

Age-Related Differences in Emotional Memory and Reactivity: The Role of Sleep Quality

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This study examined age-related differences in emotional memory and reactivity, focusing on the role of sleep. Ninety-seven participants were assigned to three groups: young adults were randomly assigned to either a wake ($n = 33$) or sleep condition ($n = 34$), and older adults completed the sleep condition ($n = 30$). Participants completed an emotional image-recognition task 12 hours after encoding. Sleep enhanced young adults' memory, particularly for neutral and negative stimuli. Older adults exhibited a positive bias in emotional reactivity, rating negative stimuli more positively than young adults. Additionally, sleep efficiency, rather than total sleep time, was associated with next-day emotional reactivity. This suggests that sleep quality may play a distinct role in emotional processing and well-being in young and older adults, with sleep efficiency emerging as a meaningful health-related factor.

Keywords: aging, emotional memory, emotional reactivity, sleep efficiency, positivity effect

Introduction

Sleep is essential for survival and mental health, including stress management, memory, concentration, and mood regulation (Alapin et al., 2000; Krause et al., 2017; Moul et al., 2002). It plays a key role in memory consolidation, resulting in better post-learning performance compared to wakefulness (Born & Wilhelm, 2012; Sara, 2017; Stickgold, 2005). Beyond its general role in cognitive functioning, sleep has been shown to interact with emotional processes, influencing how emotional information is consolidated and later evaluated. Emotional memories generally exhibit higher retention than neutral ones, with the amygdala aiding hippocam-

pal consolidation (Cunningham et al., 2014; Diekelmann et al., 2009; McGaugh, 2004). However, the extent to which sleep differentially affects emotional memory—and whether these effects vary between younger and older adults—remains unclear. Some studies have suggested that sleep preferentially enhances negative memories (Baran et al., 2012; Payne et al., 2008), whereas others have reported no differences or even greater improvements in neutral memories (Cellini et al., 2016; Jones et al., 2018; Mantua et al., 2017).

Recent research has investigated how sleep-based memory consolidation varies with age (Gui et al., 2019; Jones et al., 2016). Notably, sleep enhances neutral memory among young adults and improves positive memory among older adults (Gui et al., 2019). Similarly, young adults tend to recall more negative memories, whereas older adults demonstrate a bias toward positive memories. This pattern reflects the “positivity effect,” which describes older adults' tendency to preferentially attend to and evaluate positive information (Bennion et al., 2015; Huan et al., 2020). Socioemotional selectivity theory posits that individuals with a limited future time perspective focus more on emotional satisfaction rather than new

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information acquisition (Carstensen et al., 1999). From this perspective, sleep may preferentially support emotional processing patterns that are consistent with age-related motivational goals, thereby potentially contributing to positivity biases observed in later adulthood (Bennion et al., 2015; Payne et al., 2008).

Furthermore, sleep affects emotional reactivity—assessed through subjective ratings of valence (negative, neutral, and positive; Baran et al., 2012; Fairholme & Manber, 2015; Pilcher & Huffcutt, 1996). Poor sleep has been shown to heighten negative emotional responses and to promote more negative interpretations of otherwise neutral events (Daniela et al., 2010; Gish & Wagner, 2016; Gordon & Chen, 2014). While prior work has largely focused on memory performance, less is known about how sleep interacts with age to shape emotional reactivity. If sleep selectively enhances positive memory consolidation among older adults, it may also influence age-related differences in the subjective evaluation of emotional stimuli.

Sleep quality is a stronger predictor of emotional well-being than sleep quantity, with poor quality associated with negative emotional responses and altered next-day mood (Finan et al., 2015; Sonnentag et al., 2008; Tempesta et al., 2015). Sleep efficiency—the ratio of actual sleep time to time in bed—is a key indicator of sleep quality (Edinger et al., 2004). Low sleep efficiency has been associated with cognitive decline, Alzheimer's disease, and increased mortality risk (Blackwell et al., 2006; Chen et al., 2013; Dew et al., 2003; Wong et al., 2013; Yu et al., 2009). Recent neuroimaging evidence further suggests that poor sleep efficiency is linked to structural brain alterations relevant to aging-related neuropathology, such as Alzheimer's disease (Nolan et al., 2025). Despite sleep efficiency's importance, its role in emotional reactivity in younger and older adults remains unclear, warranting further investigation.

