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No effect of napping on episodic foresight and prospective memory in kindergarten children

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Summary

Preschool children often have problems in remembering to carry out a planned behaviour. This study investigated the impact of napping on episodic foresight (planning for future events) and prospective memory (remembering to perform an action in the future) in 2–3-year-old children. In a quasi-experimental design, we compared children who napped (nap condition, $n = 20$) after receiving information about an upcoming problem (episodic foresight task) and a delayed intention (prospective memory task) with those who stayed awake (wake condition, $n = 43$). We hypothesised that napping would improve performance in the episodic foresight and the prospective memory tasks. Contrary to the hypothesis, napping did not significantly affect children's episodic foresight or prospective memory performance, even after controlling for the group difference in age. Task performance was primarily explained by memory effects and age. Further research that incorporates stricter controls and evaluates pre-nap memory strength is necessary fully to elucidate the complex interplay between napping, age, episodic foresight, and prospective memory performance in young children.

KEYWORDS
children, episodic foresight, naps, prospective memory, sleep-dependent memory consolidation

1 | INTRODUCTION

In everyday life, adults often think and act with foresight. This helps them to cope with upcoming challenges (e.g., studying for an exam) and to avoid impending dangers (e.g., changing winter tyres to avoid an accident in winter). Thinking and acting with foresight plays an essential role in planning, regulating emotions, and making decisions and is therefore a prerequisite for independent living. Young kindergarten children, on the other hand, still live in the here and now. In many situations, it remains difficult for them to imagine an upcoming event and to prepare for it accordingly (Hudson et al., 2011; Suddendorf et al., 2011). However, under certain conditions (e.g., high motivation) 2–3-year-old children can already show rudimentary forms of future thinking (e.g., Blankenship & Kibbe, 2022; Kamber et al., 2023; Ślusarczyk & Niedźwieńska, 2013). However, by the time children start school at the latest, they are expected to show a certain degree of independence. For example, they need to think about their school lunch, pack their school bag, check their notes on homework, or remember to take their gym bag with them. It is therefore crucial to develop prospective thinking and action skills in the kindergarten years.

Thinking and acting with foresight has many facets (Szpunar et al., 2014): two of the most important are episodic foresight and prospective memory. Episodic foresight involves the ability to place oneself into a concrete, upcoming situation, anticipate potential problems, and prepare to solve the problem before the problem actually exists (Suddendorf et al., 2011). In contrast, prospective memory is the ability to set one's mind to something and actually act on that intention when the right opportunity arises (Einstein & McDaniel, 1996). For both skills, that is, episodic foresight and prospective memory, crucial developmental steps take place in the kindergarten years (Hudson et al., 2011, for a review). According to most studies, 5-year-old children are already good at directing their current behaviour towards what they will need in an upcoming situation, or putting an intention into action at the right time (e.g., Atance et al., 2015; Walsh et al., 2014; see Hudson et al., 2011; McCormack & Hoerl, 2020 for a review). For 3-year-olds and younger children, this is only true to a lesser extent (Scarf et al., 2013; Wang et al., 2008). For example, 3-year-old children accurately selected an item to open a box later in time when the items were presented immediately after they realised that the box was locked, but not when the item presentation was delayed (Suddendorf et al., 2011). Further, 2-year-olds are much more likely to execute delayed intentions if the task involves an attractive reward and is embedded in a naturalistic task (rather than in a formalised multi-trial game without reward; Kliegel & Jäger, 2007; Ślusarczyk & Niedźwieńska, 2013). Thus, there are clear weaknesses in the future-readiness skills of 2- and 3-year-olds. To date, concrete evidence on how to positively influence the performance of 3- and 4-year-olds is scarce. Given the practical importance of future-oriented thinking, research on this question could provide novel arguments for stakeholders, kindergarten teachers, and parents when making decisions about napping in the daily routine.

An important prerequisite for acting proactively and prospectively is declarative memory, that is, the ability to remember concrete, past events (episodic memory), as well as facts and knowledge that are not tied to a specific situation (semantic memory; Einstein & McDaniel, 1996; Martin-Ordas et al., 2014). Imagine, for example, a child who is going on a long car trip the next day. The child will remember that the last trips were quite boring and that there usually are no toys available within the car. Based on those memories, the child will anticipate suffering from boredom and imagine how to avoid it (episodic foresight). The child may form an intention to take a book and stuffed animal on the trip. For the successful execution of that intention, the child has to remember when the trip will take place and what to pack for playing in the car (prospective memory). Empirical evidence indicates that younger children are less likely to remember the future problem (e.g., that a locked box with a reward is waiting for them at the future location) and they are less likely to retrieve the delayed intention at the appropriate time point in prospective memory tasks (e.g., packing the toys in a bag before leaving the house and entering the car). Those differences in remembering partly explain the lower performance of younger children in tasks measuring future-oriented cognition and action (e.g., Atance & Sommerville, 2014; Wang et al., 2008).

