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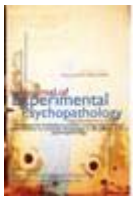

A Cognitive Model of Psychological Resilience

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Abstract

Resilience is considered to be the process by which individuals demonstrate more positive outcomes than would be expected, given the nature of the adversity experienced. We propose that a cognitive approach has the potential to guide studies investigating the relationships between adversity, stress, and resilience. We outline a preliminary cognitive model of resilience in order to facilitate the application of cognitive approaches to the investigation of resilience in the face of adversity. We argue that the situationally appropriate application of flexibility or rigidity in affective-cognitive systems is a key element in promoting resilient responses. We propose that this mapping of cognitive processing can be conceptualised as being undertaken by an overarching mapping system, which serves to integrate information from a variety of sources, including the current situation, prior experience, as well as more conscious and goal-driven processes. We propose that a well-functioning mapping system is an integral part of the cognitive basis for resilience to adversity. Our preliminary model is intended to provide an initial theoretical framework to guide research on the development of cognitive functions that are considered to be important in the resilience process.

Keywords: psychological resilience, cognitive bias, psychological flexibility, executive control, cognitive model, vulnerability, adversity

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Table of Contents

Introduction

There are profound differences in how people respond to all sorts of environmental adversities. The fact that some people cope with stressful experiences better than expected, given the nature of adversity, is the essence of the concept of resilience. Thus, a reasonable working definition of resilience is the demonstration of a relatively good outcome given exposure to adverse circumstances (Rutter, 2006). Or, as defined by Masten (2011, p. 494) resilience can be viewed as "the capacity of a dynamic system to withstand or recover from significant threats to its stability, viability or development". As pointed out by Rutter (2012), such notions imply that resilience is an interactive concept that has to be inferred from individual variations in outcome among those who have been exposed to significant stress or adversity. In other words, resilience can only be understood in the context of responding to significant adversity. At a cognitive level, adversity is typically conceptualized as a perceived discrepancy between the situation an individual is confronted with and a desired conception of reality specified by their goals, needs, investments, and aspirations for the future (e.g., Lazarus & Folkman, 1984; Schwager & Rothermund, 2013).

Early understanding of the concept of resilience was influenced by a pioneering research programme called 'Project Competence' (Garmezy, Masten, & Tellegen, 1984; Masten & Tellegen, 2012). The results of Project Competence revealed a key set of personal attributes that promoted resilience in childhood that involved the enhancement of a sense of personal agency or self-efficacy (Garmezy et al, 1984). Being able to focus attention, avoid distraction, rapidly shift mental set, and challenge negative thoughts and ideas in a reflective way were generally found to be critical for the development of personal agency and coping well in a complex world. It was concluded that deficits in these cognitive functions, induced by early social deprivation, prevented people from capitalizing on life opportunities. To illustrate, a qualitative study of people who had been hospitalized for a serious mental illness in adolescence found that what marked out those who were more resilient to this adversity in the longer term was a strong sense of personal agency that led them to assess what was and was not working for them, gave a determination to overcome adversity, and typically induced a commitment to relationships (Hauser, Allen, & Golden, 2006). Broadly speaking then, we can draw the conclusion that the personal mental qualities that characterize resilience relate to a sense of personal agency or self-efficacy, a high degree of cognitive- or executive control, cognitive flexibility, and the ability to self- regulate emotional reactivity. Further, given the range of processes that may contribute to resilient responses to adversity, it should be noted that there are likely many pathways to resilience and what works in one situation may not necessarily be as effective in other situations. From this perspective, resilience should be viewed as an interactive process, rather than a fixed trait or characteristic (Rutter, 2006).

Of course, an interactive process account of resilience does not mean that some individuals do not show better outcomes than others (resilience) in a wide set of circumstances, which is more supportive of a personality trait conception of resilience (Block & Block, 1980). We suggest that both approaches to resilience have their merits and that a science of resilience can benefit from integrating research from these different streams. Even from a trait perspective, however, it is important to point out that resilience should not be considered to be an all or none phenomenon. Rather, a probabilistic understanding of resilience seems more likely such that some individuals will be more resilient than others in a wider variety of circumstances. This is similar to theoretical conceptualizations of trait-anxiety (e.g., Spielberger, 1972), which does not assume that highly trait-anxious people are in a high state of anxiety all the time. Rather, high trait- anxious individuals have a higher frequency of elevations in state anxiety over time relative to those with lower levels of trait-anxiety.

