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Cognitive Control of Emotion in Older Adults: A Review

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Abstract

Prior studies have found that compared to younger peers, older adults become happier and regulate emotions better as they age. However, research has also demonstrated that successful emotion regulation relies on well-functioning neural networks including the cognitive control network (CCN) and default mode network (DMN), which include brain structures that tend to deteriorate in the aging process. This dichotomy of improved stress management and emotion control in conjunction with deterioration in relevant neural networks and structures is interesting and worthy of further discussion and study.

Keywords: Emotion regulation; Geriatric; Mood disorders; Cognitive control network

Introduction

Conventional wisdom has intimated that as people age, they become wise in their ability to manage emotional reactions to stress given the ability to call upon vast prior life experience. Some prior research has supported this premise, with results indicating that elderly individuals improve in their ability to manage emotional responses, particularly to negative situations [1]. There have been studies demonstrating that older adults in fact have a "positivity effect" in attention and memory [2] and compared to younger adults, older adults tend to have better recall for positive as opposed to negative information [3,4,5]. This is in contrast to the age-related declines older adults tend to experience in their cognitive functioning [6] as well as emotional functioning, particularly given the high rates of affective illness such as late-life major depressive disorder (MDD) in older individuals [7]. Further consideration and study of this paradox of improved emotion regulation in geriatric populations despite experience of age-related cognitive decline is particularly important given the ever-growing population of geriatrics including those with affective illness.

The negative cognitive impact of aging has been broadly noted [8]. Cognitive changes are sometimes due to neurodegenerative processes and/or vascular changes; among other causes, but even in normally aging brains there are declines [6]. Cognitive changes in a normal aging brain include deficits in processing speed, attention and memory including failure to engage important cognitive control processes mediating executive functions and regulatory processes [9,10]. Executive functions are top-down processes that are deliberate and work to control automatic, subcortical responses to stimuli involving integration of cognitive functions that can deteriorate as part of the normal aging process [8]. Relatedly, one hypothesized mechanism of action for emotion control strategies are that they are also top-down processes with prefrontal cortical areas impacting on limbic regions to facilitate regulatory mechanisms. Even in normal aging, deficits in executive functions and emotion regulation would be expected given typical neurodegeneration.

Definition of Emotion Regulation

Emotion regulation as a concept has been identified a few different ways. In early work by Thompson [11], emotion regulation was described as the extrinsic and intrinsic processes responsible for monitoring, evaluating, and modifying emotional reactions. Similarly,, Gross defines emotion regulation as attempts individuals make to influence which types of emotions they have, when they have them, and how emotions are experienced and expressed [12,13]. In this conceptualization of emotion regulation, strategies are differentiated along a timeline of unfolding emotional responses beginning with an evaluation of an emotional cue which subsequently triggers coordinated sets of response tendencies that involve experiential, behavioral, and physiological systems. These responses over time include antecedent-focused and response-focused emotion regulation strategies.

Model of Emotion Regulation

Antecedent-focused strategies are done prior to responding to the emotion. This strategy attempts to modify the likelihood or experience of a stressor to prevent or reduce the amount of distress it creates. Cognitive reappraisal, or construing a potentially emotion-eliciting situation in a way that changes its emotional impact [14], is an example of antecedent-focused emotion regulation. Response-focused strategies are things done once the emotion is underway. Expressive suppression, or inhibiting ongoing emotion-expressive behavior [12], is an example of response-focused emotion regulation. Within these two types of strategies, Gross posits a process model of emotion regulation that highlights five families of emotion regulation strategies [15]. The five families include situation selection, situation modification, attentional deployment, cognitive change, and response modulation. Four of these are considered antecedent-focused strategies, including situation selection, situation modification, attentional deployment, and cognitive change. The fifth is a response-focused strategy.

