

The Role of Cognitive Control in Older Adults' Emotional Well-Being

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Recently, the focus in gerontology has expanded from trying to avoid age-related decline to also trying to promote optimal aging. One key component of optimal aging is maintaining or even enhancing emotional well-being over the life span (Baltes & Baltes 1990; Lawton, 2001; Rowe & Kahn, 1987). The traditional stereotype of old age depicts a period of evitable and continuous loss, with decreased subjective well-being. However, although negative life events tend to become more frequent and cognitive function and health tend to decline as people get older, emotional well-being does not appear to be compromised by the aging process. In fact, accumulating evidence indicates that healthy emotional aging—characterized by an overall *enhancement* of emotional experience across the life span—is part of normal human development (see Carstensen, Mikels, & Mather, 2006; Charles & Carstensen, 2007; Diener, Suh, Lucas, & Smith, 1999). Theories

of aging must explain this phenomenon. How is it that older adults have such emotionally gratifying lives in the face of significant losses?

In this chapter, we attempt to explain the surprising robustness of emotional well-being in aging by integrating perspectives from cognition, emotion, and neuroscientific research. First, we review evidence that emotional well-being improves with age and discuss how age-related changes in goals motivate older adults to pursue emotionally gratifying experiences. Next, we present behavioral evidence that older adults use cognitive control to enhance their current emotional states. Then we use research findings from cognitive neuroscience to outline the requirements of implementing emotion regulation-focused strategies. We then evaluate older adults' capacity to exert cognitive control given the trajectory of cognitive and brain function in aging. Finally, we present findings indicating that older adults use cognitive resources to regulate emotion.

In this chapter, we argue that older adults use strategic control processes to achieve their emotional goals within the limitations of age-related changes to neural structures. The intersection of neurological function and affective goals in aging indicates that cognitive function—particularly executive function—is a critical factor in promoting emotional well-being in late life. Our theoretical framework emphasizes older adults' power in determining their own emotional destiny. Cognitive control allows people to direct attention and memory in ways that help satisfy emotional needs. Using cognitive control as an emotion regulation tool becomes increasingly useful with advancing age as emotional well-being takes on more importance to those with more limited futures.

Improvements in Emotional Experience With Age

Studies reveal that negative affect decreases and positive affect increases or remains stable over the life course (for reviews, see Carstensen, Isaacowitz, & Charles, 1999; Carstensen et al., 2006). From a clinical perspective, older adults have lower rates of subsyndromal depression, dysthymia, major depression, and anxiety disorders compared with younger adults (Bland, Orn, & Newman, 1988; George, Blazer, Winfield-Laird, Leaf, & Fischback, 1988; Jorm, 2000; Kobau, Safran, Zack, Moriarty, & Chapman, 2004; Weissman, Bruce, Leaf, Florio, & Holzer, 1991; Weissman, Leaf, Bruce, & Florio, 1988). This reduced prevalence of depression and anxiety among older adults signals a decrease in negative affect with age. One possibility is that emotional intensity decreases with age. Indeed, older adults show fewer physiological reactions than younger adults when reliving negative experiences (Levenson, Carstensen, Friesen, & Ekman, 1991) and less distress than younger adults after natural disasters (Phifer, 1990). Yet an overall reduction in experienced emotional intensity cannot explain the reduced rates of depression and anxiety in the aged, as the subjective experience of emotions does not decrease with age. Older adults report experiencing emotions with the same intensity as younger adults (Carstensen, Pasupathi, Mayr, & Nesselroade, 2000; Levenson et al., 1991; Magai, Consedine, Krivoshekova, Kudadjie-Gyamfi, & McPherson, 2006; Malatesta, Izard, Culver, & Nicolich, 1987; Mikels, Larkin, Reuter-Lorenz, & Cartensen, 2005; Tsai, Levenson, & Carstensen, 2000). One recent study even found that middle-aged and older adults had more intense subjective emotional experiences than younger adults, even though bodily

responses to emotions were dampened in the two older groups (Burriss, Powell, & White, 2007). These studies underscore the importance of cognition in determining emotional experiences with age.

The enhanced sense of well-being among older adults reflects both decreased negative affect and increased positive affect. On a daily basis, older adults have fewer negative emotional experiences than younger adults (Carstensen et al., 2000; Gross et al., 1997; Mroczek & Kolarz, 1998), less negative affect (Diehl & Hay, 2007), and more positive affect (Mroczek & Kolarz, 1998) and are less likely to report any unhappiness in their lives (Ryff, 1989). Thus, in group comparisons, older people seem to have greater overall well-being than younger people. There is less consistency, however, on the trajectory of well-being across adulthood—some studies reveal improvement (Carstensen et al., 2000; Charles, Reynolds, & Gatz, 2001; Lawton, Kleban, & Dean, 1993; Kunzmann, Little, & Smith, 2000; Labouvie-Vief, Diehl, Jain, & Zhang, 2007; Magai, 2001; Mroczek & Kolarz, 1998; Schroots, 2003; Staudinger, Bluck, & Herzberg, 2003), and others stability (Costa, McCrae, & Zonderman, 1987; Diener & Diener, 1996; Stacey & Gatz, 1991) or even decline (Pinquart, 2001). For instance, a literature review by Magai (2001) lends support to the enhancement trajectory with findings of a reliable decrease in anger experiences with age, whereas Stacy and Gatz (1991) found stability in older adults' negative affect over 14 years.