Many of the themes emerging in the developmental literature have also been reflected in adult research especially in the pioneering work of George Bonanno (Bonanno, 2004). Investigating reactions to major life trauma such as death of a spouse or being part of a major natural disaster or terrorist attack reveals that multiple pathways to resilience are also apparent in adulthood and that resilience is actually much more normative than might be expected (e.g. Masten, 2001). While this latter point has recently been debated (Galatzer-Levy & Bonanno, 2016; Infurna & Luthar, 2016a, 2016b), a large body of research demonstrates that certain personal attributes, such as self-enhancement, are important for the expression of resilience in adulthood (Bonanno, 2004). For instance, those high in the personality trait of hardiness (Kobasa, Maddi & Kahn, 1982; Maddi, 2002; 2006; Maddi & Koshaba, 1994) - characterized by a commitment to finding a purpose in life, a sense of personal agency, and the belief that one can learn and grow from both positive as well as distressing life experiences – tend to be more resilient than those low in this trait. Other researchers have focused on how individuals utilise positive factors and personal strengths, in order

to protect against the negative effects of risk exposure and promote positive mental health (Fergus & Zimmerman, 2005; Zimmerman, 2014). Schwager and Rothermund (2013) have argued that the automatic regulation of fundamental processes such as selective attention and affective processing are critical for resilience as they lay the groundwork for motivational change and facilitate the expression of adaptive behaviours in situations of threat and adversity. In line with this approach, research has begun to investigate the cognitive processing styles associated with the trait concept of psychological resilience (e.g. Schäfer et al., 2015; Thoern, Grueschow, Ehlert, Ruff, & Kleim, 2016). A real problem, however, is that resilience research has remained relatively fragmented, which is due in part to the absence of a clear theoretical framework added to a lack of clarity over the concept of resilience itself (Luthar, Cicchetti, & Becker, 2000).

To summarize, a substantial body of research with children, adolescents and adults suggests that there are multiple pathways to resilience and that a combination of personal attributes, family circumstances, and the nature of supportive networks outside the immediate family are critical to the development of either resilience or vulnerability in the wake of severe life adversity. In this paper, we focus specifically on the role that personal attributes, especially aspects of cognitive functioning, might play in tipping the balance towards better than expected outcomes (i.e., resilience) in the face of severe stress and adversity. Given this focus, it is worth noting that we have made a conceptual distinction between external factors that have been found to support resilience, and internal, cognitive factors. For the purposes of the cognitive model we outline in this paper, we consider these external factors to be part of the current or past situation that can guide and influence cognitive processing.

There are a number of reasons for a focus on the cognitive aspects of resilience. First, whether a situation is deemed to be stressful or not is to a large extent determined by how an individual appraises the situation (Lazarus & Folkman, 1984). While many situations are considered to be universally adverse (e.g., death of a spouse), the impact of even these tragic events actually differs very widely across people (Bonanno, 2004). Therefore, an acknowledgement of individual variation in how people interpret and appraise different situations is important. Second, we note that there is a large body of experimental psychopathology research demonstrating the association between automatic negative cognitive biases (in attention, interpretation, and memory) and emotional vulnerability (Mathews & MacLeod, 2005 for review). For example, an automatic tendency to allocate attention selectively to negative cues relative to neutral or positively valenced material is a key cognitive characteristic of anxiety. Moreover, the tendency to selectively allocate attention towards more threat-related material in high trait-anxious people is increased when they are under stress (MacLeod & Mathews, 1988). Methods developed in experimental psychopathology research to assess selective processing biases have not yet been fully utilized in the field of resilience research, and we believe that using such methods will be advantageous in furthering resilience research. Third, there is substantial evidence that anxious mood states and generally feeling stressed has a negative impact on a variety of executive functioning abilities. Executive functions (also termed executive- or cognitive-control) refer to a group of top-down mental processes consisting of inhibitory control, working memory, and cognitive flexibility and are supported largely by the pre- frontal cortex (Diamond, 2014, for review). Collectively, these executive functions allow us to remain focused, avoid distraction from temptations, as well as facilitating the ability to flexibly adjust to changing demands and circumstances. Critically for the current context, these executive functions are disproportionately impaired when people are stressed or in highly anxious mood states (Arnsten, 1998; Eysenck, Derakshan, Santos, & Calvo, 2007; Liston, McEwen, & Casey, 2009).

Thus, cognitive functions are critical at every stage of how we cope and react to stressful situations. First, whether or not a situation is psychologically stressful for a particular individual is influenced by cognitive appraisals of that situation alongside the presence of automatic processing biases to allocate cognitive resources towards the more negative or difficult aspects of the situation. Second, if the situation is stressful then the automatic processing of negativity (and the simultaneous ignoring of more positive or hopeful aspects of the situation) tends to intensify. Third, in this situation the very executive functions that are likely to help in developing appropriate coping responses are selectively impaired. Thus, there is a perfect “cognitive” storm of increasing automatic biases and appraisals towards negativity alongside a decrease in executive control functions when faced with stress (See Eysenck et al, 2007 for similar view in relation to trait-anxiety and worry). We would predict that individuals with an increased capacity to guide automatic biases, appraisals, and executive functioning, towards processing styles that are adaptive in that specific situation are more likely to develop resilience in a wide range of situations. Further, an important mechanism

in this adaptive system is the capacity to promote flexibility or rigidity in the cognitive processing system when it is appropriate to do so. Given the disparate nature of resilience research we argue that a focus on personal attributes from a cognitive perspective will facilitate the investigation of the underlying cognitive mechanisms involved in the unfolding process of resilience as people deal with stress and adversity.