Situation selection, involves taking actions to make it more likely that the situation will give rise to desirable emotions. Thus, individuals may try to avoid situations that are known/thought to bring about negative emotions (e.g. avoiding confrontation), even if the long-term consequences could be detrimental. Secondly, situation modification is conceptualized as an attempt to modify the situation directly so as to alter its emotional impact (e.g. making a joke about a bad situation). In the stress and coping literature, this is known as “problem-focused coping” [16]. Situation modification involves modifying, or problem-solving with external, physical environmental factors. The third family is attentional deployment. Attentional deployment involves regulating emotions without changing the environment, or influencing emotional responding by redirecting attention within a given situation. Attentional deployment can involve physical withdrawal of attention (e.g. covering the eyes), internal redirection of attention (e.g. distractions), and responding to external redirection of attention (e.g. a parents redirection of a hungry child by telling the child an interesting story). The fourth family is cognitive change. This refers to changing one or more appraisals in a way that alters the situation’s emotional significance by changing how one thinks either about the situation itself or about one’s capacity to manage the demands it poses. Lastly, response modulation refers to influencing physiological, experiential, or behavioral responses directly. Expressive suppression, which is an attempt to decrease ongoing emotion-expressive behavior, is an example of response modulation.

Research has found that older adults may differ from their younger counterparts with regard to antecedent- and response-focused strategy use due to the beliefs and values that guide strategy deployment. Beliefs that older adults experience and express fewer highly charged, negative emotions but are more likely to experience and express positive, low arousal emotions as well as negative, low arousal emotions were noted in one study [17]. Conversely, the experience and expression of high arousal emotions were viewed as characteristic of young age groups. Beliefs about the “acceptable” experience and expression of certain emotions in older adults likely contributes significantly to the strategies that older adult tend to utilize.

The conceptualization of the emotion regulation process is largely that it is cognitively regulated, effortful, and controlled in nature. Koole [18] notes that while the primary emotional response reflects emotional sensitivity, secondary emotional responding reflects emotion regulation and is distinct because it involves a controlled, cognitive process consisting of the monitoring and adjusting of a lower-level process. Gross’s view of emotion regulation as an antecedent- or response- focused process is also consistent with the idea of an effortful, self-monitored process, implying that executive functioning is involved. A more current conceptualization of emotion regulation synthesizes this theory and refers to the implementation of a combination of both automatic and effortful cognitive processes to modulate the experience and trajectory of an emotion and possible responses to distress [19,20].

Therefore, emotion regulation is, in part, dependent on cognitive control processes and executive function. Emotion dysregulation can occur when there is a failure of adequate cognitive control to facilitate goal-directed behaviors and thoughts. Inefficient responses of the cognitive control network (CCN) to emotional stimuli perpetuates emotion dysregulation, contributing to mood disorders and other manifestations of psychiatric illness [21-23]. For example, poor cognitive inhibition contributes to poor emotion regulation and may sustain mood disorders and depressive episodes [24-27]. Emotion dysregulation has been implicated in the maintainence of affective illness including depression [28] and improving cogntive control over the generation and persistence of emotional responses is often a target for cognitive-based psychotherapy approaches to treatment of affective illness [29,30].

Emotion Regulation and Cognitive Control Processes

Three common and extensively studied emotion regulatory processes are: rumination, or thinking repetitively about one’s negative mood state, its causes, and consequences [31]; reappraisal, which involves thinking about a stressful event from a different perspective in a way that minimizes negative emotions [32]; and expressive suppression, or controlling emotional responses by avoiding expressing them outwardly [33]. These approaches vary in their effectiveness in reducing negative affect [32,33], and the presence of less effective approaches may result in psychopathology such as MDD [31,32]. For example, patients with MDD ruminate and use expressive suppression more often and reappraisal less often than healthy controls [34]. Inefficient emotion regulation can predict subsequent depression relapse and severity [35,36]. Overall, these findings highlight the role of cognitive control processes in emotion regulation and depression.

