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EMOTION REGULATION AND MEMORY: DIFFERENTIAL ASSOCIATIONS IN YOUNGER AND MIDLIFE/OLDER ADULTS

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Background/Study Context*: Older adults may devote more cognitive resources to the processing and regulation of emotion stimuli than younger adults, but no studies have determined associations between episodic memory performance and naturalistic emotion recovery in a mixed-age sample. The current study ascertained if episodic memory scores were associated with emotion recovery in younger and midlife/older adults and if these associations were moderated by age.*

Methods*: Participants watched a montage of film clips about interpersonal loss. Self-reported negative and positive emotions were assessed prior to the video, immediately after, and again 10 min after the video. Executive functions, processing speed, and episodic memory were assessed.*

Results*: Participants with better episodic memory recovered more quickly from the mood induction than participants with lower scores. Age moderated the association between joviality recovery and memory. Specifically, there was a significantly stronger, positive association between joviality recovery and memory in midlife/older adults relative to younger adults.*

Conclusions*: Stronger memory may facilitate emotion recovery, and this may be particularly true for older adults. Older adults with memory impairment may be at risk for emotion dysregulation.*

Cognitive and emotional processes are inextricably interconnected (Adolphs & Damasio, 2001), and this may be particularly true for older adults (Reed & Carstensen, 2012). Indeed, older adults with stronger scores on cognitive tasks have advantages in regulating their emotions. For example, older adults with "high alerting ability," an attentional ability relevant for processing incoming stimuli, reported lesser decline in mood during a laboratory task that involved gazing at highly negative images when compared with older adults with lower alerting ability (Noh, Lohani, & Isaacowitz, 2011). Along similar lines, the majority of evidence about the interface between cognition and emotion regulation in older adults links attention/executive functions with emotion outcomes (Isaacowitz, Toner, & Neupert, 2009; Noh et al., 2011; Stanley & Isaacowitz, 2011).

Although there is less evidence to date, episodic memory also may be associated with emotion recovery after a negative event. After viewing sad film clips about interpersonal

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loss, amnestic patients remained sad even though they had minimal to no recollection of the content of the films (Feinstein, Duff, & Tranel, 2010). The patients' sadness persisted for a longer duration and at a higher intensity than for control participants. Feinstein et al. speculated that memory for the origin of negative emotions may facilitate recovery from those emotions and poorer memory may complicate emotion recovery.

Further, effectual emotion regulation is associated with enhanced memory for experimental stimuli; this is particularly true for negative stimuli (Dillon, TRitchey, Johnson, & LaBar, 2007; Hayes et al., 2010; Richards & Gross, 2000). In Hayes et al. (2010), participants either viewed negative images passively or they regulated emotion reactions to the stimuli. After engaging in cognitive reappraisal, which is an effective emotion regulation technique, negative emotions decreased and memory for the experimental stimuli increased.

Despite these preliminary data, there is scant evidence of associations between performance on episodic memory tasks and successful emotion regulation outcomes, particularly amongst older adults. Older adults experience age-related decreases in efficient learning and memory (Caselli et al., 2014), and if memory performance is associated with emotion regulation outcomes, older adults with memory decline may be vulnerable to emotion dysregulation and associated consequences, such as interpersonal conflict, less financial success, and poorer well-being (Birditt & Fingerman, 2005; Côté, Gyurak, & Levenson, 2010).

The current study determined if individual differences in episodic memory performance are associated with emotion recovery in older and younger adults after they view film clips about interpersonal loss. Adults spontaneously engage in down-regulation of negative emotions (Egloff, Schmukle, Burns, & Schwerdtfeger, 2006; Volokhov & Demaree, 2010), and thus during a short recovery phase after viewing the films, we expected down-regulation of sadness and other negative emotions to occur. We also expected individual variation in the effectiveness of emotion recovery such that participants with greater performances on tests of episodic memory would recover more efficiently (e.g., greater decline in negative emotions) from the mood induction than participants with lower scores on these measures (Feinstein et al., 2010).

Less is known about spontaneous recovery of positive emotions after a negative mood induction, but positive emotions are known to facilitate recovery from negative experiences (Frederickson & Levenson, 1998; Gloria, Faulk, & Steinhardt, 2013). Based on these data, we expected increases in positive emotions during the recovery phase. An exploratory prediction was that participants with better episodic memory scores would recover more efficiently in positive emotions (e.g., greater increase) from the mood induction than participants with lower memory scores.

A final aim of the study determined if associations between episodic memory and emotion recovery are moderated by age. Cognitive resources are utilized by older adults more than younger adults in the service of attending to and remembering emotion stimuli, as well as for emotion regulation (Isaacowitz et al., 2009; Knight et al., 2007; Mather & Knight, 2005; Reed & Carstensen, 2012; Stanley & Isaacowitz, 2011); therefore, we expected the associations between memory and emotion recovery would be stronger for older than younger adults.

METHODS

Participants

Participants were 23 younger adults (19–23 years old) and 21 midlife and older adults (52–79 years). The younger adults were University of Massachusetts Amherst undergraduate students recruited from the SONA psychology research participation system, for which they received one experimental extra credit point per half hour of participation. We recruited all other participants from the surrounding community by fliers, newspaper ads, research databases, or by word of mouth. The Telephone Interview of Cognitive Status (TICS-M) was used to screen midlife and older adults for cognitive impairment; a score greater than 31 was required for participation (Knopman et al., 2010). Community participants received $5 per half hour of participation.