A Cognitive Model of Resilience

On the basis of considerable success in enhancing our understanding of the cognitive aspects of emotional vulnerability (e.g. Hertel & Mathews, 2011; Mathews & MacLeod, 2005; Williams, Watts, MacLeod, & Mathews, 1988) we propose that a cognitive approach has the potential to guide studies of the relationships between adversity, stress, and resilience. An advantage of combining a cognitive model with an experimental psychopathology approach is that it allows us to derive and test specific hypotheses regarding the selective processing of emotional information. (Fox, Mackintosh & Holmes, 2014; Macleod & Bucks, 2011). Controlled experimental task environments and methodologies allow researchers to predict specific patterns of observable behaviours, e.g. response latencies between experimental conditions or between participant groups. To date, this approach has been oriented primarily towards emotional vulnerability. Here, we develop a preliminary cognitive model of resilience in order to facilitate the application of cognitive approaches to the investigation of resilience in the face of adversity. We accept that much of the key research has not yet been conducted but argue that the provision of a coherent model will help to integrate the various distinct approaches to resilience. We hope that this theoretical framework will enable researchers to develop novel hypotheses and approaches to the measurement and development of psychological resilience and positive mental health.

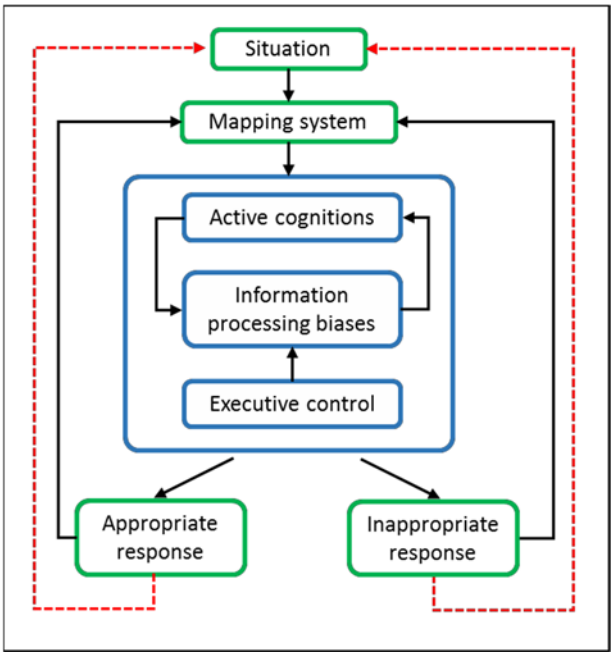

Figure 1: An information-processing model of psychological resilience.

As shown in Figure 1, our proposed model of resilience focuses on the ability to flexibly apply appropriate cognitive processing that is relevant to the current situation. Common to other cognitive models (e.g. Beck & Bredemeier, 2016; Beck & Clarke, 1988, 1997; Beevers, 2005; Mathews & MacLeod, 2005; Schwager & Rothermund, 2013; Teasdale, 1988), at the core of our model are cognitive processes, which would typically be considered to be implicit and not under conscious control; including executive control, information processing biases, and active cognitions. The novel element in our model is an overarching mapping system that guides the flexible application of information processing, relevant to current situational demands and perceived needs and goals. The function of the mapping system is to integrate information about the current situation and evaluate whether current responses are appropriate or not. If the resultant behavioural responses are not meeting the specified aim (e.g. dealing effectively with stress) then the mapping system would promote flexibility in the cognitive processing systems and facilitate the appropriate calibration of these systems. The exception to this would be when prior experience supports the use of the current

processing style to promote a more adaptive outcome in the longer term. It stands to reason that some processing strategies may take time to achieve the desired result, and that a functional mapping system would take prior experiences of cognitive styles that have been effective in similar situations into account. Alternatively, if the current approach is believed to be appropriate in achieving the currently held goal or desired state (or shift towards that state), then the mapping system would be expected to inhibit changes in the cognitive system in order to promote the desired outcome.

It is important to note that we are not arguing that flexibility in the cognitive system is universally adaptive. Rather, we propose that processing styles may be adaptive or maladaptive depending on the situation, and subsequently that transitioning between flexibility and rigidity in processing style is particularly important in promoting adaptive cognitive processing. For instance, when a particular information processing strategy is appropriate, for example in a combat scenario, the mapping system might promote a rigid selective attentional bias towards threat, then this form of processing will be maintained until such a time as that strategy has become inappropriate. Following the removal of the threat, the mapping system would be expected to promote flexibility in the cognitive processing system and guide the shifting of processing strategy. The mapping system is proposed to function closer to a conscious threshold than automatic implicit information- processing. At this level of functioning, the mapping system is theoretically capable of integrating conscious goal-driven processing as well as previous experience in order to guide flexible processing of emotional information. It is also plausible that this system would be capable of taking into account indirect experiences, such as observations of other people's reactions to similar adverse situations. We might speculate that this is one mechanism through which external support systems, such as a supportive family, might promote resilient outcomes (Garmezy et al., 1984). For example, exposure to a nurturing home environment may help to build a cognitive representation in the mapping system that promotes positive mood, rest, and recovery from other, more stressful environments. Taking this into account, a functioning mapping system would be expected to become better equipped to direct cognitive processing in line with this promotive state. This integration allows for development and long term adaptation within the model given individual difference in exposure to adversity and the learning of which processing styles are adaptive or maladaptive given the situation and timeframe.