The complexity of the age and well-being relationship may explain some of the inconsistency in the literature. For instance, some studies find an inverse curvilinear relationship with peak life satisfaction and emotional experience occurring in late adulthood and then declining somewhat in the oldest old (Mroczek, 2001; Mroczek & Spiro, 2005). Despite this overall pattern, adults in their 80s show levels of life satisfaction equal to adults in their 40s and higher than those in younger cohorts (Mroczek & Spiro, 2005), indicating that the emotional health of the elderly is well maintained. Other age-related variables, such as chronic illness, should be considered in determining how well-being may vary in adulthood. Controlling for health status can reverse negative relationships between age and emotion to reveal age-associated improvements to well-being (Kunzmann et al., 2000), yet not all studies finding age-related declines in well-being have evaluated the impact of health (see Pinquart, 2001).

As many emotion and aging studies have employed cross-sectional methods, it may be that emotional well-being is a characteristic of the current elderly population and not an effect of aging. However, a 23-year longitudinal study found decreases in negative affect across the life span in four different cohorts (Charles et al., 2001). Overall, these data indicate that, among healthy older adults, late life is a period characterized mostly by emotional health and well-being. In the next section, we review how older adults' successful maintenance of positive affect and reduction of negative affect may be related to changes in time perspective and a greater focus on regulating emotion as people get older.

Socioemotional Selectivity Theory and Prioritizing Well-Being

Socioemotional selectivity theory provides the foundation for the framework we outline here for understanding the trajectory of emotional well-being in

adult development. According to the theory, the perception of time is a key element in determining human motivation (Carstensen et al., 1999; Lang & Carstensen, 2002). The theory posits that those who view their time remaining as unconstrained, such as younger adults, are motivated to invest in the future. Information-seeking goals are particularly salient to those who perceive time as unlimited because expanding one's knowledge increases the chance of success in the future. As adults get older, however, accruing knowledge for future payoffs becomes less relevant. Those in late life benefit more from pursuing goals that provide immediate gratification; emotional goals serve this purpose. By emphasizing emotional well-being in the present, older adults optimize the time they have remaining. Thus, socioemotional selectivity theory proposes that people are motivated to pursue knowledge-seeking goals in early adulthood and transition to focusing on emotion regulation goals as they age.

Research on social relationships across the life span supports the idea that emotional goals become more important with advancing age. Longitudinal data reveal that the amount of time spent with acquaintances and close friends declines during adulthood, while time spent with close family members—and one's sense of emotional closeness with these social partners—increases with age (Carstensen, 1992). These changes suggest that young adulthood is a time for learning which people make the best social partners. Over time, social partners who provide the least emotional gratification are “pruned” to derive more emotional gains from social relationships. Even the oldest old—who experience the most death-related loss of loved ones—actively select and maintain intimate social relationships from their remaining social networks (Lang & Carstensen, 1994). Thus, the reduction in number of personal relationships in older age appears to reflect the selection of social partners in the service of emotional goals. Further, when young adults' futures are constrained by time experimentally or by circumstances that influence time perspectives, such as political upheaval or terminal illness, their desire to spend time with social partners that support emotional goals increases (Carstensen & Fredrickson, 1998; Fung, Carstensen, & Lutz, 1999).

When describing their major life goals for the future, older adults emphasize goals that hold intrinsic meaning, such as creating meaningful relationships or contributing to society. Younger adults, on the other hand, describe life span goals that emphasize learning and taking on new challenges (Bauer & McAdams, 2004). Shifts in emotional goals with age are likewise represented by age differences in the qualities people expect in an ideal person. In their descriptions of an ideal person, middle-aged adults are more likely to include qualities such as being career oriented and enjoying life (i.e., productivity and pleasure), whereas those in old age are more likely to mention having a positive view about life and social relationships (i.e., enhancing feeling of life satisfaction; Ryff, 1989). This comparison supports the idea that active regulation of emotional experience—that is, putting a positive spin on one's life experiences—becomes more important with advancing age.

Evidence of a greater focus on active emotion regulation with age goes beyond the social relationships literature. Many studies reveal that older adults have superior emotion regulation skills than younger adults do (Carstensen et al., 2000; Gross et al., 1997; Lawton, Kleban, Rajagopal, & Dean, 1992; Magai et al., 2006; McConatha, Leone, & Armstrong, 1997; Mroczek, 2001). To enhance

well-being, emotion regulation can be used to increase positive feelings (using up-regulation) or to decrease negative feelings (using down-regulation), and older adults demonstrate proficiency at both. For example, a recent study by Kliegel, Jäger, and Phillips (2007) shows that older people are more effective than younger people at “repairing” or down-regulating moods—restoring positive affect after a negative mood induction.

Older people are conscious of their emotion regulation ability, as they report greater control over their emotional states and mood stability than do younger people (Gross et al., 1997; Lawton et al., 1992). Older adults are more likely than younger adults to report controlling anger by using internal calming strategies (such as soothing oneself through self-talk; Phillips, Henry, Hosie, & Milne, 2006). In addition, older people report ruminating less about negative experiences (McConatha et al., 1997). Finally, from the coping literature, there are many studies demonstrating older adults experience less distress during difficult situations than do younger adults (see Charles & Carstensen, 2007). Thus, evidence indicates that individuals prioritize emotion regulation more as they age.