Procedure

All participants provided written informed consent and then completed a demographic form, the Beck Depression Inventory-II (BDI-II), and the Dimensions of Affective Experience Scale (DAES). Next, we administered the Wechsler Memory Scale (WMS) Logical Memory I and II and the Delis-Kaplan Executive Function System (D-KEFS) Trail Making task to participants. Participants then completed the Positive and Negative Affect Schedule—Expanded (PANAS-X) to assess momentary emotions prior to watching a 12-min video montage of four clips about interpersonal loss.

When the video montage concluded, participants reported on momentary emotion on the PANAS-X for a second time. Approximately 5 min later, we asked participants 15 standardized free recall questions about the content of the videos (e.g., "In the first clip, where did the couple picnic?"). After the recall items were completed, we assessed verbal recognition memory for the video content via a 15-item multiple-choice task (e.g., "In the first clip, did the couple picnic at the beach, on a hill, or near a lake?"). Next, participants engaged in a visual recognition task by sorting 15 color images (5 still frame shots from the film montage and 10 still frame shots from other films) into two piles; images they saw in the video and images they did not see in the video.[1]

When memory testing concluded, about 5 min later, participants completed a third and final assessment of momentary mood via the PANAS-X. Participants then separately rated the overall arousal and negativity of the film montage on Likert scales (1 = not at all, 3 = somewhat, 5 = significantly) and reported which of the four clips was most impactful. The session lasted approximately 1.5 hr; procedures were modeled after Feinstein, Duff, and Tranel (2010).

Film Stimuli

In a meta-analysis about the effectiveness of various mood induction techniques (e.g., music, social interactions, self-referent statements), out of 11 types or combinations of stimuli, film clips were the most effective method to induce mood changes (Westermann, Spies, Stahl, & Hesse, 1996). The video montage used in this study included excerpts from the movies *Up* (an elderly man losing his wife after many years of marriage with happy times, as well as challenges), *Steel Magnolias* (a mother's anger and sorrow at her daughter's funeral), *Sophie's Choice* (a mother forced to choose which child to send to his/her death by a Nazi soldier), and *Pay It Forward* (a boy tries to intervene in a fight at school and is stabbed to death as a result). We selected these films for a number of reasons. First, films about interpersonal loss are particularly effective in negative mood induction

[1] All participants scored 100% on this task, and thus these data were not included in analyses.

(Gross & Levenson, 1995) and are effective in eliciting powerful reactions from older and younger adults (Kunzmann & Grühn, 2005; Streubel & Kunzmann, 2011). Further, the *Steel Magnolias* and *Sophie's Choice* clips were used successfully in Feinstein et al. (2010) to induce sadness in research participants. *Up* and *Pay It Forward* were pilot tested for this study on undergraduates and were found to be effective in eliciting mood changes. *Up*, in particular, was selected because the content is relevant to issues of loss in aging; none of the other films had an older adult protagonist. We anticipated that the films would increase sad feelings in participants but also elicit changes in other negative emotions (e.g., fear, guilt), similar to previous research (Kunzmann & Grühn, 2005); as an exploratory hypothesis, we predicted declines in positive emotions.

Measures

Demographic Form

Participants self-reported biological age, education, and physical health and mental health (1 = excellent, 5 = terrible). They indicated current income; students reported family income (1 = less than $10,000, 5 = greater than 50,001).

Depressive Symptoms

The Beck Depression Inventory—Second Edition (BDI-II) is a 21-item self-report measure of depressive symptoms (Beck, Steer, & Brown, 1996). The BDI-II scale demonstrates high internal consistency ($\alpha = .93$ among college students, $\alpha = .92$ among outpatients, and $\alpha = .86$ in a sample of older adults) (Beck et al., 1996; Segal, Coolidge, Cahill, & O'Riley, 2008) and concurrent validity (e.g., significant positive correlations with self-report measures of trait depression and anxiety) (Storch, Roberti, & Roth, 2004).

Dimensions of Affective Experience Scale (DAES)

The DAES is a 54-item self-report scale that assesses dimensions of emotional experience and control that may change over the adult life span. Items (e.g., *I'm slow to get emotions aroused*) are rated on a Likert scale (1 = very true of me; 2 = somewhat true of me; 3 = not at all true of me). There are seven factorially derived subscales: Emotional Control, Surgency, Stability, Emotional Maturity through Moderation, Leveling of Positive Affect, Psychophysiological Responsiveness, and Sensation Seeking (Lawton, Kleban, Rajagopal, & Dean, 1992).

Neuropsychological Measures

Delis-Kaplan Executive Function System (D-KEFS) Trail Making test. D-KEFS Trail Making is a visual-motor task that measures cognitive flexibility (Condition 4: Number-Letter Switching), with additional conditions used to assess visual scanning/attention (Condition 1: Visual Scanning), visual-motor function (Condition 2: Number Sequencing), letter sequencing (Condition 3: Letter Sequencing), and motor speed (Condition 5: Motor Speed) (Delis, Kaplan, & Kramer, 2001). In all conditions, participants are asked to scan or connect dots containing numbers and letters in a particular sequence; time to completion is the score. The D-KEFS Trail Making test has demonstrated adequate test-retest reliability (Condition 1: $r = .56$; Condition 2: $r = .59$; Condition 3: $r = .59$; Condition 4: $r = .38$; Condition 5: $r = .77$).

