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SELF-REGULATION IN OLDER ADULTS: THE PRIORITIZATION OF EMOTION REGULATION

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SELF-REGULATION IN OLDER ADULTS:
THE PRIORITIZATION OF EMOTION REGULATION

DISSERTATION

A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the College of Arts and Sciences at the University of Kentucky

By
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Lexington, Kentucky

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ABSTRACT OF DISSERTATION

SELF-REGULATION IN OLDER ADULTS:
THE PRIORITIZATION OF EMOTION REGULATION

Despite having fewer cognitive resources, older adults regulate their emotions as well as, if not better than, younger adults. This study aimed to (1) test the limits of older adults' emotion regulation capacity and (2) gain a better understanding of how older adults use their more limited resources to regulate their emotions. Participants included 48 healthy older adults aged 65-85 from the community and 50 healthy younger adults aged 18-25 from the student population. They were randomly assigned to one of four experimental groups involving an initial activity that was high or low in self-regulatory demand followed by a test task of emotion regulation or attention regulation. As expected, older adults performed equally as well as younger adults on the emotion regulation test task, though worse on the attention regulation test task. Using resting heart rate variability (HRV) as a physiological measure of self-regulatory capacity, older adults appeared to allocate more resources toward the emotion regulation task compared to the attention regulation task, and relative to younger adults. The results suggest that older adults maintain their emotion regulation capacity in part by allocating more resources toward emotion regulation goals.

KEYWORDS: Self-Regulation, Emotion Regulation, Aging,
Older Adults, Heart Rate Variability

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Chapter 1: Introduction

Older adults tend to experience declines in a range of cognitive capacities, yet maintain the ability to regulate their emotions at least as effectively as younger adults (Carstensen, Pasupathi, Mayr, & Nesselroade, 2000; Kunzmann, Kupperbusch, & Levenson, 2005; Shiota & Levenson, 2009). The limits of this ability and the circumstances under which older adults might be less capable of regulating their emotions, however, remain largely unknown. Furthermore, there is disagreement over how older adults maintain their emotion regulation capacity in the face of fewer cognitive resources. Considering the pivotal role of emotion regulation for successful aging and wellbeing (Urry & Gross, 2010), it is vital to identify vulnerabilities and mechanisms of emotion regulation among older adults.

Strength Model of Self-Regulation

Self-regulation refers to overriding a dominant response in order to pursue a goal or standard (Baumeister, Bratlavsky, Muraven, & Tice, 1998). The strength model of self-regulation suggests that there is a common, limited, and fatigable reservoir of resources for all acts of self-control, including control of cognitions, emotions, and behaviors (Muraven, Tice, and Baumeister, 1998; Baumeister et al., 1998). Experimental demonstrations of the strength model typically use a dual-task paradigm in which an initial or “fatiguing” task saps self-regulatory strength, resulting in poor performance on a subsequent or “test” task. For example, those who were asked to self-regulate by refraining from eating cookies performed more poorly on a subsequent anagram task—an activity requiring self-regulation to persist in the face of difficulty—compared with those who first refrained from eating carrots, a less tempting food and therefore less fatiguing activity (Segerstrom & Solberg Nes, 2007). Only tasks that require overriding a dominant response or those that involve a high level of cognitive complexity drain self-regulatory resources and produce this fatiguing effect (Baumeister et al., 1998). The reduction in performance on a test task when preceded by a high fatiguing task compared with a low fatigue task is supported by a recent meta-analysis that included 83 studies using a variety of cognitive, behavioral, and emotional test tasks and fatiguing tasks (Hagger, Wood, Stiff, & Chatzisarantis, 2010). A few published studies have failed to replicate this effect, however (Stillman, Tice, Fincham, & Lambert, 2009; Wright et al., 2007; Wright, Stewart, & Barnett, 2008). For example, in one study, participants asked to engage in a fatiguing thought suppression task prior to a cognitively challenging verbal fluency test task did not differ in their persistence from those who were not asked to first suppress their thoughts (Stillman et al., 2009).

In the strength model, emotion regulation is regarded as one form of self-regulation that draws on the same set of limited resources as other forms of self-regulation. However, there is little research examining emotion regulation in older adults using the strength model, and no research examining the extent to which older adults can effectively regulate their emotions following a task designed to fatigue their self-regulatory strength. The strength model's dual-task paradigm is particularly well suited to test the limits of emotion regulation capacities among older adults because an emotion regulation test task can be administered in a state of fatigue when regulatory resources have been taxed.

One cognitive process thought to influence emotion regulation among older adults is their bias to process and remember more positively valenced material (Carstensen &

Mikels, 2005). Some studies suggest that when older adults are distracted with a secondary task or are instructed to process both positive and negative emotional stimuli, their bias for emotionally positive stimuli is eliminated or even reversed (Hahn, Carlson, Singer, & Gronlund, 2006; Mather & Knight, 2006; Samanez-Larkin, Robertson, Mikels, Carstensen, & Gotlib, 2009). However, an attentional bias is different from, though related to, more deliberate forms of emotion regulation. Furthermore, one study found that older adults showed no decrement in performance on a cognitive control task while simultaneously down-regulating negative emotions in response to a film clip (Scheibe & Blanchard-Fields, 2009), suggesting that emotion regulation in older adults may require fewer resources.

Theories of Emotion Regulation in Older Adults

The maintenance of emotion regulation capacity among older adults despite declines in multiple cognitive domains including executive functioning (Baudouin, Clarys, Vanneste, & Isingrini, 2009; Deignault, Braun, & Whitaker, 1992; Isingrini & Vazou, 1997), memory (Parkin, Walter, & Hunkin, 1995; Slivinski & Buschke, 1997), and processing speed (Salthouse, 1996) has been referred to as a "paradox of aging" (Carstensen, Isaacowitz, & Charles, 1999). Two prominent theories that seek to explain this paradox emphasize the role of resources; one asserts that older adults allocate greater resources toward emotion regulation, whereas the other claims they allocate fewer. Surprisingly, these theories have not yet been directly compared with one another in an empirical study.

Emotion regulation refers to a number of processes involved in modifying subjective experiences or behavioral expressions associated with emotion, including situation selection, situation modification, deployment of attention, change of cognitions, and modulation of responses (Gross, 1998). Evidence suggests that older adults are just as effective as younger adults at using one particular response modulation strategy: conscious suppression of negative emotions (Kunzmann et al., 2005; Magai, Consedine, Kirvoshekova, Kudadjie-Gyamfi, & McPherson 2006; Phillips, Henry, Hosie, & Mine, 2008; Shiota & Levenson, 2009).

