM change process led to an increase in real world emotional resilience.

Procedures that expose participants across multiple sessions to protocols configured to evoke this ABM change process also have been found to attenuate pre-existing anxiety symptoms of a dysfunctional nature. Some studies have demonstrated this in non-clinical cohorts. Thus, for example, within the clinical laboratory setting Hazen, Vasey, & Schmidt (2009) delivered 5 daily sessions of the probe protocol, configured in the avoid-threat contingency condition, to non-clinical participants who reported worrying excessively. A group of matched participants received this same probe protocol in a control condition that contained no contingency designed to evoke ABM. The former procedure was shown to successfully evoke the intended ABM change process, with participants in this avoid-threat contingency condition displaying a reduction in attentional bias to threat that was not shown by those in the control condition, as revealed by the conventional probe assessment procedure. This was accompanied by a significant reduction in emotional dysphoria that again was restricted to those who received the procedure in the avoid-threat contingency condition.

Of most direct relevance to the interests of clinical practitioners has been the repeated finding that, when this ABM change process is successfully evoked in cohorts with a clinical diagnosis of anxiety dysfunction, then it is accompanied by therapeutic improvement in symptomatology relevant to diagnostic status. For example, twice a week across a one month period, Amir, Beard, Burns, and Bomyea (2009a) delivered the probe protocol in the clinical laboratory setting, using emotional words as stimuli, to patients diagnosed with generalized anxiety disorder (GAD). Half these patients received this protocol configured in the avoid-threat contingency condition, intended to evoke the ABM change process, while half instead received it in the control condition that contained no contingency designed to evoke this process. The success of this procedure in eliciting the ABM change process was verified by the finding that patients exposed to the avoid-threat condition came to show less attention to threatening information than did those exposed to the control condition, as intended. Moreover, the former subset of patients displayed a significant reduction in anxiety symptoms across this one-month period than was exhibited by those in the control condition. Only

50% of these participants continued to meet diagnostic criteria for GAD at the end of this 4 week period, compared to 87% of the participants in the control condition.

Using the same schedule, Amir et al. (2009b) delivered a variant of the probe protocol, using faces displaying disgusted or unemotional expressions as the threat and neutral stimuli respectively, to patients diagnosed with generalized social phobia. Again, half received this configured in the avoid-threat contingency condition, while the remainder received it in the control condition. The success of the former procedure in eliciting the ABM change process was confirmed using a conventional probe assessment procedure, which revealed that across this 4 week period patients in the avoid-threat contingency condition evidenced a significant decline in attentional bias threat, as intended, while such attentional bias did not change for those in the control condition. Across this same 4-week period, patients in the avoid-threat condition also displayed a significant reduction in anxiety symptoms that was not shown by patients in the control condition. 50% of the former participants continued to meet diagnostic criteria for GAD at the end of this 4 week period, compared to 86% of those in the control condition, and clinically significant benefits were maintained at 4 month follow-up.

Other investigators have likewise demonstrated that the successful evocation of this ABM change process serves to attenuate anxiety symptoms in individuals with dysfunctional levels of social anxiety (e.g., Li, Tan, Qian, & Liu, 2008; Heeren, Reese, McNally, and Philippot, 2012). For example, within the clinical laboratory across seven successive days Li et al. (2008) delivered a version of the probe protocol, using hostile emotional faces as threat, to participants selected on the basis of their high scores on the social interaction anxiety scale (SIAS; Mattick & Clarke, 1998). For half the participants this was configured in the avoid-threat contingency condition, while for the other half it was in the control condition. The ABM process was evoked in the former case, as intended, with participants in the avoid-threat condition coming to show significantly less attention to threat on a conventional probe assessment procedure on the day following completion of these seven sessions. Importantly, when SIAS was subsequently re-administered, participants in the avoid-

threat condition exhibited a significant decline in SIAS scores, that was not evidenced by those in the control condition. Thus, once again, the successful elicitation of the ABM process, to attenuate attentional bias to threat, was accompanied by the attenuation of social anxiety.

A good many studies have demonstrated that the extended delivery of procedures intended to evoke the ABM process can attenuate dysfunctional anxiety in children also, when this attentional change process is successfully elicited by these procedures. For example, Bar-Haim, Morag, and Glickman (2011) reported such findings for chronically anxious 10 year olds. Within the clinical laboratory, across a 14-day period, these investigators gave such children the probe protocol (using emotional faces as stimuli), either configured in the avoid-threat contingency condition or the control condition. The process of ABM was evoked as intended, with children in the former condition coming to show less attention to threat than children in the latter condition, measured using the probe assessment procedure. Several days later, all the children were exposed to a stressor, involving a challenging puzzle. Children in the control condition displayed a robust elevation of anxiety elevation in response to this stressor. This anxiety response was not only significantly attenuated, but eliminated, for children in the avoid-threat condition.