It may be argued that older adults report better emotion regulation in order to conform to social expectations. Yet older people are more effective at regulating anger than younger people even when social desirability is accounted for (Phillips et al., 2006). Along these lines, age-related emotion regulation gains lead to less intense negative emotions during interpersonal conflict (Birditt & Fingerman, 2003, 2005). Older adults are also capable of up-regulating emotions on command and show physiological profiles and subjective experience demonstrating they can enhance emotional experience as successfully as younger adults (Kunzmann, Kupperbusch, & Levenson, 2005). Taken together, this literature indicates that the ability to consciously shape emotional responses to suit regulation goals is as effective, if not more effective, with advancing age.

Positivity in Older Adults' Cognitive Processing

Cognition and emotions are inextricably linked—how we think influences how we feel and vice versa. For instance, cognitive processing can alter the quality of emotional experiences already in motion (Mauss, Cook, Cheng, & Gross, 2007; Ochsner & Gross, 2007; Pasupathi & Carstensen, 2003), effectively diminishing or intensifying those experiences. Given the power of cognition in determining emotional outcomes, goal-directed cognition has been proposed as a tool for modifying affective experiences (Carstensen et al., 2006; Isaacowitz, 2006; Mather & Carstensen, 2005; Mather & Knight, 2005). Focusing cognitive resources on emotional goals offers a way to feel positive in the present. Cognitive strategies can be used to focus on positive and suppress negative information in order to enhance emotional well-being, leading to a “positivity effect” in attention and memory (Carstensen & Mikels, 2005; Mather & Carstensen, 2005). We define the positivity effect as an age by valence interaction—such that a smaller proportion of older adults' memory or processing time is devoted to negative stimuli than for younger adults and a larger proportion is devoted to positive stimuli than for younger adults.

Indeed, numerous studies have revealed positivity effects in older adults' cognitive processing (for reviews, see Carstensen et al., 2006; Mather, 2006;

Mather & Carstensen, 2005). In particular, age-by-valence interactions are often found in memory studies (Charles, Mather, & Carstensen, 2003; Grady, Hongwanishkul, Keightly, Lee, & Hasher, 2007; Grünh, Schiebe, & Baltes, 2007; Kensinger, 2008; Knight, Maines, & Robinson, 2002; Leigland, Schulz, & Janowsky, 2004; Mather & Knight, 2005; Thomas & Hasher, 2006). Recent studies suggest that older adults' memory advantage for positive stimuli is specific to memory for the items themselves and does not extend to contextual details associated with the positive items (Kensinger, Garoff-Eaton, & Schacter, 2007; Kensinger, O'Brien, Swanberg, Garoff-Eaton, & Schacter, 2007).

As memory reconstruction is influenced by internal goals (Bahrick, Hall, & Berger, 1996; Brunot & Sanitioso, 2004), we expect that older people will remember the past positively, even at the expense of accuracy. Consistent with our hypothesis, older adults selectively distort their memories in ways that promote emotional well-being—remembering their life events, affect, and choices as more positive than they actually were (Kennedy, Mather, & Carstensen, 2004; Mather & Johnson, 2000; Ready, Weinberger, & Jones, 2007). Likewise, older adults' self-defining memories are more positive than those of younger adults (Singer, Rexhaj, & Baddeley, 2007). Further, even when older adults consider their personal memories to be highly negative, they report higher levels of positive feelings associated with such memories than do younger adults (Comblain, D'Argembeau, & Van der Linden, 2005). Remembering the past in a positive light does seem to enhance older adults' well-being, as their moods improve more than those of younger adults after reminiscing about their pasts (Cappeliez & O'Rouke, 2006; Kennedy et al., 2004; Pasupathi & Carstensen, 2003).

Selective attention can also be used to achieve emotion regulation goals by allowing people to focus on and subsequently process more positive than negative information. Studies using eye tracking to monitor the visual gaze of older and younger adults while they view emotional images reveal that older adults tend to look toward positive images and away from negative ones (Isaacowitz, Wadlinger, Goren, & Wilson, 2006a, 2006b; Knight et al., 2007) or show less of a negativity bias in their sustained attention than younger adults do (Rösler et al., 2005).

Declines in emotion detection abilities cannot explain the shift toward attending to more positive information with age. Studies find that older adults can detect and visually orient to emotionally arousing and negative stimuli as well as younger adults (Hahn, Carlson, Singer, & Gronlund, 2006; Knight et al., 2007; Mather & Knight, 2006; Rösler et al., 2005). Thus, it appears that when older adults detect negative stimuli, they employ attention strategies to reorient and focus on more positive information. These studies support the proposition that older people use visual attention to implement their chronically activated emotional goals, as selective attention allows them to focus on goal-consistent information and away from goal-irrelevant information.