The mapping system is therefore a key factor in our model that is proposed to tip the balance away from vulnerability and towards resilience in the face of stress and adversity. This occurs via the allocation of contextually appropriate information processing. We believe that the applied flexibility of cognitive processing styles is best conceptualised at this stage as being guided by an overarching system. Research is needed to investigate the model's central hypothesis that the mapping system guides flexibility of information processing strategies, with respect to situational feedback, and can be guided by conscious, goal driven processes. We propose that, due to its unconscious and highly dynamic nature, the interplay between active cognitions/schemata and biased information processing is near impossible to disentangle experimentally. To some extent this extends to the concept of executive control. It is possible to derive quantitative indices of individual levels of executive control separate from emotional evaluation/valenced information processing biases. It is, however, difficult to determine whether executive control affects the activation of cognitions, controls the expression of information processing biases, or both. We propose that this triad (cognitions/biases/executive control) may be regarded as a closed system and it should be possible to test whether this system in its entirety gets more active or shifts in certain directions as a function of situational demands and the availability of guiding information that can be consciously perceived by the individual. We propose that those for whom indices of executive control indicate that more or less resources are allocated when available information indicates such a necessity, may also display more appropriate biases given situational demands. We further propose that these individuals will exhibit more resilience when faced with real life adversities.

In the remainder of this paper we aim to a) further elucidate our cognitive model of resilience to provide an integrative framework, which we hope can guide a research agenda in resilience science, b) review the resilience literature with a focus on identifying cognitive styles and processes that are associated with resilience, and c) outline how cognitive approaches may be used to examine resilience. The key cornerstones of our cognitive model are: cognitive processes (including selective information processing biases, executive control processes, and active cognitions), an overarching mapping and monitoring system, and feedback loops.

Processing biases as implicit emotion regulation strategies

As mentioned before, whether or not a particular situation is stressful or adverse is determined, not only by the purely objective situation, but also by how the situation is subjectively appraised in light of an individual's personal goals and identity. Lazarus and Folkman (1984), for instance, defined a stressful situation as consisting of a perceived discrepancy between a desired state of reality that is determined by the person's goals, needs, motives, desires and aspirations and the reality of the situation actually confronting them at a given moment. How people cope and what they do when such a discrepancy is perceived is an important part of the resilience process. Our model builds on the work of Brandtstädter and Rothermund (2002) who have made an important distinction between what they call *assimilative* and *accommodative* coping responses. Assimilative responses are those where an individual tries to actively change an adverse situation to bring it into line with personal goals and aspirations. In contrast, accommodative coping responses are those where the individual attempts to change the subjective evaluation of the situation or tries to downgrade the personal importance of the goals that are threatened. The latter ultimately leads to more positive appraisals of the situation without actually changing it.

It is important to note that neither of these coping responses (assimilative or accommodative) are always the more adaptive. Which type of coping response fosters resilience depends on aspects of the situation as well as the person. For instance, assimilation will be most effective when the situation is modifiable, opportunities and resources to change the situation are available, and the goals that are affected are important to the person. However, when the situation is uncontrollable, the possibility of changing the situation is unlikely, and alternative goals can be substituted for the goals affected by the critical event, then accommodative coping responses are likely to be the more efficient. An important point for the current discussion is the assumption that efficient coping "cannot be understood adequately without recourse to basic mechanisms in automatic processing that help to adjust cognition, affect, and motivation to superordinate self-regulatory needs" (Schwager & Rothermund, 2013, p. 58). Schwager and Rothermund (2013) argue that automatic processing mechanisms are critical for resilience because they provide the basis for an increase in the importance of a threatened goal and thereby support the self-regulatory stabilization of motivational commitment in the face of adversity. For example, there is evidence for an automatic focusing mechanism such that threat to a cherished goal leads to preferential processing of goal-related information while information that is unrelated to the goal becomes inhibited (Fishbach, Friedman, & Kruglanski, 2003). Such a focusing mechanism helps to keep people focused on new or existing goals when going through difficulties and adversity. Similarly, accommodative responses such as disengaging from a blocked goal do not always come about through a process of rational deliberation. Instead, the development of positive reappraisals of a situation requires a change in the cognitive accessibility of information that is relevant to the reappraisal or re-evaluation of the new situation. These changes can only come about by automatic information processing mechanisms that facilitate self-regulation by highlighting the positive aspects and benefits of a given situation (Schwager & Rothermund, 2013). In other words, the flexible adjustment of automatic processing biases towards the positive and negative aspects of a situation is a vital component of efficient self-regulation in difficult circumstances.