Cognitive control processes are “managed” by the superordinate CCN, a regulatory system that modulates the operation of other cognitive and emotional systems to enable the individual to accomplish goals, and includes several brain regions including the dorsal anterior cingulate cortex (dACC), as well as the dorsal lateral prefrontal cortex (DLPFC) and posterior parietal regions [37]. The dACC contributes to cognitive control by detecting conditions that signal the demand for increased control, which leads to the engagement of the DLPFC. Parietal

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regions work in concert with the dACC and DLPFC to engage cognitive resources in response to the changing demands of the environment. The CCN plays a critical role in modulating the processing of affectively-valenced stimuli. For example, difficulty inhibiting the processing of negative stimuli is associated with difficulty reappraising during emotional tasks [21,38]. Reduced cognitive flexibility, as measured by the Wisconsin Card Sorting Test (WCST), is associated with rumination [39]. Further, overreliance on suppression is both ineffective and cognitively taxing, thus diminishing cognitive resources; this has been associated with poor health and negative psychological outcomes [40]. In healthy adolescents, better daily executive function is associated with more frequent use of reappraisal as opposed to expressive suppression [41].

The generation and experience of emotions is dependent on a complex network of subcortical (i.e., amygdala, ventral striatum, periaqudeutal gray matter) and limbic structures (e.g., dorsal ACC, anterior insula) that work in concert to assign affective valence and salience to both internal and environmental stimuli. The regulation of such emotional processes is performed primarily by a combination of the CCN, the ventrolateral prefrontal cortex, and the medial prefrontal cortex. That is, the dACC is involved in detection and monitoring of affective and nonaffective stimuli and the ventral/rostral ACC primarily works in concert with the posterior parietal and DLPFC regions of the CCN to regulate affective responses, particularly when affectively-laden stimuli conflict with goal-directed behavior [42].

The medial prefrontal cortex (mPFC) can be divided into dorsal mPFC, associated with attributing mental states, and the ventral mPFC, associated with self-referential emotional processing [43]. The medial PFC is a key hub in the default mode network (DMN). Abnormal functional connectivity of the DMN during rest has been implicated in a broad range of affective illnesses [44-53].

Structures in the CCN are critical for the processes that contribute to the regulation of emotion [28]. For example, the role of the CCN in allocating resources to goal directed behaviors may be critical to the emotional regulation process of reappraisal. In addition, the DLPFC is involved in the mental manipulation of affective information [48-50]. As a group, these prefrontal cortical regions are involved in modulating the interpretation of affective stimuli processed in emotion perception regions including amygdala, insula, and ventral striatum [51-53]. During the depressed state, the CCN is often hypoactive [54-56] and characterized by abnormal functional connectivity. Hypoconnectvity of the CCN predicts poor remission rates following treatment with antidepressant medication [57].

The default mode network (DMN) is a distributed network of brain regions including precuneus/posterior cingulate cortex, mPFC, and parietal cortex which are found to be more active during rest than during performance of effortful tasks [58]. The DMN plays a key role in self-referential processing. In depression, abnormal connectivity of anterior nodes of the DMN (i.e., ventral MPFC) are associated with negative self-referential processing that may underly common depressive symptoms (e.g., rumination, guilt, negativity bias). Abnormal connectivity of the mPFC with posterior aspects of the DMN is associated with the overgeneralized autobiographical memory that is often present in depressed individuals and contributes to a negative bias about past life experiences [45-52].

Difficulty regulating affective responses, such as in disorders including major depressive disorder (MDD), can be conceptualized as an imbalance between networks key for effective regulation of emotions, including the CCN, and networks implicated in the perception and generation of emotional experiences. As noted above, during the depressed state the CCN is often hypoactive [54-56] and characterized by abnormal functional connectivity, and hypoconnectvity of the CCN predicts poor remission rates following treatment with antidepressant medication [57]. This pattern is in contrast with the hyperconnectivity of the DMN that has been found in depression.