Socioemotional Selectivity Theory (SST) seeks to explain the paradox of aging by claiming that older adults allocate more of their resources toward emotion-related goals (Carstensen et al., 1999). Specifically, there is a motivational shift to focus on more immediate goals, such as emotional wellbeing, resulting from awareness of limited time remaining in life (Carstensen, 1995). Chronological age tends to be strongly associated with a shorter perceived time horizon, though the same prioritization of emotional goals has been observed among younger adults with terminal illnesses, as well as younger adults primed to think about the brevity of their lives (Carstensen & Frederickson, 1998; Fung & Carstensen, 2001). This motivated shift in priorities is consistent with older adults' tendency to have smaller but more emotionally meaningful social networks (Fung & Carstensen, 2001), use coping strategies designed to regulate emotions rather than fix problems (Charles & Carstensen, 2008), and return more quickly to a positive emotional state following a negative one (Levenson, Carstensen, & Gottman, 1994).

In contrast to SST's assertion that older adults prioritize and allocate greater resources for emotion regulation, another possibility is that older adults require fewer resources to regulate their emotions. Improved efficiency in emotion regulation may be the result of more effective and adaptive emotion regulation strategies developed over time with experience (Blanchard-Fields, 2007). In comparison to younger adults, older adults typically use a wider array of emotion regulation strategies and use them in ways that are better suited to the demands and goals of the situation (Birditt & Fingerman, 2005; Blanchard-Fields, Mienaltowski, & Seay, 2007). Improved efficiency in emotion regulation may also be the result of practice effects. More emotion regulation experience over the course of a longer life may result in emotion regulation that is more automatic and requires fewer resources. Comparing the performance of older and younger adults on a working memory task during a simultaneous emotion regulation task suggested that older adults use fewer resources than younger adults to regulate their emotions (Scheibe & Blanchard-Fields, 2009). Furthermore, Asian Americans, who tend to suppress behavioral expression of positive emotions, reported exerting less effort than European Americans during a positive emotion suppression task (Gross, Richards, & John, 2006), suggesting the possibility that frequent practice of an emotion regulation technique may result in more efficient use of that technique. Overall, there is more empirical support for the claim that older adults allocate more rather than fewer resources for emotion regulation, though no experiments have directly compared the two contrasting accounts.

Physiology of Self-Regulation

In order to draw conclusions regarding how older adults allocate their resources for emotion regulation tasks, it would be necessary to have both self-regulatory performance outcomes as well as a measure of self-regulatory capacity. Although self-reports of self-regulatory effort and fatigue are often inaccurate (Baumeister et al., 1998; Muraven, Tice, & Baumeister, 1998), heart rate variability (HRV) is a physiological measure that may provide an index of self-regulatory capacity (Segerstrom & Solberg

Nes, 2007). HRV refers to the variability in intervals between heartbeats that result from the influence of the autonomic nervous system on the heart (Berntson et al., 1997). The two branches of the autonomic nervous system—parasympathetic nervous system (PNS) and sympathetic nervous system (SNS)—have antagonistic effects on heart rate: the SNS is excitatory and tends to increase heart rate whereas the PNS is inhibitory and tends to decrease heart rate.

The heart's intrinsic rate—its natural pace when free from any external influences such as the SNS and PNS—is approximately 100 beats/minute (Jose & Collison, 1970). At rest, the PNS is the dominant autonomic influence on the heart, serving as a kind of tonic brake that slows the heart, keeping it from beating at its much higher intrinsic rate. The PNS influence on the heart fluctuates with the breath such that there is a slight increase in its braking effect with exhalation, and a slight decrease in the braking effect during inhalation (Berntson, Cacioppo, & Quigley, 1993). These fluctuations are responsible for the variability between heartbeats that constitutes resting HRV, a measure of tonic inhibitory control of the heart (Berntson et al., 1997).

The PNS operates more quickly than the SNS, so the initial increase in heart rate that occurs during the transition from low to high arousal is due to the withdrawal of the PNS rather than an increase in SNS (Berntson et al., 1997). Greater parasympathetic tone, as indicated by higher HRV, allows for larger and quicker cardiovascular responses to situational demands (Appelhans & Leucken, 2006). Resting HRV is also indicative of overall organismic flexibility and higher order executive functioning. The autonomic nervous system is significantly influenced by cortical structures that are associated with executive functioning and self-regulation (Lane et al., 2009; Thayer & Lane, 2000).

Benarroch (1993) identified the Central Autonomic Network (CAN), a set of functionally reciprocal neural structures that integrate autonomic, neuroendocrine, and behavioral responses with emotion, attention, and other executive functions, thereby linking executive and self-regulatory functions of the cortex to parasympathetic control of the heart (see figure 1). As would be expected, higher levels of resting HRV are associated with better performance on executive cognitive tasks, less negative emotion during daily stress, better responses to negative emotional stimuli, more effective coping with stress, and better impulse control (Allen, Matthews, & Kenyon, 2000; Demaree, Robinson, Everhart, & Schmeichel, 2004; Fabes & Eisenberg, 1997; Hansen, Johnsen, & Thayer, 2003; Johnsen et al., 2003). In laboratory studies, higher levels of resting HRV are also predictive of more persistence on difficult tasks following initial exertion of self-regulatory effort (Segerstrom & Solberg Nes, 2007; Solberg Nes, Carlson, Crofford, de Leeuw, & Segerstrom, 2010).

There is general agreement that spectral analysis of HRV in the high frequency range (HF: .15 to .40 Hz) reflects primarily PNS control of the heart (Berntson et al., 1997; Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology, 1996). Resting HRV appears to decline with age up until about the sixth decade of life, after which it may remain relatively stable or even increase in very old age (Fukusaki, Kawakubo, & Yamamoto, 2000; Liao et al., 1995; Piccirillo et al., 1998). There also seem to be greater individual differences in HRV among older adults compared with younger adults (Ufuk, Demirci, Nurlu, & Komurcu, 2008). The decline in HRV with advancing age mirrors age-related declines in most areas of executive functioning and self-regulation. Although resting HRV has not yet been examined as a predictor of self-regulatory performance in older adults, there is evidence in both middle-aged and older adults that HRV responses to self-regulatory demands are similar to those found in younger adults (Matthews, Paulus, Simmons, Nelesen, & Dimsdale, 2003; Gianaros, Van Der Veen, & Jennings, 2004).

Summary and Significance

Older adults maintain the ability to regulate their emotions at least as effectively as younger adults, yet the limits and mechanisms of this maintained capacity are unclear. Two prominent theories that seek to explain this phenomenon have opposing predictions about how older adults allocate resources for emotion regulation, but no empirical work has directly compared these theories to each other. An experiment employing the strength model's dual-task paradigm and includes a measure of self-regulatory capacity such as HRV could shed light on both the limits and mechanisms of emotion regulation in older adults. The results could provide information about the potential costs of emotion regulation in older adults, as well as provide a foundation for future interventions to improve wellbeing in older adults.