This study pursued two primary aims. First, it tested the positivity effect by comparing older and younger adults in the sleep condition, assessed through both memory performance and valence ratings. Second, it examined how sleep quality—specifically, global sleep quality and sleep efficiency—relates to emotional reactivity, comparing valence ratings between good and poor sleepers. As a foundation for these aims, it first examined whether positive, negative, or neutral memories benefit most from sleep. The age

comparisons were conducted within the sleep condition, in which both age groups were tested, whereas the young-adult wake condition was included as a within-age comparison to verify that the 12-hour interval including sleep enhanced memory relative to wakefulness, providing context for interpreting the age-related findings.

Methods

Participants

Participants were recruited through online and offline notices and comprised 67 young adults (18–29 years) and 30 older adults (60–76 years). All reported no history of neurological disorders, psychiatric illnesses, or sleep-related conditions and no previous use of sleep medications. Older adults scoring below the 16th percentile (i.e., approximately 1 *SD* below the normative mean, the conventional cutoff for probable cognitive impairment) on the Korean-Mini Mental State Examination, 2nd Edition: Brief Version (K-MMSE-2: BV; Kang et al., 2020) were excluded. Of the 35 older adults initially screened, 5 were excluded based on this criterion. The 30 older adults retained for analysis scored within the normal range ($M = 15.10$, $SD = .84$, range = 13–16, out of 16). Participants avoided caffeine, drugs, alcohol, and daytime naps during the study. They were randomly assigned to either the wake or sleep condition. Supplementary Table 1 presents the demographic and neuropsychological characteristics for each condition. Older adults exhibited fewer depressive tendencies and were more morning-oriented than young adults; hence, depression and morningness–eveningness tendency were controlled for in further analyses. Global sleep quality and sleep efficiency did not differ significantly between the groups. This study was approved by the Institutional Review Board (Approval No. ***-2022-0425).

Materials

The study used 180 images from the International Affective Picture System (IAPS; Lang et al., 2008), including 60 positive, 60 negative, and 60 neutral images. Because arousal differed significantly across image categories, arousal was controlled in subsequent analyses. Half of the images were presented during encoding, and the remaining half served as novel items during recognition.

