



# Emotional Aging: Recent Findings and Future Trends

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**Contrasting cognitive and physical decline, research in emotional aging suggests that most older adults enjoy high levels of affective well-being and emotional stability into their 70s and 80s. We investigate the contributions of age-related changes in emotional motivation and competence to positive affect trajectories. We give an overview on the recent literature on emotional processing and emotional regulation, combining evidence from correlational and experimental, as well as behavioral and neuroscience studies. In particular, we focus on emotion–cognition interactions, including the positivity effect. Looking forward, we argue that efforts to link levels of emotional functioning with long-term outcomes, combining space- and time-sensitive measures of brain function, and developing interventions to improve life quality for older adults may further refine life-span theories and open promising avenues of empirical investigation.**

**Key Words:** Cognition—Emotion/emotion regulation—Life course and developmental change—Self-regulation—Successful aging—Well-being.

OLDER people are often perceived as lonely, hopeless, and sad. Even older adults who report high levels of satisfaction frequently express beliefs that most other older people are not faring well (Gluth, Ebner, & Schmiedek, in press; Hummert, Garstka, Shaner, & Strahm, 1994; Röcke & Lachman, 2008). In the last decade, however, research has shown that such negative views are unwarranted. Although many people are, indeed, facing mounting physical ailments, psychological stress, social losses, and increased dependency at the very end of life, most older people are well adjusted emotionally for the bulk of their later years (e.g., Carstensen, Pasupathi, Mayr, & Nesselrode, 2000). Naturally, individual differences are apparent: Improvements to well-being are general trends, not guarantees. Dispositional tendencies, life events, and individuals' management of such events can all influence whether well-being improves or deteriorates with age. Nevertheless, research suggests that reasonably high levels of affective well-being and emotional stability are the norm rather than the exception at least until after adults reach 70 or 80 years of age (e.g., Carstensen et al., 2000, 2009; Charles, Reynolds, & Gatz, 2001; Kessler & Staudinger, 2009; Kunzmann, Little, & Smith, 2000; Mroczek & Kolarz, 1998; Teachman, 2006). Only when people are essentially dying does "terminal" drop in affective well-being appear consistently and is largely independent of age (Gerstorf et al., in press).

At first sight, the trajectory of emotional aging may appear surprising. Given that older adults are confronted with bodily deterioration, increasingly frequent health problems and memory failures, and losses in mobility and in the social worlds, how do people maintain high levels of affective well-being? One possible explanation, which has recently received much attention, is an increasing motivation to regulate emotional states and increasing competence to do

so (Blanchard-Fields, 2007; Carstensen, 2006). Subsequently, we review recent frontiers in the quest for understanding emotional processing and emotional regulation as determinants of positive affective change with age. We start by outlining theoretical predictions about emotional aging. We then review recent evidence on age-related differences in the processing and remembering of emotional stimuli and in emotional reactivity and regulation. We next focus on the cognitive requirements and costs of emotional regulation. Finally, we delineate fruitful new directions in research on emotional aging. Specifically, we propose more systematic efforts to link levels of emotional functioning with long-term outcomes, consideration of emotional goals, combining behavioral with neuroscience studies, and interventions to counteract the costs of an emotion–regulatory focus and improve emotional aging outcomes for those not showing positive affect trajectories.

## THEORETICAL ASSUMPTIONS ABOUT EMOTIONAL AGING

Theories of emotional–motivational life-span development propose normative shifts in emotional goals and strategies across adulthood. Socioemotional selectivity theory, for example, holds that anticipated endings such as the sense that lifetime is running out give primacy to enhancing emotionally gratifying experiences in the moment as opposed to maximizing future rewards (Carstensen, 2006). This activates mood-enhancement goals and reduces the willingness to accept purely negative experiences for the sake of long-term goals. Aging is naturally associated with endings; therefore, the theory predicts motivational changes with age. However, the same motivational changes can also occur in contexts other than aging that are associated with a limited time perspective (Fung, Carstensen, & Lutz, 1999).

