Possible Sex Differences in the Wakeful Rest Effect

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Abstract

Prior work shows that a brief period of minimal interference, otherwise known as wakeful rest, has memory enhancing effects. A recent meta-analysis, Parra et. al (2026), observed large improvements in memory for older adults and patients, and, disappointingly, a smaller effect for young adults. Building off of the findings of this work and using existing data from our lab, we did a random-effects meta-regression to explore why. Specifically, we pooled 38 standardized mean differences, derived from 14 studies, to investigate the potential moderation effect of sex on the wakeful rest effect. The results show that rest was significantly beneficial for men, but not for women. Future work is needed to clarify why this pattern was observed.

Keywords: wakeful rest and memory; minimal-interference and memory; and post-encoding rest

Introduction

Considerable amounts of research have focused on understanding the wakeful rest effect since the finding that a short period of minimal interference is greatly beneficial to patients with anterograde amnesia (Cowan et al., 2004). The *wakeful rest effect* refers to a memory enhancement when people rest after learning compared to when they engage in some attention-demanding task. During the rest interval, people are not given instructions to attend to any form of stimuli or to perform any kind of task, but are instead asked to rest quietly. All studies included here required participants to rest in the lab, with no interactions with others, and no access to phones. Some studies, but not all, required participants to close their eyes during the entire interval. Experimenters also take care to provide a space with minimal interference (i.e., no noise, no screens, dim lighting, etc.). This is a period of reduced attention, where people typically engage in mind wandering. Mind wandering is characterized by thinking about the past, future, or imagining false situations and it is associated with better memory (Brokaw et al., 2016). The current study explored individual differences in wakeful rest; specifically, we explored how sex differences influence the wakeful rest effect.

All ages have been found to have better memory after resting; children, young adults, middle-aged adults, and older adults (Dewar et al., 2014; Martini et al., 2021; Mercer, 2015; Sacripante et al., 2019). Additionally, a short minimal-interference interval has been shown to reduce forgetting. This is the case even in people with anterograde amnesia, who are known to forget information as quickly as 60 s after learning (Cowan et al., 2005). This memory improvement has been observed to last up to eight days later.

Moreover, the wakeful rest effect has been observed with many different study materials. For instance, word lists, stories, maps, and photos are only some of the learning materials that have been used in studies of the effect (Cowan et al., 2004; Craig et al., 2016; Ellmore et al., 2016). These have been presented using both incidental and intentional encoding (Dewar et al., 2014).

To compare performance after a post-encoding rest interval, experimenters provide an interference interval, where people are asked to do a cognitively demanding task. Some of the interference tasks that have been used are psychometric tests, spot-the-difference, movies, social media use, and *n*-back tasks (Evans et al., 2021; Martini et al., 2020, 2021; Millar & Balota, 2018). The effect is also observed with both recall and recognition tests (Alber et al., 2014; Bao et al., 2024).

Importantly, the resulting memory benefit does not seem to be due to rehearsal of learning material during the rest period. Previous work has explored this issue and found that even when people are asked to learn information that is difficult to rehearse, such as scrambled words, maps, and faces, they still showed less forgetting than those who did not rest after learning. Many studies also ask people whether they rehearsed the information, and the majority report that they do not (Dewar et al. 2014).

An alternative explanation to the wakeful rest effect is that the interference condition leads to more forgetting, so that people in the rest period perform better in comparison. Thus, this account suggests that rest acts as a passive process. While it is certainly the case that the task done during the interference period likely does cause more forgetting of the just-learned materials, it is also the case that delaying interference also yields a reduction in forgetting. Dewar et al. (2009) asked participants to do a picture naming task immediately, 3-minutes, or 6-minutes after learning a list of words. There was also an unfilled 9-minute interval. They found that people remembered the word lists better simply by delaying interference. If the memory loss in the interference condition was due to the simple presence of an additional task, then the delay would not matter. However, if the wakeful rest benefit is due to an opportunity to consolidate the newly learned information, then it is understandable why a delayed interference task condition would yield better performance. Thus, overall, interference-related forgetting cannot solely explain the wakeful rest effect, and a more common consolidation account is favored.