Eldar et al. (2012) employed a similar protocol, now delivered across four weekly sessions in the clinical laboratory, to a sample of clinically anxious children aged 8–14 years. Across this period, those who received the avoid-threat condition showed a reduction in attention to threat faces, not evidenced by children who received the control condition, verifying that the former procedure successfully evoked the ABM process as intended. Anxiety symptoms also were significantly reduced for children in the avoid-threat condition, but did not change for children in the control condition. At the end of this four week period, 33% of the former children no longer met diagnostic criteria for an anxiety disorder, compared to only 13% of the latter children. Waters, Pittaway, Mogg, Bradley, and Pine (2013) have obtained parallel effects for 7-13 year old clinically anxious children using the visual search protocol, delivered across 10 sessions within the clinical laboratory during a 3 week period. Half the children received this protocol configured in the avoid-threat contingency

condition, and half received it in the control condition. A conventional probe assessment procedure confirmed that the former sub-group of children, alone, came to show a reduction in attentional bias to threat, confirming that this procedure successfully evoked the ABM process. There was a significant reduction in the severity of anxiety symptoms for children who received this procedure that evoked the ABM process, but no change in the anxiety symptoms experienced by children in the control condition. At the end of this three-week period, 33% of these children in the avoid-threat condition no longer met diagnostic criteria for an anxiety disorder, compared to only 6% of those in the control condition. De Voog, Wiers, Prins & Salemink (2014) reported similar findings when delivering this visual search protocol across 7 days, in the clinical laboratory, to 13 – 16 year olds reporting social phobia. Success in evoking the ABM process was confirmed using an attentional bias assessment task, which revealed significant attentional bias change in those who received the avoid-threat contingency condition, and not those who received the control condition. A significant reduction of social phobia symptoms was evident in the former subgroup of children, and not in the latter.

Before leaving this section it is relevant to note one exception to the otherwise consistent pattern of findings described above, showing that the successful evocation of the ABM change process serves to influence anxiety vulnerability and dysfunction, and this concerns spider fear. While elevated spider fear is characterized by an attentional bias towards spider relevant information (e.g., Kindt & Brosschot, 1997; Watts, McKenna, Sharrock, & Trezise, 1986), successfully evoking the process of ABM to alter this attentional bias has not been found to influence measures of spider fear. Thus, when Van Bockstaele et al. (2011) employed a procedure, based on the probe protocol, and confirmed that this procedure served to evoke the intended attentional bias modification process, giving rise to a group differences in attentional responding to spider-related information, this was not accompanied by a corresponding group difference in measures of spider fear. When Reese, McNally, Najme and Amir (2010) exposed participants who were dispositionally high in spider fear to a single session of such a procedure, configured in an avoid-spider contingency condition, and verified that

this procedure successfully evoke the intended ABM change process, the resulting reduction of attention to spider-related information led to no corresponding decline in measures of spider fear. Such findings invite the conclusion attentional bias to spider-related information does not causally contribute to spider fear, and suggest the possibility that such attentional bias may instead represent a consequence of heightened spider fear.

Although they vary widely in multiple ways, several important characteristics have been consistent across the studies reviewed in this section. First, in each study one subset of participants has been exposed to a procedure configured in a manner that is intended to evoke the target ABM change process of reducing attentional bias to threat, while another participant subset has been exposed to a different procedure configured in a way that is not expected to evoke this target change process. Second, in every study an attentional bias assessment procedure has been employed to determine whether this ABM process has been successfully evoked by the procedure intended to elicit this change process, and in the particular studies reported here this has always been the case. Third, with single exception of spider fear, in every study that has so confirmed the successful evocation of this process, so too has there been evidence that the ABM process has altered anxiety vulnerability and dysfunction. Of particular importance, when this ABM process has involved the reduction of attentional bias to threat, then it has served to attenuate dysfunctional anxiety symptoms in both non-clinical cohorts and in those meeting diagnostic criteria for clinical anxiety disorders. Such findings lend compelling support to those theoretical models that implicate attentional bias to threat as a causal factor in the etiology of anxiety vulnerability and dysfunction, while also demonstrating that therapeutic benefit accrues from evoking the ABM change process to attenuate such bias. We will now turn to consider findings from studies in which variants of these intended change process evocation procedures have been employed, but the target change process of ABM has not clearly been evoked. It will be seen that these finding remain entirely compatible with the hypothesis that the ABM change process, involving reduction of attentional bias, serves to attenuate anxiety vulnerability and dysfunction. However, it also will be seen that researchers have often

discussed these findings in ways that obscure the critical distinction between procedures and processes, leading to quite unwarranted inferences regarding the conclusions they permit concerning the emotional consequences of attentional bias modification.