Whereas socioemotional selectivity theory emphasizes selective processes underlying improved affect trajectories, other theories conceptualize emotional–motivational changes as compensatory means to adapt to declining resources with age. Dynamic integration theory poses that diminishing cognitive capacities associated with age make it more difficult to integrate and accept negative feelings, and therefore, older adults increasingly favor affect optimization over affect complexity (Labouvie-Vief, 2003). The life-span theory of control holds that individuals' capacity to control their environment and achieve their developmental goals declines in older adulthood (Heckhausen & Schulz, 1995; Heckhausen, Wrosch, & Schulz, in press). Consequently, older adults increasingly use secondary control strategies, such as emotion regulation, aimed at changing the self in order to adjust to a given situation, rather than using primary control strategies that change the situation itself.

Adding to selective and compensatory changes in emotional preferences and strategies, it is possible that learning and practice effects make older adults more competent at emotional regulation (Blanchard-Fields, 2007; Scheibe & Blanchard-Fields, 2009). Specifically, the long-term experience and practice in dealing with emotional situations should lead older adults to acquire situational, strategic, and procedural knowledge about emotional processes that increase their effectiveness in handling emotional situations. For example, with age, people may become more knowledgeable about the emotional effects of future events (Scheibe, Mata, & Carstensen, 2009), become better at tailoring their emotion–regulatory strategy to contextual demands (Blanchard-Fields, 2007), and emotion–regulatory processes become less effortful (Scheibe & Blanchard-Fields). In sum, consistent with the model of selection, optimization, and compensation (Baltes & Baltes, 1990), selective changes in emotional preferences, compensatory efforts to adapt to declining cognitive and control capacities, and the optimization of emotional behavior through lifelong learning and practice can all be expected to drive changes in emotional experience and regulation across adulthood.

Finally, some researchers have suggested that improved affect in later adulthood is a serendipitous by-product of biological decline (Cacioppo, Berntson, Bechara, Tranel, & Hawkley, in press). For instance, structural decline in emotion-sensitive brain areas could selectively impair the processing of negative stimuli, which protects against threats to well-being. In the same vein, structural degradation and functional slowing of the autonomic system may diminish physiological arousal after exposure to emotional stimuli, thereby reducing the impact of negative events (Cacioppo, Berntson, Klein, & Poehlmann, 1998). However, once an autonomic reaction is elicited, the same mechanism can prolong physiological reactions, thereby increasing the duration of negative emotional states (Charles & Piazza, 2009; Otte et al., 2005). In the next section, we investigate

empirical evidence relevant to these theoretical assumptions. As will become evident, not all these explanations are equally supported empirically.

## EMOTIONAL PROCESSING AND REGULATION ACROSS ADULTHOOD

### *Processing and Remembering of Emotional Stimuli*

Proceeding from the assumption that a limited future time perspective in older adults promotes a focus on optimizing emotional satisfaction in the present moment, in the last decade, researchers began to examine the consequences of this motivational shift for cognitive processing. Specifically, mood-enhancement goals presumably render older adults more sensitive to positive information and less sensitive to or avoidant of negative information, a phenomenon termed the “positivity effect” (Carstensen & Mikels, 2005). Practically speaking, age-related shifts in the overall ratio of positive-to-negative material attended to or remembered have the potential to improve momentary mood and longer term well-being.

As originally defined, the effect simply refers to a shifting ratio of positive to negative information with advancing age (Charles, Mather, & Carstensen, 2003; Mather & Carstensen, 2005). In the first study showing the effect, Charles and colleagues (2003, Study 1) presented participants' images differing in valence and in an incidental memory paradigm asked them to recall as many images as they could. While overall, older adults recalled fewer images than young adults, they recalled a greater number of positive images compared with negative images. In contrast, younger adults recalled similar numbers of positive and negative images. The positivity effect has been observed in attention, memory, and decision-making tasks and has been replicated across numerous laboratories (Comblain, D'Argembeau, & Van der Linden, 2005; Fernandes, Ross, Wiegand, & Schryer, 2008; Grünh, Scheibe, & Baltes, 2007; Isaacowitz, Toner, Goren, & Wilson, 2008; Isaacowitz, Wadlinger, Goren, & Wilson, 2006; Kennedy, Mather, & Carstensen, 2004; Kisley, Wood, & Burrows, 2007; Kwon, Scheibe, Samanez-Larkin, Tsai, & Carstensen, 2009; Löckenhoff & Carstensen, 2007; Mather & Carstensen, 2003; Mather, Knight, & McCaffrey, 2005; Samanez-Larkin et al., 2007; Schlagman, Schulz, & Kvavilashvili, 2006; Spaniol, Voss, & Grady, 2008). Recent studies using functional brain imaging found evidence for the positivity effect also at the level of neural activation during anticipation, exposure, and encoding of emotional stimuli (Samanez-Larkin & Carstensen, in press).

