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Research Article

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Sleep longer, think sharper: extra sleep offsets poor sleep quality in young-old adults

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Abstract

Objectives: Sleep and cognitive functioning are linked. Yet, how sleep hours and sleep quality shape day-to-day subjective cognition, including cognitive interference and memory lapses, remains unclear. This study examined the unique and joint associations of sleep hours and quality with daily cognitive interference and memory lapses, investigating age-related variations.

Methods: Participants were 915 adults (aged 43–83) from the Midlife in the United States Study who completed 8 days' diaries. Multilevel models evaluated the unique and joint associations of sleep hours and sleep quality with cognitive interference and memory lapses focusing at the within-person level, beyond between-person associations. Age-stratified models explored potential differences across age groups.

Results: Poorer sleep quality was associated with increased next-day cognitive interference, controlling for sleep hours. Individuals with poorer sleep quality across the study period also experienced greater cognitive interference and more frequent memory lapses. The association between poorer sleep quality and heightened cognitive interference was mitigated both on days when sleep hours were longer than usual and among individuals with longer sleep hours than others in the sample. Age-stratified analyses demonstrated that longer daily and habitual sleep hours mitigated the adverse effects of poorer sleep quality on cognitive interference only in adults aged 60–67.

Discussion: Poor sleep hours and quality may impair daily cognition, yet extra sleep hours can mitigate the negative association of poor sleep quality on daily cognitive interference, especially among young-old adults. These findings highlight the nuanced interplay of sleep hours, sleep quality, and age in shaping daily cognition.

Keywords: Cognitive interference, Daily diary, Joint association, Nightly sleep, Memory lapses

Balancing work and personal life often forces adults to compromise sleep hours and quality, a widespread issue affecting nearly one-third of U.S. adults who report insufficient sleep or sleep disturbances (Centers for Disease Control and Prevention, 2024; Di et al., 2022). Sleep deficiencies in hours and quality significantly influence cognitive functioning, particularly in two key areas of daily cognitive difficulties that adults frequently experience: cognitive interference and memory lapses.

Cognitive interference, defined as intrusive thoughts that disrupt daily tasks, frequently arises from insufficient sleep hours and poor sleep quality (Blanke et al., 2022; Nolen-Hoeksema et al., 2008). Similarly, sleep deficiencies impair memory processes, manifesting as memory lapses—such as forgetting routine events like taking medication (Mogle et al., 2021). After nights of shorter sleep hours or lower sleep quality, individuals often report heightened cognitive interference (Harrington et al., 2021, 2025). Sleep deficiencies disrupt memory encoding and consolidation, exacerbating cognitive challenges (Walker, 2008; Walker & Stickgold, 2006; Yoo et al., 2007).

Despite being a known precursor to objective cognitive impairment (Jessen et al., 2007), a decline in subjective cognition has yet to be fully examined in relation to how sleep hours and quality uniquely and in combination influence daily cognitive interference and memory lapses. This gap is particularly relevant for midlife and older adults, who often experience age-related changes in both sleep and cognitive function.

Sleep as the recovery process for cognitive functioning

The restorative theory of sleep provides a framework linking sleep deficiencies to subjective cognitive declines. According to this theory, sleep serves as a recovery process facilitating physical and neural restoration (Stone et al., 2008), including clearing metabolic waste from the brain (Xie et al., 2013). When replenishment is compromised by insufficient sleep, cognitive functioning is impaired (Chee & Choo, 2004; During & Kawai, 2017; Harrison & Horne, 1999), and mental fatigue increases (Ohayon, 2005). Meta-analyses further support this relationship, demonstrating that sleep deprivation predicts poorer cognitive task performance (Lim & Dinges, 2010; Pilcher & Huffcutt, 1996). A more proximal, ecologically valid mechanism may involve nightly sleep and daily subjective cognition. Building on restorative theory and related research, this study examines how nightly sleep hours and sleep quality contribute to daily perceived cognitive difficulties.

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Unique effect of sleep hours and sleep quality on daily cognitive difficulties

Sleep deficiencies are detrimental to daily subjective cognitions. This relationship is supported by both meta-analyses and individual studies, which consistently highlight the negative impact of inadequate sleep on cognitive functioning (Newbury et al., 2021; Wickens et al., 2015). Short sleep hours and poor sleep quality are related to lowered executive functioning, including decreased control for inhibition, maintaining attention, and retrieving memory (Chee & Tan, 2010; Lowe et al., 2017; Wüst et al., 2024). In addition, sleep deficiencies increase stress (McEwen & Karatsoreos, 2015) and disrupt hippocampal activity (Yoo et al., 2007), which are detrimental to maintaining attention and memory.

Studies suggest that daily sleep deficiencies in hours and quality are uniquely associated with increased cognitive interference at within-person and between-person levels. A diary study found that cognitive interference increased on days following shorter sleep hours or poorer sleep quality (Lee et al., 2019). This naturalistic finding aligns with experimental evidence, where participants awakened for more than 24 h showed increased cognitive interference and struggled to regulate intrusive thoughts (Harrington et al., 2021; Poh et al., 2016). Lack of sleep interferes with deliberate thinking (Harrington et al., 2025). Moreover, individuals with compromised sleep hours and quality, on average, are more likely to experience an increase in unguided thought (Marcusson-Clavertz et al., 2023).

Prior studies suggest that both within-person and between-person variations in sleep hours and sleep quality are associated with memory lapses. Memory processes, from encoding to retrieval, are highly sleep-dependent, with sleep deficiencies impairing memory control (Paller et al., 2021; Stickgold & Walker, 2007; Walker & Stickgold, 2006). A meta-analysis found that poor sleep quality due to obstructive sleep apnea is associated with impairments in both immediate and delayed recall of daily events and experiences anchored to specific times and places (Wallace & Bucks, 2013). Longitudinal evidence also supports these findings; poor sleep quality has been linked to memory decline among middle-aged adults (Gildner et al., 2014). Experimental studies further corroborate this pattern. Yoo and colleagues (2007) demonstrated that participants deprived of sleep prior to memory encoding exhibited a 19% deficit on a subsequent memory retention task compared to those with sufficient sleep. Similarly, shorter sleep hours and poorer sleep quality uniquely impaired performance on a memory-based recognition task.

