

Emotion regulation and successful aging

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Despite normative declines in old age, healthy elderly typically report surprisingly high levels of well-being. It is not clear why this is so. A study by Brassen and colleagues suggests that one factor may be reduced responsiveness to regret. These findings highlight the role of emotion regulation in successful aging.

Aging is normatively associated with declines in many important life domains. Sensory acuity plummets, physical abilities decline, cognitive capabilities decrease, and social networks shrink. Despite these losses, healthy older adults typically report levels of well-being at least as high as those of younger adults [1]. Why is this?

In a recent paper, Brassen *et al.* [2] hypothesized that one key to healthy aging is reduced levels of regret. To test this idea, Brassen *et al.* used a decision task with three potential outcomes: optimal-gain, non-optimal-gain, and loss. Their particular focus was on trials with non-optimal gains. In such trials, participants won some money, but less than they could have if they had taken more risk – which potentially gave rise to feelings of regret. Whereas young adults and depressed elderly appeared to respond to their regret by taking greater risks in subsequent trials, healthy elderly did not show greater subsequent risk taking. In addition, healthy elderly showed fronto-striatal and autonomic responses that were indicative of disengagement from regret experiences. Brassen *et al.* concluded that reduced regret is a key component of successful aging.

We set these intriguing findings in a broader context by considering the rapidly growing literature on emotion regulation [3]. More specifically, we argue that these findings underscore three broader points: (i) healthy aging involves the successful regulation of both positive and negative emotions; (ii) healthy aging involves the engagement of both explicit and implicit regulatory control systems; and (iii) failures of emotion regulation are associated with diverse forms of psychopathology. Each of these ideas enable new predictions and richer interpretations of the Brassen *et al.* findings.

Healthy aging involves positive and negative emotion regulation

A growing literature suggests that healthy aging involves emotion regulation, defined as processes by which we influence which emotions we have, when we have them, and how we experience and express them [3]. Although emotion regulation applies to both positive and negative emotions, research to date has focused on the regulation of negative emotions, such as anger, sadness, and anxiety.

In our view, the Brassen *et al.* findings point to the role of positive emotion regulation in healthy aging. Our interpretation – which is broader than the authors' regret interpretation – is that healthy older adults down-regulated the positive affect associated with optimal outcomes and/or up-regulated the positive affect associated with non-optimal outcomes. Several features of the Brassen *et al.* results suggest this interpretation, including: (i) greater relative ventral-striatal (VS) activation in trials with non-optimal gain for healthy older adults, typically associated with positive affect [4]; (ii) no differences in activation in brain regions such as the amygdala and insula, typically associated with negative affect; and (iii) no differences in self-reported regret after trials with non-optimal gains.

Future studies are needed to confirm whether positive emotion regulation is indeed a mechanism underlying the Brassen *et al.* findings. These studies must also tease apart potential alternative accounts involving up- versus down-regulation. Additionally, prior research has demonstrated that increased striatal activation precedes risky choices [5]; these findings must be reconciled with the current study, in which reduced striatal activity in elderly depressed and young adults was associated with risky choices.

Implicit and explicit control systems are important in emotion regulation

Researchers interested in the neural bases of emotion regulation have focused on the explicit down-regulation of negative emotion regulation. Several dozen studies have identified prefrontal control systems that include the lateral and dorsomedial prefrontal cortex [6]. Far less is known about explicit positive emotion regulation, but available studies suggest that these same prefrontal regions are implicated here, too [4].

Not all emotion regulation is explicit, however, and recent research has begun to focus on the neural bases of implicit emotion regulation. An emerging consensus suggests that different control systems may support this type of regulation. In particular, the perigenual anterior cingulate cortex (pACC) appears to play a central role in the implicit down-regulation of negative emotions, such as those occasioned by negative social evaluation [7]. This region is also implicated in the implicit down-regulation of emotional conflict [8].

Tantalizingly, Brassen *et al.* show that healthy elderly evinced greater pACC activation for trials with non-optimal gains relative to trials with optimal gains compared to depressed elderly and young adults. The authors interpret this activation as evidence of cognitive control of emotion in the healthy elderly. This finding leads the question whether the observed pACC activation is more specifically evidence

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of implicit positive emotion regulation. Future studies would need to investigate this issue. Additionally, Brassens *et al.* did not report functional connectivity between pACC and VS. The demonstration of such connectivity would support an implicit positive emotion regulation interpretation.

Emotion regulation failure and psychopathology

A growing literature has investigated the associations between failures of emotion regulation and psychopathology [3]. The focus of these studies has been on failures of down-regulation of negative emotions in the context of disorders such as Major Depressive Disorder (MDD). For example, it has been shown that left-lateralized activation in the prefrontal cortex (PFC) occurs in non-depressed individuals when down-regulating negative affect, whereas depressed individuals show bilateral PFC activation [9]. Furthermore, depressed individuals – unlike non-depressed ones – show a positive association between VMPFC and amygdala activation [9].

The Brassens *et al.* findings suggest that MDD may also be associated with failures of implicit positive emotion regulation. Such an interpretation would be in line with prior work by the same group [10], which showed that ACC activation is related to a positivity bias and emotional stability in successful aging. This finding suggests that MDD and other psychiatric disorders may involve dysregulation in explicit and implicit forms of emotion regulation in both negative and positive emotional contexts.

One puzzle in the Brassens *et al.* findings is that young adults appear to have similar regulation control system activations as the depressed elderly. It is not yet clear why

depressed older adults should appear similar in this regard to healthy younger adults, although one possibility is that increased risk-taking has different functions and consequences in younger than older adults.

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