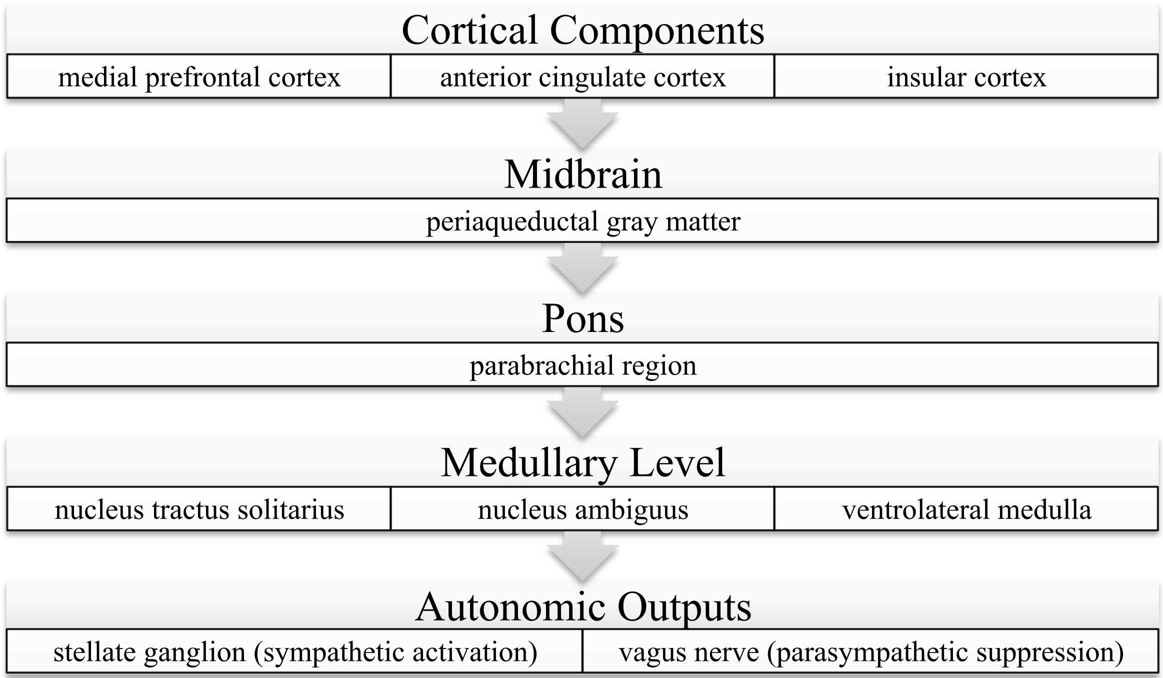
Study Aims and Hypotheses

The first aim (Aim 1) was to examine the emotion regulation performance of older adults when in a state of self-regulatory fatigue. In order to draw conclusions regarding the relationship between age and emotion regulation, a comparison test task consisting of attention regulation, as well as a comparison sample of younger adults were included. It was hypothesized that there would be a three-way interaction between level of self-regulatory fatigue (high vs. low), test task type (emotion regulation vs. attention regulation), and age group (older vs. younger) such that (*1a*) high self-regulatory fatigue would affect subsequent emotion regulation and attention regulation test tasks negatively and equally for younger adults, (*1b*) older adults would perform worse on the attention regulation test task than the emotion regulation test task, and (*1c*) the difference in performance between the emotion regulation test task and the attention regulation test task in older adults would be exacerbated in the high self-regulatory fatigue condition compared with the low-self-regulatory demand condition.

The second aim (Aim 2) was to reveal the amount of regulatory resources that older adults allocate to emotion regulation tasks in comparison to other regulatory tasks, and relative to younger adults. It was hypothesized that (*2a*) younger adults would allocate the same amount of resources to the emotion regulation test task as to the attention regulation test task. This would be indicated by an equally strong relationship between resting HRV and performance on the emotion regulation and attention regulation test tasks. Furthermore, it was hypothesized that (*2b*) older adults would allocate greater resources for the emotion regulation test task compared with the attention regulation test task. This would be reflected by a stronger relationship between resting HRV and performance on the emotion regulation test task compared with that between resting HRV and performance on the attention regulation test task.

Figure 1.

Central Autonomic Network



Note. Adapted from Gianaros and colleagues (2004).

Chapter 2: Method

Participants

Participants included 48 older adults ages 65 to 85 recruited through a database of community-dwelling older adults who had expressed interest in volunteering for research. A comparison sample of 50 younger adults ages 18-25 were recruited from the student population at the University of Kentucky who were fulfilling research participation credits for undergraduate psychology courses. Since the average educational level of the older adult participant pool is higher than that of older adults in the community at-large, a sex- and race-matched undergraduate student sample provided an adequate comparison group. Potential older adult volunteers who were identified as meeting the inclusion criteria and expressing interest in participating in research were contacted via phone to assess their eligibility and interest in participating. Potential undergraduate participants signed up for the study using an online human subject pool management portal, which features written descriptions and inclusion/exclusion criteria of each study.

All participants met the following criteria to enroll in the proposed study: a) absence of medications or disorders that would significantly alter HRV, such as benzodiazepines (Howell et al., 1995), antidepressants (Kemp et al., 2010), beta blockers (Cook et al., 1991), ACE inhibitors (Kontopoulos et al., 1997), and psychiatric disorders (Berntson & Cacioppo, 2004); b) absence of conditions that would interfere with the ability to complete the laboratory tasks, such as neurological conditions (e.g., Alzheimer's or Parkinson's Disease) or a hearing impairment; c) native English speaker. This study was approved by the Institutional Review Board of the University of Kentucky.

Procedures

Each participant attended two 1-hour lab sessions between 7 a.m. and 9 a.m. held approximately one week apart in the Psychology Department at the University of Kentucky. Due to the sensitivity of HRV to physical exercise (Hautala, Kiviniemi, & Tulppo, 2009), caffeine (Yeragani, Krishnan, Engels, & Gretebeck, 2005), and alcohol (Weise, Krell, & Brinkhoff, 1986), participants were asked to abstain from these activities from midnight. Because they were also asked to engage in a food inhibition task, participants were also asked to fast from midnight to increase the likelihood that they would be hungry. Upon arrival at the lab, participants confirmed compliance with these requirements, received a verbal description regarding lab procedures, and provided written consent.