Wechsler Memory Scale—Fourth Edition (WMS-IV) Logical Memory subtest. The WMS-IV Logical Memory I is an assessment of immediate auditory memory of two orally presented stories (Wechsler, 2009). Logical Memory II is an assessment of 20-min delayed recall and recognition of the stories. The WMS-IV Logical Memory I and II have demonstrated adequate reliability, including high internal consistency (with r values [rs] = .82 and .85, respectively) and moderate test-retest reliability (rs = .74 and .71, respectively). Convergent validity is indicated by moderate correlations with short-delay and long-delay cued and free recall scores on the California Verbal Learning Test (CVLT; rs ranging from .40 to .53).

Momentary Emotions

The PANAS-X measures Positive Affect (PA) and Negative Affect (NA), as well as three additional PA subscales (Joviality, Self-assurance, Attentiveness) and four additional NA subscales (Fear, Sadness, Guilt, Hostility). Internal consistencies for all PANAS-X scales generally are strong: .83 to .90 for the PA and NA scales, .79 to .92 for the specific NA scales, and .70 to .93 for the specific PA scales. Attentiveness is the shortest facet scale and consequently tends to have the lowest internal consistency reliability. The structure of the PANAS-X has been replicated by factor analyses in several independent samples, and its scales exhibit strong convergent validity with those of the Profile of Mood States (POMS) (McNair, Lorr, & Droppleman, 1971). Correlations between PA and NA tend to be low, ranging from −.05 to −.35; thus, they are best characterized as "quasi-independent."

Analyses

We ran analyses to characterize the sample and to test for age group differences on demographic variables, depressive symptoms, DEAS, baseline affect, neuropsychological test scores, and affect reactions to the film. Preliminary analyses involved t tests and analyses of covariance (ANCOVAs). Primary analyses determined associations, via correlation and regression, between affect recovery and cognitive variables. We determined if associations between affect recovery and memory were moderated by age; analyses to test this question were moderated multiple regressions, followed by appropriate contrasts (Aiken & West, 1991).

RESULTS

Preliminary Analyses

Participants

Participants were younger (n = 23, 65% female, 70% Caucasian) and midlife/older adults (n = 21, 33% female, 100% Caucasian; Table 1). There was a trend for differences in age group sex distribution (Pearson chi-square = 3.81, $p < .10$).[2] Younger adults were university students and they had less education than midlife/older adults, who had completed their educational careers. There were no age group differences in self-reported income,

[2] Due to a trend difference in sex distribution between age groups, sex effects on baseline emotions, as well as emotion reaction to and recovery from the films, were explored. We found no significant effects of sex on any of these variables, and effect sizes for sex were small in all cases (partial η^2 range: .01 to .05).

Table 1. Descriptive statistics for demographic and cognitive variables for younger and midlife/older adults

Characteristic	Younger	Midlife/older	t	Cohen's d	α
Age	20.92 (3.61)	65.95 (7.72)	25.58**	7.47	
Education	13.66 (2.61)	16.03 (4.09)	2.26*	0.69	
Income	3.92 (1.64)	3.20 (1.79)	1.38	0.41	
BDI-II	7.52 (4.96)	6.33 (6.22)	0.69	0.21	.85
Physical health	1.88 (0.61)	1.95 (0.59)	0.43	0.12	
Mental health	2.08 (0.65)	1.71 (0.64)	1.90	0.57	
DAES subscales					
Emotional Control	22.30 (3.03)	20.24 (4.39)	1.74	0.81	.80
Surgency	21.57 (3.89)	22.86 (4.22)	1.03	0.32	.75
Stability	17.05 (3.20)	15.62 (3.15)	1.46	0.45	.69
Emotional Maturity	19.35 (3.21)	17.52 (2.56)	2.02	0.63	.61
Leveling of Positive Affect	13.86 (2.46)	12.57 (2.52)	1.67	0.52	.65
Psychophysiological Responsiveness	10.29 (2.19)	12.00 (2.10)	2.59*	0.80	.68
Sensation Seeking	7.76 (2.19)	9.67 (1.77)	3.10*	0.96	.71
Neuropsychological scores					
Processing Speed (*z*-score)	0.41 (0.39)	−0.30 (0.73)	4.10**	1.21	
Trail Making Test, Condition 4 (*z*-score)	0.31 (0.55)	−0.35 (1.27)	2.31*	0.67	
WMS Logical Memory, Immediate Recall	24.75 (6.73)	23.57 (7.63)	0.81	0.16	
WMS Logical Memory, Delayed Recall	22.21 (6.85)	20.19 (8.44)	0.88	0.26	
WMS Logical Memory, Recognition	25.54 (2.65)	24.81 (2.66)	0.83	0.27	
Video Delayed Recall	14.29 (1.04)	13.57 (1.33)	2.04*	0.60	
Video Recognition	14.83 (0.49)	14.14 (1.31)	NA[b]	NA[b]	

[a]Lower scores on the DAES indicate greater endorsement of the scale items as being "true of me."
[b]A Mann-Whitney *U* test revealed a significant age group difference for Video Recognition mean scores ($p < .05$).
*$p < .05$; **$p < .01$.

depressive symptoms, and physical or mental health. On the DAES, midlife/older adults scored significantly lower in Psychophysiological Responsiveness and Sensation Seeking than younger adults.

