**Metamemory for Prospective Memory Performance in Younger and Older Adults:
Does the Reference Point Affect our Judgments?**

Chiara Scarampi¹² and Matthias Kliegel¹²³

¹Centre for the Interdisciplinary Study of Gerontology and Vulnerability (CIGEV),
University of Geneva, Geneva, Switzerland

²Swiss National Center of Competences in Research LIVES – Overcoming Vulnerability:
Life Course Perspectives, Geneva and Lausanne, Switzerland

³Department of Psychology, University of Geneva, Geneva, Switzerland

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Author Note

Chiara Scarampi <https://orcid.org/0000-0003-0152-1441>

Matthias Kliegel <https://orcid.org/0000-0002-2001-2522>

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Correspondence concerning this article should be addressed to Chiara Scarampi, Centre for the Interdisciplinary Study of Gerontology and Vulnerability (CIGEV), Boulevard du Pont-d'Arve 28, CH-1205 Genève, Switzerland. Email: chiara.scarampi@unige.ch

Abstract

The present study investigated age differences in the ability to predict prospective memory (PM) performance. A sample of younger ($N = 88$) and older ($N = 88$) participants completed an event-based PM task embedded in an ongoing task. Metamemory was measured by asking participants to predict their performance before completing the PM task and complete some questionnaires on self-perceptions of everyday memory ability. We manipulated A) the reference point used to evaluate performance and B) the order of presentation of the instruments. One group of participants predicted their upcoming performance with a general confidence rating (*performance* condition) whereas a different group predicted their performance in comparison to other people of their age (*peers* condition). The metamemory questionnaires were completed either at the beginning of the experimental session or after the PM task, in a counterbalanced order. In terms of performance, we did not observe age differences in PM. In terms of metamemory, younger and older participants were similarly underconfident in the *performance* condition and overconfident in the *peers* condition. Moreover, older adults reported significantly better PM abilities than younger adults, and participants generally reported more memory failures when the metamemory questionnaires were administered after the PM task and in the *performance* condition. These findings show that both younger and older adults have limited metacognitive insights, and point to reactive effects of metamemory to metacognitive reference point and order of administration of the instruments.

Keywords: aging, prospective memory, metacognition, confidence, peer comparison, metamemory

Metamemory for prospective memory performance in younger and older adults: Does the reference point affect our judgments?

Prospective memory (PM) is defined as the formation, maintenance, and delayed execution of intended actions at the appropriate time (Brandimonte et al., 1996; Einstein & McDaniel, 1990). Everyday examples of PM are remembering to take medication according to schedule or turning off the stove after cooking. Successful PM skills are crucial for the maintenance of independence and autonomy throughout the lifespan, and become especially important with advancing age, due to the increase in social and health-related PM demands, and the high risks associated with potential memory failures (Haas et al., 2020; Hering et al., 2018).

Prospective memory and aging

Over three decades of research into PM development in older age have shown a general decline in laboratory-based tasks (Ihle et al., 2013; Kliegel et al., 2008). However, closer inspection of the literature reveals high variability across findings. Whereas some studies found significant age-related declines PM performance (Koo et al., 2021; O'Connor et al., 2021), other studies suggested that PM ability does not decline with aging (Einstein & McDaniel, 1990).

This variability might be explained by age-related changes in the underlying cognitive processes. Previous studies have shown that working memory (Rose et al., 2010) and other aspects of executive function such as shifting (i.e., the capacity to switch attention from one task to another) and inhibition (i.e., the ability to refrain from performing a particular action, or to ignore distracting information; Schnitzspahn et al., 2013) can account for age differences in PM performance. Furthermore, greater age effects were found in tasks where the PM cue was not associated with the ongoing task, and thus requiring a higher degree of strategic monitoring (Kliegel et al., 2008; Mullet et al., 2013) and when there was a high

maintenance load (Ballhausen et al., 2017). In contrast, recent studies have shown that older adults can perform as well as their younger counterparts when ongoing task absorption is low (Schnitzspahn, Ihle, et al., 2011) and when the importance of the PM task is emphasized (Hering et al., 2013).

