

1 Department of Psychological, Health and Territorial Sciences, G. d'Annunzio University of Chieti-
2 Pescara
3 Via dei Vestini, 31 - 66100 Chieti, Italy
4 e-mail: alberto.didomenico@unich.it

5

6 Erika Borella

7 PhD

8 Department of General Psychology, University of Padova

9 Via Venezia, 8, 35131 Padova, Italy

10 e-mail: erika.borella@unipd.it

11

12

1 **Abstract**

2 **Objectives:** This study examined whether emotions induced by reading before sleep influence sleep
3 quality in young and older adults. **Method:** Sixty older adults (64–75 years) and 60 young adults
4 (18–35 years) were randomly assigned to three conditions: positive reading, neutral reading, and
5 control. The reading groups read a short story at bedtime, whereas the control group kept its routine.
6 Participants completed measures of affective states, subjective sleep parameters, and self-reported
7 sleep quality related to emotions over 7 consecutive days. **Results:** Older adults reported much
8 longer sleep latency and lower sleep efficiency than young adults. In both reading conditions, older
9 adults reported reduced sleep latencies compared to the control group. In the positive reading
10 condition, older adults reported an increased sleep duration compared to younger adults and the
11 other conditions. Young and older adults in the positive condition showed better self-reported sleep
12 quality than those in the neutral conditions, regardless of age. **Conclusions:** Reading at bedtime
13 appears to reduce older adults' time to fall asleep and increase their sleep duration. Positive
14 emotions induced by reading short stories at bedtime seem to be a sleep-promoting factor that
15 improves bedtime and wake time in young and older adults.

16
17 **Keywords:** *age-related differences, emotion, affective states, reading, sleep quality*

1 **Introduction**

2 The importance of sleep in promoting better physical and mental health and sustaining quality of
3 life throughout the entire life span has been well recognized (Dewald et al., 2010; Sella et al.,
4 2021). Sleep problems and negative changes in fundamental aspects of sleep (e.g., the initiation and
5 maintenance of sleep and feeling rested/satisfied at waking) have been shown to have harmful
6 effects on health and everyday functioning (Hughes et al., 2018) in young adults and especially in
7 older ones (Spira et al., 2014).

8 Even older adults with a typical aging process and without insomnia commonly report numerous
9 changes in their sleep patterns and quality that are related to a poorer quality of life (see Sella et al.,
10 2021 for a review), that is, shorter sleep duration (total sleep time, TST), lower sleep efficiency
11 (SE), and longer time spent awake trying to fall asleep (sleep onset latency, SOL) compared to
12 younger adults (Mander et al., 2017; Ohayon et al., 2017). Thus, interest in identifying factors that
13 could promote sleep quality and better sleep health in aging is growing.

14 Different factors can influence sleep quality, and emotions are among them (Alexander et
15 al., 2021). Experiencing negative emotions during the day can affect a person's sleep quality in
16 terms of length, the number of night awakenings, and the ability to fall asleep (Kim & Dimsdale,
17 2007; Vandekerckhove et al., 2011). Experiencing positive emotions during the day, instead, has
18 been associated with, among other benefits, better self-reported health (Chida & Steptoe, 2008) and
19 improved sleep quality (i.e., fewer sleep problems) not only in people suffering from sleep disorders
20 but also in healthy adults (Kalmbach et al., 2014; Ong et al., 2017; Pressman et al., 2017; Steptoe et
21 al., 2008). High daily positive affect states have been associated with better sleep efficiency and
22 quality the following night in healthy adults (Kalmbach et al., 2014; Pressman et al., 2017).

23 However, evidence is more limited on whether such an association might also be effective in older
24 people's sleep quality. Only one study to date has addressed the role of positive emotions in older
25 adults' sleep and showed that experiencing positive emotions during the day was associated with
26 better sleep quality in middle-aged and older adults (Steptoe et al., 2008).

1 Very few studies, then, have investigated the effects of experimentally induced positive emotions
2 on sleep quality (Ong et al., 2017), and these studies included only young adults. Two studies,
3 manipulating emotions during the day, found that eliciting positive emotions (in terms of gratitude
4 by writing a gratitude diary) during the day was also associated with better self-reported sleep
5 quality and reduced sleep disturbances in young adults (Emmons & McCullough, 2003; Jackowska
6 et al., 2015). Of note is that bedtime, often described as a quiet period in the day to review one's
7 behaviour and thoughts, is particularly suitable for the emergence of dysfunctional sleep-related
8 emotions and feelings in both young and older adults (Sella & Borella, 2021). Only Schmidt and
9 Van der Linden (2013) manipulated presleep negative emotions at bedtime—induced before falling
10 asleep—by writing a burdensome regret in participants' minds. The researchers found an
11 association between negative emotions (in terms of regrets) and significant delays in falling asleep
12 in young adults. To date, no studies have daily recorded emotions and sleep quality of young and
13 older adults in a naturalistic setting (such as the participants' homes) and examined at the same time
14 whether bedtime reading of short stories with emotional content (positive or neutral) could improve
15 sleep quality and sleep parameters (i.e. SOL, TST, and SE).

16 The present study aimed, for the first time, at least to our knowledge, to examine the effects
17 of positive emotions elicited before sleeping on improving self-reported sleep quality in young and
18 older adults without sleep disorders (e.g., insomnia) or other clinically relevant issues (e.g., mood
19 disorders). Because reading is considered among the calming and light activities recommended for
20 improving sleep (Leblanc et al., 2015; Mindell et al., 2009) and because reading stories with
21 positive content has been previously used as a technique to induce positive emotions in individuals
22 (Kenealy, 1986; Kučera & Haviger, 2012; Velten, 1968), we presented -neutral and positive- short
23 stories at bedtime for 7 days and measured their impact on sleep quality and parameters. Therefore,
24 while confirming previous findings (e.g., Ohayon et al., 2017) on differences between young and
25 older adults in self-reported sleep quality and parameters (longer SOL and lower TST and SE in
26 older adults compared to younger adults), we hypothesized that both young and older adults in the

1 positive and neutral conditions would show better overall self-reported sleep quality (through a
2 questionnaire) and subjective sleep parameters (including reductions in SOL, much longer TST, and
3 better SE) compared to their younger and older counterparts in the control condition. Finally, based
4 on previous evidence on the effects of positive emotions on sleep discussed above (Kalmbach et al.,
5 2014; Ong et al., 2017; Pressman et al., 2017; Steptoe et al., 2008; Emmons & McCullough, 2003;
6 Jackowska et al., 2015), we expected both young and older adults in the positive condition to show
7 better subjective sleep parameters: reductions in SOL, much longer TST, better SE, and better
8 overall self-reported sleep quality compared to their younger and older counterparts in the neutral or
9 control conditions.

10

11 **Methods**

12 *Participants*

13 Sixty young adults (age range: 18–30 years; 30 females) and 60 older adults (age range: 64–
14 74 years; 30 females) with no sleep disorders (such as insomnia) volunteered for the study.
15 Individuals were recruited through social clubs and by word of mouth in different Italian cities. All
16 participants were screened using the following inclusion criteria: (a) no depression, based on scores
17 less than 10 on the Geriatric Depression Scale (Yesavage et al., 1982) for the adults over 64 years
18 old and scores less than 14 on the Beck’s Depression Inventory II (Beck et al., 1996) for the
19 middle-aged and young adults; (b) no excessive symptoms of anxiety, that is, over two standard
20 deviations from the mean in the Italian normative data on the State–Trait Anxiety Inventory Y2
21 (STAI–Y2; Spielberger, 2010); (c) for older adults, no signs of cognitive impairment, using a score
22 of 9 out of 10 as a cut-off on the short version of the Italian Checklist for Multidimensional
23 Assessment (Gallina et al., 2006); and (d) no clinically relevant insomnia symptoms—based on
24 scores less than 5 on the Pittsburgh Sleep Quality Index (PSQI; Buysse et al., 1989) and scores less
25 than 15 on the Insomnia Severity Index (ISI; Morin et al., 2011)—or other diagnosed sleep
26 disorders as assessed with ad hoc semistructured clinical interviews (Sella et al., 2019). The

1 participants also reported no significant differences in affective states at the baseline (measured
2 using the Positive and Negative Affective Scale; Watson, et al., 1988) between the age groups and
3 across the conditions before the experimental week (Supplementary Material, Table 1S). The age
4 groups were also balanced in terms of gender and education³.

5 The study was approved by the local University's Research Ethics Committee (protocol
6 number 4108). All participants were given information about the study and gave their written
7 informed consent in accordance with the Declaration of Helsinki (World Medical Association,
8 2013).

9

10 ***Materials***

11 **Presleep emotional induction: Bedtime stories**

12 Seven short stories were compiled in a booklet assigned to the participants in neutral or
13 positive conditions.¹ Each short story included (a) a title identifying the content of the story, (b) the
14 main text containing 250 words in the Italian language, and (c) the same page layout and text font.
15 Two researchers selected the titles and content a priori (ES, EB). A professional writer was
16 involved in writing 14 short stories (Supplementary Material, Part 3).

17

18 **Measure of valence and arousal: Self-Assessment Manikin**

19 The SAM (Bradley & Lang, 1994) is a picture-oriented questionnaire composed of pictures
20 and figures measuring the valence and arousal associated with a person's emotional reaction to
21 stimuli. The respondents can rate their valence and arousal according to 9 points on the continuum,
22 with 1 indicating the lowest rating for each dimension (negative valence or low arousal) and 9
23 indicating the highest rating (positive valence or high arousal).

24

25 **Measure of sleep: Sleep diary**

1 A sleep diary is a tool for recording sleeping and waking patterns and providing information
2 about sleep-related behaviour over a specified period (Sella et al., 2019). This study considered the
3 following sleep parameters across 7 days of recordings: TST, recorded as the minutes of sleep
4 during the night; SOL, recorded as the minutes elapsed between lights off and the first sleep period;
5 and SE (%), recorded as the ratio of TST to time spent in bed.

6 7 **Bedtime Story Questionnaire**

8 The Bedtime Story Questionnaire (BSQ) is an ad hoc questionnaire comprised of 15 items
9 assessing the effects of emotional responses to reading a story (neutral or positive) the previous
10 night on self-reported sleep quality¹. The participants indicated how much they agreed with each
11 statement based on a 9-point Likert scale (1 = *completely disagree* to 9 = *completely agree*). The
12 dependent variables were the total score ($\alpha = .80$) and the three subscales: Emotion-Related Quality
13 of Bedtime (e.g., “Reading the story made me fall asleep easily”; $\alpha = .70$), Emotion-Related Quality
14 of Wake Time (e.g., “Reading the story allowed me to wake up refreshed”; $\alpha = .65$), and Emotion-
15 Related Content of the Story (e.g., “While reading the story, I was thinking about how interesting
16 [the story] was”; $\alpha = .29$). The latter subscale did not show acceptable internal consistency and thus
17 was not considered in our analyses.

18 19 **Procedure**

20 The participants completed ad hoc semistructured interviews, to assess the risk of sleep
21 disorders, and questionnaires in the following order: the SVAMA, the PANAS, the PSQI, the ISI,
22 the GDS (older adults) or BDI-II (young adults), and the STAI-Y2. Then, young and older
23 participants were randomly assigned to three experimental conditions. In the neutral condition, the
24 participants were asked to read a short story with neutral content every night. This condition
25 allowed us to test whether a calming and relaxing activity, such as reading before bed, could
26 improve the participants’ sleep quality. In the positive condition, the participants were asked to read

1 a short story with positive content every night. This condition allowed us to test the effects of
2 positive emotions as a facilitator for improving sleep quality. In the control condition, the
3 participants were asked to maintain their usual sleep habits. This condition served as a control to
4 test our hypothesis. The participants in the reading conditions (positive or neutral) read a different
5 short story (randomly ordered in the booklet) every evening 1 hr before going to sleep so as not to
6 disrupt their regular bedtime routines, in accordance with the National Sleep Foundation.