In contrast to the limited research on prospective thinking and action, well-established studies on declarative memory performance among adults and children indicate sleep to be a beneficial factor for remembering and potentially, episodic foresight, and prospective memory. Numerous studies conducted on adults demonstrate a positive impact of sleep on declarative memory performance in general (Rasch & Born, 2013). In declarative memory tasks, participants display enhanced performance when they sleep after learning, compared with staying awake (Diekelmann & Born, 2010, for a review). This phenomenon has been observed for overnight sleep (Plihal & Born, 1997) as well as for naps (e.g., Lahl et al., 2008; Tucker et al., 2006). Sleep seems not only to provide passive protection for recent memory formation, but actively aids its consolidation by reactivating the memory trace during deep sleep (Rasch et al., 2007).

Of particular interest with respect to the potential link between episodic foresight and prospective memory is the fact that information relevant for future action is consolidated during sleep (Wilhelm et al., 2011). Therefore, adult participants were more likely to recall a prospective goal after a 12-h delay if they slept during this period compared with those who stayed awake (Scullin & McDaniel, 2010). Furthermore, Diekelmann et al. (2013) demonstrated that all participants who slept for one night were able to remember to carry out a plan they had been previously informed of 2 days prior. This was only the case for 61% of participants in the wake group. Thus far, research has indicated that sleep reinforces memory in adults, in particular for recollecting information that is relevant for the future, thereby implying a correlation between sleep and episodic foresight or prospective memory. However, in a correlational study in adults, objective and subjective sleep quality did not predict episodic foresight outcomes (Demichelis et al., 2023). This result suggests that sleep quality may not be linked to episodic foresight, at least in healthy adult populations.

The substantial research on the impact of sleep on declarative memory in adulthood stands in contrast to the limited number of studies that investigated kindergarten-age children. Nevertheless, these studies have demonstrated a favourable effect of sleep on declarative memory in such young children overall (Axelsson et al., 2018; Esterline & Gómez, 2021; Kurdziel et al., 2013; Lokhandwala & Spencer 2021; Spanò et al., 2018; Williams & Horst, 2014). For instance, Williams and Horst (2014) found that a nap had a beneficial influence on the retention of newly learned words in a study involving 3-year-old children. Furthermore, 3–5-year-old children showed an improved performance in a memory game task after taking a nap, compared with when they stayed awake during the same period (Kurdziel et al., 2013). This beneficial effect of napping was particularly evident in children who had a habit of sleeping at midday (Esterline & Gómez, 2021; Kurdziel et al., 2013). However, it is uncertain whether the positive effects of napping extend to the recall of future-relevant information and translate into benefits for episodic foresight and prospective memory.

The present study aims to address this research gap by examining whether napping can enhance performance in episodic foresight and prospective memory tasks after the presentation of future-relevant information. We used a quasi-experimental design with 2–3-year-old children to investigate whether those who nap after encoding a problem and a delayed intention would prepare for the problem and would execute the intention at the appropriate time upon waking. We hypothesised that a greater proportion of children in the nap condition would exhibit better performance in the episodic foresight task compared with those in the wake condition. Furthermore, we anticipated that children in the nap condition would achieve significantly higher scores in the prospective memory task than their counterparts in the wake condition.

2 | METHOD

2.1 | Participants

The study comprised 2–3-year-old children who belonged to one of two groups: either a nap condition ($N = 20$; $n = 12$ females; $M_{age} = 3.03$ years; $SD = 0.37$; range 2.37–3.74 years) or a wake condition ($N = 43$; $n = 24$ females; $M_{age} = 3.43$ years; $SD = 0.38$; range 2.45–3.97 years). Ninety percent of the participating children had a German nationality. The children's mothers had a mean age of 35.7 years ($SD = 4.3$ years, $n = 60$ reporting) and were well-educated (16.9% secondary school diploma, 22% A-levels, 47.5% university degree, 13.6% PhD, $n = 59$ reporting). The children's fathers had a mean age of 37.2 years ($SD = 5.6$ years, $n = 57$ reporting) and were well-educated (3.4% no school diploma, 15.5% secondary school diploma, 20.7% A-levels, 46.6% university degree, 13.8% PhD, $n = 58$ reporting).

Only children who slept for at least 30 min within 4 h after encoding were included in the nap condition (see Gómez et al., 2006; Seehagen et al., 2015). Six additional children were tested but were not included in the final sample as the test did not take place because the child was picked up early ($n = 1$), for technical issues ($n = 2$), due to non-compliance with experimenter's instructions ($n = 1$), for having a language developmental delay according to the parents ($n = 1$), and for exceeding the age limit for the study ($n = 1$). Some children had missing data on one or multiple tasks. The sample size for each task is reported in the results section.