Similar notions are apparent in the literature on emotion dysfunction, which has also examined fundamental information processing biases that are largely deemed to be automatic (for reviews see, Cisler & Koster, 2010; Gotlib & Joormann, 2010; Mathews & MacLeod, 2005). Likewise, in the emotion regulation literature, processes such as biased attention allocation have been described as implicit or automatic emotion regulation strategies (Gyurak, Gross, & Etkin, 2011). Our model attempts to bring together these overlapping elements of work in the disparate fields of experimental psychopathology, emotion regulation and coping processes to deepen our understanding of resilience. We conceptualise these automatic processes as strategies for processing emotional and goal- relevant information and propose that these biases may be situationally appropriate or inappropriate, in so far as they can result in appropriate or inappropriate responses to the situation, and that this relationship between circumstance and bias is an integral factor in the development of resilience. We refer to these processes as processing biases for the purposes of the model.

One of the founders of social psychology, Kurt Lewin, is credited with the quote "if you want to truly understand something, try to change it". The ability to experimentally induce, reduce, or enhance a cognitive process provides a powerful experimental tool to examine the causal relations between cognitive processes and a range of outcome measures. Experimental methods known collectively as "cognitive bias modification" (CBM) procedures have been

developed to selectively modify automatic biases in attention (CBMa: MacLeod, Rutherford, Campbell, Ebsworthy, & Holker, 2002) and interpretation of ambiguity (CBMi: Mathews & Mackintosh, 2000). When these biases are successfully modified (e.g., when a negative bias is reduced) this reduction has been shown to be associated with changes in emotional vulnerability (Clarke, Notebaert, & MacLeod, 2014; Hertel & Mathews, 2011). To illustrate, attentional biases towards threat-related images have been shown to be associated with enhanced physiological responses (cortisol reactivity) to a laboratory stress task up to eight months later (Fox, Cahill, & Zougkou, 2010). Within this context it is interesting to note that the experimental induction of an attentional bias towards positive stimuli, relative to negative stimuli, (using a CBMa procedure) has been shown to be associated with improved physiological recovery from a stressor (Baert, Casier, & De Raedt, 2012) and reduced emotional reactions to a laboratory stressor (MacLeod et al., 2002). Likewise, training emotion recognition processes to interpret ambiguous faces as being relatively more happy than angry results in reductions in anger and actual aggressive behaviours (Penton-Voak et al., 2013). Penton-Voak et al., (2013) argue that the modification of emotion recognition biases might positively affect social interactions, thus facilitating a more positive emotion recognition bias reciprocally, in a "virtuous cycle" (p.163). This supports the notion discussed earlier that automatic information processing biases could activate specific cognitions and behaviours that subsequently influence the original processing bias in a dynamic feedback loop. Such CBM procedures provide a powerful experimental tool that has not yet been fully utilized in the resilience field. The on-going development of CBM procedures provides an excellent opportunity to test some of the hypotheses generated by our information-processing model of resilience. We propose that our model of resilience offers the opportunity to examine the causal role of cognitive processing styles in promoting resilient responses, benefiting from this wide literature on the cognitive basis of emotional vulnerability.

Executive Control processes

In addition to specific automatic strategies such as information-processing biases, goal-directed implementation of cognitive control has also been hypothesised to be a form of emotion regulation (Saunders, Milyavskaya, & Inzlicht, 2015) and the executive functions of inhibitory control, working memory capacity and cognitive flexibility are considered crucial for adequate functioning (Diamond, 2014). For example, difficulties in switching between self-generated thoughts to environmental information has been found to mediate the relationship between dysphoria and the frequency of rumination, self- blame, and catastrophizing (Rochat, Billieux, & Van der Linden, 2012). Rumination, a crucial vulnerability factor for depression (Nolen-Hoeksema, Wisco, & Lyubomirsky, 2008), has been associated with impaired filtering of currently irrelevant task instruction information and reduced flexibility to adapt behaviour to task demands (Owens & Derakshan, 2013). Importantly, these studies utilised non-valenced stimuli in the cognitive tasks and therefore, these results cannot be attributed to emotional bias. The results are likely due to cognitive inflexibility, characterised by active maintenance and tendency to perform a dominant task regardless of whether the behaviour is adaptive. In contrast, psychological flexibility is described as the ability to utilise a variety of cognitive and behavioural strategies to promote adaptation and is considered to be a fundamental component of resilience and positive mental health (Kashdan & Rottenberg, 2010). Non- emotional executive control training has also been found to affect neural mechanisms in that this type of cognitive training reduces amygdala reactivity to negative information (Cohen et al. 2016). This suggests that recruitment of executive control influences biases to irrelevant (though emotionally salient) information. We suggest that executive control processes and information processing biases play different (though interacting) roles in resilience (and vulnerability) to emotional disorders.