Joint association of sleep hours and sleep quality on daily cognitive difficulties

Sleep hours and sleep quality represent distinct yet interrelated dimensions of sleep (Pilcher & Huffcutt, 1996). Although both distinctively and jointly influence physical and mental well-being (Littlewood et al., 2019; Seow et al., 2020), their combined effects on daily cognitive difficulties, particularly cognitive interference and memory lapses, remain underexplored. Addressing this gap is essential, as it provides a more comprehensive understanding of how these two sleep dimensions interact to influence daily cognitive difficulties, rather than assessing each in isolation. Practically, it facilitates the identification of populations most vulnerable to sleep deficiencies. Finally, this approach may reveal compensatory mechanisms, such as whether sufficient sleep hours can mitigate the effects of poor sleep quality.

Empirical evidence supports the compensatory relationship between sleep hours and sleep quality in cognitive performance. A longitudinal study conducted among Chinese adults found that average sleep hours and sleep quality at the between-person level can compensate for each other (Li et al., 2022). Specifically, the detrimental effects of inadequate sleep hours on cognitive performance—such as episodic memory and attention—were mitigated by higher sleep quality, and vice versa. Moreover, the study highlights the age-dependent nature of this relationship, demonstrating an inverted U-shaped pattern: the compensatory effect increased gradually, peaked in the 60s, and then declined with advancing age. However, this study primarily focused on average sleep hours and sleep quality, thereby capturing sleep patterns only at the between-person level and not accounting for within-person variations in daily sleep deficiencies.

Building on this compensatory mechanism observed at the between-person level, we extend the investigation to examine whether similar compensatory relationships exist at the within-person level and across levels (i.e., between-person to within-person). This expectation is grounded in evidence that both sleep hours and sleep quality contribute to executive functioning (Chee & Tan, 2010; Lo et al., 2016), which relates to cognitive interference and memory lapses. By examining these relationships, we aim to determine whether sleep hours and sleep quality buffer against each other or, alternatively, amplify one another, thereby advancing our understanding of the nature of their joint association with daily cognitive difficulties.

Age-stratified analyses: the joint association of sleep hours and sleep quality on daily cognitive difficulties

Given the essential role of sleep in daily well-being and functioning, the individual associations of sleep hours and sleep quality with daily cognitive difficulties may be consistent across age groups. However, age may modify the joint association of short sleep hours and poor sleep quality with daily cognitive difficulties. Two competing theoretical perspectives offer differing predictions on how age may modify this relationship. On the one hand, age-related changes in sleep structure suggest a linear decline in the compensatory effect of sleep hours and sleep quality. On the other hand, the extant literature on retirement and sleep suggests an inverted U-shape in the compensatory effect, consistent with Li and colleagues (2022), with the greatest benefits observed in the 60s before declining in later years.

Sleep structure changes with aging, as sleep hours become shorter and sleep quality degrades (Krause et al., 2017). Age-related changes in sleep structure are associated with increased cognitive interference and memory lapses over time. For example, shorter sleep hours lower executive functioning in older adults (Lo et al., 2016), while degraded sleep structure is negatively associated with episodic memory (Scullin et al., 2013). Consequently, the compensatory effect is expected to diminish with advancing age, because both sleep hours and sleep quality have little room to offset the detrimental effect.

However, changes in social roles during midlife suggest that the compensatory effect follows an inverted U-shaped trajectory, peaking in the 60s before declining with increasing age.

Retirement is associated with an increase in sleep hours and a decrease in sleep difficulties (Myllyntausta & Stenholm, 2018). A study using the Retirement and Sleep Trajectories dataset showed that transition to retirement (e.g., 1–3 years postretirement) was associated with longer sleep hours, later bedtimes, and later wake times, but the extent of increase in sleep hours was shorter among older retirees, with sleep hours eventually declining after the 60s (Hagen et al., 2016). This pattern suggests that the compensatory effect may reach its peak in the 60s, coinciding with retirement-related improvements in sleep, before gradually declining. Building on this framework, the current study examines whether the compensatory effect of sleep hours and quality declines linearly with age or follows an inverted U-shaped trajectory driven by social role transitions in later adulthood.

Present study

The present study examined the unique and joint associations of sleep hours and sleep quality with daily cognitive interference and memory lapses. It was hypothesized that shorter sleep hours and poorer sleep quality were uniquely related to more cognitive interference (H1a) and more memory lapses (H1b). Additionally, it hypothesized that poorer sleep quality, combined with shorter sleep hours, would be associated with more cognitive interference (H2a) and more memory lapses (H2b), with longer sleep hours compensating for the detrimental effects of poorer sleep quality. The study also explored the age-dependent nature of the joint association, employing age-stratified analysis to detect nuanced effects.

Method

Participants and procedure

The current study used data from MIDUS3 (2013–2014), the second longitudinal follow-up of the original MIDUS1 cohort. When recontacting MIDUS2 participants, individuals who were deceased or cognitively unable to participate were excluded (Tun & Lachman, 2006; University of Wisconsin Survey Center, 2015). MIDUS1 participants were initially recruited (1995–1996) via random-digit dialing, targeting English-speaking, noninstitutionalized U.S. adults aged 25–74. During the MIDUS3 phase, 3,683 individuals participated in the main survey (including $n = 389$ Milwaukee African American subsample), and 1,236 individuals were invited to participate in the National Study of Daily Experiences (NSDE), an 8-day daily diary. The participants who responded to both the main survey and NSDE ($n = 1{,}236$) were younger (62.62 vs 63.75, $t(2776) = -2.99$, $p = .003$), more educated (7.66 vs 7.17, $t(2553.6) = 5.57$, $p < .001$), more likely to be employed (65.96% vs 61.17%, χ^2 (1, $N = 2{,}987$) = 6.46, $p = .011$), and rated their physical health better (3.50 vs 3.29, $t(2618.6) = 5.98$, $p < .001$) than those who responded to the main survey only ($n = 2{,}447$). The difference between the two groups was not detected at gender ($p = .331$) and race ($p = .277$). Inclusion criteria were: (1) completion of both the main survey and NSDE, (2) valid responses on key study variables and covariates, and (3) at least four valid diary days. Of 1,236 initial participants, 915 met these criteria. After excluding missing observations, the analytic sample comprised 6,076 daily observations for cognitive interference and 6,072 for memory lapses (see Supplementary Figure 1). This sample size was much larger than the minimum sample size of 50 required for multilevel modeling to avoid biased level-2 standard errors (Maas & Hox, 2005).