Central to our cognitive control framework is the proposition that these age-associated shifts in cognitive processing are the result of shifts in goals, leading older adults to have chronically activated emotional goals, whereas younger adults are not usually focused on emotional goals. Thus, we predict that younger adults will show more of a positivity effect when something in the environment induces them to activate emotional goals. At least two studies support this prediction. Mather and Johnson (2000) found that when younger

adults are instructed to focus on emotional aspects of their decision making, they remember their past decisions more positively. In this study, older adults also showed a positivity bias, but they did so with or without external emotional cues. In another study, older and younger nuns recalled autobiographical memories first reported 14 years prior (Kennedy et al., 2004). The nuns were assigned to one of three conditions: emotion focused, accuracy focused, or control. While accuracy-focused and younger control groups exhibited a negativity effect in memory processing, emotion-focused and older control groups showed similar patterns of positivity in memory processing. Like the results from the decision-making study, these research findings suggest that emotion regulation goals are chronically activated in older adults leading to more positive cognitive processing, whereas emotion regulation goals can be activated in younger adults if they are given the right cues.

Behavioral Evidence of a Cognitive Control Pathway to Well-Being

The findings presented so far suggest that older adults' path to emotional well-being in aging begins with a change in time perspectives. As perceived time remaining shrinks, older adults seek to satisfy their emotional goals by regulating their affect, and the positivity effect in cognitive processing is a result of their emotion regulation efforts (Charles & Carstensen, 2007; Carstensen et al., 2006; Mather, 2004). This section presents evidence that successful emotion regulation depends on older adults' active use of cognitive control strategies. That older adults use cognitive control to achieve well-being is supported by three lines of evidence: (a) older adults with better strategic processing abilities are more effective in regulating emotional states, (b) the presence of the positivity effect depends on cognitive processing constraints (i.e., positive bias occurs when circumstances allow for goal-directed processing), and (c) when cognitive resources are limited, older adults are more likely to exhibit a negativity bias.

Executive Processing Abilities

As stated earlier, focusing on emotional goals during information processing requires cognitive control. In order to feel positive in the face of negative information, several strategies can be implemented to direct affective outcomes. Gross (2001, 2002) outlines common strategies people use to down-regulate their affect when presented with negative material, including selecting a situation by its expected emotional outcome, modifying the emotional impact or meaning of a situation, focusing on select aspects of a situation, and altering an ongoing emotional response. All these methods of controlling emotions require self-initiated cognitive processing—in other words, executive functioning. As emotion regulation requires cognitive control, those with superior executive functioning should be better at achieving emotional goals through the use of cognitive control strategies. To test this proposition, Mather and Knight (2005) measured executive function (specifically self-initiated processing dependent on the prefrontal brain region) in older and younger adults to see if better

cognitive control abilities predicted enhanced positivity in emotional memory processing. The executive function battery included measures to assess selective attention (Fan, McCandliss, Sommer, Raz, & Posner, 2002), working memory (Baddeley, Logie, & Nimmo-Smith, 1985), and the ability to refresh recently activated representations (Johnson, Mitchell, Raye, & Greene, 2004). The study revealed that, while older adults remembered more positive than negative information compared with younger adults overall, the older adults with the best performance on cognitive control tasks were the ones most likely to express the positivity effect. Further, those older adults with low cognitive control abilities had negatively biased memories. Some have proposed that older adults are more likely to “gate out” negative affect when they have low cognitive control abilities (e.g., Labouvie-Vief, 2005). On the contrary, this section indicates that those older people with the best cognitive control function are the most positively biased—remembering less negative and more positive information than their lower-functioning counterparts.

Indeed, the way that adults make choices with advancing age provides further support for the idea that high-functioning older adults use their executive processing resources to enhance well-being. A recent study by Mather, Knight, and McCaffrey (2005) found that, when deciding between two options, older adults with better performance on tasks measuring executive functioning made decisions based on alignable features (features comparable across choices) and had better memory accuracy for alignable features than for nonalignable features. Focusing on alignable features allows people to avoid regret (and thus negative affect) when making choices, as this decision strategy requires fewer trade-offs than whole-option comparisons (Luce, Bettman, & Payne, 1997). Younger adults with high executive functioning, on the other hand, were less likely to use feature-based comparisons. This makes sense given that avoiding regret is not a priority for the young. Conversely, older adults have a greater motivation to maintain well-being in the present than do younger adults; thus, we propose that cognitive control resources are increasingly allocated for enhancing emotional well-being with advancing age.