Furthermore, there is evidence to suggest that rest is not a passive process. Instead, the idea that rest is beneficial for learning is often understood as a consolidation benefit. Specifically, the literature suggests that a short period of rest (about 10-minutes) allows the brain to reactivate the pattern of neural activity that was active at encoding. This has a consequence of strengthening the memory trace (Dudai,

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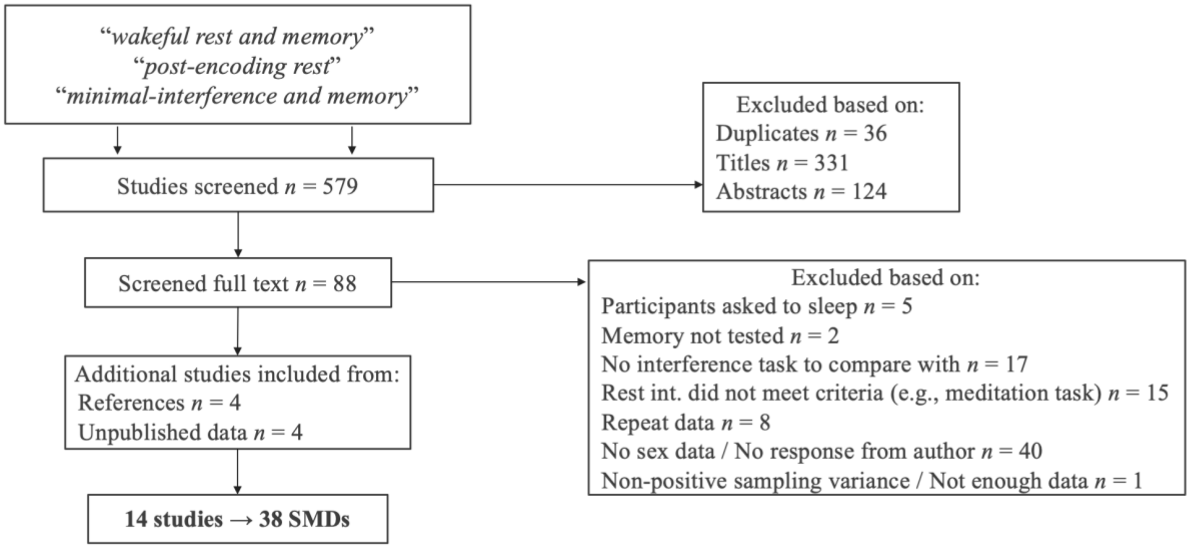

Figure 1: Literature search process.

2004). This neural reactivation is known as replay, and it has been observed during offline periods, including sleep and wakeful rest. Other mechanisms associated with memory consolidation, like reduced levels of acetylcholine and hippocampal sharp-wave ripples, may also be active during wakeful rest (Wamsley, 2022).

Critically, it should be noted that multiple studies have failed to observe an effect. To get a better handle on why the effect is sometimes observed, and sometimes not, an empirical survey of the literature was needed. In a recent meta-analysis, Parra et al. (2026) found large effects for patients with memory deficits, as well as for healthy older adults, but also found a much smaller effect size for younger adults. Thus, there is something about the younger adults in these studies that is mitigating the memory benefit from wakeful rest.

More recently, we did an exploratory data analysis from some recent work in our lab that generated a larger data set (Parra et al., unpublished #23-26). This exploration revealed a surprising sex difference in the effectiveness of post-encoding rest at reducing forgetting. This was unexpected because we had no clear *a priori* reason why this should be the case. To better understand whether this pattern was an anomalous outcome of the sample for that data set, or if it was reflective of a more general pattern, we did a planned, predictive analysis using data from previously published data sets. Thus, the current meta-regression aimed to explore this sex difference to assess its reliability.

Method

The current meta-analysis is an extension of work by Parra et al. (2026). All analyses were done using the same packages in R version 4.3.3 (R Core Team, 2024), namely; dmetar (v0.1.0; Harrer et al., 2019), meta (v7.0-0; Balduzzi et al., 2019), and metafor (v4.6.0; Viechtbauer, 2010).

The studies included here are a subset of those assessed in the earlier paper. For inclusion in the dataset, each study had to (a) investigate declarative memory in humans, (b) include a post-learning rest period, (c) as well as a post-learning interference condition, and (d) be published in English. For the current analysis, two additional inclusion criteria were used: (e) the sex of participants must have been available in the data and (f) the study needed to have recruited healthy young adults. Studies were further excluded if: there were task instructions during the minimal-interference period, including any tasks requiring attention or an instruction to sleep during the rest period.

As a starting point, we used those studies listed in two very recent meta-analyses on this subject (Parra et al., 2026; Weng et al., 2025), as well as a Google Scholar search for any manuscripts that have appeared in the year between when these were done and the present (2025-2026). Similarly, studies deemed relevant from incidental encounters were also included. Note that this approach yielded a set of declarative memory studies of the wakeful rest effect (Weng et al., 2025), although we did not separate qualitatively different participant subgroups. Thus, all of the major, relevant studies were captured. Finally, our lab had unpublished data from 4 experiments. These were included in the current dataset as well (Figure 1).