The National Study of Daily Experiences provides an adequate temporal window to capture weekday and weekend variability in sleep and subjective cognitive functioning. This duration aligns with methodological recommendations, as 7–8 days of repeated measurement typically ensure sufficient reliability in estimating within-person variability in multilevel models (Bolger et al., 2003; Sliwinski, 2008). Although longer diary periods may enhance statistical power, they also increase participant burden and attrition risk, posing challenges for large-scale longitudinal studies. The larger MIDUS study protocol was approved by the University of Wisconsin–Madison Institutional Review Board (IRB). Written informed consent was received for all MIDUS participants. The current study was exempt from an IRB review because it used secondary, de-identified data.

Measures

At the end of each day for eight consecutive diary days, participants responded to questions related to the previous night's sleep hours and quality, as well as their daily cognitive difficulties experienced that day. To assess daily cognitive difficulties, two specific measures on cognitive interference and memory lapses were selected. All the measurements were collected via Computer-Assisted Telephone Interviews (CATI).

Sleep Hours and Quality. Sleep hours were measured by asking, "How much time did you spend sleeping last night?" Responses were coded as hours and minutes, and daily sleep hours were calculated as decimal hours (e.g., 6 h and 30 min to 6.5 h). Sleep quality was measured by asking, "Rate last night's sleep quality". Responses ranged from "very bad" (= 1) to "very good" (= 4).

Daily Cognitive Interference. A six-item measurement of cognitive interference was used. Participants were asked to indicate the daily frequency of experiencing each item using a four-point scale (0 = "none of the time", 4 = "all the time"). The six items were "How often do you…": (1) think about personal problems/concerns; (2) experience thoughts difficult to stop; (3) have trouble concentrating; (4) have thoughts kept jumping into your head; (5) think about situations that upset you; and (6) think about financial situation? The daily cognitive interference score was calculated by averaging responses across six items each day (range = 0 to 3.83). The higher the score, the more participants experienced cognitive interference. Reliability coefficients by the Cranford method (Cranford et al., 2006) were adequate (person-level α = .77; day-level α = .62).

Daily Memory Lapses. Daily experiences of memory failure were rated with nine items: "Today, did you forget ……?" (1) to do an errand or chore; (2) to take a medication; (3) to finish something you started; (4) an appointment; (5) why you entered a room; (6) someone's name; (7) where you put something; (8) a word you wanted to use; and (9) important information (1 = "yes", 0 = "no"). We aggregated the number of items that participants reported "yes" each day. The score could range from 0 to 9, and higher scores indicated more memory lapses on a given day.

Covariates. We chose sociodemographic covariates known to be related to sleep and daily cognition. They included age (in years), sex (0 = *female*, 1 = *male*), race (0 = *non-White*, 1= *White*), education (1 = *no school/some grade school* to

12 = *Ph.D. or other professional degree*), and work status (0 = *nonworkers*, 1 = *workers*). Additionally, self-reported physical health (1 = *poor* to 5 = *excellent*) was used as a covariate. This was done to address potential concerns regarding the use of self-reported measures for sleep and cognitive difficulties. Moreover, weekend (Saturday/Sunday vs weekdays) was controlled to account for its effect on sleep in the general adult population. To rule out alternative hypotheses, the previous day's level of the outcome, cognitive interference, or memory lapses, was included in the models. Finally, to account for potential differences due to missing some dairy interviews, the number of missed diary days (*Range* = 0 to 4; all participants provided at least four diary days) was controlled for. Continuous covariates were centered at the sample means.

Statistical analysis

We used multilevel modeling with the lme4 package in R to account for the clustered data structure (Brown, 2021; Bryk & Raudenbush, 1992) The *lmer()* function was employed to model cognitive interference, while the *glmer.nb()* function with a multilevel negative binomial regression model was used for analyzing the frequency of memory lapses, as this variable represented nonnormal count data with excessive zeros (i.e., overdispersion rate of 1.60, $p < .001$). All models were estimated using maximum likelihood. Observations from the first day were excluded to incorporate cognitive difficulties from the previous day in the analyses.

We decomposed variances into within- and between-person levels. Daily sleep variables were person-mean centered to capture day-to-day deviations from their own average (within-person). Person-level averages were sample-mean centered to reflect overall deviations from the sample (between-person). For example, the model for daily cognitive interference as a function of both within-person sleep and between-person sleep as specified:

$$\begin{aligned}
&\text{Daily Cognitive Interference}_{di} \\
&= \beta_{0i} + \beta_1 (\text{Prior Day's Cognitive interference}_{d\text{-}1i}) \\
&+ \beta_2 (\text{Within-person Sleep Hour}_{d\text{-}1i}) \\
&+ \beta_3 (\text{Between-person Sleep Hour}_{i}) \\
&+ \beta_4 (\text{Within-person Sleep Quality}_{d\text{-}1i}) \\
&+ \beta_5 (\text{Between-person Sleep Quality}_{i}) \\
&+ \beta_6 (\text{Weekend}_{d\text{-}1i}) \\
&+ \beta_{7\,\text{to}\,13} (\text{Demographic and Health Covariates}_i) + e_{di}
\end{aligned}$$

Because sleep reported on a given day reflected the previous night's sleep, the day of both sleep hours and sleep quality was d–1 relative to other daily variables. β_2 and β_4 capture within-person effects, specifically, changes in cognitive interference on days following nights of longer-than-usual sleep hours and better-than-usual sleep quality, respectively. β_3 and β_5 represent between-person effects, indicating differences in average cognitive interference among individuals who, on average, slept longer or reported better sleep quality compared to others in the sample.