The study received approval from the Ethics Committee of the Psychology Department at Ruhr University Bochum and was conducted in accordance with the Declaration of Helsinki and the German Federal Data Protection Act. Nine kindergartens agreed to participate, and all parents gave written informed consent. Children received a small gift for participating.

2.2 | Design

Using a quasi-experimental design, a nap condition was compared with a wake control condition. In a questionnaire on children's napping habits (CSHQ; Owens et al., 2000), parents reported the frequency and duration of their child's napping during a typical week. If the child napped five times or more per week, they were classified as a habitual napper, as outlined by Kurdziel et al. Children classified as a habitual napper, were then assigned to either the nap condition (nap condition – habitual napper) or wake condition (wake condition – habitual napper). Children who were classified as a non-napper according to the questionnaire were allocated to the wake condition (wake condition – non-napper). The children in the nap condition took a nap after receiving information about an upcoming problem (episodic foresight) and about a delayed intention (prospective memory tasks), before the opportunity to solve the tasks after napping. The children in the wake condition stayed awake. For habitual nappers allocated to the wake condition (wake – habitual napper), they stayed awake in the morning outside their naptime. See Table 1 for the number of participants per condition.

2.3 | Material and procedure

The study was conducted in kindergartens in the Ruhr region, Germany. A combined task was used, consisting of an episodic foresight task (after Suddendorf et al., 2011) and a prospective memory task (after Causey & Bjorklund, 2014). This task was divided into two parts separated by a break during which the nap condition group slept and the wake condition group stayed awake. Figure 1 provides a schematic overview of the study design and procedure. The task setting comprised two tents placed next to each other in a room divided by a folding screen. Each tent had a sign indicating the tents' inhabitant (Elli the elephant and Fred the frog). A coloured buzzer fixed on the front of each tent served as a doorbell (see Figure 2). The break took place in another room.

2.3.1 | Part 1

For the assessment of episodic foresight, the children were informed that they would be playing in two tents that day. On the floor, outside of the tent, the experimenter presented a locked training box (red or yellow) with a triangle-shaped or a rectangle-shaped keyhole. The training box contained stickers. The experimenter said: "Look, that's the box. There's a hole in the front. Wow, there are sticker there. How do you get to the stickers? Open the lid. Hm… The box is locked. Oh, you need a key for that. Look at this. Here's the right key" [Experimenter showed the key]. The experimenter demonstrated to the child that the box could be unlocked using a plastic stick with the appropriate key. "Look, it works like this". [Experiment showed the locking mechanism and then gave the key to the child] "Try it out". The children were allowed to reach the stickers and received support from the experimenter if needed. Subsequently, the experimenter stored the training boxes outside and then proceeded to enter the "green frog tent" (Tent 1, see Figure 2) with the child. Inside the frog tent (Tent 1), the experimenter lifted up a cloth revealing a comparable box of a different colour (yellow or red) and with a different keyhole (triangle-shaped or a rectangle-shaped; "Test box" in Figure 2). The target box contained attractive toys such as figurines, cars, and stuffed animals. The experimenter notified the child that the key for the training box could not be used here and that the appropriate key was not in the frog tent, and therefore leaving the problem unresolved (upcoming problem for the episodic foresight task). The colour of the

TABLE 1 Number and mean age of participant in the allocated condition as a function of habitual sleep status and time of episodic foresight and prospective memory test (Part 2).

Condition	Habitual nap status	Time of the break	Number of participants	Mean age (SD)
Nap	Napper	Noon	20	3.03 (0.37)
Wake	No-napper	Morning	21	3.56 (0.30)
Wake	Napper	Morning	6	2.83 (0.22)
Wake	No-napper	Noon	16	3.44 (0.30)

Note: During the break, infants from the nap condition slept and infants from the wake conditions stayed awake. Episodic foresight and prospective memory performance were tested after the break.