Cognitive Processing Constraints

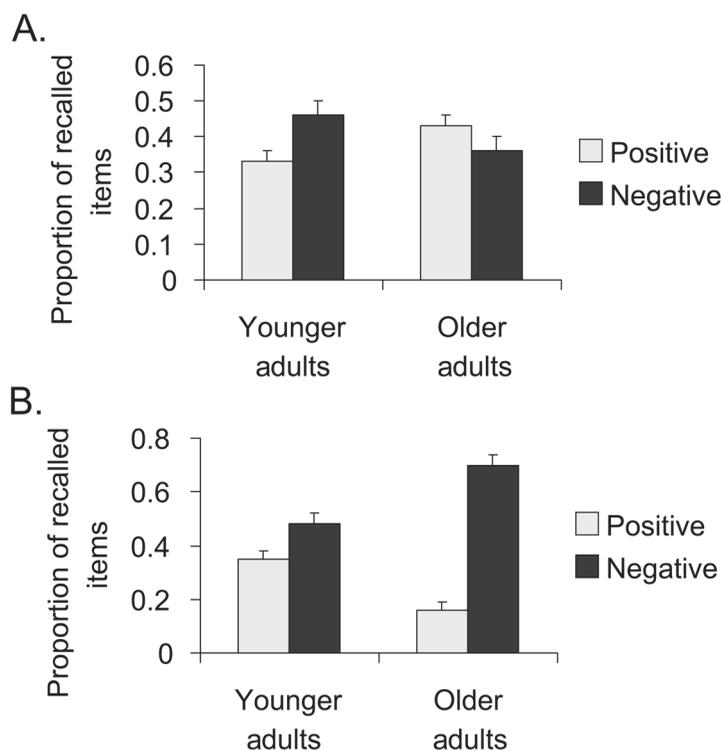
Our cognitive control framework of aging and emotional well-being posits that older adults will experience emotional enhancement to the extent that they are capable of exerting cognitive control. We have provided evidence that older adults with better executive function are more successful at creating positive cognition via goal-directed processing. However, regulating emotions requires considerable cognitive effort, even for younger adults (Ochsner et al., 2004). Controlling emotions, whether attempting to amplify or decrease emotional experiences, requires increased neural activation in executive function regions of the brain including the prefrontal cortex. Given that the prefrontal cortex—which is largely responsible for self-initiated cognitive processing—deteriorates significantly with advancing age (Greenwood, 2000; West, 1996), regulating emotional states using effortful control strategies may be more resource demanding for older people than for younger people. Thus, older adults may need to compensate for age-related neural deficits by recruiting more cognitive resources in their emotion regulation efforts. Additionally, even

in cognitively healthy young adults, control strategies can be utilized to service emotional goals only if processing circumstances allow (Muraven, Tice, & Baumeister, 1998; Wegner, Erber, & Zanakos, 1993). Therefore, we expect that the effectiveness of goal-directed processing will be inversely related to the amount of processing constraints present. In other words, older adults will be more successful in regulating emotions when they can devote considerable cognitive resources to regulation and less successful when they must split their attention between multiple tasks.

Mather and Knight's (2005) findings support this hypothesis, as they found a positivity effect in older adults' memory for pictures when participants were allowed to direct their full attention to picture viewing at encoding but a striking reversal to a negativity bias in older adults' memory when they had completed a concurrent goal-irrelevant task at encoding (monitoring sound patterns; see Figure 18.1). Thus, detracting from available cognitive resources appears to derail older adults' pursuit of emotional gratification through memory processing. This is not the case for young people, as those in the full-attention and divided-attention conditions both exhibited a negative bias in their picture memory. The younger adults' negativity in both conditions is not surprising given the lower priority of emotional well-being early in life. This study suggests that emotion regulation requires cognitive resources, and when processing constraints prohibit the use of effortful goal-related strategies, older adults cannot effectively enhance their well-being through cognitive control.

18.1

When participants could devote full attention to a picture slide show, a higher proportion of the pictures recalled later were positive among older adults than among younger adults (A). However, when distracted during the picture slide show, this positivity effect among older adults was reversed (B). Figure adapted with permission from Mather and Knight (2005).



Further support for this proposition comes from a study conducted by Knight et al. (2007) in which younger and old adults' visual attention for pairs of emotional and neutral scenes and faces was monitored using eye tracking. Visual gaze was monitored under either full- or divided-attention conditions. Similar to the memory findings of Mather and Knight (2005), older adults in the eye-tracking study showed a positivity bias in visual attention when they were allowed to devote full attention to the pictures but a negativity bias when they were forced to complete another goal-irrelevant task simultaneously. Thus, when cognitive resources are limited, older adults are not able to implement emotional goals effectively. Context can also limit access to cognitive resources. In another study, married couples reported on marital satisfaction in general (via mailed questionnaire) and under controlled conditions (in a lab while completing a conversation protocol; Henry, Berg, Smith, & Florsheim, 2007). Older married couples reported greater marital satisfaction than middle-aged couples in general, and the increase in satisfaction was explained by older adults' more positive perception of their spouses. In contrast, when couples were asked to evaluate their spouses' behavior during an experimentally controlled conversation in a lab (including an experimenter selected topic and regimented turn taking), there were no age differences in the number of negative characteristics attributed to spousal interactions. The laboratory experiment had more constraints than the overall evaluation of spousal satisfaction, and it is possible that this reduced older adults' ability to engage in regulatory processing when making emotional judgments about their partners. These studies suggest that well-being in the elderly is influenced by contextual demands on cognitive processing—only when situations allow for the implementation of control strategies can the well-being of older adults be enhanced by cognitive control.