Although the positivity effect is frequently observed, debate about its reliability and its causes continues. One issue of debate has been whether it is driven primarily by a reduced focus on negative material or by an increased focus on positive material (Grünh, Smith, & Baltes, 2005). Other

studies yield no evidence of age differences in emotional memory (e.g., Denburg, Buchanan, Tranel, & Adolphs, 2003). Murphy and Isaacowitz (2008) recently conducted a meta-analysis from which they conclude that there are few age differences in positivity. Unfortunately, the vast majority of the studies in their analysis did not even include older participants, and very few allowed for the *relative* age comparisons that would be necessary to examine the positivity effect. Essentially, they made the uncontroversial observation that both older and younger people attend more to emotional stimuli than to *neutral* stimuli.

Part of the problem in reconciling existing findings in the literature is the tendency to ignore the theoretical foundation of the positivity effect. Reasoning from socioemotional selectivity theory, the positivity effect reflects motivated cognition operating in the service of emotion regulation. When high priority goals concern well-being, people adaptively focus relatively more on positive than negative information. As operationalized, it does not matter whether the effect is driven primarily by reducing focus on negative material or enhancing focus on positive material. Either way, selective cognitive processing that is relatively positive can benefit well-being (Johnson, 2009; Kennedy et al., 2004). Similarly, reasoning theoretically, there should be conditions under which the effect is not observed. Löckenhoff and Carstensen (2007) demonstrated that when older people are explicitly provided different goals—specifically, goals about accuracy—the effect was eliminated. Mather and Knight (2006) hypothesized and found that the perception of threat represents an adaptive exception to positivity. In the face of threat, focusing on positive information would be maladaptive.

Another qualification concerns the level of processing. Theoretically, the positivity effect should be the strongest on tasks that require controlled processing (e.g., autobiographical memory, decision making) and less so on tasks that measure automatic or initial processing. In order to look away, for example, negative stimuli must be processed. On a task in which positive and negative emotion words were flanked by congruent or incongruent emotion words, older adults performed comparably well in categorizing the pairings on positive and negative trials (Samanez-Larkin, Robertson, Mikels, Carstensen, & Gotlib, 2009). Kensinger (2008) recently observed positivity in memory for low-arousal words but not high-arousal words. Memorization of arousing stimuli occurs relatively automatically, whereas the retention of nonarousing stimuli results from more controlled processing (Kensinger, 2004). Therefore, low-arousal stimuli may be more strongly influenced by emotion–regulation goals.

Neuroimaging studies have provided additional insights into positivity. At the most basic level, imaging has revealed neural correlates of behavioral findings, essentially documenting increased activation in response to positive stimuli and reduced activation in response to negative stimuli. Notably, evidence for a reduced negativity response is

observed more consistently. For example, Mather et al. (2004) report an age-related increase in amygdala activation in response to positive pictures but no change in reactivity to negative pictures. Kisley et al. (2007) and others observed that parietal activation in response to negative pictures declines linearly with age, whereas activation in response to positive pictures is age invariant. Arguably more illuminating are findings showing that reduced activation in response to negative experience is accompanied by increased activation in cortical regions associated with regulatory control (Samanez-Larkin & Carstensen, in press). Moreover, neuroimaging studies indicate that brain regions which become less sensitive to negative stimuli with age are activated in older adults by stimuli other than negative valence. For example, novelty in combination with negative valence produces comparable amygdala activation in both young and older adults (Wright, Wedig, Williams, Rauch, & Albert, 2006). The activation of several other subcortical and cortical regions responsible for emotional processing is modifiable through experiential manipulation.