There has been recent research with results suggesting that regions of the CCN and DMN tend to change in the aging process and impact emotion regulation. One study found that when comparing network activity during reappraisal and selective attention in healthy younger versus older adults, older adults continued to be able to recruit ACC and PFC regions as part of coherent network during emotion regulation but the ACC was less strongly connected with lateral DLPFC, VLPFC, DMPFC, and posterior cingulate during reappraisal. However, there was stronger connectivity during reappraisal in the VMPFC and OFC in the older group [59]. This stronger connectivity in healthy older adults between the VMPFC and the OFC may underlie the findings in psychological research related suggesting improved emotion regulation in older adulthood to some extent. When considering samples of older adults with depression, Alexopolous and colleagues have found that cerebrovascular changes including ischemia and T2 hyperintensities distributed throughout the brains of elderly patients impact on affective illness and contributes to depression [60,61]. It may be that cerebrovascular changes underlie emotion dysregulation in older adults as they impact on the structures and connectivity of the CCN.

Given the extensive research findings that cogntive control processes are essential in executive functions including emotion regulation, and that these systems can degenerate with age, the finding that there is improvement in emotional functioning despite cognitive changes in the elderly is difficult to reconcile, is perhaps mediated by vascular disease burden, and worthy of further discussion and study.

Conclusions

Some hypotheses to resolve this paradox have been suggested. One states that it there may be more efficient adaptive emotion regulation strategy use over the course of a lifetime such as effective attention deployment, the third family of antecendent-focused strategies in Gross's continuum of unfolding emotional responses. Through attention deployment, older adults may be better able to regulate emotions through situation selection, or only fully attending to emotion-evoking situations that are perceived to be manageable [62]. In addition, one study found that older adults may maintain a more detached perspective on emotion-evoking situations, thus contributing to a less personally-relevant, distanced form of reappraisal that allows for ease of reinterpreting negative situations [63]. A positivity effect has also been hypothesized, wherein elders tend to preferentially attend to positive compared to negative stimuli in a variety of contexts such as facial expressions, word lists [64], and emotional images [3] as well as recalling more positive than negative stimuli in working, short term and autobiographical memories [5,65,66]. Using the situation selection technique to only attend to positive information is likely one method used by this population to achieve this goal and curb the need for cognitive modifications to emotional response. These different techniques may also be impacted by values and beliefs held by culture and individuals regarding how to experience and express emotion in older age [17].

As noted above, neuroanatomical explanations have been proposed. Studies have compared age-related volume loss of brain structures involved in emotional processing to those structures involved in cognitive processing that may contribute to preserved emotional health and well-being. In particular, there are findings that the anterior cingulate cortex (ACC), an integral node in the CCN, may be relatively unaffected by the aging process [59] with some trends towards preservation of the rostral ACC in particular having smaller rates of decline compared to other regions. This may underlie more success in reappraisal of aging populations. However, other findings regarding the volume and function of the ACC in aging have been equivocal [67]. Additionally, some have hypothesized that cognitive compared to emotion-processing brain regions may atrophy to a greater degree in normal aging, and this has not been demonstrated [68].

The incongruous findings that there is an increase in ability of geriatric populations to manage emotional reactions to stress-evoking situations compared to younger adults, but also having high rates of depression and cognitive declines related to neuroanatomical structural and functional changes is worthy of further investigation. In particular, it is possible that emotion regulation strategy use and problems managing stress may predict later onset of affective or even cognitive illness. Perhaps pre-illness problems with regulation is a marker of underlying CCN and DMN dysregulation that will later manifest as affective or cognitive illness in older adults. Future research to further determine age differences in the neural networks underlying cognitive control of emotion will be an important next step. Determination of the relationship between functional connectivity of brain regions involved in emotion regulation and regulatory outcomes is also critical. This line of inquiry will be helpful in evaluating helpful and unhelpful emotion regulation strategies across age groups and inform intervention and prevention for underlying dysregulation contributing to affective illness.

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