Another factor that influences age differences in PM is the setting in which the prospective task is performed. If younger adults often outperform older adults in laboratory settings, older participants tend to perform significantly better in naturalistic settings (Schnitzspahn et al., 2020; Schnitzspahn, Ihle, et al., 2011). This pattern of results is known in the literature as the “age-prospective memory paradox” (Rendell & Thomson, 1999).

The role of metacognition

Another relevant underlying mechanism that might explain age differences in PM performance is metacognition – i.e., beliefs and knowledge about cognitive processes, including the ability to monitor and control one’s own performance on a cognitive task (Metcalf & Shimamura, 1994; Nelson & Narens, 1990). Within the growing literature on PM, only very limited research has targeted metacognitive factors (see Kuhlmann, 2019, for a review), and even less has looked at how these processes change in older age.

Metacognition plays an important role in self-regulation of cognition and behavior. In the context of PM, metacognitive judgments on the likelihood of successful prospective remembering are particularly relevant as they may influence encoding strategies or decisions to rely on external memory aids. Previous studies have shown that individuals are more likely to set reminders when they have low confidence in their ability to fulfil delayed intentions, regardless of objective memory ability (Cherkaoui & Gilbert, 2017; Gilbert, 2015) and independently of whether they are instructed to use an offloading strategy or they spontaneously develop one (Boldt & Gilbert, 2019).

Nevertheless, previous studies have also shown that individuals have poor insight into their PM performance. Whereas some studies have documented a general level of overconfidence in individuals' prediction-performance ratio (Devolder et al., 1990), participants in other studies revealed substantial underconfidence in their predictions (Meeks et al., 2007; Schnitzspahn, Zeintl, et al., 2011). Furthermore, Rummel and colleagues (2013) found an overestimation of actual PM performance in a nonfocal PM task and underestimation in a focal PM task. Altogether these findings suggest that individuals use metacognitive beliefs about their own memory to choose the strategy they believe will lead to higher memory performance. However, biased beliefs (in terms of over or underconfidence) may prevent them from investing in the appropriate strategy.

Metacognition, prospective memory, and aging

Age-related memory changes are often accompanied by self-reported observations of this phenomenon. Older adults are aware that memory performance changes with aging (Hertzog & Hultsch, 2000) and manifest increasing memory complains and concerns (Hülür et al., 2015; Parisi et al., 2011). Negative conceptions about getting older can impact upon both older adults' objective performance (Zuber et al., 2019) and their confidence in their own memory abilities (Bouazzaoui et al., 2015; Fourquet et al., 2020).

If on the one hand older adults report concerns regarding their everyday memory abilities, on the other hand, these concerns do not align with metacognitive predictions provided for PM tasks. Indeed, not only can older adults outperform younger participants in naturalistic tasks, but they are also better at predicting their PM performance (Devolder et al., 1990). This result might be explained by older adults' lifelong experience in naturalistic PM tasks. Being highly familiar to them, older adults might be better able to evaluate their cognitive functioning in everyday PM tasks and select appropriate strategies to perform optimally.

In contrast to the literature on memory complaints in the elderly and the results on naturalistic PM, previous research has shown that in PM laboratory tasks older adults tend to initially overestimate their ability to remember information (Cauvin et al., 2019; Scarampi & Gilbert, 2021). Cauvin and colleagues (2019) administered an event-based PM task to a sample of younger and older adults and asked them to estimate their performance at the item-level. Younger adults provided fairly accurate estimations for the prospective component of PM (i.e., remembering that something has to be done), whereas older adults were overconfident. By contrast, for the retrospective component of PM (i.e., remembering what to do), young and older adults were equally accurate and slightly overconfident. In another experiment, Scarampi and Gilbert (2021) asked participants to remember delayed intentions for a brief period, manipulating the possibility of setting reminders to create an external cue. Although performance of the older group was significantly poorer than the younger group, older adults were overconfident in their memory abilities and did not fully compensate for impaired performance, even when strategic reminder-setting was permitted. These results suggest that older adults have biased metacognitive beliefs when asked to estimate their PM in laboratory-based tasks.