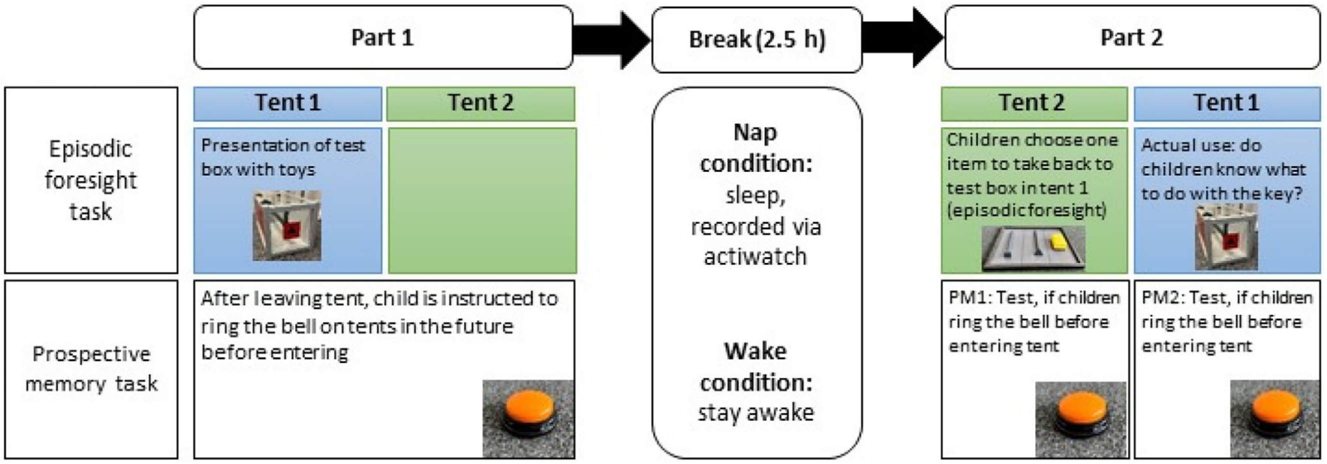

FIGURE 1 Schematic overview on design and procedures as a function of experimental condition.

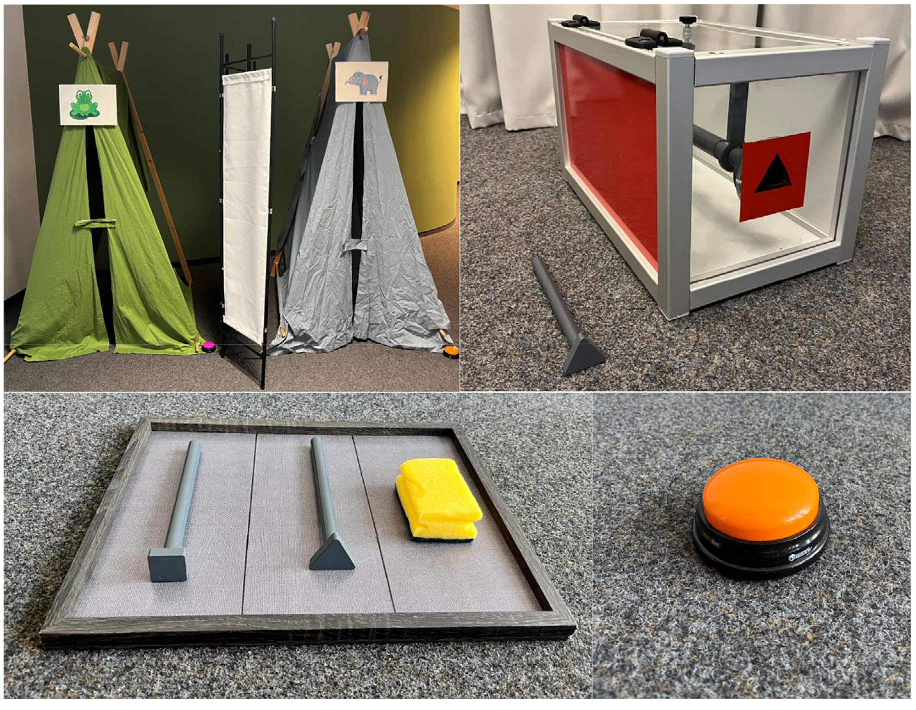

FIGURE 2 Upper row: Left: Picture of the green frog tent and the blue elephant tent. Right: Picture of the test box (50 × 31.5 × 30 cm) with triangular keyhole and a matching key (21.5 cm length, equilateral triangle with side length of 4.5 cm). The training box was identical, but its exterior was yellow instead of red with a rectangular key. Training and text box was counterbalanced across conditions. Lower row: Left: The three items the children could choose to take with them before entering the tent with the test box (incorrect key, target key, and distractor item; position counterbalanced). Right: The bell for the prospective memory task. There was one bell in front of each tent.

target box and the shape of the target key (rectangular or triangular) was counterbalanced between conditions. Then, the experimenter explained that children would have a break next before visiting the "elephant tent" and would finally return to the "frog tent". To assist the child's understanding, the procedure was visually represented on a timeline with corresponding illustrations. When leaving the frog tent, the experimenter appeared to remind them of something important and explained that there is rule when entering the tents. For the assessment of prospective memory, she instructed the children to ring the bell on the tents before entering, meaning that the children were to ring the bell before entering the elephant tent and before re-entering the frog tent (see Figure 2). These tasks required the children to execute an intention at the appropriate time (before entering the room) in the future (Walsh et al., 2014). For the break, the children left the room with the tents.