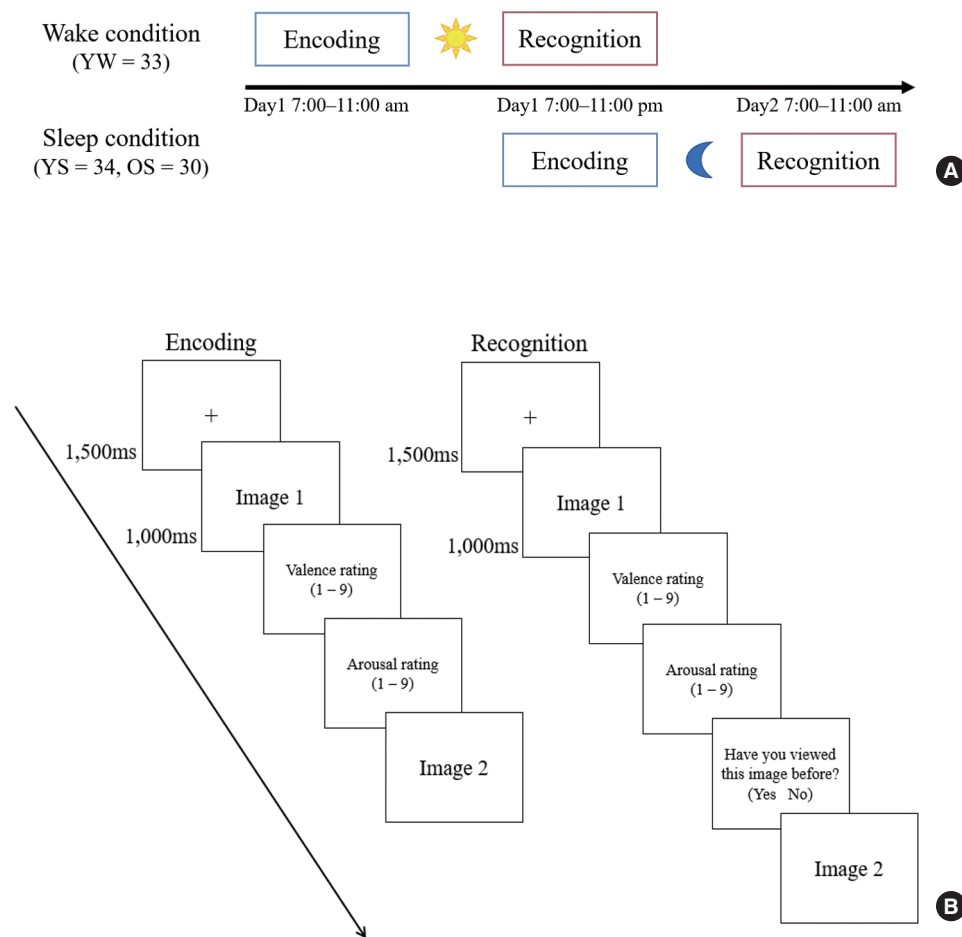


Figure 1. Experimental design and procedure. (A) Encoding took place in the morning (wake condition) or in the evening (sleep condition), followed by recognition 12 hours later. Each phase lasted approximately 50 minutes. Young adults in the sleep condition wore an actigraphy overnight. (B) In the emotional memory task, participants viewed 90 images during encoding and rated each image for valence and arousal on 9-point Likert scales. During recognition, they viewed 180 images, including 90 previously seen images and 90 foils, and again rated valence and arousal before making a yes/no memory judgment for each image.

Procedure

This study comprised two sessions, as shown in Figure 1A. Session 1 was conducted either in the morning for the wake condition or in the evening for the sleep condition (*encoding*). This scheduling held the 12-hour retention interval constant while differentiating sleep from wake, following standard paradigms (e.g., Baran et al., 2012; Jones et al., 2016). Participants completed self-report measures of sleep quality (PSQI-K; Buysse et al., 1989; Sohn et al., 2012), depressive symptoms (CES-D; Jeon et al., 2001; Radloff, 1977), circadian preference (MEQ; Horne & Ostberg, 1976; Lee et al., 2014), and affect (PANAS; Lee et al., 2003; Watson et al., 1988), followed by an emotional memory task. Session 2 was conducted 12 hours later (*recognition*). Participants in the wake condition

were instructed to avoid napping, whereas those in the sleep condition wore an actigraphy device overnight to assess total sleep time.

During encoding, participants viewed 90 stimuli (30 positive, 30 negative, and 30 neutral) in a pseudorandom order and rated each image for valence (1 = negative, 5 = neutral, 9 = positive) and arousal (1 = calm, 5 = neutral, 9 = exciting) on 9-point scales, as shown in Figure 1B. During recognition, they viewed 180 images, consisting of the 90 previously seen images intermixed with 90 new images, again rated valence and arousal, and indicated whether each image had been previously presented. Participants were not informed of the memory test during encoding.

Sleep Measures

Participants in the sleep condition completed a sleep diary for the previous night, including bedtime, wake time after sleep onset, wake time, time out of bed, and total sleep time. In young adults, total sleep time was also measured objectively using wrist actigraphy (Xiaomi Mi Band 7). To reduce participant burden, older adults did not wear actigraphy. Sleep efficiency was computed as total sleep time divided by time in bed ($\times 100$), where total sleep time was derived from actigraphy for young adults and from the sleep diary for older adults, and time in bed was derived from the sleep diary for all participants.

Data Analysis

Memory performance was indexed by d' , calculated as $z(\text{hit rate}) - z(\text{false alarm rate})$. Extreme rates of 0 and 1 were adjusted using the $1/(2N)$ correction (Snodgrass & Corwin, 1988). A repeated-measures ANOVA was conducted on d' with group (young-wake, young-sleep, old-sleep) as a between-subjects factor and valence (negative, neutral, positive) as a within-subject factor. Emotional reactivity was analyzed using repeated-measures ANOVAs on valence ratings, with age group as a between-subjects factor and stimulus valence as a within-subject factor, separately for encoding and recognition. Post-hoc comparisons used Fisher's least significant difference test and independent-samples t -tests. Sleep quality was characterized along two dimensions—global sleep

quality and sleep efficiency—and participants were independently classified as good sleepers (GS) or poor sleepers (PS) on each dimension. For the global sleep quality analyses, participants with PSQI-K total scores below 8.5 were classified as GS and those at or above this cutoff as PS (Sohn et al., 2012). For the sleep efficiency analyses, participants with sleep efficiency of 85% or higher were classified as GS and those below 85% as PS (Buysse et al., 1989). The two classifications were applied separately; a participant could therefore be classified as GS on one dimension and PS on the other. Pearson correlations were conducted to examine associations between sleep quality and emotional reactivity. All analyses were performed using IBM SPSS Statistics 25.0.