The current project aims to extend this line of research by investigating one of the possible mechanisms that guide metamemory and can explain these contradicting results. More precisely, the relationship between metacognition and PM performance may depend on the reference point used when estimating one's own memory. As speculated by Rabbitt and colleagues (1995), people cannot make absolute judgments about their own competence; they can only make relative judgments, for example, by comparing their current ability against that of others or against their memories of their own previous performance. A relevant study investigated the relationship between social comparisons and memory self-evaluations and found that older adults generally described having good memory abilities that were similar to

those of their peers (Robinson-Whelen & Kiecolt-Glaser, 1997). Accordingly, it seems plausible to hypothesize that when asked to rate their upcoming performance in comparison to their peers, older adults might be less overconfident than when asked to provide a general confidence rating.

Existing studies investigating perceived PM abilities measured with self-report questionnaires such as the Prospective and Retrospective Memory Questionnaire (PRMQ) and the short version of the Metacognitive Prospective Memory Inventory (MPMI-s) have found no age-related differences (Crawford et al., 2003) or small age variations (Rummel et al., 2019). However, Scarampi and Gilbert (2021) administered the MPMI-s at the end of a delayed-intention task and found that older adults reported higher PM abilities than their younger counterparts. This seems to suggest that metamemory can vary according to the methodology used to measure it and the order of presentation of the instruments. The current study conducted a systematic investigation of how confidence judgments change by manipulating the order of presentation of the instruments (*questionnaires* → *PM task* vs. *PM task* → *questionnaires*) and reference point used to provide metacognitive ratings (performance vs peers).

Aims of the current study

We evaluated the evidence for the hypothesis that 1) older adults would be overconfident when rating their upcoming PM performance, and this metacognitive bias would be stronger in the *performance* than in the *peers* condition. We also expected that 2) participants' metacognitive predictions would be more biased toward overconfidence when the PM task was administered before the metamemory questionnaires than after them and that 3) older adults' self-reported metamemory would be significantly lower than younger adults when the questionnaires were administered before the PM task, but significantly higher than younger adults when the questionnaires were administered after the PM task.

Method

Transparency and openness

Before commencing data collection, we preregistered our hypotheses, sample size (power calculation), experimental procedure, participant exclusion criteria, and analysis plan (<https://osf.io/64nb3/>). The data and the analysis code are available at Yareta (<https://yareta.unige.ch/#/home/detail/7f9f2517-0639-4651-9004-c891cac8f677>) whereas the research materials can be sampled at <https://app.gorilla.sc/openmaterials/266311> and can be freely cloned.

Participants

A total of 88 younger adults (age range 18-30, $M = 22.7$ years, $SD = 3.8$; 73 female) and 88 older adults (age range 65-80, $M = 69.6$ years, $SD = 4.1$; 39 female) were recruited from the Prolific website (<https://www.prolific.co>), an online platform in which participants receive payment for completion of web-based tasks.

A total of 75 participants were excluded and replaced as a result of the following pre-registered exclusion criteria (see the preregistration protocol for further information: <https://osf.io/64nb3/>): > 10 points at the PHQ-9 (43 participants); $\leq 40\%$ accuracy in the first block of the lexical decision task (2 further participants); > 3 median absolute deviation units (MAD; Leys et al., 2013) accuracy at the PM task (15 further participants). Finally, 15 additional participants were removed and replaced because they reported using external aids during the study, such as looking for an answer on the internet or writing things down.

Confirming the general comparability of the samples with traditional laboratory studies, in line with previous literature, the mean level of fluid intelligence (measured with the Digit Span Backward Task) was higher for younger adults than older adults ($t(1,165.92) = 2.50$, $p = .013$, $d = .38$), whereas the mean level of crystallized intelligence (measured with the Shipley Institute of Living Scale: Vocabulary) was higher for older adults than younger

adults ($t(1,169.65) = -8.83, p < .001, d = 1.33$).

Ethical approval was received from the Research Ethics Committee of the University of Geneva and participants provided informed consent before participating in the study.

Participation was restricted to native English speaker volunteers aged 18-30 years (younger adults) or 65+ years (older adults) with no history of major neurological and psychological conditions.