7 For 7 days, the participants in all three conditions had to complete a daily record of
8 emotions (in terms of valence and arousal, using the SAM) before falling asleep and keep a sleep
9 diary to record their subjective sleep parameters (SOL, TST, SE; Sella et al., 2019) in a naturalistic
10 setting (the participants' homes). On the first day (Day 1), each participant completed the sleep
11 diary (evening section). Those assigned to the positive and neutral conditions read a story (with
12 positive or neutral content) and completed the SAM before and after reading the story in the
13 evening and the BSQ the subsequent morning. The participants in the control condition were asked
14 to write a sleep diary during the week and complete the SAM before sleeping in the evening to rate
15 their emotional states (Supplementary Material, Figure 1S).² On the final day (Day 8), the
16 participants completed the BSQ (neutral and positive conditions) and sleep diary in the morning.
17 We then contacted all participants to collect the booklets and sleep diaries.

18

19 *Statistical analyses*

20 Linear mixed effects model analyses were conducted to elucidate the influence of presleep
21 emotions on subjective sleep parameters (TST, SOL, and SE data from the participants' sleep
22 diaries) and self-reported sleep quality (BSQ questionnaire and its subscales) in young and older
23 adults. Planned contrasts were then run between the reading conditions (neutral and positive) and
24 the control condition and between the neutral and positive conditions. The age groups and
25 conditions and their interactions were entered as fixed effects. The participant was included as a

1 random factor for all the models. All models were adjusted for the scores obtained on the SAM for
2 valence and arousal at the baseline level.

3 Linear mixed effects model analyses were also performed to ascertain the effects of the age
4 groups and conditions on the participants' affective states (valence and arousal measured using the
5 SAM) before falling asleep during the week.

6 To identify any benefits of reading a story, we calculated the benefit index as an evaluation of the
7 SAM by computing the SAM score after reading the text minus the SAM score before reading the
8 text. In addition, a series of analyses of the variance of these benefit indices (dependent variables)
9 were then performed for the two reading groups (positive and neutral conditions), controlling for
10 the SAM scores for valence and arousal at the baseline level. To investigate any changes in valence
11 and arousal between young and older adults in each reading condition, mean changes in the SAM
12 (valence and arousal scores) were examined by calculating standardized mean differences with
13 Cohen's d (Hedge, 1981).

14

15 **Results**

16 *Subjective sleep parameters: Sleep diary*

17 *SOL*. A main effect of age emerged for the SOL, $B = 8.604$, $p < .001$, 95% CI [4.41, 12.80],
18 indicating that older adults spent more time trying to fall asleep than young adults. No significant
19 main effect of the conditions on SOL emerged. Moreover, significant age x condition interaction
20 emerged, indicating that older adults in both the positive condition, $B = -8.454$, $p < .001$, 95% CI
21 [-12.52, 0.69] and the neutral condition, $B = -8.454$, $p = .007$, 95% CI [-14.39, -2.53], reported
22 much shorter times spent trying to fall asleep compared to older participants in the control condition
23 (Figure 1; Supplementary Material, Table 3S).

24 Planned contrasts between the reading (positive and neutral) conditions and the control condition
25 showed significant age x condition interaction, $B = -7.513$, $p = .007$, 95% CI [-12.79, -2.24],
26 indicating that older adults in the reading conditions reported shorter times falling asleep compared

1 to both young and older adults in the control group. No significant main effect of age and condition
2 emerged (Supplementary Material, Table 4S).

3 Planned contrasts between the reading conditions showed a significant main effect of the condition,
4 $B = -4.890, p = .023, 95\% \text{ CI } [-8.96, -0.81]$, indicating those who read at bedtime reported shorter
5 SOL than those maintaining their usual routines (Supplementary Material, Table 5S; Figure 4S). No
6 main effect of age and the age x reading condition interaction emerged.

7 *TST*. The age x condition interaction was significant, $B = 32.888, p = .046, 95\% \text{ CI } [1.59,$
8 $64.22]$, suggesting that older adults in the positive condition reported longer times spent asleep
9 compared to their older counterparts in the other conditions (control and neutral conditions). No
10 significant main effect of age and condition emerged (Figure 1).

11 Planned contrasts between the reading and control conditions and between the reading conditions
12 (positive versus neutral) did not reveal the main effects of age and condition, and no significant
13 interactions were found (Supplementary Material, Figure 5S).

14 *SE*. A main effect of age emerged for SE, $B = -2.421, p = .028, 95\% \text{ CI } [-4.50, -0.34]$,
15 indicating that older adults had lower ratios of time spent asleep to time spent in bed compared to
16 young adults. No significant main effects of all conditions emerged, but age x condition interaction
17 emerged (Figure 1).

18 Considering the planned contrasts between the reading conditions (positive and neutral) and the
19 control condition, the results revealed a significant main effect of age for SE, $B = -2.417, p = .026,$
20 $95\% \text{ CI } [-4.51, -0.33]$. There was no significant main effect of the condition, and no other
21 interactions emerged regarding SE.

22 Planned contrasts between the reading conditions (positive versus neutral) revealed a significant
23 main effect of age, $B = -2.718, p = .012, 95\% \text{ CI } [-4.77, -0.66]$ (Supplementary Material, Figure
24 6S). In general, older adults had poorer SEs than young adults in both reading conditions. No other
25 significant main effects of the conditions and no age x reading condition interaction occurred.

26

1 [Insert Figure 1 here]

2
3 ***Self-reported sleep quality: BSQ total score and subscales***

4 The main effect of reading conditions on the BSQ total score emerged, $B = 12.264, p < .001,$
5 $95\% \text{ CI } [3.90, 20.62],$ regardless of the age group, indicating both that older and young adults in
6 positive conditions reported better overall sleep quality compared with those in the neutral
7 conditions. The main effects of the condition also emerged for the BSQ subscales of Bedtime, $B =$
8 $5.756, p < .001, 95\% \text{ CI } [1.12, 10.39],$ and Wake Time, $B = 4.171, p < .001, 95\% \text{ CI } [1.44, 6.91],$
9 independently of the age groups. Both older and young adults in the positive condition reported
10 feelings of greater ease in falling asleep and being well rested in the morning than those in the
11 neutral condition (Figure 2). No age x condition interaction emerged.

12 The same pattern of findings emerged when we added the differences in the participants'
13 ratings between pre- and postemotional induction as covariates (Supplementary Material, Table 6S).

14
15 [Insert Figure 2 here]

16
17 ***Presleep mood (valence and arousal)***

18 At the baseline, the reading and control conditions did not differ in valence and arousal,
19 indicating the three groups did not report any differences in their mood before reading the stories or
20 carrying out their bedtime routines (Supplementary Material, Tables 7S and 8S; Figures 2S and 3S).
21 Although they did not differ in arousal, the age groups differed in valence, with the valence scores
22 across all conditions being lower in older adults than in young adults, $B = -0.850, p < .001, 95\% \text{ CI}$
23 $[-1.34, -0.36].$ No significant age x condition interactions emerged for valence and arousal.

24 Concerning the benefit indices on valence and arousal measured using the SAM between the
25 positive and neutral conditions for the two age groups, the results showed significant age x
26 condition interaction for the benefit index only on valence, $B = 0.624, p = .036, 95\% \text{ CI } [0.06,$

1 1.19], indicating that older adults in the positive condition reported higher valence scores after
2 reading positive stories than those in the neutral condition. No significant main effects of the
3 conditions or age on valence and arousal emerged.

4 In addition, young adults reported negligible mean changes in valence scores, $d = -0.10$, 95% CI
5 $[-0.72, 0.52]$. In contrast, older adults showed positive changes, albeit with a small effect size, $d =$
6 0.47 , 95% CI $[-0.16, 1.10]$, showing the latter had more benefits for valence than their younger
7 counterparts. Young adults showed larger differences in arousal scores than older people, $d = -0.43$,
8 95% CI $[-1.07, 0.19]$; $d = -0.30$, 95% CI $[-0.93, 0.32]$, respectively, suggesting that young adults
9 had more benefits for reduction of arousal level after reading positive stories.

10 In the neutral condition, both young and older adults reported negligible effects on valence
11 scores, $d = -0.21$, 95% CI $[-0.84, 0.41]$; $d = -0.17$, 95% CI $[-0.79, 0.45]$, respectively, whereas
12 older adults reported a larger reduction of their arousal levels, with a medium effect size on mean
13 changes, $d = -0.65$, 95% CI $[-1.39, -0.02]$, compared to young people, with small effect size, $d =$
14 -0.37 , 95% CI $[-1.00, 0.25]$.

15

16 **Discussion**

17 This study examined age-related differences between young and older adults without sleep
18 disorders (e.g., insomnia) or other clinically relevant issues (e.g., depression or anxiety) in the
19 influence of reading at bedtime on perceived sleep quality. In particular, we newly assessed in a
20 naturalistic setting whether inducing positive emotions while reading short stories before falling
21 asleep could serve as a facilitator—compared to reading short neutral stories (the neutral condition)
22 or maintaining the usual sleep routine (the control condition)—in improving self-reported sleep
23 quality in young and older adults.

24 Our results, in line with the literature (Mander et al., 2017; Ohayon et al., 2017), showed
25 age-related differences in sleep latency and efficiency in favour of young adults. We found no
26 differences between the age groups regarding sleep duration (TST). This result is consistent with

1 studies showing that the effect of aging per se on subjective sleep quality is limited (Luca et al.,
2 2015; Sella et al., 2021), while it is in contrast with those showing shorter sleep duration, typically
3 measured with objective sleep measures (e.g., polysomnography), in older adults than in young and
4 middle-aged adults (Mander et al., 2017; Ohayon et al., 2017). However, we should note the
5 underlying chronic conditions and sleep disturbances that are more common in older age can
6 influence the subjective assessment of older adults' sleep (Luca et al., 2015; Sella et al., 2021). Our
7 participants did not report any diagnosed chronic health and/or sleep disorders (as measured by the
8 PSQI), which could explain the—apparently contrasting—results.

9 Noteworthy findings emerged when we analysed the effects of reading short stories
10 compared to maintaining the usual sleep routine on the considered sleep quality parameters. As for
11 SOL, older adults in both positive and neutral conditions reported reductions in the time needed to
12 fall asleep compared to young and older adults in the control condition, whereas young adults in
13 both reading conditions did not report any significant changes. These findings suggest that reading
14 at bedtime reduced the age-related differences in sleep latency observed in older adults in the
15 control condition, which is consistent with the recommendation of adopting a calming and light
16 activity for a good bedtime routine and sleep quality (Leblanc et al., 2015; Mindell et al., 2009). In
17 other words, reading seems to reduce sleep latency for older adults (making the falling asleep
18 process easier), independently of the positive or neutral emotional content of the bedtime stories,
19 whereas the young adults' abilities to fall asleep seem less influenced by reading before sleep. Our
20 findings extend the recommendations on reading for sleep hygiene, especially in older adults.

21 As for TST, older adults in the positive condition reported longer sleep duration than those
22 in the control and neutral conditions. Sleep duration increased in older adults after reading stories
23 that induced positive emotions at bedtime, compared to young adults whose sleep duration
24 apparently was not influenced by reading. Focusing on positive emotions before sleep could also
25 lead older adults to achieve a more positive mood and/or more efficiently manage perceived stress
26 by calming the mind before falling asleep. Other aspects—decreased stress hormones and

1 inflammatory markers (e.g., cortisol level), neurobiological processes (e.g., nocturnal heart rate and
2 serotonergic function), and emotional brain networks—may also be on the path to positive emotions
3 at bedtime and subsequent restorative and good sleep (Kahn et al., 2013; Ong, 2010; Ong et al.,
4 2017). Future studies should try to further identify and clarify the mechanisms underlying the
5 benefits of positive emotions for older adults' sleep duration.