2.3.2 | Break

The break lasted for 2.5 h to facilitate lunch, rest, wake-up times, as well as an afternoon snack. The kindergarten provided activities for children who stayed awake during the break. For children who napped after lunch, the investigator attached a Micro Motionlogger Actiwatch (Ambulatory Monitoring, Inc., Ardsley, NY) onto their left wrist to determine whether the children were asleep during the break, as well as to record sleep duration and latency. Actiwatches record the vigour and frequency of movements. A validated algorithm developed by Sadeh et al. (1994) for adults and infants over 1 year was employed to calculate the minutes the children were asleep (Sadeh et al., 1994). After waking up, the children who had slept were given approximately half an hour before starting the second part of the test, in order to eliminate any potential effects of fatigue (Tassi & Muzet, 2000).

2.3.3 | Part 2

After the break, the child and the experimenter entered Tent 2 (the elephant tent). Here, the experimenter presented three items (a triangular training key, a rectangular target key, and a sponge, see Figure 2) without directly referring to the problem encountered in tent 1. The three items were exhibited side by side, and their order was counterbalanced among the children. "Look what great things I've got here. You can have a look at these now". After the child was allowed to inspect each item, the child was informed that they would return to the frog tent using the illustrated timeline. The child was then asked to choose on item to bring back to Tent 1: "Now we're going back to Fred in the frog tent. You can take one of these with you. Show me, which one do you need in Fred's tent?" Children exhibited episodic foresight when selecting the appropriate key to open the box. Children were given one point in the case when they correctly selected the appropriate key (correct future choice) and zero points if they selected the wrong key. Following this, the experimenter conducted a memory test with respect to the box with the toys by asking the child to say what was in Tent 1. Children's answer was counted as accurate if they mentioned the box or the content of the box. Children received one point for the correct answer and zero point for a wrong answer. Then, the experimenter and the child re-entered the frog tent. In the case when the children had chosen the wrong item, the experimenter presented the three items again in front of the locked box. Children were prompted to choose an item for opening the box. Children's choice indicated whether children are generally able to solve the problem without temporal displacement (i.e., knowledge present). For children who had chosen the correct item during item choice in the elephant tent before, the experimenter asked the children what they would do with the key. We analysed whether children applied the key to open the locked box. This estimated how many children may have actually selected the key for using it at the box (i.e., actual use). These two variables provided a manipulation check to examine whether children understood the task.

Prospective memory was credited if children rang the bell before entering the elephant tent (PM Task 1) and before re-entering the frog tent (PM Task 2): (a) spontaneously without help (3 points), (b) after a non-specific cue stimulus (2 points), or (c) after a specific cue provided by the experimenter (1 point). The total score for each prospective memory task ranged between 0 and 3 points. As there were two events (ringing Tent 1 and ringing Tent 2), there were two scores (PM1 and PM2).

2.4 | Data coding

The study was recorded on video with two cameras (video and audio). One rater coded the recorded videos offline. A second rater coded 20 videos independently to calculate the inter-rater reliability. The inter-rater reliability was perfect for episodic foresight ($\kappa = 1.0$), very good for memory test for the box ($\kappa = 0.90$) and prospective memory (PM1: $\kappa = 0.85$; PM2: $\kappa = 0.92$).

2.5 | Planned statistical analyses

The program R was used for statistical analyses. Preliminary analyses were conducted to test whether the two final groups differed regarding age and habitual nap status.

Given that the data were not normally distributed and the sample sizes in the nap and wake condition were unequal, we employed the more robust and conservative nonparametric tests. In the episodic foresight task, binomial tests were planned to determine whether children within one group selected the target key above chance (episodic foresight task; >33%). Subsequently, Fisher's exact test was planned to compare conditions with regard to the number of children who accomplished the task (chose the target key) and who remembered the problem (memory check; i.e., content of Tent 1). For the prospective memory task, Wilcoxon rank-sum tests were planned to compare conditions with regard to the total score in each prospective task.

3 | RESULTS

3.1 | Preliminary analyses

Children in the three wake control groups (see Table 1) did not perform differently on the episodic foresight task ($\chi^2 = 3$, $N = 43 = 0.20$, $p = 0.990$), or on the prospective memory tasks

TABLE 2 Correlations between age, habitual nap status (napper, non-napper), break duration, episodic foresight, memory test and prospective memory performance across conditions.