Participants were randomly assigned to one of four experimental groups that crossed fatigue level (high or low) with test task type (emotion regulation or attention regulation). In order to reduce the influence of extraneous variables, participants served as their own controls. They were asked to return to the lab for a follow-up session to complete the same self-regulatory fatigue task as was assigned at the first session, followed by whichever self-regulatory test task they did not complete in the first session. The order of the test task was counterbalanced across age groups, and yielded a 2 (younger vs. older) X 2 (high vs. low self-regulation fatigue task) X 2 (emotion regulation vs. attention regulation test task) mixed factorial design with the self-regulation test task serving as the within-subjects variable.

At the beginning of each session, ECG electrodes were attached to the participant's torso in a modified Lead II configuration to collect a 5-minute segment of resting HRV data. During this baseline period, participants were asked to provide demographic information and complete several questionnaires (described below). Participants were next asked to engage in a self-regulatory task that was either high or low in fatigue level. Participants in the high fatigue condition were asked to refrain from eating cookies and candies placed in front of them for a period of 5 minutes, a task that requires self-regulation in the form of inhibition of the urge to eat tempting food (Baumeister et al., 1998; Muraven, Gagne, & Rosman, 2008). Participants in the low self-regulation fatigue condition were asked to resist eating radishes for the same amount of time. The radishes are less tempting than the cookies and candies, and therefore require less self-regulatory effort to inhibit the urge to eat. This was followed by a brief measure of current affect and task appraisal.

Participants were next asked to perform an emotion regulation test task or an attention regulation test task, following by another brief assessment of current affect and task appraisal. At the conclusion of the first session, participants were provided research credits if students or $20 if community volunteers. Approximately one week later, participants returned to the lab, and were asked to engage in the same fatigue task as completed at the first session followed by whichever self-regulatory test task they did not complete at the first session. Participants completed the same baseline and post-task measures of affect and task appraisal as the first session. At the conclusion of the follow-up session, students received $5 and research credits, and older adults received $25.

Measures

Behavioral Measures.

Emotion Regulation: Performance on the emotion regulation task consisted of how well participants were able to suppress their emotional expression in response to a sadness-inducing film clip. Sadness was chosen as the target emotion because it is one that is particularly relevant in the lives of older adults, especially sadness associated with irrevocable losses (Kunzmann & Gruhn, 2005). The 3-minute video clip, which depicts a boy weeping over the death of his father, has been shown to induce a similar emotional load in both younger and older adults (Tsai, Levenson, & Carstensen, 2000). The following script was read to participants prior to showing the film clip: "We will now be showing you a short film clip. It is important to us that you watch the film clip carefully, but if you find the film too distressing, just say 'stop.' If you have any feelings as you watch the film clip, please try your best not to let those feelings show. In other words, as you watch the film clip, try to behave in such a way that a person watching you would not know you were feeling anything" (Gross & Levenson, 1993; 1997). The clip was shown on a 13" MacBook computer equipped with an integrated video camera placed approximately 18 inches from participants' faces.

The entirety of each video segment were analyzed by an experienced coder licensed in the Facial Action Coding System (FACS), an objective method of categorizing and quantifying facial behavior (Ekman & Friesen, 1976). FACS is based on a set of discrete action units (AUs) of facial expression that are coded for intensity with a Likert-type scale of intensity rating ranging from "A" (trace level intensity) to "E" (most intense possible), and duration. An extensive body of research supports the use of FACS as a valid and reliable method for assessing facial expressions, with interrater-reliabilities typically between .75 and .90 (Bartlett, Hager, Ekman, & Sejnowski, 1999; Ekman, Friesen, & Ancoli, 1980; Fox & Davidson, 1988; Sayette et al., 2001). The video was designed to induce sadness, but since participants were instructed to suppress all emotional expression, all AUs were coded to detect any failure of suppression. Consistent with previous studies employing facial coding to measure emotional suppression (Gross & Levenson, 1993; 1997), a composite measure of AU duration X intensity was chosen as the primary measure, with lower scores indicating better emotion regulation. Head and eye movements, though scorable in FACS, were not included in the suppression score.

Attention Regulation: Performance on a 3-minute dichotic listening task constituted the measure of attention regulation (Baumeister, DeWall, Ciarocco, & Twenge, 2005). Information was presented simultaneously to both ears; the participant's task was to ignore the material spoken in the right ear while attending to and writing down all words spoken in the left ear that contained the letter "m" or the letter "p." The total number of correct words was the measure of performance, with higher numbers indicating better attention regulation. This task has been used successfully in prior self-regulation research, is comparable to the emotion regulation task in terms of duration, and is equivalent to the emotion regulation task in terms of its average effect size as a self-regulation test task (Baumeister et al., 2005; Hagger et al., 2010). Due to the possibility that older adults may have had unrecognized hearing difficulties, a brief hearing test was conducted prior to the task and volume was adjusted individually for each ear as necessary.

Questionnaire Measures.

Demographic and Health Information: Age, sex, marital and employment status, years of education, height, weight, health conditions, and medications.

Trait Self-Regulation: There is some evidence that individual differences in trait levels of self-regulatory capacity can moderate the effects of self-regulation manipulations (Dvorak & Simons, 2009; Gailliot & Baumeister, 2007). Therefore, trait self-regulation was measured using the Self Control Scale (SCS; Tangney, Baumeister, & Boone, 2004), a 36-item, 5-point Likert-type scale focusing primarily on behavioral self-control (e.g. "I am good at resisting temptation," "I blurt out whatever is on my mind," "I am always on time"). The SCS is positively correlated with higher grade point average, higher self-esteem, and better relationships (Tangney et al., 2004). Its internal reliability in the sample was adequate: $\alpha = .73$.

Trait Emotion Regulation: Individuals vary in their tendency to use emotional suppression as an emotion regulation strategy, which could lead to practice effects that moderate emotion regulation performance. The Emotion Regulation Questionnaire (ERQ; Gross & John, 2003) is a 10-item measure with a 7-point Likert-type scale assessing the tendency to use the emotion regulation strategies of emotional suppression (e.g. "I control my emotions by not expressing them") and cognitive reappraisal (e.g. "I control my emotions by changing the way I think about the situation"). It has acceptable test-retest reliability (.69 after three months), and showed expected relations with coping, mood regulation, impulse control, and broad personality (Gross & John, 2003). In the sample, the two subscales demonstrated adequate reliability: $\alpha = .62$ (reappraisal) and .76 (suppression).

Time Perspective: Although chronological age is closely associated with perspective on the amount of time remaining in life, there are individual differences in the extent to which age and time perspective are correlated. To explore this possibility, the Future Time Perspective Scale (FTP; Lang & Carstensen, 2002), a 10-item measure using a 5-point Likert-type scale that asks participants the extent to which they agree with statements regarding their future time horizon (e.g. "Many opportunities await me in the future" and "I have the sense that time is running out"), was administered. The FTP has demonstrated expected relationships with age, goal prioritization, and social satisfaction (Lang & Carstensen, 2002). It showed adequate reliability in the sample: α = .90.