6 As for SE, age-related differences in SE between young and older adults appeared clearly
7 under all conditions—regardless of the type of reading—in line with our expectations and the
8 literature (Ohayon et al., 2017). However, the reading conditions (positive and neutral) did not
9 differ in their effects on SE, and these results are not in line with our expectations for the reading
10 conditions (neutral and positive) to increase SE in both young and older adults compared to those in
11 the control condition. However, SE is the ratio of time spent asleep to time spent in bed because the
12 effects of reading may thus be limited to the early part of sleep at night. Reading short stories at
13 bedtime could have reduced the time needed to fall asleep, which, in turn, increased the time spent
14 sleeping (because the time typically spent struggling to fall asleep was spent sleeping). In other
15 words, the reading activity has a limited impact on the time spent in bed (i.e. the amount of time a
16 person spends in bed regardless of whether or not he/she is sleeping during that time). This could,
17 therefore, reflect the different effects of calming and relaxing activities before going to bed (e.g.
18 reading) on the following night's sleep architecture: reading short stories at bedtime seems to
19 improve the quantitative aspects of bedtime by reducing SOL and increasing TST, while their
20 influence diminishes during the night, including the time spent in bed (which includes the time
21 spent struggling when unable to fall back asleep in the middle of the night) until waketime in the
22 morning, thereby determining people's SE. This is mere speculation, and future studies should try
23 to clarify this conjecture by also including objective sleep measurements to thoroughly examine the
24 effects of reading short stories that induce emotions on other sleep characteristics during the night
25 (e.g., NREM–REM sleep cycles).

1 Interestingly, reading appeared to reduce the older adults' sleep latency, regardless of the
2 neutral or positive emotional content of the stories, whereas only positive emotions appeared to
3 improve the older adults' sleep duration. This pattern of results did not emerge for young adults.
4 This could be because young adults, without sleep disorders, typically have an easier time falling
5 asleep compared to older adults (as found here), and therefore, reading had more limited effects on
6 the SOL because young adults' sleep latency is facilitated by their age-related advantages in
7 biological and psychophysiological sleep processes compared to older people. Instead, the
8 discrepancy between young and older adults regarding the effects of positive emotions on sleep
9 duration could be explained by the greater propensity of the latter to prioritize well-being and shift
10 their motivation in maintenance and regulation of positive affect and well-being (in line with the
11 SST; Carstensen, 2006) and, in this case, the optimization and regulation of sleep duration in older
12 ages. These results suggest that there could be a cohort effect at play as well concerning the
13 different habits that older adults and younger ones might have. In particular, time spent on the
14 internet and the use of digital tools characterizes younger generations more than older ones
15 (Mokhtari et al., 2009; Toivonen, 2013). This might also mean that older adults, who are used to
16 reading, are more prone to experience reading at bedtime as a more pleasurable activity, compared
17 to younger adults. The latter, instead, are more prone to the use of digital devices that are known to
18 interact with daily activities, including sleep (Orzech et al., 2016). These differences in
19 habits/behaviors can also account for the impact that reading has on older adults compared to
20 younger adults in terms of calming and beneficial effects at bedtime.

21 However, our results also showed that older and younger adults in the positive condition had
22 greater self-reported sleep quality scores (e.g., fewer sleep disturbances, easier times falling asleep,
23 and satisfied wake times) than those in the neutral condition, according to our tailored
24 questionnaire. Furthermore, our data revealed that both young and older adults in the positive
25 condition also reported higher scores in the BSQ subscales of Bedtime and Wake Time, meaning
26 they had better bedtimes—that is, they found falling asleep to be easier and had ameliorated moods

1 before sleeping—and were more satisfied at waking up—that is, they felt rested and had positive
2 moods in the morning—compared to their counterparts in the neutral condition. These findings
3 confirm and extend previous evidence on overall self-reported sleep quality (Ong et al., 2017;
4 Steptoe et al., 2008) at bedtime and wake time in people without sleeping problems. In summary,
5 positive emotional states conditioned before sleep, using reading as in this study, could be
6 beneficial for promoting a feeling rested upon awakening and being generally satisfied with sleep,
7 which appears true for both young and older adults.

8 Interestingly, reading stories that elicit positive emotions had different effects on the sleep
9 of young adults compared to older adults because it improved only the young adults' self-reported
10 sleep quality but not their subjective sleep parameters. This discrepancy may be related to the sleep
11 variables we investigated. The subjective sleep parameters examined quantitative aspects of sleep
12 (SOL, TST, SE), which are not sensitive to changes in young adults. In contrast, self-reported sleep
13 quality resembles a broader perception of sleep experience that also includes feelings of restfulness
14 upon awakening or initiating and maintaining good and restful sleep (Buysse, 2014; Harvey et al.,
15 2008). Positive emotions broaden pleasant feeling states and good moods for one's well-being
16 (Fredrickson, 2013), and these benefits can also build an important aspect of quality of life, such as
17 the self-reported sleep quality experience in both young and old adults. Such a positive emotional
18 state experience might also favour the maintenance of adequate or improved sleep health in older
19 adults, in line with the SST (Carstensen, 2006), and this appears especially true for older adults'
20 sleep duration because this sleep aspect becomes impaired in aging. Future studies should further
21 examine the association between sleep and emotions by considering a subjective sleep assessment
22 that also includes the emotional experience of sleep quality (as examined here using a tailored
23 questionnaire).

24 Finally, our study also explored reading as a technique to facilitate and induce positive
25 emotional states at bedtime. Regarding the emotional induction in detail, young and older adults
26 displayed different emotional advantages after reading the stories at bedtime. After we controlled

1 for pre-emotional levels (the arousal and valence levels), older adults showed an increase in valence
2 levels (as measured with the SAM before and after reading the stories) but not in arousal levels
3 compared to younger adults, and this is even more evident because older adults started with lower
4 baseline scores compared to their younger counterparts. This is consistent with typical age-related
5 differences in the processing of emotionally valenced information, in which older adults tend to
6 prioritize and shift their attention and behaviour towards more positive emotions (as the SST
7 suggests; Carstensen, 2006) and report experiencing negative affect less frequently than young
8 adults (Burr et al., 2020; Reed et al., 2014). Our results so suggest older adults with induced
9 positive emotions before sleep are more sensitive to positively increasing their emotional states and
10 improving their moods. Therefore, reading with positive emotional content might be considered a
11 suitable technique for inducing positive modulation of the valence of emotions before falling asleep
12 at an older age.

13 We should mention some limitations here. Because emotions can influence different aspects
14 of sleep and to ensure a more accurate sleep assessment, future studies should include objective
15 sleep instruments (polysomnography, actigraphy) for recording both the macrostructure (e.g.,
16 sleep–wake cycles) and microstructure of sleep (e.g., slow wave activity). In addition, future studies
17 should also investigate age-related differences in whether emotions induced at bedtime could affect
18 sleep in older and young adults with sleep disorders and reduce the excessive sleep-related
19 cognitive and metacognitive activities at bedtime that characterize these individuals. As highlighted
20 by the present results, some recommendations and implications should also be considered. Among
21 them, to reduce pre-sleep worry and, more generally, to favor good sleep quality, our results suggest
22 engaging in calming activities before bed, such as creating a relaxing routine by spending time
23 reading (Stepansky & Wyatt, 2003). However, this reading activity should be done by avoiding
24 electronic devices, which are harmful to sleep quality before bedtime (Orzech et al., 2016). In
25 particular, following the evidence found in our study, incorporating a reading activity, and using
26 short stories that elicit positive emotions before going to sleep (e.g. choosing a book by your

1 favorite author or short stories that put you in a positive mood), seems to be especially useful.
2 However, it is notable that it could be difficult to find new and suitable positive stories to read
3 before going to bed each night. We recommend that additional studies should try to examine the
4 benefits of reading positive stories in varying frequencies during the week; this activity could be
5 integrated with other sleep hygiene practices (e.g. practicing other relaxing activities such as
6 meditation, paced breathing, or keeping a comfortable sleep environment), to create an ongoing and
7 combined process of positive reinforcement with different sleep promoting activities at bedtime.
8 Systematic education on sleep hygiene (Irish et al., 2015) and nonpharmacological sleep
9 interventions (Sella et al., 2022), were shown to have several advantages over pharmacotherapy
10 (e.g. benzodiazepines) due to the absence of side effects (dependence or tolerance effects). Instead,
11 the role of tolerance and habituation for reading activities on the sleep quality of habitual readers
12 remains unexplored. Future studies should collect more evidence on the positive effects of reading
13 before bed, including follow-up assessments to examine the long-term use and maintenance effects
14 of such an activity in inducing positive emotions on sleep. Finally, the complex interplay amongst
15 sleep-promoting factors, such as reading short stories with positive content at bedtime, should be
16 considered and included in the development and/or implementation of effective personalized
17 interventions to maximize sleep improvement.

18 Overall, our results suggest reading in an ecological context influences older adults'—but
19 not younger ones—sleep latency and duration: older adults who read short stories with positive or
20 neutral emotional content reduced the time needed to fall asleep, and older participants who read
21 stories with positive emotional content prolonged their sleep durations. Positive emotions seem to
22 serve as a facilitator for improving self-reported sleep quality in both young and older adults, along
23 with having better bedtimes and moods before falling asleep, waking up satisfied and rested in the
24 morning, and experiencing improved sleep quality after reading at bedtime. Future
25 nonpharmacological interventions and educational programs adopting sleep hygiene practices could
26 implement reading activities, also eliciting positive emotions, to improve specific aspects of sleep

- 1 quality and contrast some negative changes in sleeping patterns and sleep problems, especially in
- 2 older age.
- 3

1 Footnotes

2 1. We recruited 73 healthy individuals (age range: 21–86; $M = 57.08$, $SD = 21.09$) for a pilot study,
3 and they had to rate all 14 preselected stories to confirm their emotional valence as positive or
4 neutral. The stories were rated using the SAM. A one-way analysis of variance revealed that the
5 preselected positive and neutral stories differed in terms of valence, $F(1, 72) = 190.59$, $p < .001$, η_p^2
6 $= .157$ (Positive stories: $M = 6.70$, $SD = 1.41$; Neutral stories: $M = 5.47$, $SD = 1.41$), and arousal,
7 $F(1, 72) = 20.24$, $p < .001$, $\eta_p^2 = .019$ (positive stories: $M = 5.07$, $SD = 2.10$; neutral stories: $M =$
8 4.50 , $SD = 1.93$), confirming our selections.

9
10 2. Applying all coefficients in the models here, a power analysis showed an estimated sample of
11 18–20 in each group should be sufficient to obtain a power of .80, an effect size of .30, and a p
12 value less than .05 (using the R software’s *pwr* library). We aimed to gather as many participants as
13 possible within a limited time to maximize the power, resulting in a sample size of 139 participants
14 initially and 120 participants after exclusions.

15
16 3. A series of ANOVAs were run separately to check for differences among age groups and
17 conditions regarding education and gender. The results confirmed that young and older people did
18 not differ significantly in terms of years of education, $F_s(1, 118) < 1$, and gender, age group: $\chi^2(1,$
19 $120) = 0.000$, $p = 1.000$; condition: $\chi^2(2, 120) = 0.000$, $p = 1.000$ (Appendix, Table A1;
20 Supplementary Material, Table 2S).

21

22 **Acknowledgments:**

23 This work was carried out within the scope of the project “Use-inspired basic research”, for which
24 the Department of General Psychology of the University of Padova has been recognized as
25 “Dipartimento di Eccellenza” by the Ministry of University and Research.

1 The authors would like to thank VS for his valuable contribution, and for lending his beloved and
2 authorial pen to this research.