Is anxiety vulnerability and dysfunction attenuated by procedures that do NOT demonstrably evoke the change process of attentional bias modification?

Two case series studies, designed to examine the impact of procedures intended to evoke the ABM process, have included attentional bias assessment procedures but been unable to draw confident conclusions concerning whether or not ABM was elicited, due to power issues (Rozenman, Weersing and Amir, 2011; Bechor et al., 2014). In both studies young participants were exposed to procedures involving the probe protocol, always configured in the avoid-threat contingency condition. Rozenman et al. (2011) gave 12 such sessions to 16 clinically anxious 10-17 year olds, across a 4 week period, and observed a statistically significant reduction in self-rated, parent-rated and clinician-rated anxiety symptoms. There was also a nominal reduction in their measure of anxiety bias to threat across this same period, but this was not statistically significant. Rozenman et al. attributed the non-significance to inadequate power. Bechor et al. (2014) employed a similar procedure, delivering the probe protocol configured in the avoid-threat contingency condition, to only 6 clinically anxious children aged 10-13 years, across a 4 weeks period. Reduction in self-report measures of anxiety was statistically significant. Once more, however, despite a substantial nominal reduction in their measure of attentional bias to threat, this attentional change fell short of statistical significance. Again this may reflect the very low power of the design to detect this effect. Nevertheless, without confirmation that the procedure intended to evoke the ABM process actually did so, one cannot draw conclusions about the emotional impact exerted by this target change process. Yet the authors do so. For example, Bechor et al. conclude that attentional bias modification led to significant mean reductions of anxiety symptoms. A careful reading of their text suggests that, in making this claim, these colleagues actually mean that the *procedure*, intended to elicit the process of attentional bias modification, led to such anxiety reductions. This highlights the importance of

differentiating the ABM process from the processes employed with the aim of evoking this process. Conclusions concerning the emotional impact of attentional bias modification cannot be justified unless the process of attentional bias modification has demonstrably been evoked.

Consequently, it is a serious oversight to omit from a study, conducted for the purpose of investigating the emotional impact of ABM, the assessment procedure necessary to determine whether or not the process of attentional bias modification is successfully evoked. Even when clinically relevant anxiety reduction is found to result from intended ABM evocation procedures, these emotional benefits cannot legitimately be attributed to ABM if there is no direct evidence that the ABM process actually took place. This limitation compromises interpretation of a classic study by Schmidt, Richey, Buckner and Timpano (2009), in which 8 sessions of the probe protocol were delivered across a four week period to patients with a diagnosis of social anxiety disorder (SAD). Half received this procedure configured in the avoid-threat contingency condition, intended to elicit the ABM process, while the remainder received it in the control condition. Across these four weeks, the former subgroup, but not the latter, displayed significant reductions in self-report and clinical-rated measures of anxiety. At the end of this period 72% of the former participants no longer met diagnostic criteria for SAD, compared to 13% of the latter, and treatment gains were well maintained across the four month follow-up period. Good outcomes, in terms of anxiety reduction also were obtained in a later study by Riemann, Kuckert, Rosenman, Weersing and Amir (2013), that likewise included no measure of attentional bias change. In this study, 13-17 year olds who were receiving regular CBT were exposed to same procedure employed by Schmidt et al. (2009). Those given this probe procedure configured in the avoid-threat contingency condition reported significantly greater reductions in anxiety than did those who were given it in the control condition, with clinically significant improvement being observed in 52.4% of the former compared to 4.8% of the latter.

While the treatment gains exhibited by patients who received the probe protocol in the avoid-threat contingency condition are impressive in both of the above studies, they cannot confidently be attributed to the process of attentional bias modification without evidence that this attentional change

process was successfully evoked by the procedure. In both papers the authors conclude from their findings that “attentional training” produced the observed therapeutic reduction in anxiety, despite the lack of direct evidence that attention was actually trained. Again this illustrates how easily the procedure employed in an intended intervention, can be confused with the process that this procedure is intended to evoke, and how such confusion can lead to unwarranted and potentially misleading inferences.

The prospect of misleading inferences resulting from the failure to differentiate procedures and processes is not restricted to studies in which procedures are observed to exert therapeutic benefits. The same confusion also can compromise interpretation when such benefits are found to be lacking. The difficulty drawing clear conclusions concerning whether or not the ABM process drives the attenuation of anxiety vulnerability and dysfunction, from studies in which a procedure intended to evoke the bias modification process produces no impact on anxiety, can be illustrated with reference to an experiment conducted by Bunnell, Beidel, and Mesa (2013), which failed to assess whether or not the ABM process was successfully evoked. Bunnell et al. set out to conceptually replicate Amir et al.’s (2009a) earlier study, in which the use of a procedure employing a probe protocol configured in the avoid-threat contingency condition had been shown both to significantly reduce attentional bias to threat, and to yield therapeutic benefits for patients with social anxiety disorder (SAD). While they employed a similar procedure to Amir et al., with the intention of eliciting the process of attentional bias modification, Bunnell et al. neglected to measure the attentional bias of interest. Consequently, when they did not replicate Amir et al.’s findings concerning the therapeutic benefits of the probe protocol, delivered in the avoid-threat contingency condition, they could not determine the basis of the inconsistency. Specifically, they could not distinguish the possibility that the procedure failed in their own study to evoke the target ABM change process, from the alternative possibility that the procedure remained successful in evoking this target ABM change process, but this ABM process does not reliably attenuate the symptoms of SAD. Though the implications of these two possibilities are radically different, both for theoretical