There is some promising research demonstrating that cognitive control or executive control functions can be trained with cognitive tasks requiring memory updating (Jaeggi, Buschkuehl, Jonides, & Perrig, 2008; Owens, Koster, & Derakshan, 2013), task switching (Karbach & Kray, 2009), or working memory (Klingberg, 2010). Working memory training improvements have been associated with reductions in stress reactivity, dysphoria and anxiety following training (respectively, Hoorelbeke, Koster, Vanderhasselt, Callewaert, & Demeyer, 2015; Owens et al., 2013; Sari, Koster, Pourtois, & Derakshan, 2015). In a recent meta-analysis, Motter et al. (2016) found that computer-based cognitive control training was associated with improvements in depressive symptoms and everyday functioning. The results suggest that adaptive working memory training can lead to attention control improvements and serve a protective function against emotional vulnerability. Inconsistent effects of cognitive control training on cognitive measure were also observed however, highlighting the need for further research in this area. In particular, it is important to establish a) the transfer effects of targeted cognitive training programs on other cognitive control domains

(e.g. Karbach & Kray, 2009) and b) the possible mechanisms that might underlie such transfer. For instance, executive control training with non-emotional stimuli might reduce the effects of irrelevant emotional information via influencing emotion- regulation neurological circuits (Cohen et al. 2016). Executive control training procedures offer a valuable experimental tool to investigate the potential role of cognitive control processes in resilience. These training procedures may allow us to examine the hypothesis that improved executive control facilitates shifts in processing bias strategy and importantly, how this affects resilience.

Active cognitions

Cognitive models of emotional vulnerability propose that maladaptive cognitive biases (which we describe here as biased information-processing) give rise to dysfunctional cognitions which are activated by stressful events (Beck, 1967; 2008; Beck & Clark, 1988). Dysfunctional conditions are typically considered to be automatic negative thoughts about the self, the world, and the future. The culmination of maladaptive cognitive biases and dysfunctional active cognitions is proposed to be central to emotional vulnerability. In addition, maladaptive cognitive biases and dysfunctional cognitions are proposed to reinforce one another reciprocally, leading to increased vulnerability (e.g. Muris & Field, 2008). Drawing from cognitive theories of emotional vulnerability, we propose that mental wellbeing is characterised by the reciprocally reinforcing processes of active positive cognitions, and adaptive cognitive biases. Examples of active positive cognitions might include the belief that a difficult situation is a challenge rather than a threat leading to positive beliefs about one's capacity to cope in even very difficult situations – e.g., a sense of personal agency. Positive cognitions and emotions influence positive reappraisals and adaptive information-processing (e.g., selective processing of positive relative to negative cues) leading to further active positive cognitions in an upward spiral (Garland et al., 2010). With respect to resilience, we would predict that adaptive emotional responses to adverse situations arise from appropriate guidance of the cognitive systems achieved by the mapping system. Emotion regulation frameworks propose a similar reciprocal relationship between biased attentional deployment and cognitive appraisals in producing adaptive or maladaptive emotional responses to situations (Gross & Thompson, 2007; Gross, 2015; Siemer, Mauss, & Gross, 2007). Our cognitive model of resilience therefore incorporates a reciprocal relationship between processing biases and active cognitions. As such, active cognitions that have been activated by the current situation influence, and are influenced by, biased information processing ultimately impacting emotional responses.

Feedback loops

Situations and their outcomes do not exist in isolation, but as a dynamic interplay between the individual and their environments (both internal and external). The modal model of emotion regulation (Gross, 2015) proposes a cyclical nature of processing, whereby the actions taken as a result of processing situational information directly influences the following situation ad infinitum. Our model incorporates two feedback loops (see Figure 1). The situation feedback loop, which feeds from the individual's response to the situation, indicates that the individual's response to the present situation affects the following situation. The subsequent environmental information is the product of both the original information processing and the responsive coping processes undertaken. In turn this is proposed to be monitored by the mapping system in order to further guide processing. The monitoring loop feeds from the individual's responses to the mapping system. This monitoring is proposed to be undertaken by the mapping system in order to guide the further mapping of the cognitive system. Importantly, both feedback loops in the model enable the development of adaptive processing styles via the monitoring of successful and unsuccessful strategies. We propose that these system loops, in combination with the mapping system, allow an individual greater cognitive autonomy over their circumstances and responses to them, rather than the cognitive system merely being submissive to circumstance.