3

4 **Funding**

5 The authors received no funding from any external sources.

6

7 **Conflicts of interest**

8 The authors have no conflicts of interest to disclose.

References

- 1
2 Alexander, R., Aragón, O. R., Bookwala, J., Cherbuin, N., Gatt, J. M., Kahrilas, I. J., . . . Styliadis,
3 C. (2021). The neuroscience of positive emotions and affect: Implications for cultivating
4 happiness and wellbeing. *Neuroscience and Biobehavioral Reviews*, 121, 220-249.
5 <https://10.1016/j.neubiorev.2020.12.002>
- 6 Beck, A. T., Steer, R. A., Ball, R., & Ranieri, W. F. (1996). Comparison of beck depression
7 inventories IA and II in psychiatric outpatients. *Journal of Personality Assessment*, 67, 588–
8 597. https://doi.org/10.1207/s15327752jpa6703_13
- 9 Bradley, M. M., & Lang, P. J. (1994). Measuring emotion: the self-assessment manikin and the
10 semantic differential. *Journal of Behavior Therapy and Experimental Psychiatry*, 25(1), 49-
11 59. [https://doi.org/10.1016/0005-7916\(94\)90063-9](https://doi.org/10.1016/0005-7916(94)90063-9)
- 12 Burr, D. A., Castellon, J. J., Zald, D. H., & Samanez-Larkin, G. R. (2021). Emotion dynamics
13 across adulthood in everyday life: Older adults are more emotionally stable and better at
14 regulating desires. *Emotion*, 21(3), 453–464. <https://doi.org/10.1037/emo0000734>
- 15 Buysse, D. J., Reynolds III, C. F., Monk, T. H., Berman, S. R., & Kupfer, D. J. (1989). The
16 Pittsburgh Sleep Quality Index: a new instrument for psychiatric practice and
17 research. *Psychiatry Research*, 28(2), 193-213. [https://doi.org/10.1016/0165-
18 1781\(89\)90047-4](https://doi.org/10.1016/0165-1781(89)90047-4)
- 19 Carstensen, L. L. (2006). The influence of a sense of time on human development. *Science*,
20 312(5782), 1913-1915. <https://doi.org/10.1126/science.1127488>
- 21 Chida, Y., & Steptoe, A. (2008). Positive psychological well-being and mortality: a quantitative
22 review of prospective observational studies. *Psychosomatic medicine*, 70(7), 741-756.
23 <https://10.1097/PSY.0b013e31818105ba>
- 24 Dewald, J. F., Meijer, A. M., Oort, F. J., Kerkhof, G. A., & Bögels, S. M. (2010). The influence of
25 sleep quality, sleep duration and sleepiness on school performance in children and

1 adolescents: A meta-analytic review. *Sleep Medicine reviews*, 14(3), 179-189.
2 <https://doi.org/10.1016/j.smr.2009.10.004>

3 Emmons RA and McCullough ME (2003) Counting blessings versus burdens: An experimental
4 investigation of gratitude and subjective wellbeing in daily life. *Journal of Personality and*
5 *Social Psychology* 84(2): 377–389. <https://10.1037/0022-3514.84.2.377>

6 Fredrickson, B. L. (2013). Positive emotions broaden and build. In *Advances in experimental social*
7 *psychology* (Vol. 47, pp. 1-53). Academic Press.

8 Gallina, P., Saugo, M., Antoniazzi, M., Fortuna, P., Toffanin, R., Maggi, S., & Benetollo, P. (2006).
9 Validazione della Scheda per la Valutazione Multidimensionale dell'Anziano (SVAMA).
10 *Tendenze Nuove*, 6(3), 229–264.

11 Harvey, A. G., Stinson, K., Whitaker, K. L., Moskowitz, D., & Virk, H. (2008). The subjective
12 meaning of sleep quality: a comparison of individuals with and without
13 insomnia. *Sleep*, 31(3), 383-393. <https://doi.org/10.1093/sleep/31.3.383>

14 Hedges, L. V. (1981). Distribution theory for Glass's estimator of effect size and related
15 estimators. *journal of Educational Statistics*, 6(2), 107-128.
16 <https://doi.org/10.3102/10769986006002107>

17 Hughes, J. M., Song, Y., Fung, C. H., Dzierzewski, J. M., Mitchell, M. N., Jouldjian, S., Josephson,
18 K. R., Alessi, C. A., & Martin, J. L. (2018). Measuring sleep in vulnerable older adults: A
19 comparison of subjective and objective sleep measures. *Clinical Gerontologist*, 41(2), 145–
20 157. <https://doi.org/10.1080/07317115.2017.1408734>

21 Irish, L. A., Kline, C. E., Gunn, H. E., Buysse, D. J., & Hall, M. H. (2015). The role of sleep
22 hygiene in promoting public health: A review of empirical evidence. *Sleep Medicine*
23 *Reviews*, 22, 23–36. <https://doi.org/10.1016/j.smr.2014.10.001>

24 Jackowska, M., Brown, J., Ronaldson, A., & Steptoe, A. (2016). The impact of a brief gratitude
25 intervention on subjective well-being, biology and sleep. *Journal of health*
26 *psychology*, 21(10), 2207-2217. <https://doi.org/10.1177/1359105315572455>

- 1 Kalmbach, D. A., Pillai, V., Roth, T., & Drake, C. L. (2014). The interplay between daily affect and
2 sleep: A 2-week study of young women. *Journal of Sleep Research*, 23(6), 636-645.
3 <https://doi.org/10.1111/jsr.12190>
- 4 Kahn, M., Sheppes, G., & Sadeh, A. (2013). Sleep and emotions: bidirectional links and underlying
5 mechanisms. *International Journal of Psychophysiology*, 89(2), 218-228.
6 <https://doi.org/10.1016/j.ijpsycho.2013.05.010>
- 7 Kenealy, P. M. (1986). The Velten mood induction procedure: A methodological
8 review. *Motivation and Emotion*, 10(4), 315-335. <https://doi.org/10.1007/BF00992107>
- 9 Kim, E. J., & Dimsdale, J. E. (2007). The effect of psychosocial stress on sleep: a review of
10 polysomnographic evidence. *Behavioral Sleep Medicine*, 5(4), 256-278.
11 <https://doi.org/10.1080/15402000701557383>
- 12 Kučera, D., & Haviger, J. (2012). Using mood induction procedures in psychological
13 research. *Procedia-Social and Behavioral Sciences*, 69, 31-40.
14 <https://doi.org/10.1016/j.sbspro.2012.11.380>
- 15 Leblanc, M. F., Desjardins, S., & Desgagné, A. (2015). The relationship between sleep habits,
16 anxiety, and depression in the elderly. *Nature and Science of Sleep*, 7, 33.
17 <https://doi.org/10.2147/NSS.S77045>
- 18 Luca, G., Haba Rubio, J., Andries, D., Tobback, N., Vollenweider, P., Waeber, G., ... & Tafti, M.
19 (2015). Age and gender variations of sleep in subjects without sleep disorders. *Annals of*
20 *Medicine*, 47(6), 482-491. <https://doi.org/10.3109/07853890.2015.1074271>
- 21 Mander, B. A., Winer, J. R., & Walker, M. P. (2017). Sleep and human aging. *Neuron*, 94(1), 19-
22 36. <https://doi.org/10.1016/j.neuron.2017.02.004>
- 23 Mindell, J. A., Meltzer, L. J., Carskadon, M. A., & Chervin, R. D. (2009). Developmental aspects
24 of sleep hygiene: findings from the 2004 National Sleep Foundation Sleep in America
25 Poll. *Sleep Medicine*, 10(7), 771-779. <https://doi.org/10.1016/j.sleep.2008.07.016>

- 1 Mokhtari, K., Reichard, C. A., & Gardner, A. (2009). The impact of internet and television use on
2 the reading habits and practices of college students. *Journal of Adolescent & Adult*
3 *Literacy*, 52(7), 609-619. <https://doi.org/10.1598/JAAL.52.7.6>
- 4 Morin, C. M., Belleville, G., Bélanger, L., & Ivers, H. (2011). The Insomnia Severity Index:
5 psychometric indicators to detect insomnia cases and evaluate treatment
6 response. *Sleep*, 34(5), 601-608. <https://doi.org/10.1093/sleep/34.5.601>
- 7 Ohayon, M., Wickwire, E. M., Hirshkowitz, M., Albert, S. M., Avidan, A., Daly, F. J., ... &
8 Vitiello, M. V. (2017). National Sleep Foundation's sleep quality recommendations: first
9 report. *Sleep Health*, 3(1), 6-19. <https://doi.org/10.1016/j.sleh.2016.11.006>
- 10 Ong, A. D. (2010). Pathways linking positive emotion and health in later life. *Current Directions in*
11 *Psychological Science*, 19(6), 358-362. <https://doi.org/10.1177/0963721410388805>
- 12 Ong, A. D., Kim, S., Young, S., & Steptoe, A. (2017). Positive affect and sleep: A systematic
13 review. *Sleep Medicine Reviews*, 35, 21-32. <https://doi.org/10.1016/j.smrv.2016.07.006>
- 14 Orzech, K. M., Grandner, M. A., Roane, B. M., & Carskadon, M. A. (2016). Digital media use in
15 the 2 h before bedtime is associated with sleep variables in university students. *Computers*
16 *in Human Behavior*, 55, 43-50. <https://doi.org/10.1016/j.chb.2015.08.049>
- 17 Pressman, S. D., Jenkins, B. N., Kraft-Feil, T. L., Rasmussen, H., & Scheier, M. F. (2017). The
18 whole is not the sum of its parts: Specific types of positive affect influence sleep
19 differentially. *Emotion*, 17(5), 778. <https://doi.org/10.1037/emo0000256>
- 20 Reed, A. E., Chan, L., & Mikels, J. A. (2014). Meta-analysis of the age-related positivity effect: age
21 differences in preferences for positive over negative information. *Psychology and*
22 *aging*, 29(1), 1. <https://doi.org/10.1037/a0035194>
- 23 Schmidt, R. E., & Van der Linden, M. (2013). Feeling too regretful to fall asleep: Experimental
24 activation of regret delays sleep onset. *Cognitive Therapy and Research*, 37(4), 872-880.
25 <https://doi.org/10.1007/s10608-013-9532-5>

- 1 Sella, E., Cellini, N., Miola, L., Sarlo, M., & Borella, E. (2019). The influence of metacognitive
2 beliefs on sleeping difficulties in older adults. *Applied Psychology: Health and Well-
3 Being*, 11(1), 20-41. <https://doi.org/10.1111/aphw.12140>
- 4 Sella, E., & Borella, E. (2021). Strategies for controlling sleep-related intrusive thoughts, and
5 subjective and objective sleep quality: how self-reported poor and good sleepers
6 differ. *Aging & Mental Health*, 25(10), 1959-1966.
7 <https://doi.org/10.1080/13607863.2020.1783513>
- 8 Sella, E., Miola, L., Toffalini, E., & Borella, E. (2021). The relationship between sleep quality and
9 quality of life in aging: a systematic review and meta-analysis. *Health Psychology Review*,
10 1-23. <https://doi.org/10.1080/17437199.2021.1974309>
- 11 Sella, E., Toffalini, E., Canini, L., & Borella, E. (2022). Non-pharmacological interventions
12 targeting sleep quality in older adults: a systematic review and meta-analysis. *Aging &
13 Mental Health*, 1-15. <https://doi.org/10.1080/13607863.2022.2056879>
- 14 Spielberger, C. D. (2010). Test anxiety inventory. *The Corsini encyclopedia of psychology*, 1-1.
15 <https://doi.org/10.1002/9780470479216.corpsy0985>
- 16 Spira, A. P., Chen-Edinboro, L. P., Wu, M. N., & Yaffe, K. (2014). Impact of sleep on the risk of
17 cognitive decline and dementia. *Current Opinion in Psychiatry*, 27(6), 478.
18 <https://doi.org/10.1097/YCO.000000000000106>
- 19 Stepanski, E. J., & Wyatt, J. K. (2003). Use of sleep hygiene in the treatment of insomnia. *Sleep
20 Medicine Reviews*, 7(3), 215-225. <https://doi.org/10.1053/smr.2001.0246>
- 21 Steptoe, A., O'Donnell, K., Marmot, M., & Wardle, J. (2008). Positive affect, psychological well-
22 being, and good sleep. *Journal of Psychosomatic Research*, 64(4), 409-415.
23 <https://doi.org/10.1016/j.jpsychores.2007.11.008>
- 24 Toivonen, T. (2013). Cohorts and reading time on the basis of the Finnish time use data 1979-
25 2009. *Research on Finnish Society*, 6, 15-24. <https://doi.org/10.51815/fjsr.110716>