understanding and for the refinement of therapeutic practice, Bunnell et al. do not engage with this issue, and appear not to recognize how failure to assess attentional bias limits interpretation. Instead, they represent their findings as evidence that “attentional training” does not have clinical value, despite this inability to determine whether or not their procedure successfully evoked the intended process of training change in attentional bias to threat.

It is commendable that a number of investigators have sought to progress this field of research by amending the procedures employed with the objective of evoking the ABM change process. Of course, it must be expected that some of the resulting procedures will prove to be ineffective in eliciting this process. However, it is highly informative to note that whenever a procedure has failed to evoke ABM, as assessed by directly measuring whether it alters attentional bias to threat, then so too has it been observed to exert no impact on anxiety. In some cases, procedural refinement has involved the minor amendment of existing protocol. Thus, for example, Maoz, Abend, Fox, Pine and Bar-Haim (2013) amended the probe protocols by presenting the emotional stimuli subliminally, and delivered this amended procedure to socially anxious students in the four laboratory sessions. They found no evidence of any resulting difference in attentional bias to threat between those who received it configured in the avoid-threat contingency condition, and those who received it in the control condition. Thus, this procedure failed to evoke the ABM process. And in the absence of such ABM, there also was no evidence of any emotional impact, with these two subgroups of participants demonstrating no differential change in self-reported anxiety or anxiety reactivity to a stressor.

A rather different type of procedural innovation has involved more ambitious methods of delivery to enable protocols, previously shown capable of eliciting the ABM process under laboratory conditions, to be completed by participants outside the constraints of the laboratory setting. In a recent study by Enock, Hoffman and McNally (2014), this was achieved by using a smartphone platform to deliver a variant of the probe protocol employed successfully by Amir et al. (2009b) within the laboratory setting. Enock et al.’s study differed from Amir et al.’s in many ways

other than the use of a mobile platform. For example, participants were unselected volunteers, who completed on average only around half the sessions they were directed to, and drop-out rates were high. The smartphone procedure prove unsuccessful in evoking ABM, as indicated by failure to observe any resulting difference in attentional responding to threat between participants who received it in the avoid-threat contingency condition, and those who received it in the control condition. Given that the ABM process was not evoked by this manipulation, it is unsurprising that these two subgroups of participants showed no differential change in anxiety symptomatology.

More often, remote delivery has involved internet-based procedures that have participants' complete sessions on their home computers. Carlbring et al. (2012) used this approach to deliver the probe protocol, previously employed in the laboratory setting by Amir et al. (2009b), to successfully evoke ABM and reduce social anxiety in patients with social anxiety disorder. In Carlbring et al.'s procedure, patients with social anxiety disorder were instructed to access 8 sessions of this protocol on-line, which they completed in their home environment. This procedure was unsuccessful in evoking the ABM process. This was indicated by the observation that participants who received it configured in the avoid-threat contingency condition, and those who received it in the control condition, did not come to exhibit differing attentional bias to threat, measured using the conventional probe assessment procedure. In the absence of such attentional bias modification, it again should come as no surprise that these two subgroups of participants likewise evidenced no differential improvement in anxiety symptomatology. This is precisely what would be expected if the therapeutic agent of such enhanced symptom improvement, obtained in previous studies, has been the ABM process. The same pattern of findings since has been reported by Boettcher, Berger, & Renneberg (2012), Boettcher, Hasselrot, Sund, Andersson, & Carlbring (2014), Boettcher et al., (2013), Rapee et al. (2013), and other investigators who have used internet delivery to enable clinical anxiety patients to complete such protocols within their unconstrained home environments. In these studies, participants have completed the procedure across periods ranging from 2 – 12 weeks, using their own differing computers and typically making their own decisions concerning the specific

settings in which to complete each session, which potentially may expose them to substantial distraction (for example, from television, music, or family conversation). In each case, assessment of attentional bias to threat has revealed that the procedure failed to evoke the ABM process, as evidenced by the absence of any resulting difference in attentional bias to threat between participants who received it in the avoid-threat contingency condition, and those who received it in the control condition. This failure to evoke the ABM process has consistently been accompanied by the absence of any differential change in anxiety symptoms between these two subgroups of participants. This pattern of findings does not challenge the premise that the process of ABM exerts a therapeutic impact on anxiety vulnerability and dysfunction. Rather, it lends weight to the supposition that it is the process of ABM that has been the therapeutic element in those many studies that have observed such therapeutic benefits, from procedures that have demonstrably succeeded in eliciting the ABM process.