Film Stimuli

t tests indicated no significant (*p*s > .20) age group differences in arousal ratings (younger: $M = 2.95$, $SD = 1.02$; midlife/older: $M = 3.40$, $SD = 1.31$; Cohen's $d = 0.38$) or in negativity ratings (younger: $M = 3.48$, $SD = 0.98$; midlife/older: $M = 3.50$, $SD = 1.19$; Cohen's $d = 0.02$) about the film montage. Further, there were no age group differences as to which of the four film clips was rated as most impactful (chi-square = 6.16, $p > .10$); the most frequent selections were *Sophie's Choice* (58.5%), followed by *Up* (22.0%).

Neuropsychological Test Scores

Four of the five Trails subscales measure processing speed under conditions of low cognitive burden (Trails 1, 2, 3, and 5). These scores were significantly correlated (*r*s ranging from .40 to .81, median = .61, *p*s < .01); subsequently, scores on these tasks were standardized and aggregated into a single Processing Speed score (Cronbach's $\alpha = .84$) for all subsequent analyses. Younger adults were significantly faster than midlife/older adults on the Processing Speed composite score, as well as on Trail 4, an executive function measure of cognitive flexibility (Table 1). There were no significant sex differences in neuropsychological test scores after controlling for age (*p*s > .30), and effect sizes for sex effects were small (partial η^2 range: .01 to .11).

There were no age group differences for immediate recall, delayed recall, or recognition on WMS Logical Memory (Table 1). Midlife/older adults recalled less verbal information than younger adults about the content of the videos. Verbal video recognition score had negative skew, but all transformations, including log, square root, and inverse, did not improve skew and kurtosis score; therefore, we conducted analyses on raw scores with nonparametric statistics. An independent samples Mann-Whitney *U* test indicated that younger adults performed significantly better ($p < .05$) than midlife/older adults on the verbal video recognition task.

PANAS-X Scores

Baseline affect. Prior to watching the film, midlife/older adults reported significantly ($p < .05$) greater scores for PA, Joviality, Assurance, and Attentiveness (PA: $t = 4.80$, $df = 34$, $p < .001$, Cohen's $d = 1.58$; Joviality: $t = 3.34$, $df = 43$, $p < .01$, Cohen's $d = 0.98$; Attentiveness: $t = 4.40$, $df = 43$, $p < .001$, Cohen's $d = 1.32$; Assurance: $t = 4.47$, $df = 43$, $p < .001$, Cohen's $d = 1.31$); we controlled these scores in subsequent analyses (Table 2). There were no significant age group differences in baseline NA, Fear, Sadness, Guilt, or Hostility scores.

Reactions to the films. As predicted, the video montage produced a broad range of emotion reactions. The largest increases were for NA, Sadness, and Hostility and the largest decreases were in PA and Joviality (Table 2). All analyses on negative affect scores relied on log-transformed scores to correct for positive skew. Age group differences in reactions to the film were determined. We statistically controlled variance differences in baseline positive affects using a general linear model univariate ANCOVAs. Midlife/older adults had higher Assurance score than younger adults, $F(1, 41) = 7.4$, $p < .05$; partial $\eta^2 = .15$. There were no other significant age group differences in reactions to the film for positive or negative emotions.

Table 2. Descriptive statistics and Cronbach's α for PANAS-X scores: Baseline, immediately after films, and 10-minutes after the film

	Baseline				After film				10 min after film			
	Y	M/O	Y	M/O	Y	M/O	Y	M/O	Y	M/O	Y	M/O
Scale	*M* (*SD*)	*M* (*SD*)	α	α	*M* (*SD*)	*M* (*SD*)	α	α	*M* (*SD*)	*M* (*SD*)	α	α
Negative scales												
Negative Affect	1.27 (0.33)	1.15 (0.26)	.75	.83	1.43 (0.46)	1.47 (0.50)	.86	.84	1.21 (0.32)	1.24 (0.35)	.79	.88
Fear	1.35 (0.55)	1.21 (0.38)	.81	.90	1.35 (0.60)	1.21 (0.36)	.89	.83	1.21 (0.36)	1.14 (0.24)	.72	.78
Sadness	1.26 (0.67)	1.08 (0.27)	.90	.69	1.68 (0.68)	1.71 (0.66)	.82	.74	1.28 (0.57)	1.36 (0.47)	.91	.78
Guilt	1.15 (0.30)	1.05 (0.09)	.73	**	1.10 (0.22)	1.17 (0.35)	.59	.79	1.03 (0.11)	1.17 (0.43)	.71	.90
Hostility	1.12 (0.32)	1.10 (0.21)	.75	.50	1.47 (0.51)	1.79 (0.78)	.67	.86	1.22 (0.37)	1.32 (0.43)	.77	.69
Positive scales												
Positive Affect[a]	2.40 (0.66)	3.50 (0.73)	.86	.90	2.02 (0.65)	3.09 (0.80)	.89	.87	2.06 (0.71)	3.24 (0.78)	.91	.89
Joviality[a]	2.43 (0.64)	3.18 (0.87)	.86	.93	1.69 (0.72)	2.38 (0.86)	.91	.89	1.96 (0.81)	2.74 (0.89)	.92	.91
Attentiveness[a]	3.04 (0.89)	4.13 (0.76)	.77	.91	2.58 (0.80)	3.80 (0.91)	.75	.81	2.69 (0.87)	3.82 (0.93)	.73	.89
Assurance[a]	1.97 (0.69)	3.06 (0.95)	.84	.91	1.67 (0.72)	2.93 (0.90)	.85	.85	1.75 (0.75)	2.96 (0.96)	.86	.86

Note. Y = younger adults; M/O = midlife/older adults.
[a]Baseline scores for older adults were significantly greater than for younger adults (*p*s $< .01$).
**There was insufficient variability to calculate α for this scale; negative covariance among items violated reliability model assumptions.