Resource Limitation-Related Negativity

This chapter has cited many studies finding the positivity effect in older adults' processing, and the review indicates that older people control their processing using effortful strategies. However, older adults do not always have access to sufficient cognitive resources for emotional goal implementation (e.g., when multitasking as described previously). Interestingly, when older adults' cognitive resources are constrained, they sometimes show a negativity bias in information processing. Unlike older control participants, older adults in divided-attention conditions are negatively biased when processing emotional material in memory and visual attention tasks (Knight et al., 2007; Mather & Knight, 2005). This seems perplexing. Why should older adults focus on negative information *more* when their access to cognitive resources is limited? In his theory of ironic processes of mental control, Wegner (1994) proposes that when people try to control their cognition, they must initiate two processes: an operating process that searches for information consistent with goals and a monitoring process that searches for evidence that goal implementation has failed. Wegner's theory maintains that the operating process is more resource intensive than the failure monitoring process. Thus, if self-initiated control is used to create a desired mental state, encountering cognitive resource limitations can compromise the processing of goal-consistent information while allowing goal-inconsistent material (i.e., negative information) to get through. Applying this theory to our

research, we expect that older adults' emotion regulation strategies can backfire as cognitive loads increase. Given this expectation, the observation that older adults show a negativity bias when they are distracted but not when they can devote their full attention to processing information is consistent with the notion that they are, in fact, attempting to implement emotional goals by using cognitive control strategies.

Neuroscientific Evidence of a Cognitive Control Pathway to Well-Being

Socioemotional selectivity theory has contributed greatly to our understanding of human development and the trajectory of emotional well-being throughout the life span. Elaborating on Carstensen's socioemotional selectivity theory, our cognitive control framework of aging and emotional well-being attempts to explain—from a neurocognitive perspective—*how* older adults direct their emotional states to align with their emotional goals using cognitive processing. Thus far, we have considered the behavioral evidence supporting the proposal that cognitive control influences well-being in the elderly, but we must also consider findings from cognitive neuroscience in order to determine if adults have the functional capacity to implement control strategies in late life. To accomplish this, we must determine the neurological functioning requirements for regulating emotions through controlled processing, and we must demonstrate that older adults have these functional resources intact.

Neurofunctional Requirements

Controlling emotions through cognitive processing requires the appraisal of affective information (Ochsner & Gross, 2004) and the alignment of cognition with emotional goals (Mather & Carstensen, 2005; Mather & Knight, 2005). These two criteria require cognitive processes dependent on the amygdala, prefrontal cortex, and the anterior cingulate (see Davidson, Jackson, & Kalin, 2000; Kim & Hamann, 2007; Knight & Mather, 2006; Ochsner & Gross, 2007).

The amygdala is responsible for appraising the affective quality of information (for review, see Lane & Nadel, 2000). This type of processing is often referred to as a "bottom-up" processing, as it is reactive and automatic (Ochsner & Gross, 2007). The amygdala is especially useful in detecting emotionally intense material (Anderson, Christoff, Panitz, De Rosa, & Gabrieli, 2003; Cunningham, Raye, & Johnson, 2005; Dolcos, LaBar, & Cabeza, 2005; Kensinger & Corkin, 2004) and providing rapid responses to emotional information (Grieve, Clark, Williams, Peduto, & Gordon, 2005; Mu, Xie, Wen, Weng, & Shuyun, 1999). The amygdala is necessary for implementing emotion regulation strategies because the affective value of information must be known before goal-directed processing can take place. For example, if you are watching a horror film but want to avoid feeling disgusted during the gruesome scenes, you can use distracting thoughts to reduce emotional engagement in those scenes. However, you must recognize when those gruesome scenes occur so that you can quickly initiate and terminate your emotion regulation strategy without missing too much of the movie.

As the amygdala activates early in emotion processing, (LeDoux, 2003), it can help determine when regulation strategies should be implemented.

In contrast, the prefrontal cortex and anterior cingulate cortex are considered “top-down” processing regions, as they are involved in higher-order cognition allowing for flexible, situation-dependent responses necessary in emotional control (for review, see Ochsner & Gross, 2007). The prefrontal cortex is responsible for executive function—coordinating sensory inputs, internal goals, and monitoring outputs—and is a critical region in the implementation of cognitive control (MacDonald, Cohen, Stenger, & Carter, 2000; Miller & Cohen, 2001). The lateral prefrontal cortex is involved in working memory function (Smith & Jonides, 1999), which is useful for keeping goal-consistent information in mind. Also important in emotional control is the medial region of the prefrontal cortex, which is thought to govern emotion regulation (including up- and down-regulation; Bonanno, Papa, Lalande, Westphal, & Coifman, 2004; Damasio, 1996). Accordingly, research suggests the prefrontal cortex modulates activity in the amygdala in a top-down manner (Berkowitz, Coplan, Reddy, & Gorman, 2007). For example, studies with younger adults have found that conscious use of emotion regulation strategies leads to enhanced brain activation in the lateral, particularly the dorsolateral, prefrontal cortex and decreased amygdala activation (Anderson et al., 2004; Beauregard, Levesque, & Bourgouin, 2001; MacDonald et al., 2000; Ochsner, Bunge, Gross, & Gabrieli, 2002). Thus, the prefrontal cortex appears to assist in emotion regulation by inhibiting automatic activation in the amygdala. As older adults are motivated to avoid negative feelings, we expect to see this same pattern of enhanced prefrontal activity and decreased amygdala activity when older adults encounter negative information.