To explore potential age differences in the joint associations of sleep hours and sleep quality with cognitive interference, we conducted age-stratified analyses. These associations were examined across within-person, between-person, and cross-levels. Age was categorized into three groups based on the median (Mdn = 60) and the 75th percentile (Mdn = 67) of the age distribution: 43–59 years (Group 1; $n = 438$), 60–67 years (Group 2; $n = 257$), and 68–89 years (Group 3; $n = 220$).

Results

Participant characteristics and descriptive statistics of the main variables are shown in Supplementary Table 1. Our sample was 60 years old ($M = 60.5$, $SD = 9.16$) and consisted of 56.5% female ($n = 526$). The majority were non-Hispanic White (82.3%, $n = 753$). On average, participants slept 7.16 h ($SD = 0.99$) and reported a mean sleep quality of 2.11 ($SD = 0.43$). The intraclass correlations were 0.41 for sleep hours, 0.29 for sleep quality, 0.59 for cognitive interference, and 0.47 for memory lapses.

Table 1 shows results from multilevel models testing unique associations of sleep hours and sleep quality with cognitive interference and memory lapses, respectively. In support of H1a, at the within-person level, on days following poorer sleep quality than participants' usual, cognitive interference was greater than usual ($B = -0.05$, $SE = 0.01$, $p < .001$, 95% CI [−0.07, −0.04]). This association became significant after controlling for sleep hours, which were not significantly associated with next-day cognitive interference ($p = .067$). These within-person associations were found after controlling for prior day's cognitive interference, weekend, sociodemographic and background covariates, and between-person associations. The control variables remained consistent across all analyses. At the between-person level, participants with poorer sleep quality reported more cognitive interference on average ($B = -0.14$, $SE = 0.02$, $p < .001$, 95% CI [−0.18, −0.09]), after controlling for sleep hours. Yet, such between-person association was not found for sleep hours ($p = .351$) after taking into account average sleep quality.

Turning to memory lapses, at the within-person level, no significant associations were observed for either sleep hours ($p = .163$) or sleep quality ($p = .818$), controlling for each other. However, partially supporting H1b, poorer average sleep quality at the between-person level was significantly associated with more memory lapses ($B = -0.35$, incident rate ratio = 0.71, $SE = 0.08$, $p < .001$, 95% CI [−0.51, −0.18]). Average shorter sleep hours were not significantly associated with memory lapses ($p = .118$). Both average sleep hours and sleep quality were estimated simultaneously, controlling for each other.

Table 2 shows the interactive associations of sleep hours and sleep quality with cognitive interference and memory lapses. Specifically, four interaction terms were created to examine associations within a level (i.e., within-person and between-person) and across levels (i.e., between-person to within-person). There was a significant interaction between within-person sleep hours and within-person sleep quality ($B = .01$, $SE = 0.01$, $p = .021$, 95% CI [0.002, 0.03]). As depicted in Figure 1A, longer daily sleep hours attenuated the relationship between lower-than-usual sleep quality and increased cognitive interference the following day. A simple slope analysis revealed the nature of the interaction. The two slopes differed significantly, yet were in the same direction ($z = 1.99$, $p = .046$; see Figure 1A for the detailed statistical result). The negative association

Table 1. Multilevel modeling examining the independent effect of sleep hours and sleep quality on cognitive interference and memory lapses.

Predictor	Cognitive interference				Memory lapses				
	B	*SE*	*p*-value	95% CI	*B*	*Exp(B)*	*SE*	*p*-value	95% CI
Fixed effect									
Intercept	0.39	0.03	<.001	[0.33, 0.45]	−1.12	0.33	0.11	<.001	[−1.33, −0.91]
Within-person level									
Prior day's outcome[a]	0.27	0.01	<.001	[0.25, 0.29]	0.14	1.15	0.02	<.001	[0.11, 0.18]
Sleep hours	−0.01	0.004	.067	[−0.02, 0.001]	−0.02	0.98	0.02	.163	[−0.06, 0.01]
Sleep quality	**−0.05**	**0.01**	**<.001**	**[−0.07, −0.04]**	0.01	1.01	0.03	.818	[−0.06, 0.07]
Weekend[b]	−0.06	0.01	<.001	[−0.08, −0.04]	−0.08	0.92	0.04	.034	[−0.16, −0.01]
Between-person level									
Sleep hours	−0.01	0.01	.351	[−0.03, 0.01]	0.04	1.04	0.04	.216	[−0.03, 0.11]
Sleep quality	**−0.14**	**0.02**	**<.001**	**[−0.18, −0.09]**	**−0.35**	**0.71**	**0.08**	**<.001**	**[−0.51, −0.18]**
Age	−0.002	0.001	.185	[−0.004, 0.001]	0.01	1.01	0.00	.004	[0.004, 0.02]
Male[c]	−0.03	0.02	.136	[−0.07, 0.01]	−0.09	0.91	0.07	.202	[−0.23, 0.05]
White[d]	−0.01	0.03	.59	[−0.07, 0.04]	0.08	1.08	0.10	.435	[−0.11, 0.27]
Education	0.01	0.004	.03	[0.00, 0.02]	0.06	1.07	0.01	<.001	[0.03, 0.09]
Workers[e]	0.01	0.02	.657	[−0.03, 0.05]	0.10	1.10	0.08	.225	[−0.06, 0.26]
Physical health	−0.02	0.01	.019	[−0.04, −0.004]	−0.12	0.89	0.04	.001	[−0.19, −0.05]
Missed diary[f]	−0.03	0.01	.006	[−0.06, −0.01]	−0.06	0.94	0.04	.168	[−0.15, 0.03]
Random effects									
Person-level variance	0.06	0.01		[0.05, 0.07]	0.65		0.02		[0.62, 0.67]
Residual variance	0.10	0.002		[0.10, 0.11]					