Data Extraction

The standardized mean difference was calculated between the post-rest and post-interference memory scores. Before standardizing the mean differences, we included the main measure of interest reported by the paper (i.e., some studies reported memory performance change between baseline and post-retention intervals, while others reported proportion change, or simply delay scores). As in Parra et al. (2026), we calculated Hedges' g (Hedges, 1981) for within- (g_w) and between- (g_b) subjects designs as shown below:

$$g_w = \frac{x_{rest} - x_{int}}{\sqrt{\frac{s_{rest}^2 + s_{int}^2}{2}}} \times (1 - \frac{3}{4(n_{rest}-1)-1})$$

$$g_b = \frac{x_{rest} - x_{int}}{\sqrt{\frac{(n_{rest}-1)\, s_{rest}^2 + (n_{int}-1)\, s_{int}^2}{(n_{rest}-1)+(n_{int}-1)}}} \times \left(1 - \frac{3}{4(n_{rest}+n_{int}-2)-1}\right).$$

Effect sizes were separated based on sex, so that two effect sizes were included (one for females and the other for males) for each comparison. For studies that compared performance in the rest period with multiple interference conditions, each effect size was computed relative to the rest period.

Meta-Regression

A moderator analysis was done to explore the effect of sex on the benefit of wakeful rest. The random-effects model was estimated using the restricted maximum likelihood (REML) method and the Knapp-Hartung adjustment was used (Knapp & Hartung, 2003; Viechtbauer, 2005).

Outliers & Influential Points To detect any outliers, we identified confidence intervals that did not overlap with the confidence interval of the pooled effect. Effect sizes were identified as influential points if they met one of three conditions:

(1) $\boldsymbol{DFFITS_k} > 3\sqrt{\frac{\mathbf{1}}{\boldsymbol{k-1}}}$,

(2) $\boldsymbol{D_k} > 0.45$, or

(3) $\boldsymbol{hat_k} > \mathbf{3}\frac{\mathbf{1}}{\boldsymbol{k}}$.

Results

Due to some small sample sizes ($n \leq 5$), the male effect sizes were removed from the King and Nicosia (2022) dataset, although the female effect sizes were kept. Similarly, people who identified as non-binary or another gender ($n < 10$), were excluded from the analysis. Again, this was done due to extremely small sample sizes which compromised our ability to derive meaningful statistics.

The compiled data in our corpus to date resulted in 14 studies and 38 effect sizes. One study investigated the effect in adults (i.e., didn't specify young adults, per se; Fatania & Mercer, 2017). We opted to keep the study with a broader age range (18-61 years), because the average age of the participants in that study is in line with the age range in our other younger adult studies (*M*age = 26.93, *SD* = 13.15). Descriptive statistics are shown in Tables 1 and 2; unpublished data were excluded from the calculation of average publication year. Note that some data may still be coming in from slow-to-respond authors.

Based on the data from our corpus, the overall effect of wakeful rest on memory, prior to the inclusion of sex, was marginally significant, $g = 0.10$ (*95%CI*: -0.01-0.21; $p = .07$). The estimated between-study heterogeneity was $\tau^2 = 0.03$ (*95%CI*: 0.01-0.16), with $I^2 = 40.1\%$ (*95%CI*: 11.5%-59.5%), indicating low to moderate heterogeneity. The prediction interval of the effect size ranged from $g = -0.26$ to 0.46. This suggests that negative intervention effects cannot be ruled out for future studies.

Table 1: Descriptive statistics for categorical variables.

		n
Design		
	within-	24
	between-	14
Learning material		
	word lists	14
	stories	12
	rating task	10
	paired associates	2
Immediate test		
	yes	28
	no	10
Interference task		
	spot-the-difference	8
	working memory	22
	declarative memory	4
	social media	2
	word search	2
Test type		
	free recall	8
	recognition	24
	cued recall	6

Table 2: Descriptive statistics for continuous variables.

	M (*SE*)	*Min*	*Max*
Publication year	2020 (0.6)	2016	2024
Rest (*min*)	11.3 (2.8)	5	30

Two effect sizes were identified as outliers, both of these involved female participants (Hudachek & Wamsley, 2024 #9; King & Nicosia, 2022 #28). After removing these effect sizes, the random-effects model was significant, $g = 0.15$ (*95%CI*: 0.07-0.22; $p = .0004$). The estimated between-study heterogeneity was reduced, $\tau^2 < .0001$ (*95%CI*: 0.00-0.03), with $I^2 = 0.0\%$ (*95%CI*: 0.0%-37.8%). Using the previously mentioned criteria, one influential point was identified (Hudachek & Wamsley, 2024 #9), which had also been identified as an outlier.