It should be acknowledged that, even under laboratory conditions, procedures intended to evoke the ABM process sometimes fail to do so. Such occasional failures to elicit the ABM process has sometimes been observed when laboratory-based procedures employing the widely used probe protocol have been delivered to non-clinical participants in a single session (Julian, Beard, Schmidt, Powers, and Smits, 2012), and to clinically anxious participants across multiple sessions (Britton et al., 2013; Schoorl, Putman, & Van der Does, 2013; Schoorl, Putman, Mooren, Van der Werff, & Van der Does, 2014; Shechner et al., 2014). This brings into question the degree to which the probe-based procedure is reliable in eliciting this target change process. However, once again, the findings do not challenge the evidence that the ABM process exerts a therapeutic benefit on anxiety vulnerability and dysfunction. Rather, they augment this evidence, by revealing that whenever the procedure fails to evoke the ABM process then it delivers no such therapeutic benefit.

Apprehension of this vitally important point is made possible only by maintaining the clear distinction between procedure and process. With this distinction in place, the overall pattern of findings permits two equally important conclusions. First, procedures employed with the intention of

evoking the ABM change process often, but certainly not invariably, serve to successfully evoke the process of ABM. Second, when these procedures do successfully evoke the ABM process, as evidenced by a relative reduction of attention to threat in the avoid-threat contingency condition, then so too do they beneficially influence anxiety vulnerability and dysfunction, whereas when they do not successfully evoke the ABM process then they deliver no such beneficial impact on anxiety. In principle it could potentially be argued that variability across studies, in terms of whether or not the procedures adopted with the intention of evoking the ABM process do or do not elicit significant change in attentional bias, might be attributable to the previously noted unreliability of some tasks currently employed to assess attentional bias (Schmukle, 2005). However, the very tight alignment observed across these studies, between the success of such procedures in evoking attentional bias change as measured using these assessment tasks, and their success in attenuating anxiety vulnerability and dysfunction, mitigates against the idea that between-study variability in attentional bias change reflects only measurement error. Instead it suggests that the adopted assessment procedures genuinely discriminate those studies in which the ABM process has or has not been evoked, and the attenuation of anxiety vulnerability and dysfunction consistently and exclusively results the successful evocation of this bias modification process. Recent critical reviews commonly have failed to recognize this underlying pattern, because they often have neglected to appropriately distinguish procedure from process (e.g., Emmelkamp, 2012). This also has been true of several influential meta-analyses. While the meta-analytical approach certainly has the capacity to illuminate the basis of inconsistencies in the emotional outcomes of studies that have been designed to modify anxiety-linked attentional bias, this requires that meta-analyses maintain a rigorous distinction between the procedures intended to evoke the ABM process, and this process itself, which may or may not be successfully evoked by these procedures. Unless this distinction is kept clear, there is a significant risk that meta-analytical studies may serve to consolidate, rather than to resolve, confusion.

The need to distinguish process from procedure in ABM meta-analyses

Across the past 6 years, at least nine meta-analytic reviews of the ABM literature have been published (Bar-Haim, 2010; Beard et al., 2012; Cristea et al., 2015a; Cristea et al., 2015b; Hakamata et al., 2010; Hallion & Ruscio, 2011; Heeren et al., 2015; Linetzky et al., 2015; Mogoase et al., 2014). Meta-analysis can be an extremely powerful tool. Its major value comes from the statistical power it affords to determine both the significance, and the size, of effects obtained when combining data from across a large sample of chosen studies. Nevertheless, there are potential pitfalls that must be avoided when employing this approach. Perhaps the most widely recognized problem concerns the interpretive difficulties that arise when the chosen sample inappropriately mixes studies that are dissimilar in important ways. Averaging the effects obtained across such discrepant studies can obscure, rather than illuminate, important patterns of effects that have significant implications. In the words of Hans Eysenck (1984) “adding apples and oranges may be a pastime for children learning to count, but unless we are willing to disregard the difference between these two kinds of fruit, the result will be meaningless (pg. 57)”. To be fair, the counter to Eysenck' criticism is that such summation may be warranted when the questions motivating meta-analysis concern fruit in general (Smith et al., 1980). However, what this hoary example serves to highlight is that the range of studies it is legitimate to combine within any meta-analysis depends critically upon the specific question that it intended to answer. As many methodologists have emphasized, it is possible to draw meaningful conclusions from any given meta-analysis only if the appropriate collection of studies is included (Sharpe, 1997).