Note. $N = 915$; 6,076 daily observations for cognitive interference, 6,072 daily observations for memory lapses. *Exp(B)* indicates incident rate ratio (IRR).
[a]Cognitive interference, memory lapses.
[b]Weekend = 0, weekdays = 1.
[c]Female = 0, male = 1.
[d]Non-White = 0, White = 1.
[e]Nonworker = 0, workers = 1.
[f]Number of days participants missed a diary. Significant associations are bolded (*$p < .05$). As we ran the negative binomial model with memory lapses as the dependent variable, the model did not estimate the residual variance.

between sleep quality and cognitive interference was stronger when within-person sleep hours were one standard deviation below the mean ($B = -0.06$, $SE = 0.01$, $p < 0.001$, 95% CI [−0.08, −0.05]).

There was a significant interaction between between-person sleep hours and within-person sleep quality ($B = .02$, $SE = 0.01$, $p = .032$, 95% CI [0.002, 0.03]). Figure 1B illustrates the nature of this interaction, where the two slopes differed significantly yet were in the same direction ($z = 2.10$, $p = .035$). The joint association across levels exhibited a consistent pattern with the joint association at the within-person level (see Figure 1B for detailed statistical results).

The joint association of sleep hours and sleep quality on memory lapses was also analyzed at the within-person, between-person, and cross-levels. As shown in Table 2, the joint association of sleep hours and sleep quality was not significantly associated with memory lapses at either the within-person or between-person level ($p > .05$ for all four interaction terms).

The age-stratified analyses focused on cognitive interference, the only outcome significantly linked to the joint effects of sleep hours and sleep quality. As shown in Table 3, after controlling for sleep hours, the association of sleep quality and cognitive interference was significant in Group 1 (aged 43–59), Group 2 (aged 60–67), and Group 3 (aged 68–89), with consistent effects across the age groups. For example, in Group 1 (aged 43–59), at the within-person level, sleep quality was negatively associated with more cognitive interference ($B = -0.06$, $SE = 0.01$, $p < .001$, 95% CI [−0.08, −0.04]), after controlling for sleep hours. A similar negative association was observed at the between-person level ($B = -0.13$, $SE = 0.03$, $p < .001$, 95% CI [−0.20, −0.07]). No significant interactive associations of sleep hours and sleep quality were observed at both the within-person and between-person levels in Group 1.

Most congenial to our exploration of age differences, the joint association of within-person sleep hours and within-person sleep quality with cognitive interference was only significant in Group 2 (aged 60–67; see Model 2 of Table 3; $B = 0.04$, $SE = 0.01$, $p = .005$, 95% CI [0.01, 0.06]), but not in other age groups (all *p*s > .05). A follow-up simple slope analysis, as shown in Figure 2A with detailed statistical results, revealed that the difference between the two slopes was significant ($z = 2.31$, $p = .020$). When within-person sleep hours were one standard deviation below the mean, poorer sleep quality was significantly associated with greater cognitive interference ($B = -0.08$, $SE = 0.02$, $p < .001$, 95% CI [−0.11, −0.04]). In contrast, when within-person sleep hours were one standard deviation above the mean, the slope was nonsignificant ($p = .640$).

Like the interaction at within-person levels, the joint association of between-person sleep hours and within-person sleep quality with cognitive interference was only significant in Group 2 (aged 60–67), but not in other age groups (see Model 2 of Table 3; $B = 0.05$, $SE = 0.01$, $p = .001$, 95% CI [0.02, 0.08]). A follow-up simple slope analysis remained consistent

Table 2. Multilevel modeling examining the joint association of sleep hours and sleep quality on cognitive interference and memory lapses.

Predictor	Cognitive interference				Memory lapses				
	B	*SE*	*p*-value	95% CI	*B*	*Exp(B)*	*SE*	*p*-value	95% CI
Fixed effect									
Intercept	0.38	0.03	<.001	[0.33, 0.44]	−1.12	−0.33	0.11	<.001	[−1.33, −0.91]
Within-person level									
Prior day's outcome[a]	0.27	0.01	<.001	[0.25, 0.29]	0.14	−1.15	0.02	<.001	[0.11, 0.18]
Sleep hours	−0.004	0.004	.319	[−0.01, 0.004]	−0.02	−0.98	0.02	.276	[−0.06, 0.02]
Sleep quality	**−0.05**	**0.01**	**<.001**	**[−0.07, −0.03]**	0.01	−1.01	0.03	.663	[−0.05, 0.08]
Weekend[b]	−0.06	0.01	<.001	[−0.08, −0.04]	−0.08	−0.92	0.04	.029	[−0.16, −0.01]
Between-person level									
Sleep hours	−0.01	0.01	.523	[−0.03, 0.01]	0.04	−1.04	0.04	.237	[−0.03, 0.11]
Sleep quality	**−0.13**	**0.02**	**<.001**	**[−0.18, −0.09]**	**−0.35**	**−0.71**	**0.08**	**<.001**	**[−0.51, −0.18]**
Age	−0.001	0.001	.242	[−0.004, 0.001]	0.01	−1.01	0.004	.005	[0.004, 0.02]
Male[c]	−0.03	0.02	.131	[−0.07, 0.01]	−0.09	−0.92	0.07	.215	[−0.22, 0.05]
White[d]	−0.02	0.03	.536	[−0.07, 0.04]	0.08	−1.08	0.10	.425	[−0.11, 0.27]
Education	0.01	0.004	.028	[0.001, 0.02]	0.06	−1.07	0.01	<.001	[0.03, 0.09]
Workers[e]	0.02	0.02	.489	[−0.03, 0.06]	0.10	−1.10	0.08	.248	[−0.07, 0.26]
Physical health	−0.02	0.01	.022	[−0.04, 0.00]	−0.12	−0.89	0.04	.001	[−0.19, −0.05]
Missed diary[f]	−0.03	0.01	.011	[−0.06, −0.01]	−0.06	−0.94	0.04	.151	[−0.15, 0.02]
W.Sleep Quality × W.Sleep Hours	**0.01**	**0.01**	**.021**	**[0.002, 0.03]**	0.03	−1.03	0.03	.295	[−0.02, 0.08]
W.Sleep Quality × B.Sleep Hours	**0.02**	**0.01**	**.032**	**[0.002, 0.03]**	−0.04	−0.97	0.07	.600	[−0.17, 0.10]
W.Sleep Hours × B.Sleep Quality	0.01	0.01	.529	[−0.01, 0.02]	0.01	−1.02	0.03	.617	[−0.04, 0.07]
B.Sleep Hours × B.Sleep Quality	0.03	0.02	.132	[−0.01, 0.06]	−0.01	−0.99	0.04	.856	[−0.08, 0.07]
Random effects									
Person-level variance	0.06	0.01		[0.05, 0.07]	0.64	0.02			[0.62, 0.67]
Residual variance	0.10	0.002		[0.10, 0.11]					