Such findings are inconsistent with the assumption that structural degradation of brain regions responsible for the processing of negative material underlies positive affect trajectories. What was a very reasonable alternative explanation of the positivity effect at the time it was first reported—namely that it was a by-product of structural degradation of the amygdala and other emotion-sensitive brain areas (Cacioppo et al., in press)—is ceding ground. Arguably, the most persuasive evidence is that the effect can be eliminated experimentally, making biological or cognitive decline unlikely causes.

#### *Emotional reactivity and emotional regulation*

Once emotional stimuli are processed, they elicit subjective, physiological, and behavioral reactions. Notably, individuals do not just passively witness emotional ups and downs but try to control—consciously or unconsciously—which emotions they have and how they experience and express them (Gross, 1998b). Consistent with the notion that emotional behavior improves via lifelong learning and practice, self-report studies indicate that older adults are more confident than younger adults that they can control their emotions (Gross et al., 1997; Kessler & Staudinger, 2009; Lawton, Kleban, Rajagopal, & Dean, 1992). Older adults also score higher than young adults on three of four branches of the Mayer–Salovey–Caruso emotional intelligence test, namely facilitating, understanding, and managing emotions (Kafetsios, 2004). Emotions can be regulated in many different ways and at different points in the emotion-generative process. A useful distinction is between antecedent-focused and response-focused emotion regulation (Gross, 1998a). Much of older adults' advantage in day-to-day life likely lies in antecedent-focused regulation, that is, the selection of environments and use of cognitive strategies that target

emotional experiences before they occur (Charles & Carstensen, 2007). Mixed age-related findings were reported for response-focused emotion regulation, targeting the subjective experience, physiological arousal, and external displays of emotions once they have been elicited. In this context, it is not clear whether due to biological decline, older adults react less strongly than younger adults to emotional events initially, making it easier for them to regulate their emotional reactions.

Patterns of age differences in emotional reactivity differ as a function of the relevance of stimuli. Early laboratory evidence on emotional reactivity indicated diminished physiological arousal in older adults when watching emotional film clips, reliving emotional memories, or discussing conflicting issues with their spouse, whereas subjective reports of emotions were comparable to those of younger adults (Labouvie-Vief, Lumley, Jain, & Heinze, 2003; Levenson, Carstensen, Friesen, & Ekman, 1991; Tsai, Levenson, & Carstensen, 2000). When viewing films dealing with age-typical losses, such as loss of loved ones, however, older adults report stronger feelings of sadness and have comparable physiological reactions to young adults (Kunzmann & Grühn, 2005). Moreover, cardiovascular reactivity in response to laboratory stressors such as challenging cognitive or speech tasks is actually increased in older adults (Uchino, Holt-Lunstad, Bloor, & Campo, 2005). Experience-sampling data show mixed patterns of age differences in self-reported reactivity to daily stress (Mroczek & Almeida, 2004; Neupert, Almeida, & Charles, 2007; Röcke, Li, & Smith, 2009; Stawski, Sliwinski, Almeida, & Smyth, 2008; Uchino, Berg, Smith, Pearce, & Skinner, 2006), although these data make it hard to distinguish regulated from unregulated emotional experience.

Taken together, existing research suggests a pattern of weaker coupling between subjective and physiological reactivity to emotional stimuli: Under conditions of comparable subjective emotional experience in young and older adults, accompanying physiological arousal appears to be diminished in older adults (e.g., Tsai et al., 2000). Vice versa, under conditions of comparable physiological arousal, subjective feelings are increased in older adults (Kunzmann & Grühn, 2005). In addition, existing evidence suggests that older adults have lesser reactivity than young adults in most, but not all, contexts. In some situations, older adults' reactivity is comparable to or even greater than that of young adults. This makes it unlikely that biological changes alone account for changes in emotional reactivity. Future research should aim at studying the context dependency of age differences in emotional reactivity more systematically.