Results

Memory Performance (d')

Memory performance (d') exhibited a main effect of group, $F(2, 94) = 43.75, p < .001, \eta^2_p = .48$, with young adults in the sleep condition showing higher d' scores than those in the wake condition, and older adults showing lower d' scores than both young adult groups (Table 1). Moreover, memory performance exhibited a main effect of valence, $F(2, 188) = 5.12, p = .007, \eta^2_p = .05$, and a significant group $\times$ valence interaction, $F(4, 188) = 2.58, p = .039, \eta^2_p = .05$. Simple effects analyses showed that young adults in the sleep condition had higher d' scores than those in the wake condition for

Table 1. Memory Performance (d') and Valence Ratings across Groups

	YW ($n = 33$)	YS ($n = 34$)	OS ($n = 30$)	F	LSD	YS vs. OS (p -value)
d'						
Positive	2.44 (.62)	2.57 (.53)	1.42 (.68)	33.71***	3 < 1 $\approx$ 2	< .001
Negative	2.46 (.65)	2.92 (.52)	1.54 (.61)	43.63***	3 < 1 < 2	< .001
Neutral	2.38 (.81)	2.91 (.58)	1.54 (.78)	28.50***	3 < 1 < 2	< .001
Encoding						
Positive		7.09 (.74)	6.82 (1.08)			<i>ns</i>
Negative		3.39 (.74)	4.53 (1.17)			< .001
Neutral		5.44 (.45)	5.58 (.80)			<i>ns</i>
Recognition						
Positive		6.88 (.69)	6.55 (1.08)			<i>ns</i>
Negative		3.24 (.71)	4.48 (1.39)			< .001
Neutral		5.28 (.32)	5.51 (.96)			<i>ns</i>

YW = young adults in the wake condition; YS = young adults in the sleep condition; OS = older adults in the sleep condition; 1 = YW; 2 = YS; 3 = OS; LSD = Fisher's least significant difference test.

*** $p < .001$.

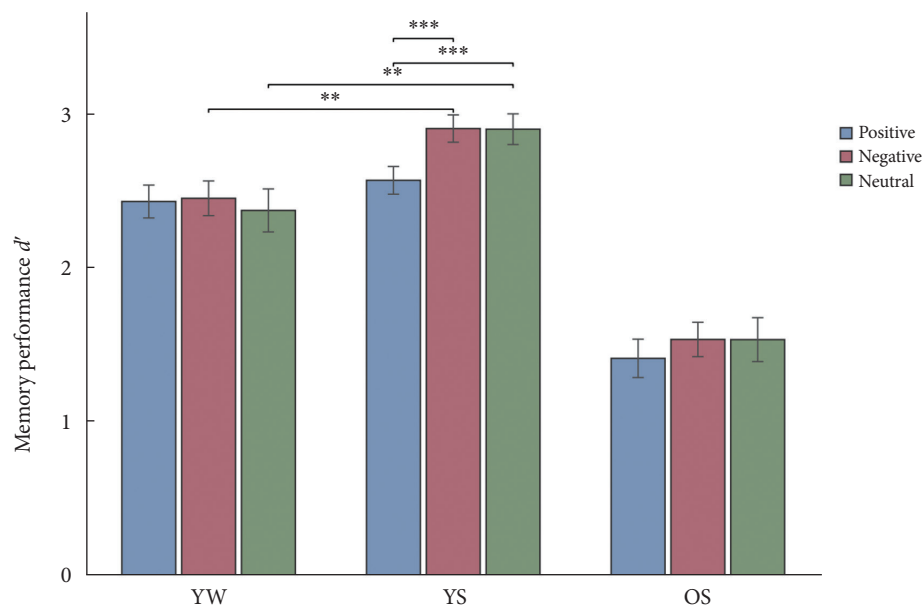


Figure 2. Influence of sleep and wake on memory performance for positive, negative, and neutral stimuli in young and older adults. Memory performance (d') is shown separately for each stimulus valence category.

Error bars represent standard errors of the mean. Older adults in the sleep condition (OS) scored significantly lower than both young groups (YW, YS) across all valence categories (all $p < .001$); see Table 1 for the complete between-group (LSD) comparisons.

YW = young adults in the wake condition; YS = young adults in the sleep condition; OS = older adults in the sleep condition.

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

negative and neutral stimuli, $t(65) = 3.17$, $p = .002$ and $t(65) = 3.09$, $p = .003$, respectively, but not for positive stimuli, $t(65) = .98$, $p = .330$. Within the sleep condition, young adults also performed better for negative and neutral stimuli than for positive stimuli, $t(33) = 4.11$, $p < .001$ and $t(33) = 4.65$, $p < .001$, respectively. Older adults showed a similar but weaker pattern, with better performance for negative than positive stimuli, though this difference was not statistically significant, $t(29) = 2.01$, $p = .054$ (Figure 2).