Table 3. Affect recovery scores for younger and midlife/older adults

Scale	Younger adults	Midlife/older adults	*t*	Cohen's *d*
Negative scales				
Negative Affect	−2.04 (2.61)	−2.29 (4.67)	0.22	0.07
Fear	−0.88 (1.98)	−0.38 (1.66)	0.90	0.27
Sadness	−1.96 (1.83)	−1.76 (2.57)	0.30	0.09
Guilt	−0.42 (1.50)	−0.05 (2.29)	0.65	0.19
Hostility	−1.50 (1.96)	−2.81 (3.72)	1.50	0.44
Positive scales				
Positive Affect	0.63 (3.56)	1.57 (3.99)	0.84	0.25
Joviality	2.17 (3.28)	2.86 (4.19)	0.62	0.18
Attention	0.42 (1.82)	0.10 (2.21)	0.54	0.16
Assurance	0.50 (1.41)	0.19 (2.50)	0.52	0.15

Note. Affect recovery scores = Affect at 10 min after film − Affect immediately after the film.

Recovery after the films. Controlling for differences in baseline positive affects using general linear model univariate ANCOVAs, it was found that midlife/older adults had higher Assurance than younger adults, $F(1, 41) = 5.4$, $p < .05$; partial $\eta^2 = .10$. There were no other age group differences for any positive or negative emotions.

Primary Analyses

PANAS-X Scores

Affect recovery between the end of the film and after 10 min was of central interest. The project tested if affect recovery was associated with cognitive scores and if this association was moderated by age. To capture recovery, difference scores were calculated between emotion ratings immediately after the film and 10 min after the film (i.e., affect recovery = affect at 10 min after film − affect immediately after the film). Positive difference scores indicate that affect increased over time; participants generally experienced increases in positive emotions following the film (Table 3). Negative difference scores indicate that an affect decreased over time, which was the case, on average, for negative emotions. *t* tests revealed no significant ($p < .05$) age group differences in recovery for negative emotions. For positive emotions, age group differences in baseline scores were controlled; results of ANCOVA analyses indicated no significant ($p < .05$) age group differences in recovery for positive emotions. Overall, recovery scores were greatest for NA, Sadness, Hostility, and Joviality; these same emotions were most responsive to the film manipulation (Table 2).

Associations Between Cognitive Scores and Affect Recovery

Correlations between the six cognitive measures and nine affect recovery scores were calculated (Table 4); because video recognition memory was not normally distributed, we reported nonparametric correlations (Spearman rho) for this variable. Processing Speed composite and Trail Making Condition 4 scores were not significantly associated with affect recovery scores. Logical Memory Delayed Recall and Video Delayed Recall and Recognition scores and recovery in negative affects were significantly ($p < .05$) negatively correlated, indicating that participants with stronger memories tended to experience greater declines in negative affects during the recovery period, suggesting more efficient recovery.

Table 4. Correlations between cognitive scores and affect recovery after viewing film clips about interpersonal loss

Scale	Processing Speed	Trail Making Condition 4	LM Delayed Recall	LM Recognition	Video Delayed Recall	Video Recognition[a]
Negative affects						
NA	.06	.00	−.18	.30*	−.28	−.42**
Fear	.13	−.06	−.30*	.01	−.31*	−.37*
Sadness	.18	.09	−.20	−.02	−.28	−.39**
Guilt	.12	−.08	−.25	.31	−.38*	−.37*
Hostility	−.01	.05	−.11	.14	−.21	−.23*
Positive affects						
PA	−.25	−.07	.24	.10	.40**	.33*
Joviality	−.16	.09	.28	.13	.33*	.42**
Attentiveness	−.29	−.28	.06	−.04	.26	.20
Assurance	−.08	−.14	.27	.02	.27	.29

Note. $N = 44$. LM = Logical Memory.
[a]Spearman rho is reported in this column rather that Pearson *r*.

An exception to this pattern was a positive correlation between logical memory recognition and NA recovery. There were significant ($p < .05$) positive correlations between memory scores and recovery in positive emotions. These results indicate that participants with greater memory scores tended to experience greater increases in positive emotions during recovery, again suggesting more efficient recovery.