Note. $N = 915$; 6,076 daily observations for cognitive interference, 6,072 daily observations for memory lapses. *Exp(B)* indicates incident rate ratio (IRR). B.Sleep Hours = Between-person level sleep Hours; W.Sleep Hours = Within-person level sleep hours; W.Sleep Quality = Between-person level sleep quality; W.Sleep quality = Within-person level Sleep quality.

[a]Cognitive interference and memory lapses.

[b]Weekend = 0, weekdays = 1.

[c]Female = 0, male = 1.

[d]Non-White = 0, White = 1.

[e]Nonworker = 0, workers = 1.

[f]Number of days participants missed a diary. Significant associations are bolded ($*p < .05$).

as the joint association of within-person sleep hours and within-person sleep quality, while the two slopes differed significantly ($z = 3.12$, $p = .002$; See Figure 2B for the detailed statistical results).

Discussion

Findings from this study contribute to the literature in three important ways. First, using daily diary data from a sample of middle-aged and older adults in the U.S., we observed a significant increase in daily cognitive interference following nights with poorer sleep quality. Importantly, this association was found after accounting for sleep hours, highlighting the independent and unique role of sleep quality in adults' daily cognitive difficulties. Second, we identified joint associations of sleep hours and sleep quality on cognitive interference, with a pattern suggesting that sufficient sleep hours mitigate the negative effect of poorer sleep quality on cognitive interference. Third, this compensatory mechanism was evident only among adults aged 60–67, suggesting that extending sleep hours may compensate for poorer sleep quality in mitigating daily cognitive difficulties among young-old adults.

This study found a robust association between sleep quality and cognitive interference at both the within-person and between-person levels, after controlling for sleep hours at each level. This finding aligns with predictions based on the restorative theory of sleep, showing that sleep deficiencies manifested in daily life are associated with increased perceived cognitive difficulties. Similar to Lee and colleagues (2019), our finding suggests that both daily poor sleep quality and habitually poor sleep quality are uniquely associated with heightened cognitive interference. Although cognitive interference was not associated with either within-person sleep hours or between-person sleep hours in this study, after controlling for sleep quality, inconsistent results have been reported on the association between sleep hours and cognitive functioning (Cárdenas-Egúsquiza & Berntsen, 2022). In contrast to prior studies (Wüst et al., 2024; Yoo et al., 2007), memory lapses were independently associated with sleep quality but not with sleep hours in the current study. This discrepancy may be attributed to the overall sleep patterns of the participants. The participants had 7.16 h of sleep on average. The detrimental effects of daily short sleep hours on memory lapses may be less pronounced because our participants had a sufficient amount of sleep overall.

One of the most notable findings of this study is the joint association of sleep hours and sleep quality with cognitive interference. Although it is well-established that sleep deficiencies

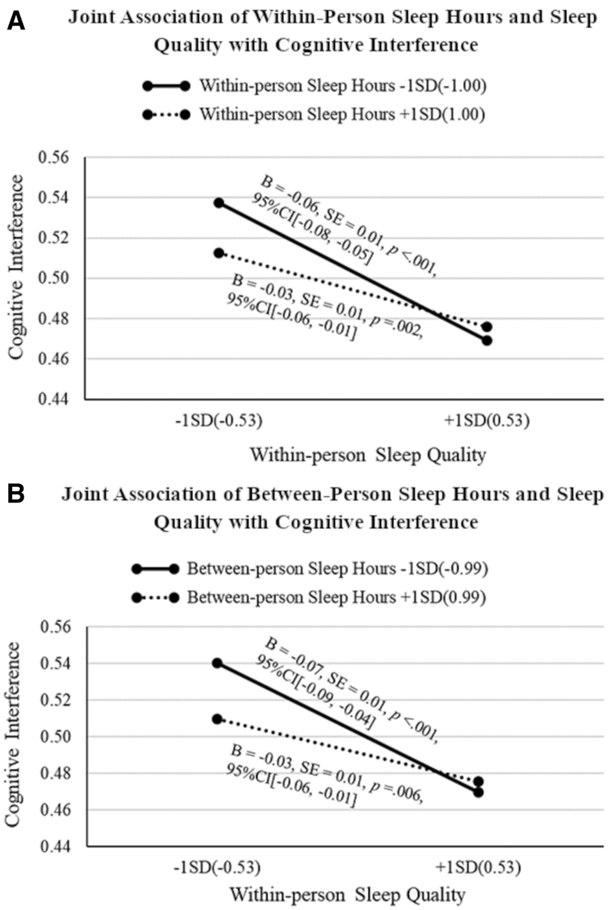

Figure 1. Joint associations of sleep hours and sleep quality with cognitive interference: within-person and between-within-person levels.