Emotional Reactivity

Valence ratings were compared between young and older adults in the sleep condition using repeated-measures ANOVAs with age as a between-subjects factor and valence as a within-subject factor. During encoding, emotional reactivity exhibited main effects of age, $F(1, 62) = 4.05$, $p = .049$, $\eta^2_p = .06$; and valence, $F(1.23, 76.05) = 350.02$, $p < .001$, $\eta^2_p = .85$, as well as a significant age $\times$ valence interaction, $F(1.28, 76.05) = 19.80$, $p < .001$, $\eta^2_p = .24$. Simple effects analyses revealed that older adults rated negative stimuli more positively than young adults, $F(1, 62) = 22.26$, $p < .001$, $\eta^2_p = .06$ (Table 1 and Figure 3A). During recognition, emotional reactivity

exhibited main effects of age, $F(1, 62) = 4.27$, $p = .043$, $\eta^2_p = .06$, and valence, $F(1.16, 71.89) = 323.50$, $p < .001$, $\eta^2_p = .83$, as well as a significant age $\times$ valence interaction, $F(1.16, 71.89) = 23.70$, $p < .001$, $\eta^2_p = .28$. The same pattern emerged at recognition, with older adults rating negative stimuli more positively than young adults, $F(1, 62) = 20.63$, $p < .001$, $\eta^2_p = .25$ (Table 1 and Figure 3A).

Association between Sleep Quality and Emotional Reactivity Valence Rating Based on Global Sleep Quality

Two complementary indices of sleep quality—global sleep quality (PSQI-K) and sleep efficiency—were used, with participants independently classified as GS or PS on each index. Global sleep quality was assessed using the PSQI-K to classify participants as either GS ($n = 72$) or PS ($n = 25$). Repeated-measures ANOVAs were conducted with sleep quality as a between-subjects factor and valence as a within-subject factor. During encoding, main effects of global sleep quality and valence were observed, $F(1, 95) = 4.51$, $p = .036$, $\eta^2_p = .05$; $F(1.18, 112.27) = 465.43$, $p < .001$, $\eta^2_p = .83$, with no significant interaction. During recognition, main effects of global sleep quality and valence were observed, $F(1, 95) = 4.04$, $p = .047$, $\eta^2_p =$