Studies are now beginning to emerge, in which younger and older participants are explicitly asked to regulate their emotions in response to mood induction. In these studies, older adults are found to be equally as effective or more effective than young adults in following instructions to reduce or amplify the experience, autonomic arousal, and outward display of negative emotions in their facial expres-

sions and language (Kunzmann, Kupperbusch, & Levenson, 2005; Magai, Consedine, Krivoshekova, Kudadjie-Gyamfi, & McPherson, 2006; Phillips, Henry, Hosie, & Milne, 2008). Nevertheless, given the mixed findings on stress reactivity and emotion regulation effectiveness in the laboratory, it is unlikely that response regulation alone explains older adults' ability to maintain high well-being in everyday life. Instead, many older adults likely are experts in antecedent-focused emotion regulation in that they structure their daily environments and use cognitive control strategies that increase the likelihood of positive, gratifying encounters and minimize negative ones (Charles & Carstensen, 2007; Charles & Piazza, 2009).

Because most emotions occur in social contexts, choice of social partners could reflect antecedent-focused regulation. There is ample evidence that older adults tend to prefer familiar social partners (Fredrickson & Carstensen, 1990) and have smaller social networks, with a higher percentage of emotionally close partners, than younger adults (Lang, 2001). Theoretically, interactions with familiar partners are easier to navigate. Older adults were further found to experience and perceive less anger in interpersonal situations (Bucks, Garner, Tarrant, Bradley, & Mogg, 2008; Charles & Carstensen, 2008), select more efficient strategies to solve interpersonal problems (Birditt, Fingerman, & Almeida, 2005), and tailor their problem-solving strategies more to contexts, using a combination of instrumental and emotion-regulatory strategies (Blanchard-Fields, 2007). Older adults also appear to benefit more than younger adults from the avoidance of interpersonal confrontations (Charles, Piazza, Luong, & Almeida, 2009). Additionally, self-report evidence shows an age-related shift away from the response-focused strategy of emotional suppression toward the antecedent-focused strategy of reappraisal, which also appears to be more efficient and less cognitively demanding (John & Gross, 2004). All these antecedent-focused strategies can help avoid emotionally challenging situations or, if these are unavoidable, decrease their impact through adaptive problem-solving or cognitive restructuring. This may help explain why exposure to daily stressors is generally reduced with age (Birditt et al., 2005; Stawski et al., 2008), and ultimately, average levels of affective well-being are enhanced.

#### *Cognitive requirements and costs of emotional processing and regulation*

Recently, researchers have started to explore the cognitive demands associated with emotion regulation, focusing particularly on the positivity effect in attention and memory. Theoretically, the implementation of emotion-regulatory goals requires cognitive control abilities such as focusing attention, maintaining attention in the face of distraction, or suppressing unwanted thoughts (Mather & Knight, 2005; Ochsner & Gross, 2005; Schmeichel, 2007). Indeed, the more cognitive resources older adults have the better they



seem to be able to selectively attend to positive stimuli and avoid negative ones. Among older adults with low executive functioning and when attention needs to be divided among several tasks, the positivity effect no longer emerges in emotional recall (Mather & Knight, 2005) and attention (Knight et al., 2007). Under these conditions, both young and older adults show a negativity bias, recalling and attending to negative stimuli relatively more than to positive stimuli. Performance on an executive attention task also predicted richer recall of positive historical events among older adults (Petrican, Moscovitch, & Schimmac, 2008), and the ability to resist mood declines during a frustrating laboratory task by showing positive gaze preferences (Isaacowitz, Toner, & Neupert, 2009). These findings are inconsistent with assumptions from dynamic integration theory that cognitive decline leads to disengagement from negative stimuli. Instead, it appears that negative stimuli automatically demand attention and that cognitive control is necessary to disattend to negative stimuli and attend to positive stimuli.