- 1 Vandekerckhove, M., Weiss, R., Schotte, C., Exadaktylos, V., Haex, B., Verbraecken, J., &
2 Cluydts, R. (2011). The role of presleep negative emotion in sleep
3 physiology. *Psychophysiology*, 48(12), 1738-1744. [https://doi.org/10.1111/j.1469-
5 8986.2011.01281.x](https://doi.org/10.1111/j.1469-
4 8986.2011.01281.x)
- 5 Velten Jr, E. (1968). A laboratory task for induction of mood states. *Behaviour research and
6 therapy*, 6(4), 473-482. [https://doi.org/10.1016/0005-7967\(68\)90028-4](https://doi.org/10.1016/0005-7967(68)90028-4)
- 7 Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of
8 positive and negative affect: the PANAS scales. *Journal of Personality and Social
9 Psychology*, 54(6), 1063. <https://doi.org/10.1037/0022-3514.54.6.1063>
- 10 Yesavage, J.A., Brink, T.L., Rose, T.L., Lum, O., Huang, V., Adey, M., et al. (1982). Development
11 and validation of a geriatric depression screening scale: A preliminary report. *Journal of
12 Psychiatric Research*, 17(1), 37–49. [https://doi.org/10.1016/0022-3956\(82\)90033-4](https://doi.org/10.1016/0022-3956(82)90033-4).

APPENDIX

Table A1. Descriptive statistics (mean and standard deviations) for the demographic characteristics, subjective sleeping difficulties, subjective sleep parameters, and emotion-related sleep quality by age group (young and older adults) and condition (control, neutral and positive)

Variable	Young adults						Older adults					
	Control		Condition		Positive		Control		Condition		Positive	
	<i>(n = 20)</i>		<i>(n = 20)</i>		<i>(n = 20)</i>		<i>(n = 20)</i>		<i>(n = 20)</i>		<i>(n = 20)</i>	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Age	24.20	3.97	24.65	4.87	24.25	4.54	69.60	3.69	69.70	3.52	69.30	3.35
Female (%)	50	-	50	-	50	-	50	-	50	-	50	-
Education	13.55	1.46	13.35	1.31	13.50	1.10	13.50	1.51	13.50	1.51	13.75	1.79
Subjective sleep difficulties												
PSQI	2.95	1.50	3.10	1.65	3.25	1.52	3.95	1.12	3.75	1.26	3.60	1.12
ISI	4.15	2.74	3.75	2.43	2.75	2.20	5.05	2.76	5.00	3.39	5.00	3.36
Subjective sleep parameters (sleep diary)												
TST (min)	472.20	60.27	458.02	70.29	463.63	57.95	452.79	46.42	450.42	55.01	478.47	51.46
SOL (min)	10.49	9.31	13.41	12.44	10.53	8.46	18.92	12.84	16.07	14.83	12.73	10.68
SE (%)	98.28	4.14	97.52	2.63	99.31	3.62	95.20	4.32	95.32	5.26	95.75	4.14
Emotion-related sleep quality (BSQ)												
BSQ total score	-	-	61.25	15.52	73.69	19.23	-	-	60.98	17.85	71.44	16.44
BSQ-Bedtime	-	-	31.33	9.25	37.24	11.45	-	-	30.81	11.93	36.80	9.19

BSQ-Wake time	-	-	16.46	5.79	20.72	6.31		-	-	16.21	4.79	18.37	6.62
---------------	---	---	-------	------	-------	------	--	---	---	-------	------	-------	------

Note. PSQI: Pittsburgh Sleep Quality Index; ISI = Insomnia Severity Index; TST: total sleeping time; SOL: sleep onset latency; SE: sleep

efficiency; BSQ = Bedtime Story Questionnaire.

FIGURES

Figure 1. Interaction between condition (control vs. neutral vs positive) and age group (young vs older adults) for (a) Sleep Onset Latency, (b) Total Sleep Time, and (c) Sleep Efficiency. The error bars represent 95% confidence intervals of the estimated means.

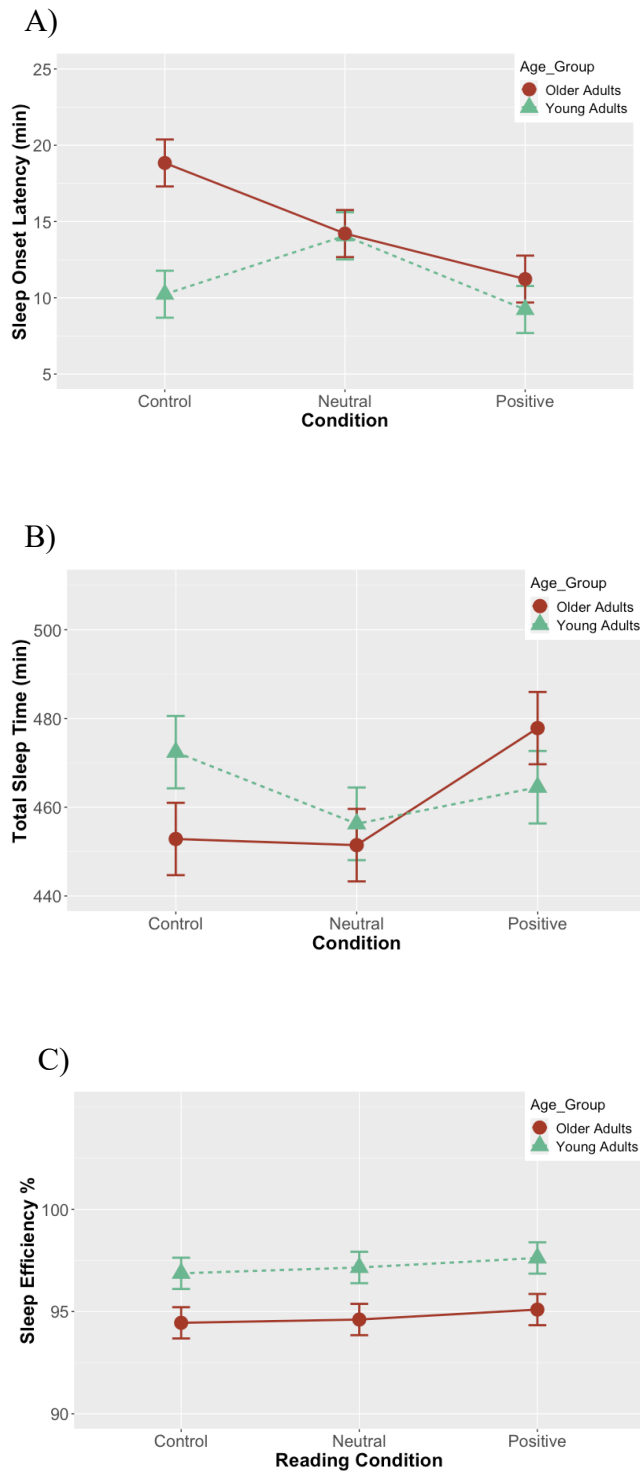
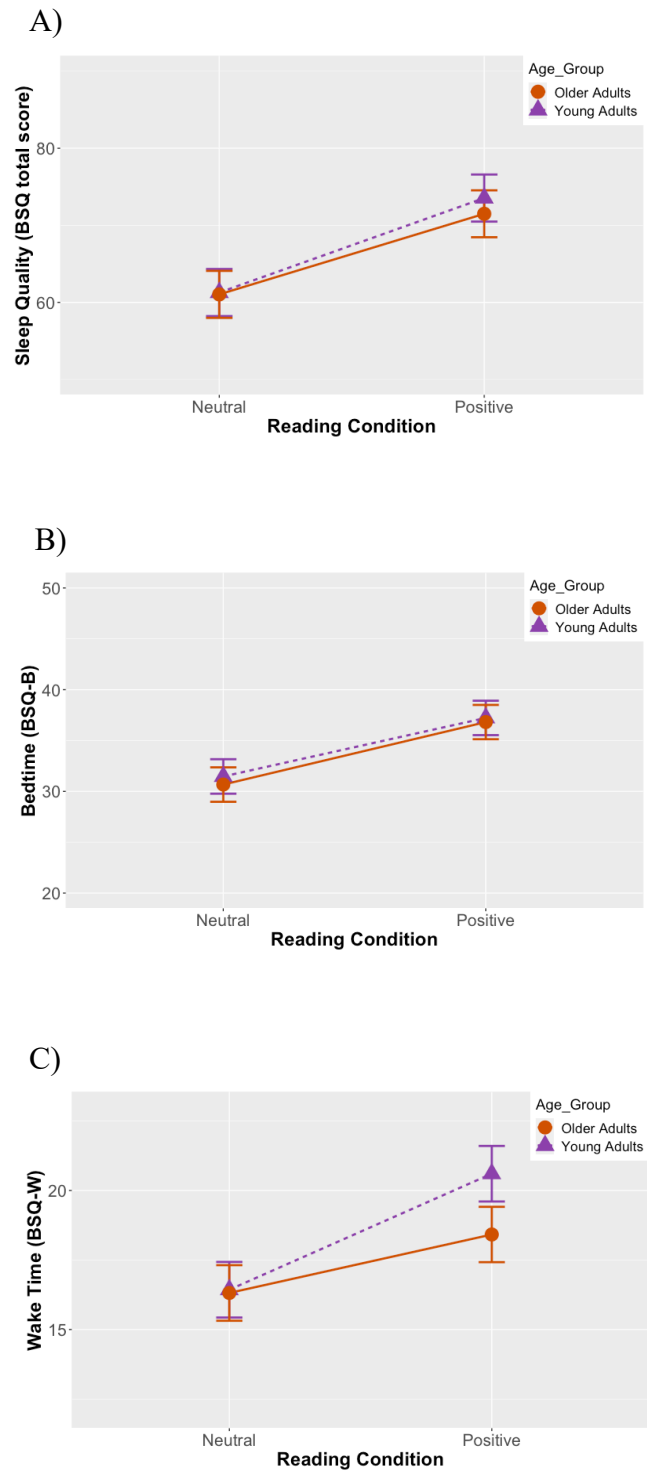


Figure 2. Interaction between condition (neutral vs. positive) and age group (young vs. older adults) for (a) Bedtime Story Questionnaire (BSQ) total score, (b) BSQ bedtime, and (c) BSQ wake time. The error bars represent 95% confidence intervals of the estimated means.



SUPPLEMENTARY MATERIAL

How emotions induced by reading influence sleep quality in young and older adults

Summary of the content:

PART 1 – Additional Tables

PART 2 - Additional Figures

PART 3 – Details of Bedtime Story Questionnaire (BSQ)

PART 1 – ADDITIONAL TABLES

Table 1S. Descriptive statistics of PANAS (positive and negative affect) and SAM (valence and arousal) as a function of age group (young and older adults) and condition (Control, Neutral, Positive).