Affect: The Positive and Negative Affect Scale - Expanded Form (PANAS-X; Watson & Clark, 1994) was used to check for baseline differences in affective state and explore affect as a potential moderator of self-regulatory performance. The PANAS-X includes broad measures of positive and negative affect in addition to multiple subscales for specific emotions. Only the subscales for attentiveness and fatigue were included because these are most connected to self-regulatory exertion and fatigue. All subscales demonstrated adequate internal consistency (αs = .66 to .95) in the sample.

Task Appraisal: To explore task appraisal as a potential moderator, participants were asked to report on how difficult, stressful, effortful, and fatiguing they found each self-regulation fatigue task and test task using a Likert-type scale of 1 ("not at all") to 7 ("very much").

Physiological Measures.

Heart Rate Variability (HRV): ECG data was collected using a Biopac Systems (Goleta, CA) MP150 amplifier with ECG100B module. The ECG was continuously sampled at 1000 Hz and recorded using Biopac Acqknowledge software. Mindware (Gahanna, OH) HRV 2.1 software was used to visually inspect and edit artifacts and missed beats. Mindware HRV software provides spectral analysis of the data, yielding log HF HRV (.15-.4 Hz) as a measure of parasympathetically mediated HRV. The mean HF HRV across the 5 minutes of usable ECG data preceding the fatiguing self-regulation task from each session was used to create the resting HRV variable for each individual. The correlation of HF HRV between the two sessions was acceptable ($r = .76$). ECG files with ectopic beats or movement artifacts that required editing more than 10% of total beats were excluded from analyses, a conservative threshold consistent with current recommendations (Peltola, 2012; Salo, Huikuri, & Seppanan, 2001).

Data Analysis

Power Analysis. Previous studies found that the average effect size for fatiguing tasks involving resisting delicious food is large: $d = .80$. A recent meta-analysis found medium to large effect sizes for self-regulation test tasks involving affective regulation ($d = .71$) and cognitive regulation ($d = .60$; Hagger et al., 2010). However, no dual-task paradigm studies have previously examined interactions between fatiguing or test tasks with age. Since effect sizes for the relationship between HRV and self-regulatory performance are typically in the small to medium range (Allen et al., 2000; Fabes & Eisenberg, 1997; Segerstrom & Nes, 2007), a sample large enough to detect small to medium effect sizes was chosen. With an alpha level set at .05 and a power of .80, the power analysis indicated that a sample size of 96 total participants (12 per cell) would yield ample power to detect small-to-medium effects.

Aim 1. A mixed design (between-within) ANOVA was conducted to examine the hypothesized three-way interaction between self-regulation fatigue level (high vs. low), self-regulation test task (emotion regulation vs. attention regulation), and age group (older vs. younger). Since self-regulation test task was the repeated measure, it served as the within-subjects variable, whereas age group and fatigue level were between-subjects variables. Significant interactions were explored with follow-up t-tests to determine the nature and direction of the interaction.

Aim 2. Because the dependent variable of self-regulation test task was the repeated measure, standard hierarchical regression techniques would not allow for testing interaction effects involving the test tasks. Therefore, a sum/difference regression—the analogue to a mixed design ANOVA (West, Aiken, Wu, & Taylor, 2007)—was conducted to examine the hypothesized three-way interaction between resting HRV, age group, and test task. According to this method, two new dependent variables were computed after standardizing the self-regulation test task performance scores: the sum of an individual's emotion regulation and attention regulation performance ("Sum"), and the difference (emotion regulation – attention regulation) between the two scores ("Difference"). Two separate hierarchical regressions were then conducted on each of the new dependent variables. The "Sum" regression coefficients represent the main effects of the between-person variables (age and HRV) on self-regulatory performance, whereas the "Difference" regression coefficients represent the interaction effects of age and HRV with test task type. The intercept for the "Difference" regression represents the main effect of self-regulatory test task.

For each hierarchical regression, the continuous predictor variables of HRV and age were centered in order to facilitate interpretation of interaction effects (Aiken & West, 1991). In Step 1, the main effects of HRV and age were entered. In step 2, the interaction term of age X HRV was entered. Significant interactions were interpreted by plotting the effect of the simple slopes at one standard deviation above and below the overall mean. All regression coefficients are reported as unstandardized coefficients (β) with associated standard errors (*SE*).

Chapter 3: Results

Demographic Data and Descriptive Statistics

Demographic data are reported in Table 3.1. The mean age of the older adults was 72.31 (SD = 4.04); the younger adult sample had a mean age of 20.24 (SD = 3.06). The gender composition of the older adult sample (54% female) was not significantly different from that of the younger sample (60% female) ($\chi 2(1, 98) = .34$, $p = .56$). The younger adult sample was racially more diverse than the older adult sample, though not at a statistically significant level ($\chi 2(3, 98) = 7.34$, $p = .07$). As expected, the annual family income of the older adults was relatively high (mode = $50,000 – $75,000/year), but not significantly different from that of the younger adults ($U = 968$, $Z = -1.21$, $p = .23$). The older adults were also highly educated with 65% reported having graduated college). In sum, the younger and older age groups were closely matched in terms of gender, race, and SES.

Descriptive statistics for potential moderator variables are displayed in Table 3.2. Not surprisingly, older adults scored lower on the FTP than younger adults ($t(94) = -10.63$, $p < .001$, $SE = .17$), meaning that they tend to see less time remaining in life. Consistent with other research (John & Gross, 2004), older adults in the current study reported using suppression less frequently than younger adults as an emotion regulation strategy ($t(94) = -2.07$, $p < .05$, $SE = .24$). Interestingly, older adults reported higher levels of self-control on the Self-Control Scale relative to younger adults ($t(95) = 2.60$, $p = .01$, $SE = .09$), despite the large body of research showing that older age leads to reduced executive control. And compared with the younger adults, older adults endorsed more positive mood, higher levels of attention, and less fatigue at baseline, post-fatiguing task, and post-test task, regardless of the level of fatiguing condition or the kind of test task. There were no significant differences between the age groups in terms of their appraisals of the difficulty of the test tasks ($F(1,92) = 1.45$, $p = .24$). The level of fatigue condition similarly had no influence on the appraisal of task difficulty ($F(1,92) = .83$, $p = .44$). The interaction of fatigue condition X age group was also non-significant ($F(1,92) = .65$, $p = .52$).