can hinder cognitive functioning (Keage et al., 2012; Lo et al., 2016), our results highlight that sufficient sleep hours can mitigate the negative impact of poor sleep quality when examined jointly. The compensatory relationship between sleep hours and sleep quality is observed across levels (i.e., from between-person to within-person levels) and is also evident at the within-person level. That is, the increase in cognitive interference following a night of poorer sleep quality was less pronounced when the night's sleep exceeded the individual's average sleep hours or for individuals who typically obtain sufficient sleep hours. To address alternative interpretations, it is worth noting that participants' average sleep hours ranged from 6 to 8 h—well below the threshold typically associated with cognitive impairment due to excessive sleep (≥10 h; Low et al., 2019). This extends the findings of Li et al. (2022), who identified the compensatory relationship only at the between-person level, showing that habitually sufficient sleep quality buffers against the detrimental effect of habitually shorter sleep hours on cognitive functioning among older Chinese adults.

The age-stratified analysis demonstrated that the interaction between sleep hours and sleep quality was exclusively significant among individuals aged 60–67 years, with no observable effects in those younger than 60 or older than 67. We speculate that this phenomenon may be attributed to the transitional social dynamics characteristic of individuals in their 60s. This period typically coincides with retirement, which engenders both enhanced temporal flexibility for sleep-related behaviors and the cessation of occupational stressors (Hagen et al., 2016; Teräs et al., 2023). Prior to this age range, work-life demands and occupational stress may constrain sleep schedules, leaving little opportunity to experience the compensatory role of sufficient sleep hours in mitigating the impact of poorer sleep quality on cognitive interference. Conversely, in the postretirement period beyond age 67, the changes in sleep structure, such as shorter sleep hours and poorer sleep quality, may diminish the likelihood of the compensatory effect.

The findings of this study have important practical implications for sleep interventions and clinical health initiatives. Decline in subjective cognition—such as self-reported cognitive interference and memory lapses—has been identified as a predictor of objective cognitive declines, including mild cognitive impairment and dementia (Mitchell et al., 2014; Parfenov et al., 2020). Research suggests that objectively measured global cognition and memory gradually decline following the onset of subjective cognitive decline (Koppara et al., 2015). Notably, subjective cognitive decline has been found to precede Alzheimer's disease by an average of 6.8 years and all-cause dementia by 6.9 years in older adults (Kang et al., 2024). The present study highlights the importance of addressing both sleep hours and quality in sleep health interventions to mitigate the risk of subjective cognitive decline. The compensatory relationship between sleep hours and quality underscores the need for public health recommendations that encourage extended sleep hours when individuals experience poor sleep quality, particularly among adults aged 60–67. This age-specific insight is particularly relevant for retirement health planning, where tailored sleep strategies could help support cognitive function during this transitional life stage.

This study is not without limitations. Although it controlled for the prior day's cognitive interference and memory lapses, it cannot fully establish a causal relationship between sleep and cognitive functioning, as the design only suggests the directionality of the association. Additionally, the measurement of sleep hours and sleep quality has limitations. First, sleep quality was assessed using an even-numbered scale, potentially encouraging dichotomous responses (e.g., good vs bad). However, the mean rating was 2.11 ($SD = 0.43$), with 26.76% of days rated as good or very good. Second, participants self-reported sleep and wake times the following afternoon, introducing possible recall bias. However, the short recall window and use of computer-assisted telephone interviews likely reduced memory distortion. Third, specific sleep disorders (e.g., insomnia or obstructive sleep apnea) were not systematically assessed across the three MIDUS waves, so chronic sleep conditions were not formally screened. Addressing these limitations in future studies will provide a clearer understanding of the relationship between sleep and cognitive functioning.

Conclusion

Our findings establish that sleep hours and sleep quality play distinct yet interconnected roles in daily cognitive difficulties in naturalistic settings, with sleep quality being associated with daily cognitive interference both uniquely and jointly with sleep hours.

Table 3. Multilevel modeling examining age-stratified joint association of sleep hours and sleep quality on cognitive interference.