		Age	Habitual nap status	Break duration	Episodic foresight	Memory check	PM1	PM2
Age	r	1	**−0.642***	**−0.269***	0.080	−0.031	**0.401****	**0.587*****
	N		63	62	61	60	54	53
Habitual nap status	r		1	**0.356****	−0.181	−0.156	−0.147	**−0.317***
	N			62	61	60	54	53
Break duration	r			1	0.169	−0.010	**−0.314***	**−0.301***
	N				60	60	53	52
Episodic foresight	r				1	**0.327***	−0.021	0.032
	N					58	52	51
Memory check	r					1	0.051	0.038
	N						51	50
PM1	r						1	**0.561*****
	N							51
PM2	r							1
	N							

Note: In the case of dichotomous variables (i.e., habitual nap status, episodic foresight, memory check), point-biserial correlations were employed.
***$p < 0.001$; **$p < 0.01$; *$p < 0.05$ (in bold).

(Kruskal-Wallis-H = 1.80, $p = 0.407$; Kruskal-Wallis-H = 1.35, $p = 0.510$, respectively). As a result, they were combined into one group (wake condition, $n = 43$).

The break between the two parts of the task lasted on average 155 min (SD = 8.05) in the nap condition and 150 min (SD = 6.04) in the wake condition. The duration of the break differed significantly between conditions, $t(60) = 2.83$, $p = 0.006$, $d = 0.77$. According to the actiwatch device, children in the nap condition slept an average of 77.83 min during the midday period (SD = 22.81; range = 43–152 min, $n = 18$). The sleep latency (time from the end of Part 1 until the child fell asleep) was 63 min on average (SD = 14.5; range = 45–91 min, $n = 18$). Actiwatch data of two children could not be analysed due to technical difficulties. For these cases, the sleep logs by the kindergarten teachers were analysed. The children slept for 35 and 90 min.

There were significant differences between the conditions in the age and habitual nap status. In the current study, age was confounded with assignment to a condition, as the older children had a tendency to discontinue napping and were thus allocated to the wake condition. The mean age of the children was significantly lower in the final nap condition compared with the wake condition ($t[61] = -3.89$, $p < 0.001$, $d = -1.05$). Furthermore, more habitual nappers were included in the nap condition (all habitual nappers) compared to the wake condition (14% habitual nappers). See Table 2 for correlations between age, habitual nap status, episodic foresight, memory check, and PM1 and PM2.

To account for the influence of age, habitual nap status, and break duration on the relationship between the independent and dependent variables, residualisation was employed. Since age and habitual nap status, and break duration were highly intercorrelated, we only controlled for age. This technique involved regressing the dependent variable (future choice or PM) on the control variable (age) to create residual scores. The residuals represent the portion of the dependent variable's variance (future choice or PM) that is not explained by the control variable (age). Subsequently, as regression residuals are metrically scaled, Wilcoxon rank-sum tests were conducted using these residual scores resulting from residualisation procedures as the dependent variable.

3.2 | Napping and episodic foresight

As proxy for the younger children's general task understanding, we analysed (a) the proportion of 2-year-old children who chose the wrong item during item choice, but chose the target item during the present knowledge test afterwards, and (b) the proportion of 2-year-old children who chose the target during item choice and applied it to open the box afterwards. Only four out of the eleven 2-year-olds chose the wrong item during item choice. Half of them ($n = 2$; total sample: 85%) selected the correct key in front of the locked box and 50% ($n = 2$) did not (total overall: 15%). Seven out of the eleven 2-year-olds chose the correct item, all of them correctly applied the item to open the box (i.e., actual use, see Figure 1; $n = 1$ missing information; total sample: 78%).

The data analysis of episodic foresight included $n = 20$ children from the nap condition and $n = 41$ children from the wake condition. Fifty percent of the children in the nap condition and 71% of the children in the wake condition correctly selected the key to solve the problem (future choice). Initially, a binomial test was used to determine whether the children in each condition chose the correct key more frequently than expected by chance (i.e., >33%). The children in the nap condition did not select the correct key more often than