A test for subgroup differences suggested that there was a difference between the male and female effect sizes ($Q_{between} = 3.94$, $p = .047$). However, a Knapp-Hartung-adjusted meta-regression testing using sex as a moderator did not reach conventional levels of significance, $F(1,36) = 3.56$, $p = .067$ (Figure 2), although it was trending in that direction. Sex was able to explain $R^2_* = 21.26\%$ of heterogeneity across the effect sizes. The estimated effect size for the females was quite small ($g = 0.02$; *95%CI*: -0.12-0.16; $p = .76$), while that of the males was, in comparison, much larger ($g = 0.22$; *95%CI*: 0.05-0.39; $p = .01$).

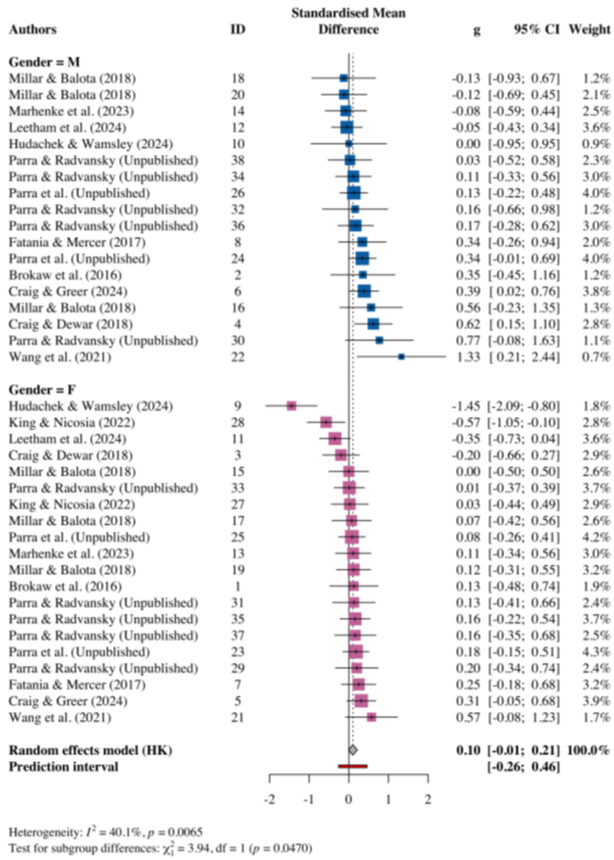

Figure 2: Forest plot with effect sizes separated by sex.

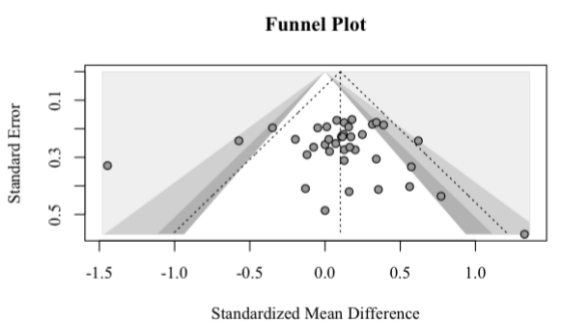

Figure 3: Funnel plot.

Egger's regression test was not significant for asymmetry ($\hat{\beta}_0 = 0.25$; $t = 0.32$; $p = .75$), suggesting that there was no evidence of a publication bias (Figure 3).

Discussion

This meta-regression explored sex differences in the wakeful rest effect. Evidence has already shown that there are quantitative differences in effect sizes across ages, as well as across amnesic vs. healthy populations (Parra et al., 2026). Thus, these are qualitatively different subsamples that should be treated, in some meaningful way, as separate. The effect was strongest for patients with memory deficits. That is, patients with amnesia showed the greatest benefit from a period of wakeful rest after learning. Moreover, while it was significantly smaller, it was still clearly present and very large for older adults.

However, in the face of these clear wakeful rest benefits for people with anterograde amnesia and older adults, there was a disappointingly smaller, but still significant, effect for healthy younger adults. The current study was done in an effort to explore whether sex might moderate the influence of rest on memory performance specifically in college-aged people.