Translating this principle into the present context, it follows that we will be able to draw meaningful conclusions, concerning whether or not the process of attentional bias modification serves to influence anxiety symptomatology, only from the meta-analysis of studies that have successfully evoked this ABM process. Yet in none of the meta-analyses reported to date, purportedly conducted to evaluate whether attentional bias modification conveys this emotional

impact, has it been the case that inclusion criteria have required the successful evocation of the attentional bias modification process. Instead, the selection of studies has been based on the experimenter's use of procedures that they *intended* to evoke the ABM process. It is appropriate to recognize that this type of meta-analysis does have substantial value, so long as the conclusions drawn concern only the therapeutic impact of these candidate procedures. Knowing whether, on average, procedures intended to evoke attentional bias modification consistently deliver therapeutic benefits for a given clinical cohort is of great potential importance to the clinician deciding whether or not to employ such a procedure within their chosen intervention program. However, meta-analyses that evaluate the therapeutic impact of such procedures, without distinguishing whether or not the ABM process has been successfully evoked, cannot permit conclusions concerning whether the process of attentional bias modification serves to attenuate emotional vulnerability. And yet, it has been commonplace for meta-analyses to draw such conclusions, supposedly concerning the emotional consequences of attentional bias modification, by averaging across proverbial "apples and oranges", respectively represented by studies that have successfully evoked the ABM process and by studies that demonstrably have not evoked the ABM process.

Failure to differentiate between these two very different types of studies had little impact on early meta-analyses, such as that reported by Hakamata et al. (2010). This was because, at that stage, virtually all the published studies carried out with the intention of evoking the ABM process had succeeded in elicited this process, as evidenced by significant change on measures of attentional bias to threat. Given that the successful evocation of the ABM process is quite reliably accompanied by changes in anxiety, averaging across these studies revealed a significant medium effect of (procedures intended to evoke) ABM on measures of anxiety, with a large fail-safe calculation (Hakamata et al., 2010). Hence, the conclusions drawn in early meta-analysis, concerning the potential therapeutic value of the ABM process, were strongly encouraging. However, as investigators have become more ambitious in terms of how they deliver procedures intended to evoke the ABM process, so too has there been a growing number of studies in which these

procedures have failed to elicit attentional bias modification. Unfortunately, in more recent meta-analyses, these studies where attentional bias modification has not taken place have simply been added to the body of studies where attentional bias modification has been successfully elicited. Consequently, and unsurprisingly, these more recent meta-analysis have tended to find more heterogeneous effects on anxiety, with much smaller average effect sizes (e.g., Mogoase et al., 2014; Cristea et al. 2015a; 2015b). Instead of pinpointing the locus of this heterogeneity, which likely reflects whether or not the ABM process took place, authors have commonly based their conclusions on these average effects, sometimes resulting in questionable inferences.

Consider, for example, the conclusions drawn by Cristea et al. (2015a), on the basis of their observation that, when averaging across studies that did and did not elicit the intended bias change process (which remained an unacknowledged distinction), anxiety and depression effects were found to be small. Surprisingly, these colleagues infer from this that the positive findings reported in prior meta-analyses “may have been influenced by a variant of the ‘experimenter effect’ or other experimental artefacts, unrelated to the scope and purported mechanisms of action of these interventions (pg. 14)”. A more parsimonious account is that beneficial emotional effects depend upon the “purported mechanisms of action” being successfully evoked by the adopted procedures, and that Cristea et al.’s meta-analysis was unable to demonstrate this because this meta-analysis failed to distinguish between studies in which the adopted procedure did or did not evoke the purported mechanism of attentional bias modification. In a recent response to Cristea et al, we re-analysed the data from the studies included in their meta-analysis, subdividing these into studies in which the target cognitive bias modification process was successfully evoked by the adopted procedures, and those in which it was not (Grafton et al., in press). Most pertinent to the issues presently under consideration is the subset of these studies in which the adopted procedure was intended to evoke ABM. Our reanalysis of this subset of studies served to demonstrate that when the adopted procedures successfully evoked the ABM process, as evidenced by a significant reduction in attentional bias to threat, then so too was there a significant positive impact on emotional disposition,

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which had a large effect size ($g = .602$; 95% CI .139 – 1.066). In contrast, when the adopted procedures did not successfully evoke the ABM process, as evidenced by no significant change in attentional bias to threat, then there was no trace of any such emotional impact ($g = -.01$; 95% CI -.184 – 1.63). Distinguishing studies on the basis of whether or not the ABM process has or has not been successfully evoked permits the most meaningful conclusions concerning the emotional impact of modifying attentional bias.