Predictor	Age group (43–59; *N*=438)				Age group (60–67; *N*=257)				Age group (68–89; *N*=220)			
	B	*SE*	*p*-value	95% CI	*B*	*SE*	*p*-value	95% CI	*B*	*SE*	*p*-value	95% CI
Fixed effect												
Intercept	0.41	0.05	<.001	[0.30, 0.51]	0.44	0.06	<.001	[0.32, 0.56]	0.17	0.07	.009	[0.04, 0.31]
Within-person level												
Prior day's outcome[a]	0.26	0.02	<.001	[0.23, 0.30]	0.21	0.02	<.001	[0.17, 0.25]	0.37	0.02	<.001	[0.32, 0.41]
Sleep hours	−0.002	0.01	.802	[−0.01, 0.01]	−0.01	0.01	.446	[−0.03, 0.01]	−0.01	0.01	.333	[−0.02, 0.01]
Sleep quality	**−0.06**	**0.01**	**<.001**	**[−0.08, −0.04]**	**−0.05**	**0.02**	**.004**	**[−0.08, −0.01]**	**−0.03**	**0.02**	**.041**	**[−0.06, −0.001]**
Weekend[b]	−0.07	0.01	<.001	[−0.10, −0.05]	−0.06	0.02	<.001	[−0.09, −0.03]	−0.03	0.02	.108	[−0.06, 0.01]
Between-person level												
Sleep hours	−0.02	0.02	.208	[−0.05, 0.01]	−0.01	0.02	.497	[−0.05, 0.02]	0.03	0.02	.095	[−0.005, 0.06]
Sleep quality	**−0.13**	**0.03**	**<.001**	**[−0.20, −0.07]**	**−0.16**	**0.04**	**<.001**	**[−0.24, −0.07]**	**−0.10**	**0.04**	**.015**	**[−0.19, −0.02]**
Age	−0.01	0.00	.056	[−0.01, 0.0002]	0.00	0.01	.794	[−0.02, 0.01]	0.01	0.004	.041	[0.0003, 0.02]
Male[c]	−0.01	0.03	.664	[−0.07, 0.04]	−0.08	0.04	.031	[−0.15, −0.01]	−0.01	0.04	.698	[−0.08, 0.06]
White[d]	−0.02	0.04	.649	[−0.10, 0.06]	−0.01	0.05	.802	[−0.11, 0.09]	−0.002	0.05	.971	[−0.09, 0.09]
Education	0.01	0.01	.031	[0.001, 0.03]	−0.002	0.01	.817	[−0.02, 0.01]	0.01	0.01	.088	[−0.002, 0.03]
Workers[e]	−0.05	0.04	.237	[−0.13, 0.03]	0.003	0.04	.932	[−0.07, 0.08]	0.09	0.04	.016	[0.02, 0.16]
Physical health	−0.01	0.02	.338	[−0.04, 0.02]	−0.03	0.02	.105	[−0.07, 0.01]	−0.03	0.02	.066	[−0.07, 0.002]
Missed diary[f]	−0.03	0.02	.133	[−0.06, 0.01]	−0.03	0.03	.35	[−0.08, 0.03]	−0.03	0.02	.217	[−0.07, 0.02]
W.Sleep Quality × W.Sleep Hours	0.01	0.01	.502	[−0.01, 0.03]	**0.04**	**0.01**	**.005**	**[0.01, 0.06]**	0.02	0.01	.108	[−0.004, 0.04]
W.Sleep Quality × B.Sleep Hours	0.02	0.01	.145	[−0.01, 0.04]	**0.05**	**0.01**	**.001**	**[0.02, 0.08]**	−0.02	0.02	.327	[−0.05, 0.02]
W.Sleep Hours × B.Sleep Quality	0.001	0.01	.927	[−0.02, 0.03]	0.03	0.02	.251	[−0.02, 0.07]	0.01	0.02	.618	[−0.02, 0.04]
B.Sleep Hours × B.Sleep Quality	0.02	0.03	.336	[−0.03, 0.08]	0.08	0.04	.054	[−0.001, 0.16]	−0.06	0.04	.117	[−0.13, 0.01]
Random effects												
Person level variance	0.06	0.01		[0.05, 0.08]	0.06	0.01		[0.05, 0.08]	0.04	0.01		[0.03, 0.06]
Residual variance	0.11	0.003		[0.10, 0.12]	0.09	0.004		[0.09, 0.10]	0.09	0.004		[0.08, 0.10]

Note. $N=915$; 6,076 daily observations for cognitive interference. B.Sleep Hours = between-person level sleep hours, W.Sleep Hours = Within-person level sleep hours, W.Sleep Quality = Between-person level sleep quality, W.Sleep quality = Within-person level sleep quality.
[a]Cognitive interference.
[b]Weekend = 0, weekdays = 1.
[c]Female = 0, male = 1.
[d]Non-White = 0, White = 1.
[e]Nonworker = 0, workers = 1.
[f]Number of days participants missed a diary. Significant associations are bolded ($*p < .05$).

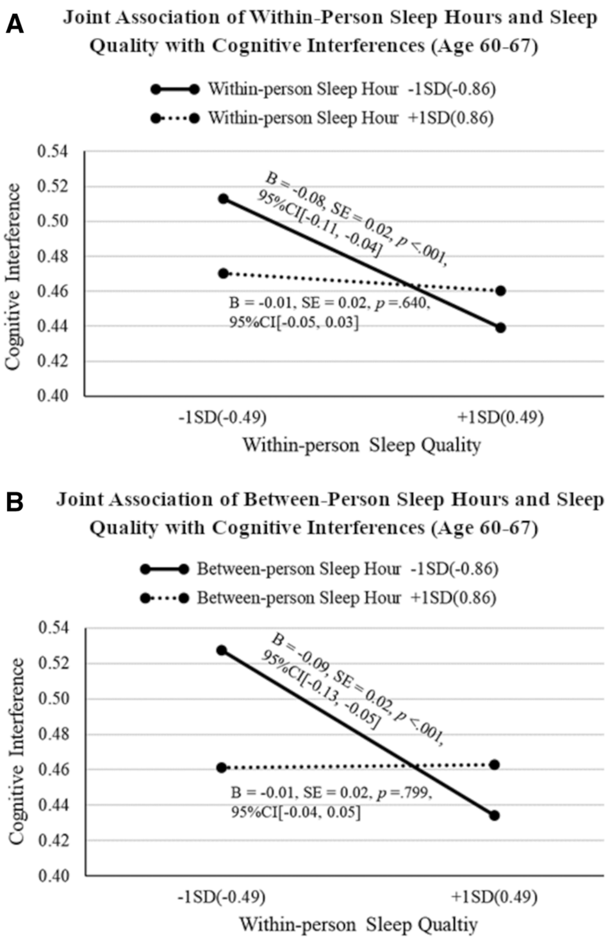

Figure 2. Age-stratified joint associations of sleep hours and sleep quality with cognitive interference (aged 60–67): within-person and between-within person level.

Most significantly, we identified a critical age-specific effect among adults aged 60–67, wherein sufficient sleep hours can compensate for poor sleep quality in daily cognitive interference. These findings suggest that sleep prevention strategies or interventions should be tailored to life-stage requirements, with particular attention to preretirement adults who may face unique cognitive demands while navigating work-life transitions.

Supplementary material

Supplementary material is available at *The Journals of Gerontology, Series B: Psychological and Social Sciences* online.

Data availability

All MIDUS data are publicly available through the Inter-university Consortium for Political and Social Research. This study is not preregistered.

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Conflict of interest

None declared.

Author notes

In the descriptive statistics comparing participants who completed both the main survey and the NSDE with those who completed only the main survey, participants with missing employment data ($n = 696$) were excluded from the analyses.

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