	Young adults						Older adults					
	<i>Reading Condition</i>						<i>Reading Condition</i>					
	Control* (n=20)		Neutral (n=20)		Positive (n=20)		Control* (n=20)		Neutral (n=20)		Positive (n=20)	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
<i>PANAS-P</i>	33.15	5.22	31.40	5.93	32.45	4.22	30.70	5.07	31.00	4.82	31.85	4.40
<i>PANAS-N</i>	17.85	5.91	16.35	4.55	16.85	4.02	17.10	3.63	18.50	3.76	17.30	4.59
<i>PRE-READING</i>												
<i>SAM-V</i>	6.12	1.44	5.70	1.51	6.14	1.51	5.27	1.62	5.33	1.21	5.47	1.32
<i>SAM-A</i>	3.79	1.88	3.04	1.75	4.15	1.80	3.81	1.25	4.19	1.70	3.51	1.70
<i>POST-READING</i>												
<i>SAM-V</i>	-	-	5.41	1.13	6.00	1.29	-	-	5.11	1.31	6.12	1.41
<i>SAM-A</i>	-	-	2.47	1.23	3.41	1.55	-	-	3.11	1.55	3.05	1.26
<i>Benefit indexes</i>												
<i>SAM-V</i>	-	-	-.27	1.07	-.14	1.47	-	-	-.21	1.43	.65	1.09
<i>SAM-A</i>	-	-	-.57	1.50	-.74	2.05	-	-	-1.09	1.80	-.46	1.37

Note. PANAS-P= Positive and Negative Affective Scale-Positive score; PANAS-N= Positive and Negative Affective Scale-Negative score; SAM- V: SAM, Valence; SAM-A: SAM, Arousal.

*Since the control group did not read any bedtime stories, the SAM (valence and arousal) was only completed before going to bed.

Table 2S. Results of linear regressions on PANAS positive and negative scores.

<i>Dependent variable</i>	<i>Fixed effect</i>	<i>Est.</i>	<i>Std. Error</i>	<i>t-value</i>	<i>p</i>	<i>CI</i>	
PANAS, Positive	Intercept	31.950	.3847	83.053	<.001	[31.19; 32.71]	
	<i>Age Group</i>						
	Older vs young	-.900	.544	-1.654	.098	[-1.97; .17]	
	<i>Reading Condition</i>						
	Neutral	-.550	.544	-1.011	.312	[-1.62; .52]	
	Positive	-.150	.544	-.276	.783	[-1.22; .92]	
	<i>Age Group * Reading Condition</i>						
	Older adults vs Neutral	.500	.7694	.650	.516	[-1.01; 2.01]	
	Older adults vs Positive	.950	.769	1.235	.217	[-.56; 2.46]	
	PANAS, Negative	Intercept	17.850	.360	49.563	<.001	[17.14; 18.56]
<i>Age Group</i>							
Older vs young		-.350	.509	-.687	.492	[-1.35; .65]	
<i>Reading Condition</i>							
Neutral		-.600	.509	-1.178	.239	[-1.60; .40]	
Positive		-.750	.509	-1.473	.141	[-1.75; .25]	
<i>Age Group * Reading Condition</i>							
Older adults vs Neutral		.400	.720	.555	.579	[-1.01; 1.81]	

Older adults vs .550 .720 .764 .445 [-.86; 1.96]
Positive

Note. Condition=Positive vs Neutral vs Control; Age Group=Older adults vs Young adults; PANAS-P= Positive and Negative Affective Scale-Positive score; PANAS-N= Positive and Negative Affective Scale-Negative score.

Baseline category for Age Group was “young adults”. Baseline category for Reading Condition was “Control condition”.

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

Table 3S. Results of mixed-effects models on subjective sleep parameters (sleep diary) with valence and arousal (baseline) as a covariate.

<i>Dependent variable</i>	<i>Fixed effect</i>	<i>Est.</i>	<i>Std. Error</i>	<i>t-value</i> [^]	<i>p</i>	<i>CI</i>	
TST	Intercept	483.063	12.221	39.529	<.001	[459.29; 506.64]	
	<i>Age Group</i>						
	Older vs young adults	-19.567	11.557	-1.693	.093	[-41.79; 2.65]	
	<i>Reading Condition</i>						
	Neutral	-16.151	11.552	-1.398	.165	[-38.35; 6.07]	
	Positive	-7.899	11.510	-0.686	.494	[-30.03; 14.22]	
	<i>Age Group * Reading Condition</i>						
	Older adults vs Neutral	14.767	16.340	0.904	.368	[-16.67; 46.16]	
	Older adults vs Positive	32.888	16.290	2.019	.046*	[1.59; 64.22]	
	<i>Affective status (pre- emotional induction)</i>						
	Valence	-.222	1.340	-0.166	.869	[-2.86; 2.39]	
	Arousal	-2.506	1.325	-1.892	.059	[-5.05; .14]	
	SOL	Intercept	7.217	2.203	3.276	<.001	[2.94; 11.46]
<i>Age Group</i>							
Older vs young adults		8.604	2.181	3.944	.001	[4.41; 12.80]	
<i>Reading Condition</i>							
Neutral		3.826	2.180	1.755	.082	[-.37; 8.02]	
Positive		-1.003	2.174	1.755	.645	[-5.19; 3.18]	
<i>Age Group * Reading Condition</i>							
Older adults vs Neutral		-8.454	3.085	-2.741	.007	[-14.39; -2.53]	
Older adults vs Positive		-6.607	3.077	-2.147	<.001	[-12.52; .69]	
<i>Affective status (pre- emotional induction)</i>							
Valence		-.072	.231	-.313	.754	[-.52; .38]	
Arousal		.914	.232	3.943	<.001	[.46; 1.37]	
SE		Intercept	96.339	1.174	82.061	<.001	[94.04; 98.60]
	<i>Age Group</i>						
	Older vs young adults	-2.421	1.084	-2.232	.028	[-4.51; -0.33]	

<i>Reading Condition</i>					
Neutral	.286	1.084	.264	.792	[-1.80; 2.37]
Positive	.751	1.080	.696	.488	[-1.32; 2.83]
<i>Age Group * Reading Condition</i>					
Older adults vs Neutral	-.125	1.533	-.081	.935	[-4.89; 1.90]
Older adults vs Positive	-.103	1.528	-.067	.946	[-3.73; 2.93]
<i>Affective status (pre- emotional induction)</i>					
Valence	.247	0.131	1.884	.060	[-.01; .51]
Arousal	-.233	0.129	-1.807	.071	[-.48; .02]

Note. Condition= Positive vs Neutral vs Control; Age Group=Older adults vs Young adults; TIB= Time in Bed; TST= Total Sleep Time; SOL=Sleep Onset Latency; WASO=Wake After Sleep Onset; NAW= Number of Awakenings; SE= Sleep Efficiency. Baseline category for Age Group was “young adults”. Baseline category for Reading Condition was “Control condition”.

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

Table 4S. Results of planned contrasts for reading condition (neutral, positive) versus control condition on subjective sleep parameters (sleep diary) with –SAM– valence and arousal (baseline) as a covariate

<i>Dependent variable</i>	<i>Fixed effect</i>	<i>Est.</i>	<i>Std. Error</i>	<i>t-value</i> [^]	<i>p</i>	<i>CI</i>
	Intercept	482.931	12.293	39.285	<.001	[458.96; 506.79]
	Age Group					
	Old vs young adults	-19.464	11.751	-1.656	.100	[-42.25; 3.32]
	Reading Condition	-12.032	10.135	-1.187	.238	[-31.69; 7.62]
TST	<i>Age Group * Reading Condition</i>					
	Older adults vs Reading	23.824	14.333	1.662	.099	[-3.97; 51.62]
	<i>Affective status (pre- emotional induction)</i>					
	Valence	-0.103	1.341	-0.077	.939	[-2.73; 2.52]
	Arousal	-2.663	1.317	-2.022	.044*	[-5.22; -.05]
	Intercept	7.501	2.223	3.374	<.001	[3.175; 11.82]
	Age Group					
	Old vs young adults	8.583	2.226	3.855	.100	[4.26; 12.90]
	Reading Condition	1.3998	10.135	.728	.468	[-31.69; 7.62]
SOL	<i>Age Group * Reading Condition</i>					
	Older adults vs Reading	-7.513	2.718	-2.765	.007*	[-12.79; -2.24]
	<i>Affective status (pre- emotional induction)</i>					
	Valence	-.098	.231	-.421	.674	[-.55; .36]
	Arousal	.880	.231	3.812	.001*	[.43; 1.33]
	Intercept	96.302	1.1660	82.594	<.001	[94.02; 98.56]
	Age Group					
	Old vs young adults	-2.417	1.0767	-2.245	.026*	[-4.51; -0.33]
SE	Reading Condition	.5199	0.9281	0.560	.576	[-1.28; 2.32]
	<i>Age Group * Reading Condition</i>					
	Older adults vs Reading	-0.1160	1.3126	-0.088	.056	[-2.66; 2.43]
	<i>Affective status (pre- emotional induction)</i>					

Valence	0.2513	0.1311	1.917	.072	[-.01; .51]
Arousal	-0.2295	0.1271	-1.805	.930	[-.48; .02]

Note. Condition=Control vs Neutral vs Positive); Age Group=Older adults vs Young adults; TIB= Time in Bed; TST= Total Sleep Time; SOL=Sleep Onset Latency; WASO=Wake After Sleep Onset; NAW= Number of Awakenings; SE= Sleep Efficiency.

Baseline category for Age Group was “young adults”. Baseline category for Reading Condition was “Control condition”.

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

Table 5S. Results of planned contrasts for neutral versus positive condition on subjective sleep parameters (sleep diary) with –SAM– valence and arousal (baseline) as a covariate

<i>Dependent variable</i>	<i>Fixed effect</i>	<i>Est.</i>	<i>Std. Error</i>	<i>t-value</i> [^]	<i>p</i>	<i>CI</i>
	Intercept	466.076	13.750	33.895	<.001	[439.41; 492.72]
	Age Group					
	Older vs young adults	-5.183	12.416	-.417	.677	[-29.14; 18.76]
	Reading Condition	7.906	12.390	.638	.525	[-16.00; 31.80]
TST	<i>Age Group * Reading Condition</i>					
	Older adults vs Reading	18.692	17.560	1.065	.290	[-15.17; 52.58]
	<i>Affective status (pre- emotional induction)</i>					
	Valence	-.248	1.755	-.142	.887	[-3.72; 3.16]
	Arousal	-2.182	1.635	-1.334	.183	[-5.34; 1.09]
	Intercept	11.311	2.329	4.856	<.001	[6.77; 15.81]
	Age Group					
	Older vs young adults	.006	2.1152	0.003	.997	[-4.07; 4.09]
	Reading Condition	-4.890	2.110	-2.317	.023*	[-8.96; -.81]
SOL	<i>Age Group * Reading Condition</i>					
	Older adults vs Reading	1.985	2.992	.663	.509	[-3.79; 7.76]
	<i>Affective status (pre- emotional induction)</i>					
	Valence	-.168	.295	-.571	.568	[-.74; .41]
	Arousal	1.008	.276	3.649	<.001	[.47; 1.55]
	Intercept	97.09	1.225	79.236	<.001	[94.71; 99.46]
	Age Group					
	Older vs young adults	-2.718	1.066	-2.550	.012*	[-4.77; -.66]
	Reading Condition	.409	1.064	.385	.701	[-1.28; 2.32]
SE	<i>Age Group * Reading Condition</i>					
	Older adults vs Reading	.169	1.508	.112	.911	[-2.73; 3.08]
	<i>Affective status (pre- emotional induction)</i>					
	Valence	.109	.161	.681	.496	[-.20; .42]

Arousal -.127 .148 -.861 .390 [-.41; .16]

Note. Condition=Control vs Neutral vs Positive); Age Group=Older adults vs Young adults; TIB= Time in Bed; TST= Total Sleep Time; SOL=Sleep Onset Latency; WASO=Wake After Sleep Onset; NAW= Number of Awakenings; SE= Sleep Efficiency.