Neuroscience research also supports the notion that emotion regulation requires cognitive control. Ochsner and Gross (2005) propose that emotion regulation depends upon prefrontal and cingulate control systems that feed back into, and modify activation in, subcortical systems like the amygdala and insula associated with emotional responding. As noted earlier, reduction in subcortical activation during exposure to negative stimuli with age is coupled with increased activation in exactly those cortical areas thought to be responsible for executive control (Samanez-Larkin & Carstensen, in press). Moreover, when prefrontal control areas are damaged such as in Alzheimer's patients, a positivity effect is no longer observed (Wright, Dickerson, Feczko, Negeira, & Williams, 2007). These patients show greater (rather than lesser) amygdala activation in response to negative pictures. It is intriguing to assume that in these patients, cognitive control processes are no longer effective in inhibiting amygdala activation in response to negative stimuli.

At first, the idea that emotion regulation improves with age despite the fact that it requires cognitive control may seem counterintuitive given pervasive findings of cognitive decline with age. The pattern is less surprising in light of the postulated motivational changes toward optimizing emotional satisfaction in the present moment. Older adults may devote greater resources to emotion-regulatory goals than young adults (Mather & Knight, 2005). Another possibility is that due to enhanced procedural knowledge, emotion regulation becomes less effortful with age. Indeed, new evidence points to the possibility that the amount of invested cognitive resources can well vary across strategies and across individuals (Richards, 2004). Instructions to suppress emotional reactions during picture viewing, in comparison to no instructions, led to reduced memory for emotional pictures in young adults but did not impair memory in older adults (Emery & Hess, 2009). Similarly, instructions to

reduce negative feelings after a disgust induction diminished young adults' performance on a simultaneous working memory task but did not affect older adults' performance (Scheibe & Blanchard-Fields, 2009).

There is some evidence that speaks against this interpretation. Experience-sampling findings show that older adults' performance on attention tasks is more strongly reduced on high-stress days as compared with low-stress days than is the case in younger adults (Sliwinski, Smyth, Hofer, & Stawski, 2006). This suggests that exposure to stress diminishes older adults' cognitive performance more than is the case for young adults. However, this study did not inquire about individuals' motivation to regulate their emotions arising from the stressful events, thus leaving open the possibility that older adults were more motivated to regulate their stress response than young adults and therefore allocated more cognitive resources to this task. Studies are currently under way that repeatedly sample affect, emotion regulation motivation, and cognition in the same participants across hours or days, allowing further elucidation of the cognitive requirements and cognitive costs of emotion regulation.

#### AVENUES FOR FUTURE RESEARCH

Throughout this review, we identified several open issues that need further investigation. In addition to these, we suggest three fruitful directions that research on emotional aging can take to help improve understanding and experience of emotional life in adulthood and old age.

##### *Establishing Direct Links Between Emotional Goals, Emotion Regulation, Cognitive Biases, Mood, and Affective Well-Being*

Although the role of emotion regulation in successful emotional aging is often postulated, direct evidence linking emotional processing and regulation in the laboratory or in daily life to long-term outcomes is surprisingly rare. Studies are needed that connect levels of emotion regulation-relevant behaviors and outcomes, linking emotional goals to emotional processing in the brain to emotional regulation to momentary mood and to everyday affective well-being, health, and longevity. Among young adults, for example, manipulating attentional focus toward happy faces and away from angry faces was found successful in reducing frustration and increasing persistence in a subsequent stress task (Johnson, 2009). In a sample of older adults, Urry et al. (2006) was able to link amygdala activity after negative mood induction to diurnal cortisol patterns, thereby relating emotional competence to health-related outcomes. Those older adults who were more successful in reducing amygdala activation after being instructed to reduce their emotional response to the negative mood induction showed more adaptive cortisol patterns. Comparing adults of various ages, Kessler and Staudinger (2009) showed that self-reported

affect regulation in threatening or difficult situations mediates age differences in self-reported global affect. These initial studies are promising but are only a start in the quest of establishing that emotional motivation and competence truly underlie aging-related improvements in affective well-being.