Missing Data and Data Transformation

Due to technical error, there was a failure to record 9 videos, 5 of which were in the younger adult sample. There were 36 videos that had missing frames, though these were distributed evenly between the younger adult (n = 19) and older adults (n = 17). These missing video sections occurred at random points during the recording of the videos and, according to Apple Computer consultants, occurred due to insufficient processing speed to play and record high resolution videos simultaneously. The sections of missing frames were less than .5 seconds each, and the total amount of missing time ranged from 1 to 20 seconds (*M* = 10 seconds) for the 3-minute video. There was a technical failure to record resting HRV data for 1 older adult session and 2 younger adults sessions. In these cases, resting HRV was calculated from a single HRV recording rather than the average from the two separate sessions. The ECG files from 2 older adults were excluded because of excessive ectopic beats that made it impossible to reliably calculate resting HRV. Missing HRV data and FACS coding data was imputed using the Expectation Maximization function in SPSS.

Because the majority of individuals successfully suppressed their facial expressions while watching the sadness-induction video, there were a large number of zero scores and a significant positive skew on the emotion regulation performance variable. To normalize the distribution, a constant was added before applying a log 10 transformation. All scores were then multiplied by -1 so that higher (less negative) scores indicated better self-regulation, making the directionality of the emotion regulation performance score equivalent to that of the attention regulation score.

Aim 1

The hypothesized 3-way interaction between self-regulation fatigue level, self-regulation test task, and age group was not significant ($F(1, 92) = .03$, $p = .87$). Surprisingly, there was not a main effect for fatigue condition ($F(1, 92) = 3.58$, $p = .62$). However, consistent with hypothesis *1b,* there was a significant interaction between age group and self-regulation test task ($F(1, 92) = 12.62$, $p < .001$, $\eta_p^2 = .20$). As expected, there were no differences between younger and older adults on emotion regulation performance ($t(96) = .39$, $p = .70$, $SE = .14$), though older adults performed worse than younger adults on the attention regulation test task ($t(95) = -4.84$, $p < .001$, $SE = .68$). Furthermore, as predicted, older adults performed worse on the attention regulation test task than the emotion regulation test task ($F(1,47) = 5.36$, $p = .025$, $\eta_p^2 = .10$). Figure 3.1 shows the pattern of the interaction. The order in which participants completed the test task (i.e., emotion regulation test task at the first vs. the second lab visit) was not associated with performance on either task ($F(2, 94) = .052$, $p = .95$).

Aim 2

The regression for the "Sum" self-regulatory performance variable was significant ($F(3, 91) = 2.94$, $p = .04$, $R^2 = .04$). The main effect of age was significant ($\beta = .81$, $t = 2.36$, $p = .02$, $SE = .34$), but neither HRV ($\beta = -.079$, $t = -0.57$, $p = .57$, $SE = .14$) nor the interaction between age and HRV were significant (β = .25, t = 0.70, p = .49, *SE* = .36), indicating that older adults had worse self-regulatory performance across both tasks.

The regression for the "Difference" self-regulatory performance variable was also significant (F(3, 91) = 7.15, $p < .01$, $R^2 = .16$). The main effect of age group was significant (β = .93, t = 2.86, $p < .01$, *SE* = .33), as was that of HRV (β = .31, t = 2.35, p = .02, *SE* = .13), indicating that older adults performed better on the emotion regulation task than the attention regulation task, and that HRV was positively related to performance on the self-regulatory test tasks. These two-way interactions were qualified, however, by a significant interaction between HRV and age (β = -.54, t = -2.44, p = .02, *SE* = .23), indicating a three-way interaction between HRV, age, and test task type on self-regulatory performance. The simple slope for the relationship between HRV and self-regulatory performance was significant for the older adults (β = .31, t = 2.35, p = .02, *SE* = .13) but not for the younger adults (β = -.23, t = -1.30, p = .20, *SE* = .18), indicating that HRV was positively associated only with emotion regulation performance, and only for the older adults. Figure 3.2 displays the interaction effect. The intercept was not significant (β = -.26, t = -1.14, p = .26, *SE* = .22), meaning that there was not a main effect for test task.

Table 3.1

Participant Demographic Characteristics

Variable	N	Older Adults	Younger Adults
Sex			
Male	42	22	26
Female	56	20	30
Education			
Some high school	1	1	0
High school graduate	14	5	9
Some college	49	11	38
College graduate	16	14	2
Post-graduate training	17	17	0
Employment status			
Employed full-time	5	4	1
Employed part-time	17	6	11
Retired	36	36	0
Unemployed	4	2	2
Student	35	0	35
Marital status			
Married	38	35	3
Single	48	2	46
Divorced	6	6	0
Widowed	5	5	0
Annual family income			
< $10K	2	0	2
$10,000 – 19,999	5	2	3
$20,000 – 29,999	8	4	4
$30,000 – 39,999	2	2	0
$40,000 – 49,999	9	6	3
$50,000 – 74,999	21	15	6
$75,000 – 99,999	20	6	14
$100,000 – 149,999	10	2	8
>$150,000	17	8	9
Race and ethnicity			
White	82	45	37
African American	10	2	8
Asian American	4	1	3
More than one	2	0	2

Table 3.2

Descriptive Statistics

Variable	Older Adults	Younger Adults
	M (SD)	M (SD)
Self-Control Scale	3.80 (.43)*	3.56 (.47)
Emotion Regulation Questionnaire		
Reappraisal	5.05 (.74)	5.05 (.83)
Suppression	3.26 (1.17)*	3.76 (1.17)
Future Time Perspective	3.87 (.99)***	5.73 (.71)
Video Activity Appraisal	2.52 (1.51)	2.18 (1.11)
Listening Activity Appraisal	4.01 (1.24)	3.65 (1.13)
PANAS – baseline (average)		
Positive	3.36 (.57)***	2.55 (.68)
Negative	1.10 (.15)	1.17 (.17)
Attentive	3.89 (.56)***	3.03 (.72)
Fatigued	1.52 (.49)***	2.57 (.94)
PANAS – post-low-fatiguing task		
Positive	2.91 (.82)***	2.04 (.75)
Negative	1.07 (.18)	1.13 (.21)
Attentive	3.50 (.80)***	2.35 (.76)
Fatigued	1.52 (.43)***	2.83 (1.00)
PANAS – post-high-fatiguing task		
Positive	3.41 (.56)***	2.23 (.73)
Negative	1.06 (.08)	1.07 (.09)
Attentive	3.93 (.59)***	2.66 (.88)
Fatigued	1.58 (.48)***	2.66 (1.15)
PANAS – post-emotion regulation task		
Positive	3.32 (.69)***	2.40 (.78)
Negative	1.30 (.41)	1.20 (.31)
Attentive	3.89 (.69)***	2.81 (.81)
Fatigued	1.40 (.57)*	1.99 (.95)
PANAS – post-attention regulation task		
Positive	3.45 (.78)***	2.54 (.62)
Negative	1.16 (.24)	1.25 (.33)
Attentive	3.82 (.67)*	3.26 (.83)
Fatigued	1.64 (.68)*	2.34 (1.25)