To this end, we analyzed the available data from 14 studies, which yielded 38 standardized mean differences, with 20 of them representing female data. From this meta-regression, we found that a short period of rest was beneficial for performance for the men, but not for the women. Sex differences in cognitive tasks have been found before (Downing et al., 2008), although individual differences in many laboratory cognitive tasks are not common (Goldberg et al., 1977; Imbrosciano & Berlach, 2005).

The reason why wakeful rest may not be as beneficial for women is unclear at this time. There are a number of plausible causes. For example, it may be that women are less likely to be resting during the rest period. Instead, their thoughts go to those current concerns, such as the demands of homework, extracurricular activities, social relationships, and/or other personal responsibilities. Further, the majority of participants represented here are college students, who often need to balance demanding schedules. It is well-known that women suffer more from general anxiety (Altemus et al., 201). As such, it may be that college-aged women are more likely to engage in worry or goal-oriented thoughts during periods of time when their thoughts are not consumed by some other attention demanding task. These additional current concerns could interfere with the consolidation processes that are thought to be active during rest. Without these consolidation processes, there is no wakeful rest benefit.

It may be tempting to speculate that an influence of hormonal factors (e.g., menstrual cycle phase) exists and that this variability contributed to the pattern of results we observed. However, there is an abundance of research showing that cognitive abilities, including memory performance, do not vary across the menstrual cycle (Maki et al., 2002; Leeners et al., 2017; Sundström Poromaa & Gingnell, 2014; Philips & Sherwin, 1992; Hatta & Nagaya, 2009; Jang et al., 2025; Sommer, 1973; Gordon & Lee, 1993). Moreover, while cortisol levels do significantly impair memory (Het et al., 2005), this effect is not influenced by gonadal hormones associated with the menstrual cycle (Kuhlmann & Wolf, 2005).

These results clearly underscore the need to take into account, to some degree, individual differences when exploring general principles of cognition. Likewise, interventions should be tailored to characteristics of the individual. By not taking these into account, the presence of real cognitive phenomena can potentially be masked.

Our finding is striking given that so many cognitive phenomena tend to show very small or absent sex differences. Those sex differences that do appear may be a result of some societal bias, such as those of math performance (Benbow, 1988). However, with wakeful rest, it is unclear what, if any, societal or cultural bias there would be for our sample. Instead, it is possible that some factor other than potential state or general anxiety-related thoughts may be preventing consolidation processes to unfold.

Having said this, we readily acknowledge that these are simply suppositions at this point, and more research is needed to understand the cognitive and affective processes occurring during wakeful rest, as well as those that may interfere with the consolidation benefit, particularly in younger women.

While the current meta-analysis is the first to explore any sex differences in the wakeful rest effect, it should be kept in mind that there are a few potential limitations. One of these is that the current study, out of necessity, involved uneven sample sizes across studies ($M_F = 53.65$, $SE_F = 7.91$; $M_M = 41.28$, $SE_M = 9.27$). This is because the majority of studies recruited college students taking courses in Psychology, which is a female-dominated major.

In addition, the small sample sizes for the males in our corpus created a power issue from a limited set of available studies. Nonetheless, a wakeful rest effect was clearly found for men, but not for the women. That said, if anything, given the small sample sizes, one would expect the opposite, which is definitively not what we are seeing here.

Moreover, due to low sample sizes, there is some inconsistency in the results. For instance, the test for subgroup differences was significant, while the Knapp-Hartung-adjusted meta-regression did not yield a significant sex moderator. This inconsistency likely reflects the fact that the Knapp-Hartung adjustment applies a more conservative correction than the standard subgroup test. Despite not reaching conventional significance, however, the effect was marginal, and it may reach conventional levels of significance with the addition of more studies as they become available.

Related to this, another limitation was that many authors did not respond to requests for their data. There were about 40 additional studies, that otherwise met the criteria for inclusion into the dataset, but which we were not able to incorporate into our analysis. Although Egger's regression test was not significant for asymmetry (Figure 3), this presents an issue because of all the potentially available data that were not included.

Finally, although the estimated effect sizes differed between men and women, the observed effect is small. Thus, given the limitations, the results reported here should be considered preliminary and should be interpreted with caution. Empirical research is needed in order to draw conclusions about sex differences in wakeful rest effect.

Conclusion

In sum, the current study suggests that the wakeful rest effect is dependent on how different people experience the rest period itself; whether or not rest is beneficial to memory may rely on our ability to engage in mind wandering, for instance. The present work contributes to a deeper understanding of the wakeful rest effect. Notably, the pattern of performance of men, unlike that of women, more closely mirrored the pattern of data in the seminal studies of brain damaged patients. In contrast, the women appeared to show little to no benefit from a period of wakeful rest after new learning.

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