Mapping appropriate cognitive processing

Our model hypothesises that a central predictor of positive outcomes is the appropriate mapping of processing bias strategies to the context. Just as in the coping processes literature (e.g., Schwager & Rothermund, 2013), an implication of this is that most processing styles should not be considered to be universally adaptive, or maladaptive. To illustrate this, a tendency for attention to gravitate towards cues signalling potential danger can be highly dysfunctional as this tendency occurs far more frequently even under conditions of little danger, as in anxiety

disorders (MacLeod & Mathews, 2012). This bias can also, however, be highly functional in contexts of high threat and serves to facilitate adaptive emotional responses. For example, soldiers exposed to greater levels of threat while on active duty have been shown to display increased threat related attentional bias (Wald et al., 2015). This attentional bias towards threat in dangerous situations is likely to allow the individual to better address the combat environment more appropriately. Moreover, while an attention bias towards threat before military training was associated with post-traumatic stress disorder (PTSD) symptoms, an attention bias *avoiding* threat during actual training has been associated with PTSD symptoms (Wald et al., 2015) implying that vigilance for threat is associated with positive outcomes in threatening situations.

This research supports an evolutionary developmental approach, which supports the proposition that cognitive processing styles presumed to be maladaptive, are in fact an adaptation to situational demands, particularly in early life (Ellis et al., 2012; Frankenhuis & de Weerth, 2013; Frankenhuis & Del Giudice, 2012). Several mechanisms by which an adaptive developmental mechanism may result in a maladaptive outcome have been proposed (Frankenhuis & Del Giudice, 2012). One plausible mechanism is that the process itself is not maladaptive, but rather a mismatch between the situation and the strategy employed results in maladaptive outcomes. It follows that appropriate mapping of information processing strategies to situational demands would predict more positive outcomes and associate with resilience. Our cognitive model predicts that the appropriate mapping of information processing to contextual demands promotes adaptive responses and positive outcomes, reflecting resilience.

Several criteria for the study of resilience are of note. First, resilience must be clearly operationalised. For example, resilience has been described as the ability to “bounce back” from negative experiences (e.g. Bonanno, 2004; Tugade & Fredrickson, 2004). A valid index of resilience would be the efficiency with which an individual recovers psychologically and physiologically following a stressful event (also see Baert et al., 2012). Therefore, we might operationalise resilience as the rate of decrease of a particular stress-marker in the period following a stress induction. Heart rate, heart rate variability, self-reported mood or anxiety are among the viable measures that might be used in such a design. Second, an initial stress response is necessary. Individuals resistant to stress cannot be said to recover from it or react resiliently. It will be important to capture a range of responses to induced stress and their trajectories. As such, baseline measures are necessary in addition to the measures taken during or immediately following the stress induction and the multiple measures during the recovery period. We have proposed this cognitive model of resilience to highlight how methods from cognitive science may be applied to resilience research. A specific hypothesis of our model is that the mapping of an appropriate pattern of information processing during the period will predict faster psychophysiological recovery following a stress induction procedure. To examine shifts in processing bias from baseline to during a stressor, and finally during a recovery period, multiple measurements, if not continuous measures, of the cognitive process in question are needed during each stage of the design. Task contingencies promoting processing biases expected to be more or less adaptive in the given circumstance might be used to examine the role of selective information processing biases during and following stress experimentally. For example, we would expect an increase in ability to recover from stress if a participant is shown happy and determined faces during the stressful episode, but impaired recovery if the participant is exposed to angry and despairing faces.

The degree of control that one has over exposure to adversity is an important factor in exhibiting adaptive responses, and with respect to our model, the associated resilient pattern of information-processing. For example, the degree of control an individual has over aversive experiences has been shown to modulate the expression of learned fear (Hartley, Gorun, Reddan, Ramirez, & Phelps, 2014). Participants who were able to control (escape) stressors showed improved fear extinction and reductions in retrieval of conditioned fear. Conversely, individuals who were unable to control stress exposure showed reduced fear extinction and increased fear expression at follow-up. In an early study, Brandtstädter, Voss, & Rothermund (2004) hypothesized that the degree to which attentional biases towards threat is expressed would depend upon the degree of control that an individual believed they had over the impending danger or threat. Using a visual search task, they found evidence for this view by showing that when people can avoid the aversive consequences of a danger cue (by completing a secondary task) the sensitivity of the perceptual system to danger cues was enhanced whereas sensitivity actually decreased when there was no possibility of control. Using a somewhat similar methodology, biases in the prioritisation of stimuli conditioned to be pain-related have also been shown to be influenced by individuals’ (perceived) control over pain experiences (Notebaert et al., 2011). Those participants who were told that performance speed on a secondary task would influence the likelihood of receiving

an electro-cutaneous shock prioritized attention towards a conditioned pain stimulus, whereas participants who were not told about this contingency did not. Taken together, these studies highlight the importance of perceived control over adverse parts of the environment in guiding cognitive resources, suggesting that situational control is an important influencing factor in the development of resilience. These findings support the model of assimilative and accommodative coping (Brandtstädter & Rothermund, 2002) mentioned earlier, in which negative features of the environment should be suppressed when there is no possibility of escape or avoidance, but should be enhanced when there is a chance to actively change or escape from the problem. To further test the role of situation controllability, researchers might follow Notebaert et al. (2011) and expand upon the basic stress recovery study described above by manipulating the perceived control that participants have over threat exposure during the stress induction phase. If stressor controllability proves to be a valuable contributor to the mapping of appropriate processing styles, then this would support the view that perceived control over a situation helps to promote resilient responses.