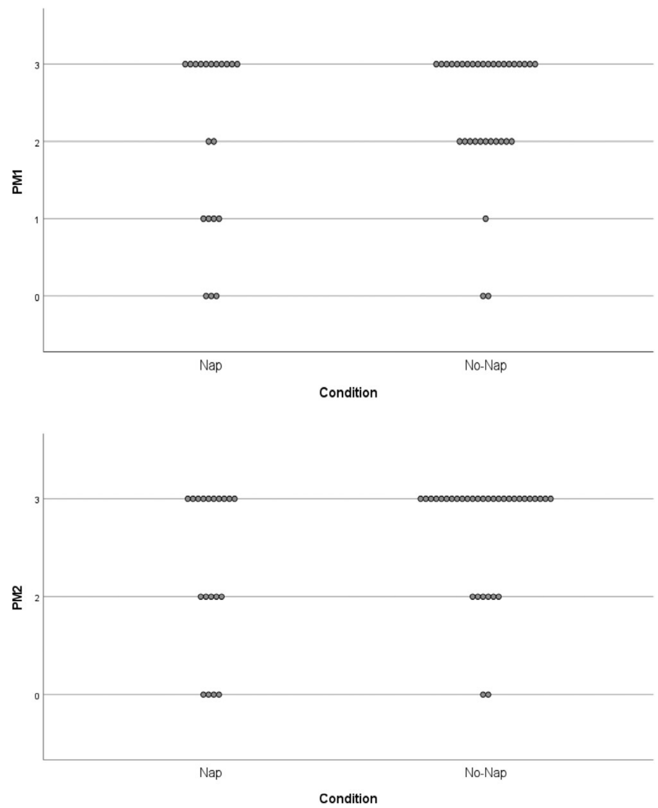

FIGURE 3 Scores for the prospective memory tasks (upper: PM1, lower: PM2) as a function of condition. Each circle represents one child.

expected by chance, $p = 0.087$. In contrast, children in the wake group selected the correct key more often than expected by chance, $p = 0.012$. Contrary to our expectations, there was no effect of napping on the choice of the correct key (Fisher's exact test: $p = 0.157$).

Data analysis for the memory test of the content of tent 1 had to exclude three children from the wake condition because the experimenter failed to ask the memory question, resulting in a sample of $n = 38$ children in the wake condition and $n = 20$ in the nap condition. Performance in the episodic future thinking task was positively related to the memory test of the content of the tent (Table 2). However, children from the wake condition (37%) did not significantly remember the box or the toys in Tent 1 more often than children from the nap condition (15%), Fisher's exact test: $p = 0.129$.

Because of the group differences in age, we repeated those analyses after extracting the variance explained by age (residualisation). Again, there were no significant differences in the likelihood to choose the correct key between condition, when considering group differences in age ($W = 437$, $p = 0.684$). However, when controlling for age, children in the wake condition were more likely to remember the content of Tent 1 (i.e., memory test) more often than children in the nap condition ($W = 188$, $p = 0.002$).

Within the nap condition, the nap duration recorded by actigraphy during the break did not correlate with item choice (point-biserial correlation $r = 0.293$, $p = 0.238$, $n = 18$) or memory test ($r = -0.158$, $p = 0.531$, $n = 18$). Nap latency was not associated with item choice (point-biserial correlation $r = -0.178$, $p = 0.481$, $n = 18$) or memory test (point-biserial correlation $r = 0.065$, $p = 0.797$, $n = 18$). Furthermore, across conditions, there was no correlation between the duration of the break and item choice or memory across conditions (Table 2).

3.3 | Napping and prospective memory

Figure 3 displays the score for the prospective memory task for each child as a function of condition. The data analysis for each prospective memory task included $n = 34$ in the wake condition. Nine children from the wake condition had to be excluded due to experimenter errors. For the nap condition, $n = 20$ children for PM1, and $n = 19$ children for PM2 could be included. One child from the nap condition had to be excluded for PM2 due to experimenter error.

There were no significant differences in the performance of children in the nap condition compared with those in the wake condition for both the first ($W = 294$, $p = 0.356$) and second ($W = 293$, $p = 0.058$) prospective memory tasks. Because of the group differences in age, we repeated those analyses after extracting the variance explained by age (residualisation). Wilcoxon rank-sum tests with residuals revealed no significant differences between the nap and the wake condition for PM1 and PM2 ($W = 369$, $p = 0.670$; $W = 376$, $p = 0.330$, respectively).

Within the nap condition, nap duration recorded by actigraphy in the nap condition did not correlate with prospective memory performance (PM1: $r = -0.139$, $p = 0.583$, $n = 18$; PM2: $r = -0.106$, $p = 0.687$, $n = 17$). However, nap latency was negatively correlated with performance in PM2 ($r = -0.505$, $p = 0.039$, $n = 17$). Likewise, the duration of the break negatively correlated with prospective memory performance across conditions: the longer the break, the less the children remembered to ring the bell in Tent 1 and Tent 2 (Table 2).

4 | DISCUSSION

This study is the first to examine the effects of napping on episodic foresight and prospective memory in kindergarten children using a quasi-experimental design. Contrary to expectations, napping did not significantly impact the children's ability to choose the correct tool for a future task (episodic foresight), or to remember to carry out a plan (prospective memory), even after controlling for age.