Another fruitful direction is to assess individual differences in emotional goals. Several theories about emotional aging postulate age-related changes in emotional goals with age, but the exact meaning of emotional goals is rarely made explicit. Emotional goals could mean attending to positive or negative information or to regulate emotions. They could mean enhancing, maintaining, or inhibiting emotions. For instance, all the studies reviewed here appear to proceed on the implicit assumption that by default, individuals are motivated to enhance positive affective states and diminish negative ones. Recent findings challenge this assumption. There may well be circumstances when people want to maintain or enhance negative affect or dampen positive affect, for instance when sadness is socially appropriate during funerals, when excitement undermines one's concentration, or when fear elicited through horror movies is mixed with pleasure (Riediger, Schmierek, Wagner, & Lindenberger, 2009; Tamir, Chiu, & Gross, 2007). Using experience sampling across 9 days, Riediger and colleagues found that such contra-hedonic motivations were reported at 15% of measurements and were most prevalent in adolescents. Pro-hedonic motivations (wanting to maintain positive affect or dampen negative affect), in contrast, were most prevalent in older adults.

In addition, older people appear to experience mixed emotions more often than younger adults and appear to be comfortable with the simultaneous experience of positive and negative emotions (Carstensen et al., 2000). Older people also seem to perceive high-arousal positive stimuli as less pleasant and high-arousal negative images as more aversive than younger adults (Grühn & Scheibe, 2008; Keil & Freund, 2009), possibly because physiological recovery from high-arousal stimuli of either valence is prolonged in older, less flexible systems. This likely affects the affective states that people of different ages value and would ideally like to feel in everyday life (Tsai, Knutson, & Fung, 2006). Differences in emotional goals need to be taken into account when studying emotional reactivity and regulation in both behavioral and neuroscience studies.

#### *Using Time- and Space-Sensitive Measures to Disentangle Emotional Reactivity and Regulation*

Behavioral and neuroscience studies addressing emotional processing and aging have proliferated in the past few years. These studies have great potential to further tease apart the contributions of emotional reactivity versus regulation, or brain degradation versus motivation, in successful emotional aging. Specifically, neuroscience find-

ings can provide information about when and to what extent neural systems are engaged during emotional processing and regulation.

Time-sensitive (e.g., electroencephalography (EEG), reaction time, gaze patterns) and space-sensitive measures (e.g., functional magnetic resonance imaging) offer differential advantages and should be combined in future research. One obvious advantage of brain imaging lies in the possibility to localize the cortical and subcortical regions involved in emotional processing and regulation and, moreover, study the simultaneous activation (or connectivity) of multiple regions. In the future, it will be fruitful to manipulate emotional goals directly in order to account for age differences in individual's spontaneous tendency to regulate emotions. To date, there is only one brain imaging study in which older adults were explicitly instructed to regulate their subjective emotional response during picture viewing (Urry et al., 2006). In this study, a coupling was found between activation in the amygdala and in the ventromedial cortex, consistent with the cognitive control account of emotion regulation. Studying young comparison groups and other emotion regulation strategies will help to uncover differential cortical activation in further studies.

Due to the reliance on blood flow, functional magnetic resonance imaging studies are limited in their temporal resolution. They are therefore less useful to understand the timing of emotional processes. When exposed to emotional stimuli, an intriguing assumption is that limbic structures are engaged very early in the emotion-generative process and that prefrontal control systems are engaged somewhat later, modifying the initial activation of the subcortical systems. A useful strategy would be to combine functional magnetic resonance imaging with electroencephalographic, autonomic, or behavioral (e.g., reaction time, gaze preferences) measures that track responses over time on a scale of milliseconds. Initial (unregulated) emotional reactivity should be observable immediately after stimulus onset and can be compared with regulated emotional processing at later stages.

Time-sensitive studies could further corroborate the notion that the positivity effect serves emotion-regulatory goals. Intriguingly, positivity preferences are more reliably found at later points in the emotion-generative process when emotion-regulatory goals had time to take effect. Negative processing is not impaired in initial attention (Leclerc & Kensinger, 2008; Mather & Knight, 2006). Langley et al. (2008) had participants complete a rapid serial visual presentation task and found no positivity effect at the early stage of cognitive processing. In contrast, an ERP study found a positivity effect in the late LPP amplitude at 700–1,000 ms (Langeslag & van Strien, 2009). New eye-tracking findings indicate that positive preferences in older adults only emerge 500 ms or later after stimulus onset and increase linearly over time, suggestive of cognitive control processes (Isaacowitz, Allard, Murphy, & Schlangel, 2009).