Researchers must be mindful that the experience of dealing with adversity is an essential component in the study of resilience and this needs to be taken into account in both longitudinal and in cross-sectional (trait) designs. This is especially important given our proposal that the mapping system develops over time through the monitoring of the cognitive processing associated with appropriate responses in different situations and integrating this with prior experience. Therefore, in order to discern the cause and effect of resilient responses to adversity, prospective longitudinal designs are necessary. Field and Lester (2010) have argued that longitudinal research is necessary in order to examine the causal relationships between processing biases and anxiety in childhood. We also suggest that prospective research is needed to examine the development of the proposed mapping system with respect to experienced adversity – and adaptive responses to that adversity. This research would help to examine how adaptations in the mapping system might support the development of resilience over the lifetime. Our model can be used to investigate the direction of causality between the proposed mapping system, and patterns of cognitive processing in promoting resilient outcomes. Experimental designs are essential in this endeavour. These designs have the potential to experimentally manipulate the environment and/or cognitive processing styles, which greatly enhance statistical power relative to correlational and longitudinal designs (Bakermans-Kranenburg, & van Ijzendoorn, 2015). For example, it is possible to experimentally induce a positive change in environment, for example with cognitive behavioural therapy, and examine how this positive environmental change influences resilience to stressors. Individual differences in cognitive processing in response to these positive environments (for example, the appropriate mapping of processing strategy) would be expected to predict the degree to which individuals derive benefit from these experiences (also see Pluess, 2015; Pluess, & Belsky, 2012). Such designs enable a more direct examination of the respective roles of processing styles, and the mapping system in resilience. An increased understanding of the causal mechanisms by which resilience is demonstrated and developed in response to adversity, may offer important insights into how resilience might be boosted and drive future empirically based resilience interventions.

Applying a Cognitive Approach to Resilience

In the prior sections we have outlined the key aspects of our cognitive model of resilience. In terms of the personal attributes component of resilience, we have argued that the role of information processing biases and how they interact with executive control processes and active cognitions have not been well established in terms of resilience. We presented research from cognitive approaches to emotion vulnerability, such as CBM, in order to highlight how these experimental interventions might be applied to resilience research. Further, we have argued that situationally appropriate application of flexibility or rigidity in these cognitive systems is a key element in promoting resilient responses. We proposed that this mapping of cognitive processing can be conceptualised as being undertaken by an overarching mapping system, which serves to integrate information from the current situation, prior experience, as well as more conscious and goal-driven processes. A well-functioning mapping system is proposed therefore to be an integral part of the cognitive basis for resilience to adversity. Our preliminary model is intended to provide an initial theoretical framework to guide research on the development of personal attributes, especially cognitive functions that are considered to be important in the resilience process. We have highlighted different perspectives in resilience science where many researchers focus on the development of resilience as a process in reaction to adversity in both children and adolescents (e.g., Garmezy et al., 1984) and in adults (Bonanno, 2004), while others focus on the personality trait aspects of resilience (Block & Block, 1980). The latter approach leads to research

designs in which those scoring low or high on a standardized personality trait scale are compared in terms of an aspect of their cognitive functioning (e.g., Schäfer et al., 2015). The former calls for longitudinal designs in which the unfolding of resilience can be observed over time in response to different adversities. Our model of resilience centers around the dynamic process of applying appropriate cognitive processing styles, given the situational demands. This focus on the cognitive aspects underlying resilience necessitates treating resilience as a process, in particular with longitudinal designs. However, it is worth noting that trait approaches to resilience also have their place. For example, we would expect individuals that generally apply appropriate cognitive processing strategies would exhibit resilient responses across a wider variety of situations, and can therefore be considered more highly trait resilient. Just as with trait notions of anxiety, we consider that high trait-resilience people will have resilient outcomes in a wider range of situations (than those low in trait-resilience) but not necessarily be resilient in all situations. Further, if we approach resilience research solely from a process perspective, we are likely to neglect the wealth of resilience literature exploring trait-approaches. We therefore argue that both approaches have a place in building a comprehensive science of resilience. We contend, that researchers must be careful to clearly define and operationalise resilience, including specifying whether resilience is being treated as an outcome, a trait, or a process (see Southwick, Bonanno, Masten, Panter-Brick & Yehuda, 2014 for a discussion on this issue). These steps would allow empirical data to guide resilience research and help to avoid some of the definitional and conceptual issues that surround resilience research. We hope that our preliminary cognitive model offers a first step towards developing a solid theoretical framework that draws together the emerging fields of research on positive mental health and resilience within an information-processing framework.

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