Note. *$p < .05$, **$p < .01$, ***$p < .001$

Figure 3.1

Interaction of age group by test task on self-regulatory performance (z-scores)

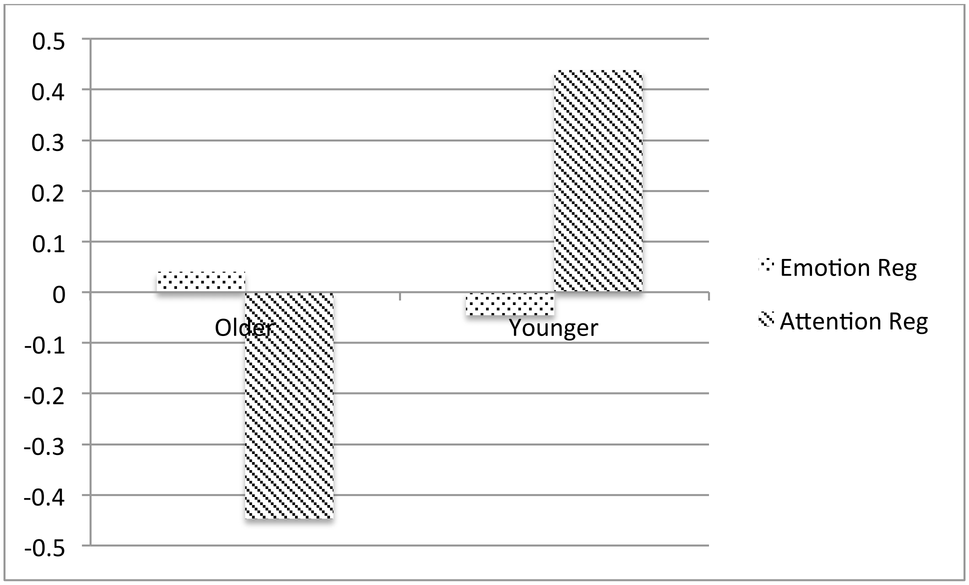
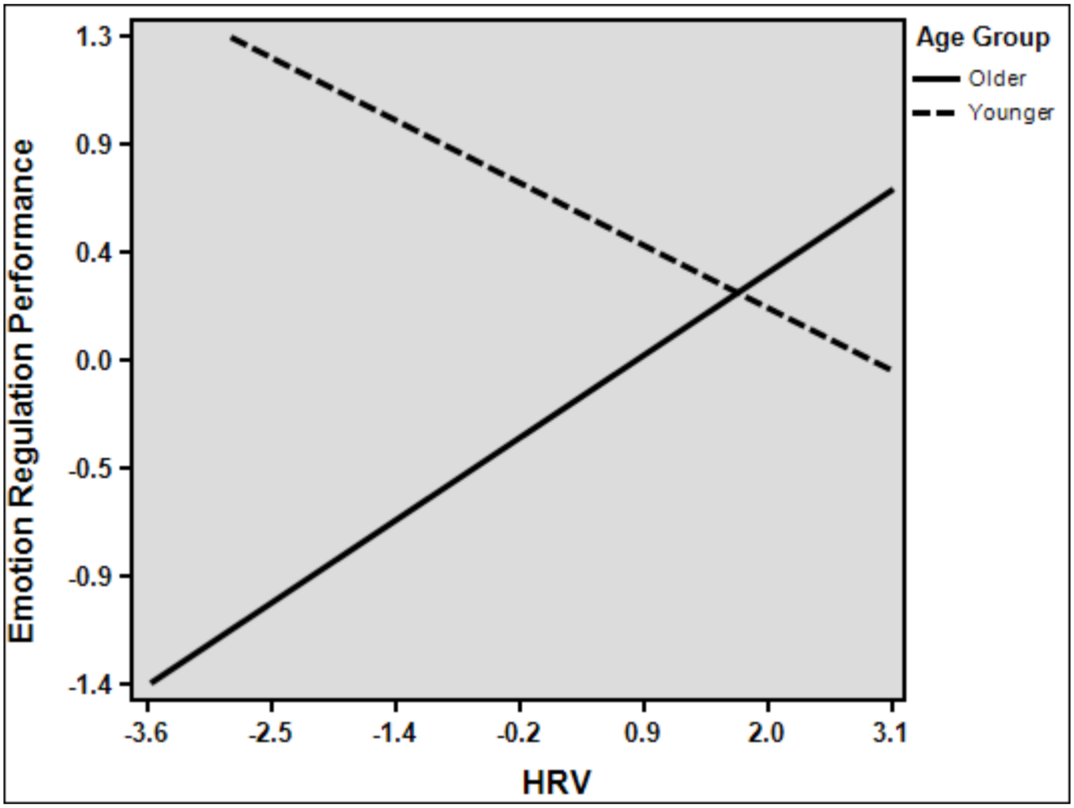


Figure 3.2

Interaction of heart rate variability by age group on emotion regulation performance



Chapter 4: Discussion

The preservation of emotion regulation capacity despite the many physical and psychological declines associated with advancing age has been referred to as a paradox of aging. Two prominent theories seeking to explain this paradox claim that older adults either use *fewer* resources to regulate their emotions because this process becomes more automatic and less effortful, or conversely use *more* of their resources to regulate their emotions because of the priority they place on emotional wellbeing. The primary aims of the current study were to (1) test the claim that older adults are capable of regulating their emotions even when in a state of self-regulatory fatigue, and (2) determine how much of their self-regulatory capacity is expended to regulate emotions compared with other forms of self-regulation, and relative to younger adults.

Consistent with findings from other studies, older adults in the current study demonstrated that they were equally as capable as younger adults at regulating their emotions, in this case emotional suppression while watching a video designed to induce sadness. Within older adults, performance on the emotion regulation task was superior to that of the attention regulation task. This finding is also consistent with those from other studies showing age-related declines in attention regulation but maintenance of emotion regulation capacity, though the current study appears to be the first to directly compare emotion regulation and attention regulation performance among older adults. The superiority of emotion regulation performance by older adults also provides support for the claim that emotion regulation is a unique form of self-regulation for older adults.

Because there were no differences in performance between the high and low self-regulatory fatigue conditions (i.e., cookies vs. radishes), suggesting a failure to sufficiently fatigue participants in the high self-regulation condition, the results are unable to shed light on the question of whether older adults can regulate their emotions effectively when in a state of self-regulatory fatigue (Aim 1). However, by combining the self-regulatory performance data with HRV—a proxy for self-regulatory capacity—results pertaining to Aim 2 suggest that older adults are allocating more of their self-regulatory resources for emotion regulation relative to attention regulation, and relative to younger adults. This finding is consistent with a core premise of SST, namely that older adults maintain the capacity to regulate emotions because they prioritize emotional wellbeing.