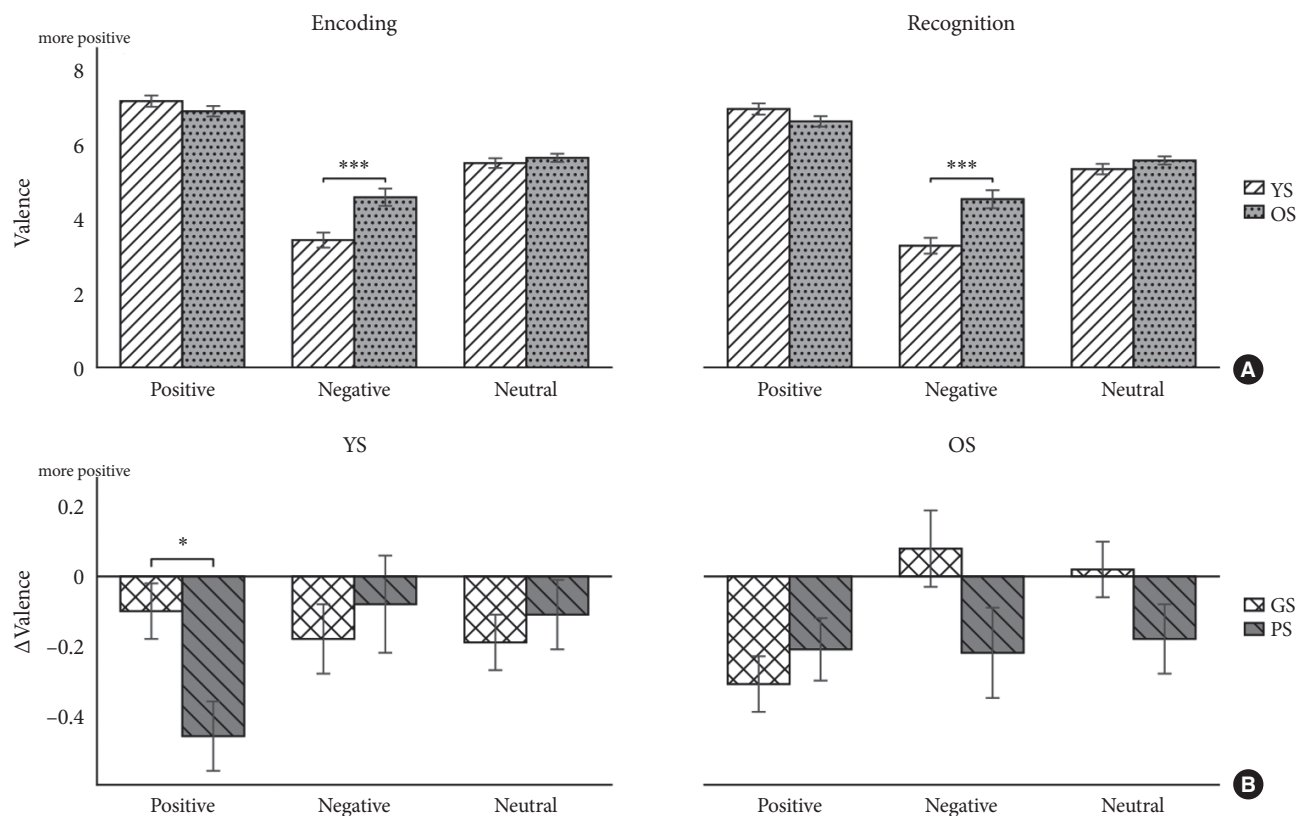


Figure 3. Valence ratings and changes. (A) Valence ratings for positive, negative, and neutral images during encoding and recognition in young adults in the sleep condition (YS) and older adults in the sleep condition (OS). (B) Changes in valence ratings (Δ Valence), calculated as recognition minus encoding ratings, as a function of sleep efficiency in YS and OS. Positive Δ Valence values indicate that ratings became more positive at recognition than at encoding. Good sleepers (GS) had sleep efficiency of 85% or higher, whereas poor sleepers (PS) had sleep efficiency below 85%. Error bars represent standard errors of the mean.

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

.04; $F(1.15, 109.16) = 377.23$, $p < .001$, $\eta^2_p = .80$, with no significant interaction. These findings indicate that overall valence ratings differed between good and poor sleepers regardless of stimulus valence.

Change in Valence Based on Sleep Efficiency

A three-way mixed-design ANOVA was conducted on Δ valence, with age and sleep efficiency (GS, PS) as between-subjects factors and valence as a within-subject factor. A main effect of valence was observed, $F(1.48, 88.69) = 5.17$, $p = .009$, $\eta^2_p = .06$, as was a significant three-way interaction between age, sleep efficiency, and valence, $F(1.48, 88.69) = 8.25$, $p = .002$, $\eta^2_p = .12$. Simple effects analyses revealed that young adults with higher sleep efficiency rated positive stimuli more positively than those with lower sleep efficiency, $F(1, 32) = 5.37$, $p = .027$, $\eta^2_p = .14$ (Supplementary Table 2

and Figure 3B). Among older adults, group differences were not significant, although those with higher sleep efficiency tended to rate negative and neutral stimuli more positively than those with lower sleep efficiency.

Differential Roles of Sleep Quantity and Sleep Quality in Emotional Reactivity

Correlation analyses were conducted between total sleep time (TST), sleep efficiency, memory performance (d'), and emotional reactivity (Δ valence). TST and sleep efficiency were moderately positively correlated, $r = .54$, $p < .001$ (Table 2). Neither TST nor sleep efficiency was significantly correlated with d' for any valence (all $|r|s \leq .12$, all $ps > .34$). In contrast, sleep efficiency was associated with emotional reactivity: higher sleep efficiency was significantly associated with greater increases in valence for positive and

Table 2. Relationship between Sleep Measures and Δ Valence ($n = 64$)

		Total sleep time	Sleep efficiency
Total sleep time		1	.54***
d'	Positive	.12	-.01
	Negative	.07	-.10
	Neutral	.02	-.04
Δ Valence	Positive	-.01	.31*
	Negative	.04	.25*
	Neutral	-.13	.21

Δ Valence = Recognition valence rating – Encoding valence rating.

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

negative stimuli, $r = .31$, $p < .05$; $r = .25$, $p < .05$. However, TST was not significantly correlated with Δ valence for either stimulus type, and neither TST nor sleep efficiency was significantly associated with Δ valence for neutral stimuli.