For each significant correlation between affect recovery and memory, we ran a moderated multiple regression to determine if age moderated the association between recovery and memory. For example, there was a significant correlation between logical memory delayed recall and fear recovery; the following hierarchical regression tested if the association was moderated by age group:

$$\text{Fear recovery} = a + b_1 \times \text{LM delayed recall} + b_2 \times \text{Age group} + b_3 \times (\text{LM delayed recall} \times \text{Age group}) + u$$

We controlled differences in baseline affect when necessary. For example, there was a significant correlation between logical memory delayed recall and joviality recovery and this hierarchical, moderated multiple regression tested if the association was moderated by age group:

$$\text{Joviality recovery} = a + b_1 \times \text{Baseline joviality} + b_2 \times \text{LM delayed recall} + b_3 \times \text{Age group} + b_4 \times (\text{LM delayed recall} \times \text{Age group}) + u$$

We ran 13 moderated regressions, one each to test if age moderated the significant association between affect recovery and memory for all significant correlations in Table 4. Results indicated that age group significantly moderated ($p < .05$) the association between

Table 5. Moderated multiple regression: Predicting joviality recovery from video delayed recall and age group

Dependent variable	Independent variables	*B*	*SE*	*β*	*t*
	Model 1				
Joviality recovery	Baseline joviality	0.13	0.08	0.23	1.58
	Video delayed recall	1.00	0.44	0.33	2.21*
	$R^2 = .14$, $F(2, 42) = 3.38$, $p < .05$				
	Model 2				
Joviality recovery	Baseline joviality	0.10	0.09	0.18	0.27
	Video delayed recall	1.08	0.46	0.36	2.38*
	Age group	0.87	1.23	0.12	0.71
	$R^2 = .15$, $F(3, 41) = 2.40$, $p < .10$				
	Model 3				
Joviality recovery	Baseline joviality	0.09	0.09	0.16	1.04
	Video delayed recall	−2.31	1.45	−0.76	−1.59
	Age group	−29.01	12.28	−3.95	−2.36*
	Video delayed recall × Age group interaction	2.14	0.88	3.91	2.44*
	$R^2 = .26$, $F(4, 40) = 3.51$, $p < .05$				

joviality recovery and video delayed recall (Table 5). There is a stronger, positive association between joviality recovery and memory in midlife/older adults relative to younger adults (Figure 1).[3,4]

DISCUSSION

Episodic memory scores were associated with affect recovery scores after participants watched a film montage about interpersonal loss. Memory scores for the film stimuli, in particular, were associated with several indices of emotion recovery. These data suggest that participants with stronger episodic memory might recover more quickly from an aversive mood induction than participants with lower scores. Emotion recovery was indicated by decreases in negative emotions and increases in positive emotions after viewing film clips about interpersonal loss. Our results are consistent with Feinstein et al. (2010),

[3]We ran all moderated regressions a second time using age as a continuous variable, instead of age group. Results were nearly identical, and the significant ($p < .05$) moderation effect found for age on the association between joviality recovery and video delayed recall was replicated.

[4]Perhaps participants who perform more poorly on the video memory recall have worse moods at the 10-min recovery assessment because they are discouraged by their memory performance and not because of less efficient emotion regulation. We cannot test this alternative hypothesis directly but post hoc analyses explored this idea by correlating video memory scores with the 10-min recovery emotion report. We found six significant ($p < .05$) negative correlations between negative emotions and video memory scores, indicating that lower memory performance was associated with greater negative affect; lower memory also was associated with greater Assurance. Thus, we found fewer significant correlations between memory performance scores and the final emotion report, as compared with significant correlations between memory performance and emotion recovery (7 vs. 11), and one of the seven was in the opposite direction (i.e., better assurance with poorer memory), which seems inconsistent with ideas of discouragement after memory testing. Further, participants in this study had normal-range memory and are unlikely to have had an accurate sense of subtle individual differences in memory performances for the video stimuli.

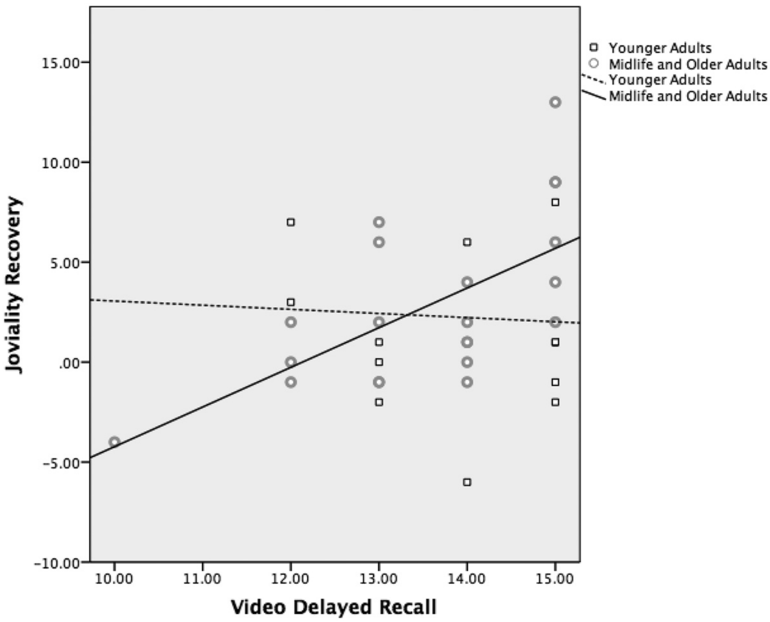

Figure 1. Association between joviality recovery and video delayed recall: Moderated by age group.

who reported that amnestic participants recovered less efficiently from a negative mood induction than control participants.

