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Review article

The link between optimism bias and attention bias: A neurocognitive perspective

Laura Kress*, Tatjana Aue

University of Bern, Switzerland

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ABSTRACT

Both optimism bias and reward-related attention bias have crucial implications for well-being and mental health. Yet, the extent to which the two biases interact remains unclear because, to date, they have mostly been discussed in isolation. Examining interactions between the two biases can lead to new directions in neurocognitive research by revealing their underlying cognitive and neurophysiological mechanisms. In the present article, we suggest that optimism bias and reward-related attention bias mutually enforce each other and recruit a common underlying neural network. Key components of this network include specific activations in the anterior and posterior cingulate cortex with connections to the amygdala. We further postulate that biased memory processes influence the interplay of optimism and reward-related attention bias. Studying such causal relations between cognitive biases reveals important information not only about normal functioning and adaptive neural pathways in maintaining mental health, but also about the development and maintenance of psychological diseases, thereby contributing to the effectiveness of treatment.

1. Introduction

Being able to adequately predict future events is crucial in everyday life, especially when planning behavior and making decisions (Damasio, 1994). Humans, however, tend to overestimate the likelihood of future positive events and underestimate the likelihood of future negative events (Sharot et al., 2011; Weinstein, 1980). This phenomenon, named optimism bias, describes a positivity bias in expectancies about the future and has cognitive (forming beliefs about the future, imagining and judging future events, estimating probabilities), motivational (maintaining favorable self-perception, denying threat), and affective origins (mood, hope; Armor and Taylor, 1998). Moreover, it entails a behavioral component (initiating goal-directed behavior, persistent pursuit of goals).

Optimism bias has been studied extensively in recent years because of its implications in everyday life (e.g., goal persistence, positive affect; Armor and Taylor, 1998; Shepperd et al., 2015) and in the clinical domain (e.g., better physical health, lowered depression rates; Garrett et al., 2014; Hevey et al., 2014; Korn et al., 2014). Despite the theoretical and practical significance of optimism bias, its underlying neural and physiological functioning have not yet been completely identified, and its interplay with other cognitive biases, for instance, in attention or memory, remains to be determined.

Of note, taking other cognitive biases into account instead of studying optimism bias in isolation can fill several important gaps in the literature. Such an approach could (a) shed further light on the cognitive mechanisms underlying optimism bias, (b) allow investigation of why optimism bias exists and how it is maintained over time, and (c) help with the understanding of the extent to which the highly beneficial role of optimism bias is rooted in other cognitive biases. Moreover, studying optimism bias (known to play a role in mental health; Garrett et al., 2014; Korn et al., 2014) in relation to other cognitive biases could (d) uncover divergences and commonalities in health and psychopathology (first by comparing interplay among reward-related biases between the two populations; subsequently by also comparing reward-related and negative biases) and contribute to a better understanding of psychopathologies by (e) including potential mediating and moderating factors in models of psychiatric diseases, thereby fostering the understanding of complex disease-specific chains of causality, and (f) revealing how interacting cognitive biases constitute risk factors for psychopathologies and identifying the mechanisms impeding their treatment (Kraemer et al., 2001). Furthermore, taking into account how different cognitive biases that are relevant in psychological disorders interact can (g) enhance prevention of psychopathology, (h) improve the effectiveness of state-of-the-art treatment (Aue and Okon-Singer, 2015; Everaert et al., 2012; Hirsch et al., 2006), and (i) lead to more fine-grained diagnosis of patients. In summary, studying optimism bias in relation to other cognitive biases could not only broaden our

* Corresponding author at: University of Bern, Institute of Psychology, Division of Experimental Psychology and Neuropsychology, Fabrikstr. 8, 3012 Bern, Switzerland.
E-mail address: laura.kress@psy.unibe.ch (L. Kress).

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knowledge about the bias itself (a–c) but could also advance theoretical models in psychopathology (d–f) and provide help for clinical practice (h–i).

In order to take a first step toward filling these gaps in the literature, the present article aims to (a) set up a framework of neurocognitive processes that might influence or be influenced by biased optimistic expectancies and (b) stimulate future research in the field by outlining specific hypotheses within the framework that are yet to be examined. We concentrate on attentional processes with a specific focus on *reward-related* processes (for the sake of brevity, we use the term "attention bias" instead of "reward-related attention bias" in the remainder of this article). Several ways in which optimism bias and attention bias may interact and the extent to which they rely on shared neural mechanisms are outlined.

We specifically focus on the interplay between optimism bias and (reward-related) attention bias for several reasons: First, it is likely that optimism and attention biases interact to reach a common goal: A motivation to reach a rewarding goal has been suggested to underlie both biases and is associated with shared neural activations (optimism bias: Bateson, 2016; Buehler et al., 1997; Richter et al., 2012; attention bias: Mohanty et al., 2008; Pessoa and Engelmann, 2010; Small et al., 2005). Here, motivation represents the driving force for behavior that is directed to a specific goal (i.e., a desired outcome), whereas reward functions as an incentive that makes this goal desirable. Second, in the empirical literature and theories on psychopathology (Aue and Okon-Singer, 2015), attentional processes have been repeatedly suggested to influence (optimistic) expectancies, which further underscores our claim that both biases should be examined by using an integrative approach. For instance, certain brain activations have been proposed to contribute to optimism bias by biasing attention to positive stimuli (Aue et al., 2012; Sharot, 2011; Sharot et al., 2007). Third, the first evidence that processes present in optimism bias and attention bias are indeed causally associated has been provided (Kress et al., submitted; Peters et al., 2015). Specifically, induced state optimism has been causally related to biased attention away from negative stimuli (Peters et al., 2015), and induced optimistic expectancies have been shown to guide attention toward rewarding and away from punishing stimuli (Kress et al., submitted).