Discussion

This study investigated age-related differences in emotional evaluation and memory following sleep. The findings indicate that older adults rated negative stimuli more positively than young adults during both encoding and recognition, providing evidence for an age-related positivity bias in emotional reactivity. This pattern is consistent with socioemotional selectivity theory, which proposes that older adults actively engage in emotional regulation strategies to enhance well-being by minimizing negative experiences (Carstensen et al., 2000; Kim & Min, 2004). Such a positivity bias in emotional evaluation may contribute to greater psychological resilience and life satisfaction in later adulthood (Höglund et al., 2020). However, this effect was not observed for positive and neutral stimuli, which may reflect cultural differences in the emotional salience of IAPS images for South Korean older adults. For instance, images depicting “hamburgers” or “golf,” which may evoke positive emotions among Western older adults, may not carry the same emotional meaning for South Korean older adults, potentially attenuating positive responses. Because the cultural salience of the stimuli was not assessed directly, this account is post hoc and speculative and should be treated as a tentative hypothesis for future study rather than a confirmed explanation.

However, the positivity effect did not extend to memory performance. Although older adults exhibited more positive emotional

evaluations, both young and older adults in the sleep condition demonstrated better memory for negative than positive images, with no significant differences between age groups. This dissociation tentatively suggests that age-related positivity may be expressed more strongly at the level of emotional evaluation rather than during memory encoding or retrieval, with older adults possibly regulating emotional responses at earlier perceptual or evaluative stages while leaving memory processes relatively unaffected. This pattern contrasts with previous studies reporting selective enhancement of positive memories in older adults (Gui et al., 2019; Jones et al., 2016; Reed et al., 2014). One possible explanation is that age groups differed in task orientation, with older adults placing greater emphasis on subjective experience than on accuracy, consistent with socioemotional selectivity theory (Carstensen et al., 1999). Further research is needed to test these possibilities directly.

We further examined the role of sleep quality in emotional reactivity by considering two dimensions: global sleep quality and sleep efficiency. The results indicate that sleep quality was associated with emotional evaluation, underscoring its relevance for emotional processing. Participants with better global sleep quality evaluated images more positively than those with poorer sleep quality—consistent with prior evidence linking sleep quality to emotional reactivity (Shin et al., 2017; Sonnentag et al., 2008; Wang et al., 2024). Because the interaction with stimulus valence was not significant, global sleep quality appears to influence emotional evaluation in a valence-general manner.

Sleep efficiency, however, showed a more valence-specific pattern. Among young adults, higher sleep efficiency was associated with more positive evaluations of positive stimuli relative to those with poorer sleep efficiency, whereas no differences were observed for negative or neutral images. This aligns with prior findings indicating that greater sleep efficiency is linked to enhanced positive affect in young adults (Wang et al., 2024), suggesting that efficient sleep may facilitate responsiveness to positive emotional information during early adulthood. Young adults also tended to evaluate images more negatively the next day. Because recognition ratings were obtained in the morning, this pattern may partly reflect time-of-day effects on emotional evaluation, with lower morning alertness contributing to a negativity bias. This interpretation is

consistent with prior evidence that reduced wakefulness and increased fatigue bias emotional perception toward negativity (Schmidt et al., 2007).

In contrast, sleep efficiency showed a different pattern among older adults. Although group differences did not reach statistical significance, older adults with higher sleep efficiency tended to evaluate negative and neutral stimuli more positively, whereas those with lower sleep efficiency showed more negative evaluations. Because this difference was not statistically significant, this pattern is preliminary and should be interpreted with caution; it tentatively suggests that, in later adulthood, higher sleep efficiency may accompany more positive appraisal of non-positive emotional information. Taken together, these findings tentatively indicate that sleep efficiency may serve distinct emotional functions in younger versus older adults—enhancing responsiveness to positive stimuli in young adults while supporting positive evaluation of neutral and negative information in older adults.

The present findings also highlight a dissociation between sleep quality and its downstream effects on memory versus emotional evaluation. Although sleep efficiency was associated with more positive valence ratings the following day, it was not correlated with memory performance (d'). This pattern aligns with the theoretical framework proposing that declarative memory consolidation and affective tone regulation rely on partially distinct sleep mechanisms (Walker & van der Helm, 2009). Declarative memory consolidation is primarily supported by NREM sleep, whereas emotional tone regulation is more closely linked to REM sleep (Lipinska et al., 2022; Wiesner et al., 2015). Higher sleep efficiency reflects more continuous, less fragmented sleep, which may better preserve REM sleep and thereby support more positive emotional evaluation the following day. Because memory consolidation relies more on NREM processes, it may remain relatively stable across individuals regardless of sleep efficiency, which would explain why d' was unrelated to sleep efficiency despite the group-level memory benefit of sleep. This is consistent with recent evidence that REM fragmentation selectively disrupts emotional habituation without impairing declarative memory (Viselli et al., 2025).