The mechanism that links episodic memory, particularly for emotion stimuli, and emotion recovery is unknown. Feinstein et al. (2010) hypothesized that a clear understanding of the cause of negative emotions may facilitate recovery from those emotions. An important distinction between their study and the current research is that their amnestic participants had very poor recall of the film stimuli, whereas the memory capabilities of participants in this study were in the normal range. Even so, individual differences in memory were associated with meaningful emotion outcomes. Future research to determine how memory for a negative stimulus, and stronger memory scores overall, may facilitate emotion recovery is warranted. Persons with less complete memories for a stimulus may be vulnerable to poor emotion recovery (Richards & Gross, 2000). That is, effective emotion regulation may require attention to and elaboration of stimuli, which in turn leads to enhanced memory for the stimuli (Knight & Ponzio, 2013).

We found partial support for the hypothesis that age would moderate the association between memory and emotion recovery. Recovery in joviality following the film was more strongly associated with free recall memory for the film stimuli in midlife and older adults than in younger adults. This finding is consistent with converging evidence that cognitive resources are utilized differently by older adults than younger adults in the service of emotion processing and emotion regulation during laboratory tasks (Isaacowitz et al., 2009; Knight et al., 2007; Mather & Knight, 2005; Stanley & Isaacowitz, 2011). It is unclear why recovery in negative emotions was not moderated by age as predicted; the lack of effects here may be a consequence of the small sample and/or an indication that positive emotion recovery is a better index of effective emotion regulation than negative emotion recovery. Future work is necessary to explore these ideas.

Limitations

The samples were small and were ones of convenience. The midlife/older adult subsample had a large age range. We did not collect observational or physiological measures of emotion recovery, nor did we measure differential age-group motivations to regulate emotions. However, on the DAES, midlife/older and younger adults did not report significant differences in emotion control, emotion maturity, or emotion stability.

Future Directions

The current work is innovative because an association between memory skills and emotion recovery was discovered in persons across the adult life span with normal-range cognition. Further, memory may be more strongly associated with emotion regulation outcomes for midlife and older adults than younger persons, particularly in service of positive emotion recovery from a negative stimulus. Replication of this finding and more thorough exploration of recovery in negative emotions is warranted, particularly with a larger and more diverse sample. This future research should examine midlife and older adults separately. Further, the current findings, in conjunction with other work (Isaacowitz et al., 2009; Knight et al., 2007; Mather & Knight, 2005; Maxfield, Pyszczynski, Greenberg, Pepin, & Davis, 2012; Stanley & Isaacowitz, 2011), suggests that older adults with memory impairment or executive dysfunction may be at risk for emotion dysregulation. Future research should determine if memory impairment in older adults is associated with emotion dysregulation and incomplete recovery from negative experiences. Understanding the origin of emotion dysregulation in older adults with memory impairment may lead to effective interventions to improve emotion outcomes. Finally, future work should pursue alternative explanation for the associations between poorer memory and less efficient emotion regulation, such as feelings of discouragement after memory testing.

REFERENCES

Adolphs, R., & Damasio, A. R. (2001). The interaction of affect and cognition: A neurobiological perspective. In J. P. Forgas (Ed.), *Handbook for affect and social cognition* (pp. 27–49). Mahwah, NJ: Lawrence Erlbaum Associates Publishers.

Aiken, L. S., & West, S. G. (1991). *Multiple regression: Testing and interpreting interactions*. Thousand Oaks, CA: Sage Publications.

Beck, A. T., Steer, R. A., & Brown, G. K. (1996). *Beck depression inventory* (2nd ed.). San Antonio, TX: The Psychological Corporation.

Birditt, K. S., & Fingerman, K. L. (2005). Do we get better at picking our battles? Age group differences in descriptions of behavioral reactions to interpersonal tensions. *Journals of Gerontology*, *60B*, P121–P128. doi: 10.1093/geronb/60.3.P121

Caselli, R. J., Locke, D. E. C., Dueck, A. C., Knopman, D. S., Woodruff, B. K., Hoffman-Snyder, C., Reiman, E. M. (2014). The neuropsychology of normal aging and preclinical Alzheimer's disease. *Alzheimer's & Dementia*, *10*, 84–92. doi: 10.1016/j.jalz.2013.01.004

Côté, S., Gyurak, A., & Levenson, R. W. (2010). The ability to regulate emotion is associated with greater well-being, income, and socioeconomic status. *Emotion*, *10*, 923–933. doi: 10.1037/a0021156

Delis, D. C., Kaplan, E., & Kramer, J. H. (2001). *Delis Kaplan Executive Function System, technical manual*. San Antonio, TX: The Psychological Corporation.

Dillon, D. G., TRitchey, M., Johnson, B. D., & LaBar, K. S. (2007). Dissociable effects of conscious emotion regulation strategies on explicit and implicit memory. *Emotion*, *7*, 354–365. doi: 10.1037/1528-3542.7.2.354

Egloff, B., Schmukle, S. C., Burns, L. R., & Schwerdtfeger, A. (2006). Spontaneous emotion regulation during evaluated speaking tasks: Associations with negative affect, anxiety expression, memory, and physiological responding. *Emotion*, *6*, 356–366. doi: 10.1037/1528-3542.6.3.356

Feinstein, J. S., Duff, M. C., & Tranel, D. (2010). Sustained experience of emotion after loss of memory in patients with amnesia. *Proceedings of the National Academy of Sciences of the United States of America, Early Edition*, *107*, 7674–7679. doi: 10.1073/pnas.0914054107

Frederickson, B. L., & Levenson, R. W. (1998). Positive emotions speed recovery from the cardiovascular sequelae of negative emotions. *Cognition & Emotion*, *12*, 191–220. doi: 10.1080/026999398379718