The conclusion that older adults prioritize emotion regulation is based on a novel application of HRV, but is also consistent with findings from the cognitive and affective neuroscience literature. For example, relative to younger adults, older adults tend to show greater activation of areas associated with executive control (e.g., dorsolateral and ventrolateral regions of the prefrontal cortex) during episodes of emotion regulation, suggesting that older adults may be engaging more neural resources to achieve the same level of emotion regulation as their younger counterparts (for a review, see Mather, 2012). Similarly, older adults often show a compensatory over-activation of certain brain regions, such as the dorsal PFC and parietal regions, when performing particular cognitive tasks that rely on inhibition (for a review, see Grady, 2012).

Results from the current study have important implications for self-regulation theory generally, and the strength model specifically. One of the tenets of the strength model of self-regulation is the interchangeability of different types of self-regulatory tasks. For example, a fatiguing emotion regulation task is assumed to impair subsequent attention regulation test tasks to roughly the same extent as fatiguing attention regulation tasks impair subsequent emotion regulation test tasks. However, the strength model is based almost entirely on research with undergraduate student samples. The current study suggests that for older adults the type of self-regulatory task is an important factor in understanding and predicting the patterns of self-regulatory fatigue and performance.

If, as the results of the current study suggest, older adults are using more of their self-regulatory resources to meet their emotion regulation goals, this has implications for the health of older adults and interventions targeting older adults. By prioritizing emotion regulation over other forms of self-regulation, older adults might be more likely to find themselves with fewer self-regulatory resources to devote to other activities that typically require self-regulation, such as exercise or dieting. However, the importance that older adults place on emotional wellbeing could be harnessed in approaches to encouraging healthy behaviors. For example, public health campaigns to increase physical activity among older adults might be more effective if they emphasized the emotional benefits of physical activity.

Within the broad scheme of research on emotion regulation and aging, this study offers several innovations and advantages over previous studies. First, it appears to be the only study in which emotion regulation performance among older adults is directly compared to other forms of self-regulation. Second, this study is the first to employ resting HRV as a proxy for self-regulatory capacity among older adults. This provides further insight into the mechanisms of how older adults maintain emotion regulation capacity despite declines in other domains of mental functioning, and expands the use of this technology for future research with older adults. Third, the results are particularly relevant to theory testing as theoretically based predictions were pitted against each other, in this case the question of whether older adults use more or less resources for emotion regulation.

There are limitations to the current study. The lack of online physiological measures or self-report data during the emotion regulation test task makes it difficult to know whether lack of emotional expression in the face was due to successful suppression versus absence of emotional response to the video. There was a brief measure of post-video affect, but this probed state affect following rather than during the video. In future attempts to replicate the current findings, it would be helpful to incorporate online physiological measures such as skin conductance, blood pressure, and muscular activity in order to distinguish successful suppression from lack of emotional response.

There was a failure to manipulate self-regulatory fatigue as demonstrated by the lack of differences between the high and low self-regulatory fatigue groups on test task performance. A handful of other studies have also failed to replicate this fatiguing effect on subsequent test task performance (Stillman, et al., 2009; Wright et al., 2007; Wright et al., 2008), but the manipulation failure might have been due to individual differences in the desire to eat certain kinds of food. Future research using this paradigm could incorporate measures specific to the fatiguing task in order to produce more reliable and powerful fatiguing effects. For example, studies using a food temptation paradigm could include only participants who report actively dieting or who rate certain foods as highly tempting.

Because emotion regulation performance was based on suppression of sadness, a particular emotion regulation strategy for a particular emotion, the findings do not necessarily generalize to other emotion regulation strategies or other emotions. However, the primary purpose of the current study was to test proposed mechanisms of emotion regulation among older adults in those cases where older adults are equally as effective as younger adults. Suppression of sadness was chosen as the emotion regulation task because previous research suggests that this produces equivalent emotional load and performance among older and younger adults (Shiota & Levenson, 2009; Tsai et al., 2000).

As this study used a cross-sectional design, the results can be interpreted only as they apply to age differences rather than aging *per se*. Cohort effects, for example, cannot be ruled out as an alternative explanation to the findings. Similarly, there were two age groups rather than a middle-aged group, making it impossible to know whether the trajectory of changes is linear with age. However, as Hertzog (1996) suggests, when exploring a new phenomenon in the field of aging, it is best to use a cross-sectional design with extreme age differences to see if there is an effect.

In summary, older adults were just as capable as younger adults at regulating their emotions. One of the mechanisms explaining this preserved capacity appears to be a prioritization of emotional wellbeing that is reflected in greater self-regulatory effort directed at emotion regulation. These results are consistent with and provide further support for Socioemotional Selectivity Theory.

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Curriculum Vitae

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Education

Arizona State University, Mesa, AZ (8/2003 – 5/2006)
M.S. in Exercise and Wellness

Wesleyan University, Middletown, CT (1993 – 1998)
B.A. in Philosophy

Professional Positions

Graduate Teaching Assistant, Arizona State University, Tempe, AZ (2004 – 2005)

English Teacher, Japan Exchange Teaching Program, Kawasaki, Japan (1998 – 2001)

Awards and Honors

National Research Service Award (F31AG039208), National Institute on Aging (2011 – present)

Nietzel Visiting Distinguished Faculty Award, University of Kentucky (2012)

Dissertation Year Fellowship, University of Kentucky (2011-2012)

Jesse G. Harris Memorial Dissertation Award, University of Kentucky (2012)

Graduate Student Incentive Program Award, University of Kentucky (2011)

Facial Action Coding System (FACS) Certification (2011)

Excellence in Clinical Performance Award, University of Kentucky (2010)

Research Challenge Trust Fund Award, University of Kentucky (2008 – 2013)

Graduate Student Travel Award, University of Kentucky (2008 – 2013)

Kentucky Opportunity Fellowship, University of Kentucky (2006 – 2007)

Daniel R. Reedy Fellowship, University of Kentucky (Fall 2006 – Spring 2009)

Graduate College Tuition Award, Arizona State University (Fall 2004 – Spring 2005)

Seed Grant, Pressure Positive Company (2004)

Publications

Evans, D.R., Eisenlohr-Mouhl, T.A, Button, D., Baer, R.A., & Segerstrom, S.C. (in press). Self-regulatory deficits associated with unpracticed mindfulness approaches to pain. *Journal of Applied Social Psychology*.

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