The anterior cingulate has also been associated with emotional control (Botvinick, Braver, Barch, Carter, & Cohen, 2001; Knight & Mather, 2006; Ochsner et al., 2004; Ochsner & Gross, 2004). Specifically, this structure has been associated with implementing reappraisal strategies and monitoring emotion regulation efforts. For example, reappraising (reinterpreting) the emotional quality of a situation is linked with activation of the dorsal anterior cingulate cortex (see Ochsner & Gross, 2005). The anterior cingulate is also activated when people monitor the results of their control strategy for evidence of implementation failures (MacDonald et al., 2000). This region, like the prefrontal cortex, has been implicated in regulating activity in the amygdala (Beauregard et al., 2001). Finally, the proximity of the anterior cingulate to autonomic and endocrine regions suggests that this structure has the anatomical connections to evaluate and regulate emotional responses.

Aging and Emotion Regulation-Dependent Brain Function

As outlined in previous sections, we propose that older adults use control strategies, such as inhibiting negative information, refreshing goal-relevant information, and selectively rehearsing positive memories, to achieve their emotional goals. Yet such control processes typically decline with age (Grady, Springer, Hongwanishkul, McIntosh, & Winocur, 2006; Hedden & Gabrieli, 2004; Johnson & Raye, 2000; Knight & Mather, 2006; MacPherson, Phillips, & Della Sala, 2002; Prull, Gabrieli, & Bunge, 2000; Zacks, Hasher, & Li, 2000). In addition, the brain regions associated with initiating control processes face considerable decline

with age. For example, the prefrontal cortex is subject to more atrophy than other brain regions (Coffey et al., 1992; Raz, 2000; Resnick, Pham, Kraut, Zonderman, & Davatzikos, 2003) with the lateral prefrontal cortex encountering the greatest decline of any prefrontal subregion (Tisserand et al., 2002). Furthermore, findings from positron-emission tomography reveal age-related declines in glucose metabolism in frontal brain regions (Mielke et al., 1998). Other emotion regulation structures also show pronounced deterioration with advancing age. Cross-sectional and longitudinal imaging data reveal significant brain atrophy in the anterior cingulate in older adults, even within a 4-year time span (Good et al., 2001; Resnick et al., 2003). On the other hand, the amygdala is well maintained in aging compared with most other brain regions (Grieve et al., 2005; Mather, 2004; Mu et al., 1999). Thus, age-related changes to emotion processing structures appear to negatively impact those responsible for emotion control while leaving the amygdala more or less intact.

Despite the age-associated decline in cognitive control abilities and emotion control-related neural structures, regulation of emotion and social behavior (associated with the frontal lobe) functions well in older age (for review, see Mather, 2004). Recent functional imaging research supports the idea that older adults spontaneously recruit additional cognitive resources to meet their processing needs and are more successful at achieving their cognitive goals when they do so. For instance, older adults' memory processing abilities are challenged when distractors are present, as inhibiting goal-irrelevant information becomes more difficult with age (Earles, Smith, & Park, 1994). Yet Gutchess et al. (2007) found that when high-functioning older adults complete a recognition task while distracted, they recruit unique neural regions and have better memory performance than do low-functioning elders. It seems that while older adults may experience significant age-related losses to cognitive control structures, they can compensate for their losses by exerting more cognitive effort.

In sum, evidence presented so far indicates that the primary affective appraisal structure (amygdala) remains stable while emotion control regions decline with age. Yet even with age-related deterioration to regulation structures, healthy older adults can promote their emotional well-being by recruiting additional cognitive resources to implement their regulation goals. Age differences in neural activation during emotion processing provide further support for this proposition.

Functional Evidence of Goal-Directed Emotion Processing in the Elderly

Older adults report experiencing negative emotions less frequently than do younger adults (Birditt, Fingerman, & Almeida, 2005; Carstensen et al., 2000; Diehl & Hay, 2007; Gross et al., 1997; Mroczek & Kolarz, 1998). These self-reports are supported by functional imaging studies finding that older adults have less brain activation in response to negative information than do younger adults (Mather et al., 2004; Samanez-Larkin et al., 2007). Older adults' reduced brain activation in response to negative information does not appear to reflect declines in emotion detection structures or function (see Knight & Mather, 2006), as the ability to detect emotionally arousing stimuli more quickly than other stimuli is preserved in older age (Hahn et al., 2006; Knight et al., 2007; Mather &

Knight, 2006). Instead, older adults' reduced brain activation for negative material is consistent with the notion that older people apply cognitive control when attempting to reduce negative emotional experiences. Our theoretical framework predicts that if older adults use cognitive control to achieve well-being, they may have amygdala responses equal to younger adults in early emotion processing but more reappraisals and inhibition of amygdala responses when the experienced affective information is negative. On the other hand, when older adults encounter positive information, other prefrontal regions responsible for maintaining information should be more active (such as dorsolateral prefrontal regions associated with working memory).