Although the main aim of the current paper is to stimulate research on the interplay of optimism and attention bias, we also discuss the potential role of biased memories in influencing the link between optimism and attention bias. Notably, because attention and memory are highly interactive processes (Chun and Turk-Browne, 2007) and biased memories have been associated with optimistic expectancies (Roy et al., 2005), consideration of memory bias provides additional important information about critical cognitive bias interplay. Therefore, we want not only to emphasize the role of other cognitive biases that may influence the link between optimism and attention bias, but also to motivate researchers to take additional biases into account in future investigations and theoretical models.

It is further important to note that our ideas build on past work from our laboratory on expectancy biases in fear and anxiety and their link to attention biases (Aue and Okon-Singer, 2015). Although the previous and current articles focus on biased expectancies as related to attention processes, the current article adds several new and important aspects:

a. Optimism bias represents a specific form of future expectancies that stands out from other forms in terms of robustness (as shown by selective updating of pessimistic but not optimistic expectancies when people are confronted with disconfirming feedback; see Sharot et al., 2012b, 2011).

b. Because optimism bias is suggested to play an important role in the maintenance of depression (Garret et al., 2014; Korn et al., 2014), in regard to implications for the clinical context, we concentrate on implications for depression in the current article, in contrast to anxiety in the previous article.

c. The current article focuses on reward-related biases in information processing that likely derive from a motivation that is different from negativity biases, which are most often centered around various forms of punishment (including frustrating non-reward), the latter being the focus of the previous article.

d. The current article proposes possible mechanisms of neural communication that link optimism bias and attention bias and therefore could advance future research paths not only in cognitive research but also in neuroscientific research.

After outlining the rationale for the current framework and its specific focus on optimism and attention bias, we next briefly introduce the two phenomena of interest. We emphasize their relevance and underlying neural networks, which constitute the basis on which we have built our framework. Of note, we keep these sections short, as both optimism bias and attention bias have been reviewed earlier (optimism bias: Sharot, 2011; reward-related attention bias: Pool et al., 2016a). In the present article, therefore, our primary focus is on the relation of the two cognitive biases and the neural foundations of the proposed relation. To further refine our model and inspire future research and theorizing in the area, we additionally propose that memory processes influence the interplay of the two biases of main interest.

2. Optimism bias

When trying to define optimism bias, one encounters a major problem: On the one hand, different terms (e.g., wishful thinking, unrealistic optimism, comparative optimism, and overoptimism) have been used to refer to the same psychological phenomenon (or at least highly similar phenomena), while on the other hand, the same terms have been used for slightly different phenomena in past research. Despite being aware that there are fine-grained differences between the different concepts, we pool them together by using the broad term *optimism bias* (as currently there is not enough literature on any of the subconcepts of optimism bias to focus our framework on just one of them). Representing the main character of all concepts mentioned, optimism bias is thus defined as an overestimation of positive future events and an underestimation of negative future events (this definition is used by all studies on optimism bias cited in this article). Moreover, in the present article, optimism bias is exclusively defined as a bias in expectancies directed toward the future (not the present or past), a definition that has been widely accepted in the literature (e.g., Armor and Taylor, 1998; Campbell et al., 2007; Chambers et al., 2003; Jefferson et al., 2016; Sharot, 2011; Shepperd et al., 2013; Weinstein, 1980; for a more detailed discussion on the definition of optimism bias, see Bortolotti and Antrobus, 2015).

Moreover, it is important to note that optimism bias is closely linked to anticipation of reward (Sharot, 2011). In fact, in humans, optimistic expectancies are usually directed toward a rewarding goal (Bateson, 2016), and anticipating reward is the crucial motivating force in optimism bias shown by non-human animals (e.g., Matheson et al., 2008). One major component of reward is "wanting". It describes individuals being motivated to strive for reward through both unconscious incentive salience processes and conscious desires for incentives or cognitive goals (Berridge and Kringelbach, 2008; Pool et al., 2016b). Because it represents the phase of reward expectation, wanting is an important factor in shaping optimism bias. In contrast to wanting (i.e., reward expectation), "liking" (i.e., reward consummation) represents the pleasure component of reward, and "learning" (i.e., reward satiety) refers to associations and representations about rewards (Berridge and Kringelbach, 2011). Both liking and learning might additionally contribute to optimism bias by determining the hedonic value of the expected reward and influencing subsequent predictions about future rewards. The three phases of Berridge and Kringelbach's model can, therefore, be essential to the formation of optimism bias and its maintenance over time.