These results are at odds with the findings of established research in adults (Rasch & Born, 2013) which demonstrated that sleep improves episodic memory, as well as linking sleep to better remembering in children (e.g., Williams & Horst, 2014). Declarative memory has been suggested to represent the basis for episodic future thinking and evidence is cumulating that this assumption is also true in childhood (Atance & Jackson, 2009). This idea also aligns with our finding of a positive correlation between successful future thinking and remembering the content of the tent from the first part of the experiment. For example, Atance and Sommerville (2014) demonstrated that age-related changes in episodic foresight from 3- to 5-years-of-age can be attributed to better memory performance in older preschool children. The result also suggests that the ability to retain episodic memories is one limiting factor in foreseeing a future episode during early childhood.

With regard to prospective memory, our findings revealed no significant differences between the nap and wake conditions in either of the prospective memory tasks. However, age emerged as a significant predictor of performance in both tasks, indicating that older children were better at remembering to perform the intended actions. This is in line with previous research on the development of prospective memory in preschool children (Mahy et al., 2014). A previous large-scale study with a lifespan sample from middle childhood to late adulthood also found no effect of sleep on prospective memory (Occhionero et al., 2020). Rather, age emerged as the significant predictor for performance in prospective memory tasks (Occhionero et al., 2020). Furthermore, in the present study, the duration of the break and sleep latency were found to have a negative correlation with prospective memory performance in the second task. This highlights the challenges for children of maintaining the delayed intention over time, which is closely related to the phenomenon of interference. It is important to consider that remaining awake after learning can subject a newly acquired memory to interference or even forgetting before sleep sets in.

Given that future thinking functions differently from memory, it seems reasonable to conclude that sleep may not be a relevant factor in this context. This suggests that there is no clear advantage to sleep for future thinking in this age-group. However, since this is the first study examining the effect of napping on episodic foresight, more studies are needed to fully rule out the importance of sleep for prospective memory and episodic foresight in this age-group. The practical implications of our findings pertain to the practice of napping in day-care facilities, a topic that is frequently the subject of debate in parents and kindergarten teachers. The findings of this study indicate that it is inadvisable to attempt to induce sleep in children who have ceased to nap.

4.1 | Limitations and future directions

This study acknowledges several limitations that should be addressed in future research. Firstly, there are several confounding variables such as age and habitual nap status that are confounded with developmental status and sleep. To isolate the effect of napping on episodic foresight and prospective memory, future studies should incorporate age-matched control groups and randomly assign habitual sleepers to the sleep or wake condition. Alternatively, a within-subject design could be employed to assess the within-group effect of napping in sleepers. Prior research suggests that naps have the greatest impact on memory game performance in kindergarten children who habitually nap (Kurdziel et al., 2013). Therefore, future studies involving kindergarten children should implement rigorous control conditions such as self-matched or within-control conditions to disentangle the potential confounding effects of habitual nap status, age, developmental status, and testing time on task performance.

Secondly, the strength of the participants' memory of the encountered problem or the box in tent 1 prior to the break after Part 1 was not evaluated. It is possible that the nap had benefits that were not captured in the data, as well as changes within the nap group. In adults, the benefit of sleep seems to be most evident for pre–post tests and for night sleep compared with naps (see meta-analysis by Berres & Erdfelder, 2021). In a study by Wilhelm et al. (2012) it was demonstrated that in preschool-aged children, an intermediate pre-nap performance level results in the greatest gains in a motor skill task. Testing the pre-nap performance level would also allow for the exploration of the potential link between future thinking and memory in young children.

Lastly, there are feasibility considerations. The current study highlights the time-intensive nature and potential for high attrition rates associated with conducting extensive sleep studies in kindergarten and preschool-aged populations. Recently, Blankenship and Kibbe (2022) introduced a novel task for 2-year-olds that may be easier to use with 2-year-olds. That paradigm avoids spatial displacement, verbal instructions are accompanied by behavioural demonstrations, target actions are simple, and only one small apparatus is needed during the procedure. Future research could also consider implementing online, future-oriented paradigms or testing children during home visits or in the lab to enhance feasibility and participant retention (Schreiber et al., 2024).

5 | CONCLUSION

A midday nap did not positively affect children's episodic foresight abilities and prospective memory, even when controlling for confounding factors. Task performance was primarily explained by memory for the encountered problem and age. Further research that incorporates stricter controls and evaluates pre-nap memory strength is necessary to fully elucidate the complex interplay between napping, age, episodic foresight, and prospective memory performance in young children. A deeper understanding of these processes could inform strategies to optimise cognitive development during this critical period.

AUTHOR CONTRIBUTIONS

Carolin Konrad: Conceptualization; funding acquisition; writing – original draft; methodology; formal analysis; project administration. **Babett Voigt:** Conceptualization; funding acquisition; methodology; writing – review and editing; project administration.

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CONFLICT OF INTEREST STATEMENT

We have no known conflict of interest to disclose.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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