Gloria, C. T., Faulk, K. E., & Steinhardt, M. A. (2013). Positive affectivity predicts successful and unsuccessful adaptation to stress. *Motivation and Emotion*, *37*, 185–193. doi: 10.1007/s11031-012-9291-8

Gross, J. J., & Levenson, R. W. (1995). Emotion elicitation using films. *Cognition & Emotion*, *9*, 87–108. doi: 10.1080/02699939508408966

Hayes, J. P., Morey, R. A., Petty, C. M., Seth, S., Smoski, M. J., McCarthy, G., & LaBar, K. S. (2010). Staying cool when things get hot: Emotion regulation modulates neural mechanisms of memory encoding. *Frontiers in Human Neuroscience*, *4*, 230. doi: 10.3389/fnhum.2010.00230

Isaacowitz, D. M., Toner, K., & Neupert, S. D. (2009). Use of gaze for real-time mood regulation: Effects of age and attentional functioning. *Psychology and Aging*, *24*, 989–994. doi: 10.1037/a0017706

Knight, M., & Ponzio, A. (2013). The effects of emotion regulation on explicit memory depend on strategy and testing method. *Emotion*, *13*, 1041–1054. doi: 10.1037/a0033533

Knight, M., Seymour, T. L., Gaunt, J. T., Baker, C., Nesmith, K., & Mather, M. (2007). Aging and goal-directed emotional attention: Distraction reverses emotional biases. *Emotion*, *7*, 705–714. doi: 10.1037/1528-3542.7.4.705

Knopman, D. S., Roberts, R. O., Geda, Y. E., Pankratz, V. S., Christianson, T. J. H., Petersen, R. C., & Rocca, W. A. (2010). Validation of the telephone interview for cognitive status-modified in subjects with normal cognition, mild cognitive impairment, or dementia. *Neuroepidemiology*, *34*, 34–42. doi: 10.1159/000255464

Kunzmann, U., & Grühn, D. (2005). Age differences in emotional reactivity: The sample case of sadness. *Psychology and Aging*, *20*, 47–59. doi: 10.1037/0882-7974.20.1.47

Lawton, M. P., Kleban, M. H., Rajagopal, D., & Dean, J. (1992). Dimensions of affective experience in three age groups. *Psychology and Aging*, *7*, 171–184. doi: 10.1037/0882-7974.7.2.171

Mather, M., & Knight, M. (2005). Goal-directed memory: The role of cognitive control in older adults' emotional memory. *Psychology and Aging*, *20*, 554–570. doi: 10.1037/0882-7974.20.4.554

Maxfield, M., Pyszczynski, T., Greenberg, J., Pepin, R., & Davis, H. P. (2012). The moderating role of executive functioning in older adults' responses to a reminder of mortality. *Psychology and Aging*, *27*, 256–263. doi: 10.1037/a0023902

McNair, D. M., Lorr, M., & Droppleman, L. F. (1971). *Manual: Profile of Mood States*. San Diego, CA: Educational and Industrial Testing Service.

Noh, S. R., Lohani, M., & Isaacowitz, D. M. (2011). Deliberate real-time mood regulation in adulthood: The importance of age, fixation and attentional functioning. *Cognition & Emotion*, *25*, 998–1013. doi: 10.1080/02699931.2010.541668

Reed, A. E., & Carstensen, L. L. (2012). The theory behind the age-related positivity effect. *Frontiers in Psychology*, *3*, 109. doi: 10.3389/fpsyg.2012.00339

Richards, J. M., & Gross, J. J. (2000). Emotion regulation and memory: The cognitive costs of keeping one's cool. *Journal of Personality and Social Psychology*, *79*, 410–424. doi: 10.1037/0022-3514.79.3.410

Segal, D. L., Coolidge, F. L., Cahill, B. S., & O'Riley, A. A. (2008). Psychometric properties of the Beck Depression Inventory II (BDI-II) among community-dwelling older adults. *Behavior Modification*, *32*, 3–20.

Stanley, J. T., & Isaacowitz, D. M. (2011). Age-related differences in profiles of mood-change trajectories. *Developmental Psychology*, *47*, 318–330. doi: 10.1037/a0021023

Storch, E. A., Roberti, J. W., & Roth, D. A. (2004). Factor structure, concurrent validity, and internal consistency of the Beck Depression Inventory-Second Edition in a sample of college students. *Depression & Anxiety*, *19*, 187–189.

Streubel, B., & Kunzmann, U. (2011). Age differences in emotional reactions: Arousal and age-relevance count. *Psychology and Aging*, *26*, 966–978. doi: 10.1037/a0023424

Volokhov, R. N., & Demaree, H. A. (2010). Spontaneous emotion regulation to positive and negative stimuli. *Brain and Cognition*, *73*, 1–6. doi: 10.1016/j.bandc.2009.10.015

Wechsler, D. (2009). *Wechsler Memory Scales* (4th ed.). San Antonio, TX: Pearson.

Westermann, R., Spies, K., Stahl, G., & Hesse, F. W. (1996). Relative effectiveness and validity of mood induction procedures: A meta-analysis. *European Journal of Social Psychology*, *26*, 557–580. doi: 10.1002/(SICI)1099-0992(199607)26:4<557::AID-EJSP769>3.0.CO;2-4