A recent meta-analysis by Linetzky, Pergamin-Hight, Pine, & Bar-Haim (2015) lends weight to our contention that, to advance understanding concerning the therapeutic benefits of the ABM process, meta-analyses must distinguish between studies in which the procedures have succeeded or failed to evoke the ABM process. Linetzky et al. did not restrict inclusion of purportedly ABM studies on the basis of whether or not the ABM process was successfully evoked. Rather, as in previous meta-analysis, studies were included if the adopted procedure was simply intended to evoke the ABM process. However, Linetzky et al. did investigate the moderating influence of what they classed as a procedural variable – specifically, whether the procedure was completed in the clinical laboratory or remotely over the Internet in the home environment. This variable significantly moderated the degree to which anxiety patients benefited from procedures intended to evoke the ABM process. Meta-analysis revealed a significant therapeutic benefit, in terms of anxiety reduction, when these procedures were delivered in the clinical laboratory, but no such therapeutic benefit when they were delivered over the Internet. Importantly, the meta-analysis also showed that this variable moderated the success of these procedures in evoking the intended attentional bias modification process, as evidenced by the reduction of attention to threat. Such reduction in attentional bias was statistically significant, and had a large effect size, when procedures involved delivery within the clinical laboratory, but there was no evidence of significant decline in attentional bias to threat when the procedures involved delivery over the Internet.

Still more direct evidence that the therapeutic benefit of procedures, intended to evoke the ABM process, depends on the degree to which these procedures succeed in evoking this process,

comes from meta-analyses that have examined the association between training induced change in attentional bias to negative information, and change in anxiety vulnerability and dysfunction. It commonly has been found that the magnitude of the change in anxiety resulting from exposure to such procedures is a function of the degree to which these procedures serve to evoke the ABM process (e.g., Hakamata et al., 2012; Mongoase et al., 2014; Heeren et al., 2016). Thus, for example, Hakamata et al. (2010) found that, across studies employing such procedures, the magnitude of the induced reduction in attentional bias to negative information correlated 0.75 with the magnitude of the observed reduction in measures of anxiety. Similarly, Heeren et al. (2015) report finding in their more recent meta-analysis that, across studies, the size of the reduction in attentional bias to negative information induced by such procedures correlated 0.9 with the magnitude the resulting reduction in anxiety reactivity to an experimental stressor.

These findings sit comfortably with the conclusions, based on our critical review of the literature, that procedures adopted with the intention of evoking the ABM process do not always do so, but when the ABM process is successfully evoked then this quite reliably impacts on anxiety vulnerability and dysfunction. It is unfortunate that some meta-analyses of this literature have served to obscure, rather than to highlight, this consistent and important pattern of effects. We contend that, in large part, this can be attributed to a failure to distinguish, within these particular meta-analyses, between the process of ABM, and procedures that have been adopted with the intention of evoking this ABM process. Understanding is always threatened, and confusion invited, when experimental psychopathologists neglect to clearly differentiate target change processes from the procedures adopted with the aim of eliciting such processes.

Closing Comments

We have reviewed compelling evidence for the existence of an anxiety-linked processing bias involving heightened attentional vigilance for threat, and illustrated how the progressive refinement of assessment procedures has steadily advanced understanding of this process. We also have shown

that efforts to reduce anxiety vulnerability and dysfunction, by directly modifying this attentional bias to threat, have produced mixed outcomes. Inconsistent findings are commonplace in experimental psychopathology research, and the careful appraisal of such heterogeneity is always important, as the identification of its basis can drive both the advancement of theoretical understanding and improvement of clinical practice. As we have striven to emphasize, the success of our endeavors to understand the basis of inconsistency depends critically upon always maintaining a firm distinction between the target change process that candidate interventions seek to elicit, and the procedures employed for the intended purpose of evoking this change process.

We have pointed out a tendency to neglect this distinction, between process and procedure, within much of the recent literature concerning attentional bias modification, and shown that this has given rise to some confusion and misleading claims concerning whether or not the modification of attention bias, to reduce attention to threat, delivers anxiolytic benefits. We also have illustrated how the differentiation of process and procedure restores clarity, by pinpointing the locus of inconsistency. This reveals that successful evocation of this target ABM process quite consistently exerts a beneficial impact on anxiety vulnerability and dysfunction, but procedures employed with the purpose of evoking the ABM process do not consistently elicit this target change process. Such clarity does not itself eliminate problems, and we do not contend that the unreliable capacity of existing procedures to consistently evoke the ABM change process is less important than would have been the potential unreliability of this change process in driving the reduction of anxiety. The fact that the procedures currently used with the intention of modifying attentional bias are not robust in terms of their capacity to evoke the ABM process represents a significant problem for progress within this research domain. However, the recovery of clarity concerning the distinction between process and procedure serves to identify the specific nature of the problem that we face in this area of experimental psychopathology research. This, in turn, points us in the direction of its solution. Specifically, it indicates that high priority should now be placed on the development of improved procedures, capable of more effectively eliciting the ABM change process.