Despite these contributions, several limitations should be acknowledged. First, the absence of a wake-condition control group for older adults limited direct comparisons across age groups. Sec-

ond, the study focused exclusively on young and older adults, excluding middle adulthood—a period during which the positivity effect may begin to emerge (Charles et al., 2003). Third, although all participants in the sleep condition completed a sleep diary, only young adults additionally wore an actigraphy device, which was used to estimate total sleep time. Consequently, the sleep efficiency values used in the present analyses incorporated objective measurement in young adults but relied entirely on self-report in older adults. Because self-reported and objective sleep estimates often diverge, particularly in older adults (Lauderdale et al., 2008), measurement modality is partially confounded with age. The older-adult sleep-efficiency findings should therefore be regarded as preliminary. Finally, the relatively long experimental duration (approximately 50 minutes) may have induced cognitive fatigue in older adults, potentially influencing memory performance and emotional evaluations.

In conclusion, this study offers three contributions. First, it demonstrates that sleep efficiency—rather than total sleep time—is associated with next-day emotional reactivity. Second, it provides evidence for the positivity effect in older adults at the level of emotional evaluation. Third, it shows that this positivity bias does not uniformly extend to memory performance, as both age groups showed better memory for negative than positive images. Together, these findings suggest that sleep quality may be more consequential than sleep duration for emotional evaluation, with implications that may differ between younger and older adults.

Author contributions statement

SYK, a graduate student at Kyungpook National University who is now a researcher at Severance Hospital, contributed to conceptualization, methodology, investigation, formal analysis, and writing of the original draft. HSK, a professor at Kyungpook National University, contributed to conceptualization, supervision, and writing through review and editing. Both authors approved the final submission.

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Supplementary Table 1. Characteristics and Neuropsychological Data of Participants

		YW (n = 33)	YS (n = 34)	OS (n = 30)	F/ χ^2 /t	Scheffe
Age (years)		23.06 (2.62)	22.71 (2.25)	67.23 (4.42)	2,007.7***	1 = 2 < 3
Gender (women) ^a		20	22	21	.61	ns
Education	Elementary or junior	-	-	5		
	Senior	-	-	12		
	Enrolled in college	21	24	-		
	College graduate	12	10	10		
	Post-graduate	-	-	3		
K-MMSE-2: BV ^b		-	-	15.10 (.84)	-	-
Socioeconomic status		2.97	2.71	2.80	.86	ns
Marital status	Single	33	34	1		
	Married	-	-	24		
	Divorced	-	-	2		
	Widowed	-	-	3		
Positive affect		23.85 (6.73)	24.29 (6.87)	26.90 (6.34)	1.90	ns
Negative affect		19.76 (6.85)	18.91 (5.85)	17.97 (6.78)	.59	ns
CES-D		15.70 (8.48)	15.50 (8.08)	10.90 (7.04)	3.65*	1 = 2 > 3
MEQ-K		42.94 (8.52)	44.18 (8.78)	62.87 (9.37)	49.12***	1 = 2 < 3
Sleep quality	Global sleep quality	7.18 (2.58)	6.59 (2.64)	6.27 (2.88)	.94	ns
	Sleep efficiency ^c	-	83.38 (13.39)	82.83 (12.97)	.11	ns

CES-D = Center for Epidemiologic Studies Depression Scale; MEQ-K = Korean version of Morningness–Eveningness Questionnaire; YW = young adults in the wake condition; YS = young adults in the sleep condition; OS = older adults in the sleep condition; 1 = YW; 2 = YS; 3 = OS.

^aChi-Square, ^bK-MMSE-2: BV = Korean-Mini Mental State Examination, 2nd Edition: Brief Version. ^cStudent's independent-samples t-test; Positive and negative affect were measured using the Positive and Negative Affect Schedule (PANAS).

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

Supplementary Table 2. Δ Valence across Groups Based on Sleep Efficiency

	Good sleeper (<i>n</i> = 40)	Poor sleeper (<i>n</i> = 24)	Good sleeper vs. Poor sleeper (<i>p</i> -value)
YS			
Positive	-.10	-.46	< .05
Negative	-.18	-.08	<i>ns</i>
Neutral	-.19	-.11	<i>ns</i>
OS			
Positive	-.31	-.21	<i>ns</i>
Negative	.08	-.22	<i>ns</i>
Neutral	.02	-.19	<i>ns</i>

Δ Valence = Recognition valence rating–Encoding valence rating; Good sleeper = sleep efficiency of 85% or higher; Poor sleeper = sleep efficiency of less than 85%; YS = young adults in the sleep condition; OS = older adults in the sleep condition.