A refinement and extension of stimuli used to elicit emotions also may be useful. Neuroscience findings to date have relied heavily on facial or pictorial material that was classified as positive, negative, or neutral based on young adult norms. It is unclear whether these stimuli are strong enough to affect subjective mood, and emotion regulation instructions were rarely used, limiting the types of strategies that can be studied. Future studies should further attend to potential age differences in the subjective meaning of stimuli (e.g., Grühn & Scheibe, 2008; Keil & Freund, 2009) and consider the use of age-relevant material (e.g., young vs. old faces; Ebner, Riediger, & Lindenberger, in press).

### *Changing Trajectories of Emotional Aging Through Intervention*

Research on emotional processing and regulation can be used in several ways to design interventions that help improve older adults' quality of life. As noted previously, affective well-being increases with age on average but certainly not for everyone. There are interindividual differences in the magnitude and direction of affect change. Similarly, whereas a sense of limited time perspective will change emotional goals for most older adults, not everyone will show such motivational changes and the associated influences on information processing. One important avenue therefore is to teach people with less adaptive profiles the use of specific emotional competencies found to underlie affective well-being. Wrosch, Bauer, Miller, and Lupien (2007) developed a writing intervention to alleviate life regrets, which can seriously compromise health. The intervention targeted multiple reappraisal processes, including downward social comparison, external attributions, and alternative goals, and was effective for reducing regret intensity and preventing increased sleep problems over 3 months. Other potentially trainable emotional competencies include affective forecasting, emotion identification, deceit detection, and interpersonal knowledge. Such competencies support antecedent-focused emotion regulation (i.e., knowing which situations and persons to approach or avoid), which as we have argued, underlie positive affective change with age.

A second avenue for intervention is to correct for the costs of an enhanced emotion regulation focus with age. The same emotional changes that lead to improved well-being, such as attending to positive more than negative information, can diminish older adults' decision-making abilities and learning in certain situations. Compared with younger adults, older adults perform more poorly on tasks involving avoidance learning (Samanez-Larkin, Hollon, Carstensen, & Knutson, 2008), disregard negative information in decision making (Löckenhoff & Carstensen, 2007), are poorer at detecting deceit (Stanley & Blanchard-Fields, 2008), and show greater planning impairment after positive mood induction (Phillips, Smith, & Gilhooly, 2002). These changes can impair older adults' health care and financial choices and make them

particularly vulnerable to fraud (Denburg et al., 2007). Interventions that instruct older adults to abandon their emotional focus and be more analytic (i.e., focusing on the specific facts presented rather than emotional reactions) when their health or finances are at stake or that present health care and financial messages in positive (gain-oriented) rather than negative (loss oriented) framings may improve older adults' decision making and learning.

Third, older adults' advantages in the emotional domain may be used effectively to improve cognitive interventions. Researchers might want to explore the usefulness of emotionally based instructions, emotional learning and memory material, and mood induction during cognitive training for improving cognitive interventions. Given the role of intact cognitive functioning for successful emotion regulation, in the long run, improved cognitive functioning will benefit affective well-being as well.

### CONCLUSION

In contrast to decline associated with physical and cognitive aging, emotional aging appears to benefit from age. Shifts in cognitive processing of emotional stimuli and enhanced emotional motivation and emotional competence likely contribute to improvements. More research is needed to establish causal links among features of emotional processing and affective well-being concurrently and over time. We maintain that newly emerging neuroimaging studies in combination with time-sensitive methods (e.g., EEG, reaction times, or gaze preferences) point to potentially productive avenues of research that may inform understanding of emotional development in adulthood. At the same time, existing knowledge can be used to develop interventions to correct and enhance life quality in old age.

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