Much of ongoing research is motivated by this objective (c.f., MacLeod & Clarke, 2015). Some of this work involves laboratory experimentation designed to evaluate the impact of procedural variables on the degree to which existing protocols serve to elicit the ABM process. Such procedural variables range from obvious candidates such as instruction (e.g., Grafton, Mackintosh, Vujic & MacLeod, 2014), through to more novel types of variations involving the use of neural stimulation. For example, we recently have found that the success of the probe protocol in evoking the ABM process can be significantly enhanced by the simultaneous delivery of tDCS stimulation to the dorsolateral prefrontal cortex (Clarke, Browning, Hammond, Notebaert, & MacLeod, 2014). However, future efforts to improve the effective evocation of the ABM process should not be constrained to appraising only how procedural variables may influence the success of existing protocols, but should also involve the development and evaluation of quite new candidate approaches. A firm commitment to the goal of optimizing evocation of the ABM process is unlikely to be best served by an unwavering commitment to a particular procedural approach, based on historical precedence, but by a readiness to embrace and promote procedural innovation, in the quest for continuous improvement. Such procedural innovation already is resulting in new candidate techniques for modifying attentional bias to threat, often based on gamification principles (c.f., Kapp, 2012), encouraging early findings suggesting that these may evoke the ABM process more effectively than do previously employed techniques (e.g., Notebaert et al., 2015; MacLeod, Grafton, Notebaert, Clarke & Rudaizky, 2014; Dennis & O'Toole, 2014). Whatever specific technique is employed, future work must recognize the potential moderating impact of delivery context, as existing data clearly demonstrate that this procedural variable can influence whether or not the ABM process is elicited. Procedures that involve delivery in the controlled context of the clinical laboratory are more successful in eliciting the ABM process than are those that involve remote delivery into the home environment. We are pleased to see the advent of research designed to test clearly articulated explanations of this observation, by empirically determining how procedural refinements can enhance the evocation of the ABM process within the home context (e.g., Kuckertz

et al. 2014). Based upon the patterns of findings within the existing ABM literature, revealed by differentiating the ABM process from the procedures employed with the intention of eliciting this process, there are firm grounds for confidence that refinement of these procedures to improve their capacity to successfully evoke this target ABM process will provide the practitioner with progressively more effective anxiety-management tools.

The importance of distinguishing process from procedure, both in our efforts to appraise the validity of candidate explanations of psychopathology, and in our attempts to exploit the resulting understanding in ways that deliver therapeutic benefits, is not restricted to the domain of anxiety-linked attentional bias. Clearly, the need to maintain this distinction is equally important when investigating other types of information processing biases that plausibly may contribute to anxiety vulnerability, such as interpretive bias (c.f. MacLeod & Mathews, 2012), or to other forms of dysfunctional symptomatology, such as addictions (c.f. Cox, Fadardi, Intriligator, & Klinger, 2014), or eating disorders (c.f. Renwick, Campbell, & Schmidt, 2013). Whatever the bias under consideration, in order to exploit the capacity of cognitive bias modification approaches to advance theoretical understanding by illuminating whether it causally contributes to dysfunctional symptoms of interest, and to reveal whether the manipulation of this bias can yield clinically significant therapeutic benefits in terms of symptom attenuation, we must not confuse the target process of bias change with the procedures intended to evoke this process. Progress in all fields of experimental psychopathology will be optimized by clearly differentiating the four key elements of our discipline identified within Figure 1, by understanding the relationship between them, and by embracing the complementary contributions they make to the advancement of our science and practice. Meaningful advances will require the continuous synthesis of progress in the theoretical formulation of candidate dysfunctional processes that may explain psychopathology, in the development of assessment techniques to sensitively measure these putative processes, in the specification of the target change processes that the findings indicate may attenuate psychopathology, and in the creation, evaluation and refinement of procedures with the intended capacity to evoke such change procedures. Such

integration requires a broad canvas. For more than half a century, BRAT has delivered fully on its original commitment to providing this breadth, and by bringing together these complementary lines of research endeavor this journal has made an unparalleled contribution to the past progress of our field. In re-affirming this commitment, the incoming editorial team provides the assurance that, under their leadership, BRAT will continue to lead the way, by fostering cutting-edge developments that will powerfully shape the future of experimental psychopathology. Consequently, we look forward with no small measure of excitement to the years that lie ahead.

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ANXIETY-LINKED ATTENTIONAL BIAS AND ITS MODIFICATION

| | |
|---|---|
| Pathological Processes | Change Processes |
| Pathological Process Assessment Procedures | Intended Change Process Evocation Procedures |

Figure 1. The process and procedures pertinent to experimental psychopathology research