These predictions for negative stimuli are supported by functional resonance imaging (fMRI) experiments comparing brain activation in younger and older adults while they view faces with emotional and neutral expressions. Evidence from these studies indicates that age is associated with reduced amygdala activation in response to negative information (Fischer et al., 2005; Gunning-Dixon et al., 2003; Iidaka et al., 2002; Keightley, Chiew, Winocur, & Grady, 2007; Mather et al., 2004; Tessitore et al., 2005). Another study, using event-related potential recording (ERP), found that older age was related to an elimination of the negativity bias in brain activation frequently observed in younger adults (Wood & Kisley, 2006). In addition, fMRI studies find evidence that dampened amygdala response to negative material in older people coincides with an enhanced activation in the anterior cingulate cortex (Gunning-Dixon et al., 2003; Iidaka et al., 2002) and the prefrontal cortex (Fischer et al., 2005; Gunning-Dixon et al., 2003; Tessitore et al., 2005). Furthermore, a study that measured brain activity in response to positive and negative faces using ERP in 252 participants and fMRI in a subset of 80 of these participants found that activation in the medial prefrontal cortex during viewing of fearful faces increased with age, whereas activation in the same region during viewing of happy faces decreased with age (Williams et al., 2006). These imaging findings support our hypothesis that emotion regulation structures responsible for inhibiting or reappraising information will activate when older people encounter negative information but not positive information. In addition, Mather et al. (2004) found that older adults but not younger adults experienced greater amygdala activation in response to positive pictures compared to negative pictures. We interpret these findings as evidence that older adults use cognitive control to diminish their negative emotional experiences but not their positive emotional experiences.

While older adults may be grouped together for research purposes, they are by no means homogeneous. Widely variable experiences, health, and functioning lead to increased diversity in late life. As outlined previously, we predict that differences in cognitive function among older people will relate to variability in emotional well-being, as access to cognitive resources allows older people to direct information processing toward emotional goals. Behavioral evidence presented earlier demonstrated an enhanced positivity effect in older people with higher cognitive control abilities (Mather & Knight, 2005; Mather et al., 2005). Applied to the neural correlates of emotional control, we predict that older adults will enlist cognitive resources, supported by prefrontal regions, to down-regulate emotional experience when they are confronted with negative information. If this is the case, older adults' prefrontal function should predict their success at down-regulating negative affect. One research team has found

that resting electrical activity in the left prefrontal cortex predicts emotion regulation abilities in younger and older adults (Jackson, Burghy, Hanna, Larson, & Davidson, 2000; Jackson et al., 2003). Notably, this investigation measured emotion regulation using a technique that minimized subject-expectancy effects (eyeblick startle responses), addressing the criticism that many studies on aging and emotion regulation use self-report to measure the use of regulation strategies. Taken together, the neuroscientific literature on aging and emotional control strongly indicates that cognitively healthy older adults can successfully regulate their emotions through the use of effortful processing strategies.

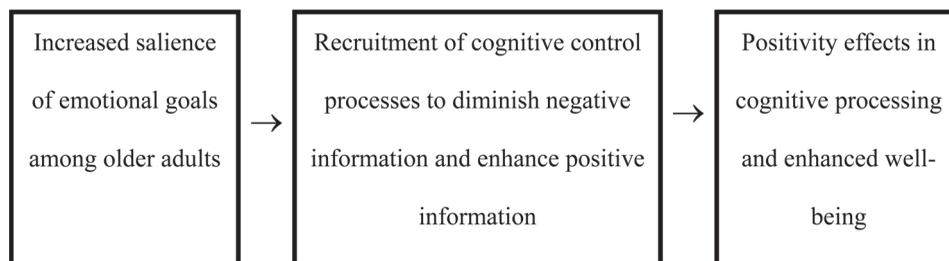
Closing Remarks

In conclusion, this chapter offers a theoretical framework for understanding the source of enhanced well-being in late life by integrating research from socioemotional and cognitive neuroscientific orientations. We build on Carstensen's socioemotional selectivity theory that argues that older adult's heightened awareness of time's value brings about an enhancement in motivation to find emotional gratification in life. Socioemotional selectivity theory focuses on the changes with goals seen as people's time perspective changes (the first box shown in Figure 18.2). Recent formulations of the theory have argued that older adults shift to focus relatively more on positive than negative information than younger adults do (Carstensen & Mikels, 2005; Charles & Carstensen, 2007) and that they avoid situations that are likely to be emotionally negative (Carstensen, Gross, & Fung, 1997; Charles & Carstensen, 2007), but these discussions of socioemotional selectivity theory have not focused much on the mechanisms of how the age differences in goals result in differences in emotional well-being. In this chapter, we outlined our account of how cognitive control plays a key role in implementing older adults' emotional goals, filling in some of the mechanisms represented by the middle box in Figure 18.2.

While we have focused primarily on the impact of cognitive control on well-being, research indicates that emotional status can affect cognitive status as well. Older adults who have a positive outlook about their cognitive abilities are more

18.2

In order for older adults' emotion-regulation goals to have an impact on what they attend to and remember, cognitive control mechanisms are necessary to implement the goals.



likely to set challenging goals for themselves and experience enhanced gratification from doing cognitive tasks (West, Thorn, & Bagwell, 2003). In addition, higher levels of emotional well-being predict more gradual decline in perceptual speed (Gerstorf, Lövdén, Röcke, Smith, & Lindenberger, 2007). Finally, maintaining a focus on emotional well-being can produce gains in physical health by reducing physiological symptoms of stress (Urry et al., 2006). Thus, it is likely that emotional well-being and cognitive function affect each other in a feedback loop wherein enhanced well-being leads to greater cognitive engagement and better health, in turn promoting greater life satisfaction (Rowe & Kahn, 1997). Our framework linking cognitive control and well-being reflects the changing tenor in the field of aging—from evitable decline to new opportunities.

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