Baseline category for Age Group was “young adults”. Baseline category for Reading Condition was “Control condition”.

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

Table 6S. Results of mixed-effects models on BSQ (and its subscales) with valence and arousal (baseline) as a covariate.

<i>Dependent variable</i>	<i>Fixed effect</i>	<i>Est.</i>	<i>Std. Error</i>	<i>t-value[^]</i>	<i>p</i>	<i>CI</i>	
BSQ	Intercept	59.627	4.0782	14.621	<.001	[51.73; 67.53]	
	<i>Age Group</i>						
	Older vs young adults	-.236	4.335	-.055	.957	[-8.61; 8.13]	
	<i>Reading Condition</i>						
	Positive	12.264	4.330	2.833	.005	[3.90; 20.62]	
	<i>Age Group * Reading Condition</i>						
	Older adults vs Positive	-1.808	6.131	-0.295	.768	[-13.64; 10.03]	
	<i>Affective status (pre- emotional induction)</i>						
	Valence	.257	.443	0.580	.562	[-.62; 1.12]	
	Arousal	.052	.429	0.122	.903	[-.78; .91]	
Bedtime	Intercept	31.487	2.456	12.822	<.001	[26.73; 36.24]	
	<i>Age Group</i>						
	Older vs young adults	-.796	2.408	-.331	.742	[-5.44; 3.85]	
	<i>Reading Condition</i>						
	Positive	5.755	2.404	2.394	.019	[1.12; 10.39]	
	<i>Age Group * Reading Condition</i>						
	Older adults vs Positive	.389	3.405	.114	.909	[-6.18; 6.96]	
	<i>Affective status (pre- emotional induction)</i>						
	Valence	-.133	.292	-.453	.651	[-.71; .43]	
	Arousal	.196	.278	.705	.481	[-.34; .76]	
Waketime	Intercept	14.986	1.392	10.764	<.001	[12.30; 17.70]	
	<i>Age Group</i>						
	Older vs young adults	-.116	1.419	-.082	.935	[-2.86; 2.62]	
	<i>Reading Condition</i>						
	Positive	4.171	1.417	2.943	.004	[1.44; 6.91]	
	<i>Age Group * Reading Condition</i>						
	Older adults vs Positive	-2.068	2.007	-1.031	.305	[-5.94; 1.81]	
	<i>Affective status (pre- emotional induction)</i>						
	Valence	.071	.159	1.741	.082	[-.04; .58]	

Arousal -.153 .153 -.217 .828 [-.33; .27]

Note. Condition=Positive vs Neutral; Age Group=Older adults vs Young adults; BSQ=Bedtime Story Questionnaire. Baseline category for Age Group was “young adults”. Baseline category for Reading Condition was “Neutral condition”.

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

Table 7S. Results of mixed-effects models on presleep emotional states (valence and arousal) at baseline level.

<i>Dependent variable</i>	<i>Fixed effect</i>	<i>Est.</i>	<i>Std. Error</i>	<i>t-value</i>	<i>p</i>	<i>CI</i>
SAM, Valence	Intercept	-.276	.154	-1.786	.078	[-.57; .02]
	<i>Age Group</i>					
	Older vs young adults	.061	.218	.281	.779	[-.36; .48]
	<i>Reading Condition</i>					
	Positive vs Neutral	.133	.218	.609	.544	[-.29; .55]
	<i>Age Group * Reading Condition</i>					
	Older adults vs Positive	.732	.308	2.37	.020*	[.14; 1.33]
SAM, Arousal	Intercept	-.571	.235	-2.426	.018	[-1.02; -.11]
	<i>Age Group</i>					
	Older vs young adults	-.515	.332	-1.550	.125	[-1.16; .13]
	<i>Reading Condition</i>					
	Positive vs Neutral	-.172	.332	-.518	.606	[-.82; .47]
	<i>Age Group * Reading Condition</i>					
	Older adults vs Positive	.794	.470	1.689	.095	[-.11; 1.70]

Note. Condition=Positive vs Neutral; Age Group=Older adults vs Young adults. Baseline category for Age Group was “young adults”. Baseline category for Reading Condition was “Neutral condition”.

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

Table 8S. Results of mixed-effects models on benefit indexes for SAM valence and arousal.

<i>Dependent variable</i>	<i>Fixed effect</i>	<i>Est.</i>	<i>Std. Error</i>	<i>t-value</i>	<i>p</i>	<i>CI</i>
Benefit index - SAM, Valence	Intercept	2.710	.247	10.963	<.001	[2.22; 3.19]
	<i>Age Group</i>					
	Older vs young adults	-.174	.207	-.841	.403	[-.57; .22]
	<i>Reading Condition</i>					
	Positive vs Neutral	.340	.206	1.650	.103	[-.06; .74]
	<i>Age Group * Reading Condition</i>					
	Older adults vs Positive	.624	.292	2.133	.036	[.06; 1.19]
	<i>Affective status (pre- emotional induction)</i>					
	Valence	.033	.030	1.105	.270	[-.60; -.48]
	Arousal	-.542	.033	-16.332	<.001	[-.02; .09]
Benefit index - SAM, Arousal	Intercept	1.375	.288	4.772	<.001	[.81; 1.93]
	<i>Age Group</i>					
	Older vs young adults	.299	.230	1.304	.196	[-.14; .74]
	<i>Reading Condition</i>					
	Positive vs Neutral	.589	.229	2.571	.012	[.15; 1.03]
	<i>Age Group * Reading</i>					

<i>Condition</i>					
Older adults vs	-.443	.325	-1.365	.761	[-1.07; .18]
Positive					
<i>Affective status (pre- emotional induction)</i>					
Valence	.029	.040	.728	.467	[-.04; .11]
Arousal	-.695	.036	-19.511	<.001	[-.76; -.62]

Note. Condition=Positive vs Neutral; Age Group=Older adults vs Young adults. Baseline category for Age Group was “young adults”. Baseline category for Reading Condition was “Neutral condition”.

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

PART 2 – ADDITIONAL FIGURES

Figure 1S. Overview of the participant flow in each of the three conditions during the study

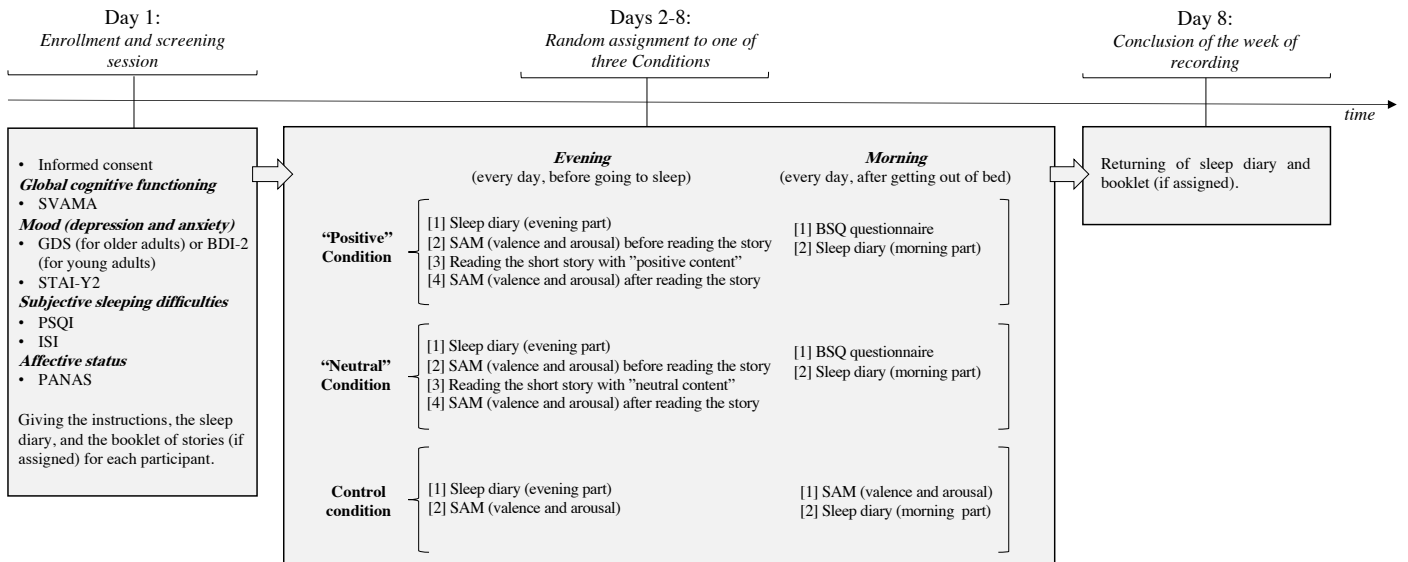


Figure 2S. Interaction between Reading Condition (Neutral vs Positive) x Age Group (Young vs Older Adults) for benefit index of SAM, Valence. The error bars represent 95% confidence intervals of the estimated means.

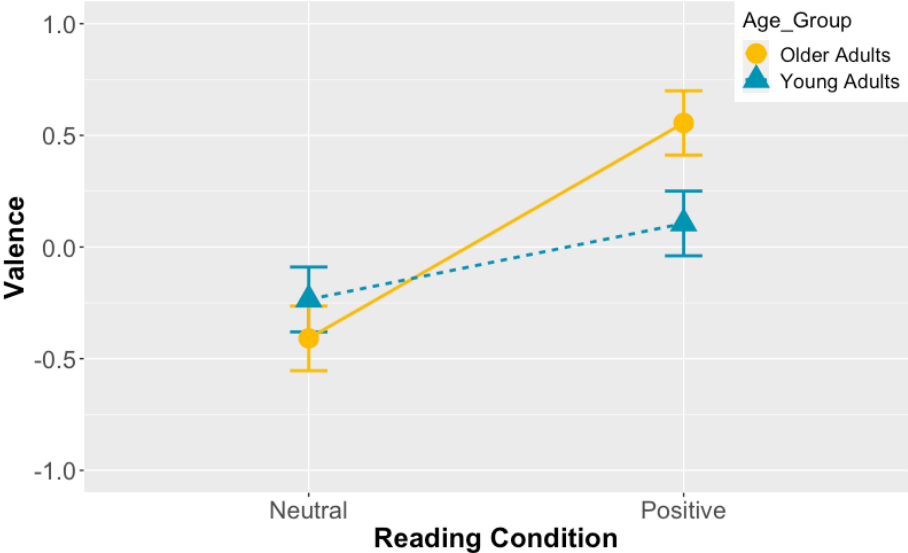


Figure 3S. Interaction between Reading Condition (Neutral vs Positive) x Age Group (Young vs Older Adults) for benefit index of SAM Arousal. The error bars represent 95% confidence intervals of the estimated means.

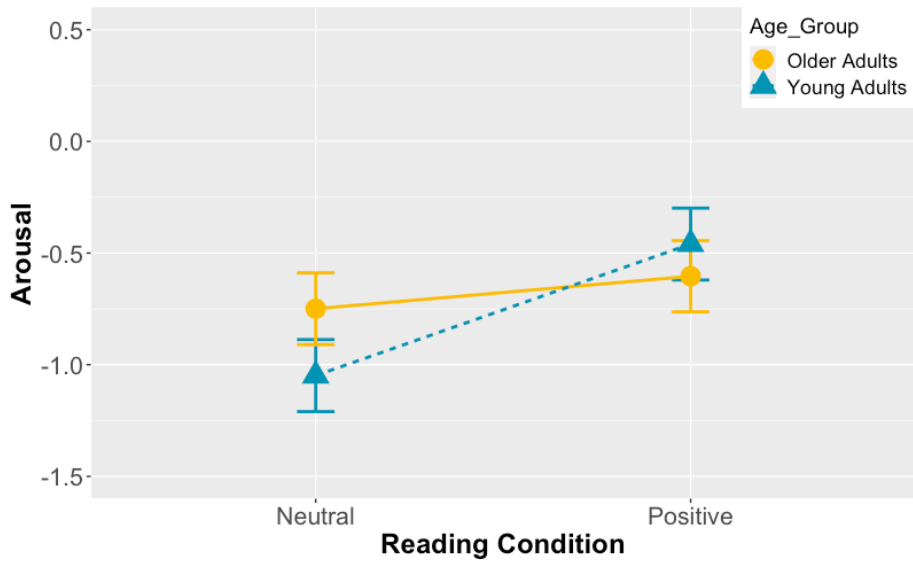


Figure 4S. Interaction between Reading Condition (Neutral vs Positive) x Age Group (Young vs Older Adults) for Sleep Onset Latency (SOL). The error bars represent 95% confidence intervals of the estimated means.

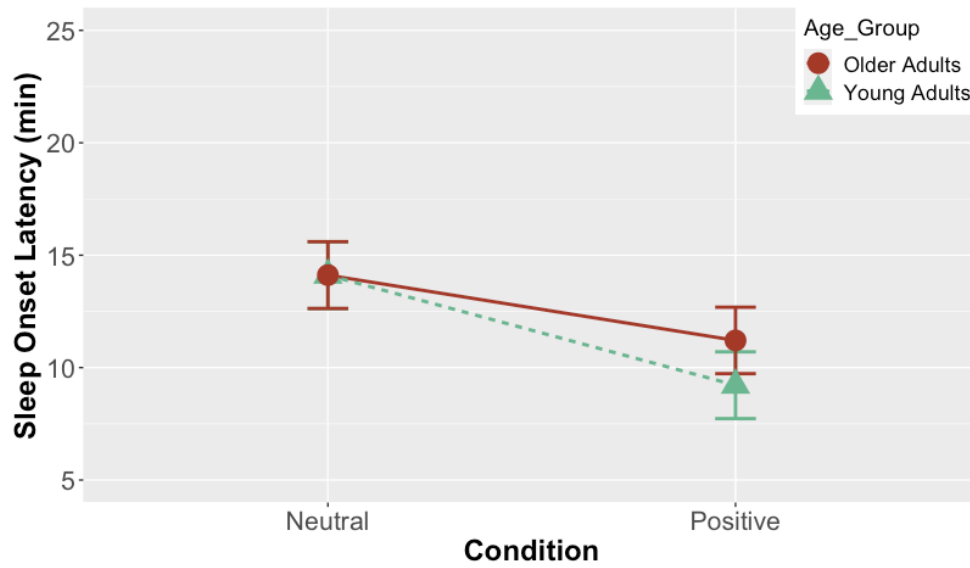


Figure 5S. Interaction between Reading Condition (Neutral vs Positive) x Age Group (Young vs Older Adults) for Total Sleep Time (TST). The error bars represent 95% confidence intervals of the estimated means.

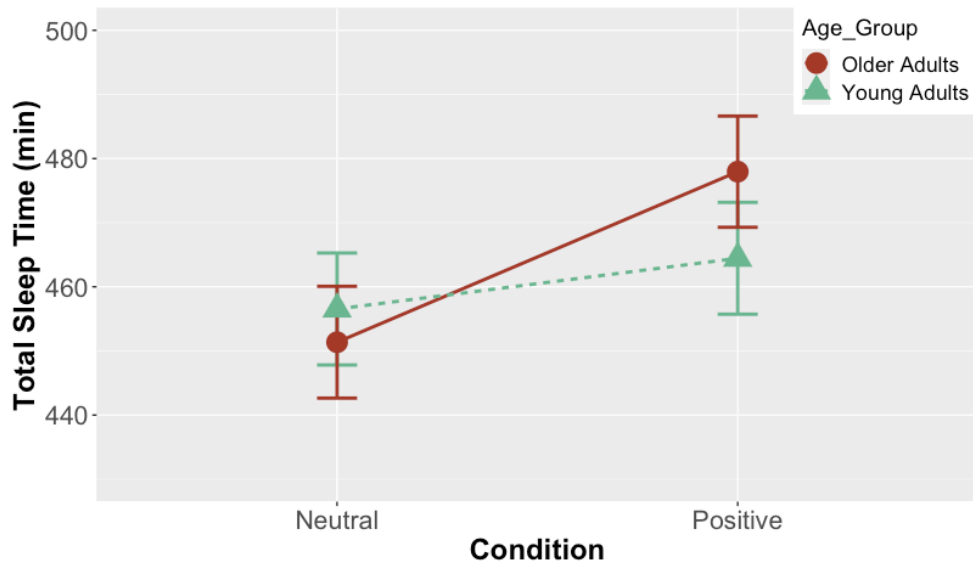
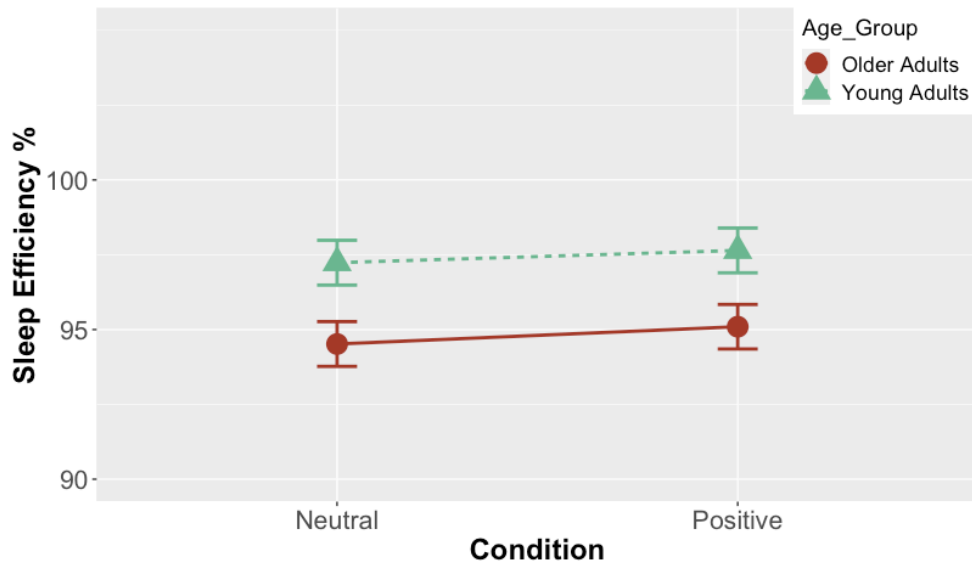


Figure 6S. Interaction between Condition (Neutral vs Positive) x Age Group (Young vs Older Adults) for Sleep Efficiency (SE). The error bars represent 95% confidence intervals of the estimated means.



PART 3 – DETAILS OF *BEDTIME STORY QUESTIONNAIRE (BSQ)*

3.1 Confirmatory factorial analysis

The Bedtime Story Questionnaire (BSQ) is an ad hoc questionnaire comprising 20 items to examine the influence of induced emotions by reading story at bedtime (named “emotional-related quality of bedtime”; 12 items), and waketime (named “emotional-related quality of waketime”; 4 items), and the interest/enjoyment of reading before going to bed (named “emotion-related content of the story”; 4 items). Before running the linear mixed effects (LME) model analyses, we decided to confirm the theoretically-driven structure of the BSQ using the confirmatory factor analysis (CFA) was used to examine the structural reliability of the three factors. This enabled us to validate the structural reliability of the three factors.

The CFA for BSQ included the scores for each participant in the two experimental groups (neutral and positive) obtained at the first BSQ on the first day of the experiment week. The goodness of the models’ fit to the data was assessed using multiple indexes: the comparative fit index (CFI); the non-normed fit index (NNFI); and the Root Mean Square Error of Approximation (RMSEA) (Schermelleh-Engel et al.; 2003). Modification indices were also calculated to explore the fit issue of poor fit indices and then to identify excessive correlated residual between items (local dependence). The results of the first CFA showed that the fit indices were not adequate (CFI= .82; NNFI= .79; RMSEA= .21). The modification indices of the CFA suggested the existence of severe cross-loadings (i.e. excessive correlated residuals) for six pairs of items (see Table 9S). Therefore, we decided to remove the following redundant items: 5, 6, 9, 11, 16. After removing the five redundant items and fitting the model again, the CFA fit indices were improved (CFI= .98; NNFI= .97; RMSEA= .10). The final version of BSQ is composed of 15 items.

Table 9S. Pairs of items with correlated residuals and relative modification indices (MI)

Item A	Item B	MI
Item 6: <i>Reading the story last night, before going to sleep ...</i> did not allow me to fall asleep easily	Item 11: <i>Reading the story last night, before going to sleep ...</i> made me sleep badly all night	97.062
Item 9: <i>Reading the story last night, before going to sleep ...</i> made me nervous	Item 16: <i>While I was reading the story last night, before going to sleep ...</i> I felt very tense/nervous	67.548
Item 6: <i>Reading the story last night, before going to sleep ...</i> did not allow me to fall asleep easily	Item 9: <i>Reading the story last night, before going to sleep ...</i> made me nervous	38.961
Item 11: <i>Reading the story last night, before going to sleep ...</i> made me sleep badly all night	Item 16: <i>While I was reading the story last night, before going to sleep ...</i> I felt very tense/nervous	34.063
Item 5: <i>Reading the story last night, before going to sleep ...</i> was truly enjoyable	Item 15: <i>While I was reading the story last night, before going to sleep ...</i> I was thinking about how interesting it was	29.258
Item 6: <i>Reading the story last night, before going to sleep ...</i> did not allow me to fall asleep easily	Item 20: <i>This morning, the reading of the story last night before going to sleep ...</i> did not allow me to wake up very rested	25.234

3.2 The Bedtime Story Questionnaire (BSQ)

INSTRUCTION

Referring to the story No# that you read last night before going to bed, indicate the extent you have felt this way this morning.

1	2	3	4	5	6	7	8	9
Strongly disagree				Neutral				Strongly agree

Reading the story last night, before going to sleep ...

1. allowed me to fall asleep easily
2. was uninteresting [R]
3. relaxed me
4. had no influence on my falling asleep [R]
5. was truly enjoyable¹
6. did not allow me to fall asleep easily [R]
7. had no influence whatsoever on my sleep throughout the night [R]
8. allowed me to sleep well throughout the night
9. made me nervous [R]
10. had a positive influence on my sleep throughout the night
11. made me sleep badly all night [R]
12. had a positive influence on my falling asleep

While I was reading the story last night, before going to sleep ...

13. I was thinking about how much I enjoyed reading it
14. I did not feel nervous while reading it
15. I was thinking about how interesting it was
16. I felt very tense/nervous [R]

This morning, the reading of the story last night before going to sleep ...

¹The gray font indicates items removed after CFA.

17. did not have any positive influence on my awakening [R]

18. allowed me to wake up very rested

19. had no influence on my awakening [R]

20. did not allow me to wake up very rested [R]

SCORING:

- Global BSQ score: Sum all items. Scores can range from 20 – 180. Higher scores representing greater subjective sleep quality related to reading the story.

Subdomains:

- Quality of emotional-related quality of bedtime= Sum of #1, #2, #3, #4, #5, #6, #7, #8, #9, #10, #11, and #12. Scores can range from 12 – 108, with higher scores representing greater bedtime quality related to reading the story.
- Emotion-related content of the story= Sum of #13, #14, #15, and #16. Scores can range from 4 – 36, with higher scores representing higher positive mood at bedtime related to reading the story.
- Emotional-related quality of waketime= Sum of #17, #18, #19, and #20. Scores can range from 4 – 36, with higher scores representing greater waking quality related to reading the story.

R: reverse score