A statistical power analysis based on a medium effect size ($\eta_p^2 = .06$) was performed with G*Power 3.1 (Faul et al., 2007) for sample size estimation. In order to achieve 80% power ($\alpha = .05$), a sample size of 175 participants was required. We therefore set the final sample size to 176 usable datasets to ensure an equal number of participants in each condition.

Participation took approximately 30 minutes, for which participants were paid £3.50.

Design

The study was programmed using Gorilla (<https://gorilla.sc/>; Anwyl-Irvine et al., 2020) and followed a $2 \times 2 \times 2$ between-subjects factorial design comparing younger and older adults on two critical manipulations: the reference point used for metacognitive estimates in the PM task (*performance* vs. *peers*) and the order of presentation of the instruments (*questionnaires* $\rightarrow$ *PM task* vs. *PM task* $\rightarrow$ *questionnaires*).

Materials

Two hundred sixteen words were generated from the English Lexicon Project (Balota et al., 2007) database. All words were 6-12 letters and 2-4 syllables in length and had a log-transformed Hyperspace Analogue to Language (HAL) frequency within one standard deviation of the mean (i.e., 3.76-8.56). Two hundred ten pseudowords were generated with the Wuggy algorithm (Keuleers & Brysbaert, 2010).

Measures

PM Task

The paradigm conformed to the traditional Einstein and McDaniel (1990) laboratory assessment of PM, with the PM task being embedded in an ongoing task. The ongoing task consisted of a lexical-decision task (LDT). Participants were presented with strings of letters, one at the time, and asked to indicate whether they thought it was a real word or a non-word. For the PM task, participants learned a target syllable and were asked to press a different key on the keyboard whenever they detected a word containing the learnt syllable.

Metacognitive Judgments Scale

In addition to the PM task, we measured metacognitive beliefs. After completing the practice trials, participants were asked to use a slider to estimate their upcoming performance. Participants in the *performance* condition were asked to estimate the probability of successful future PM performance on a scale from 0% to 100%. Participants in the *peers* condition were asked to rate their upcoming performance in comparison to their peers. Therefore, they indicated their performance on a 0–99 percentile rank scale.

Metacognitive Prospective Memory Inventory short version (MPMI-s)

The short version of the MPMI (Rummel et al., 2019) is a questionnaire for the assessment of self-reported PM abilities and strategy use. In the current study, we administered only the Prospective Memory Ability (PMA) scale, which measures individuals' perceptions of their own PM abilities (e.g., "If I've borrowed something from someone for a while, I remember to give it back to that person the next time we see each other"). The scale consists of 8 items, half of which are reverse-coded and refer to prospective forgetting rather than prospective remembering. Each item is rated on a 5-point Likert scale (1=rarely, 2=rather rarely, 3=sometimes, 4=rather often, 5=often).

Prospective and Retrospective Memory Questionnaire (PRMQ)

The PRMQ (G. Smith et al., 2000) provides a self-report measure of prospective and retrospective memory failures in everyday life. It consists of 16 items, split equally between items asking about retrospective (e.g., “Do you fail to recognize a place you have visited before?”) and prospective (e.g., “Do you decide to do something in a few minutes' time and then forget to do it?”) memory errors. Participants rate each item on a 5-point Likert scale (1=never, 2=rarely, 3=sometimes, 4=quite often, 5=very often). Higher scores indicate a higher incidence of memory failures.

Multifactorial Memory Questionnaire (MMQ)

The MMQ (Troyer & Rich, 2002) consists of three scales measuring separate aspects of metamemory. In the current study, we administered only the Ability Scale, which measures self-perception of everyday memory ability. Participants rate on a 5-point Likert scale how often they experienced 20 common memory mistakes over the previous two weeks (0=all the time, 1=often, 2=sometimes, 3=rarely, 4=never).

Patient Health Questionnaire-9 (PHQ-9)

The PHQ-9 (Kroenke et al., 2001) is the depression module of the Patient Health Questionnaire, a self-administered version of the PRIME-MD diagnostic instrument for common mental disorders. It is a test for making criteria-based diagnoses of depressive disorders. It asks participants to rate the presence of depressive symptoms in the past 2 weeks. As a severity measure, the PHQ-9 score can range from 0 to 27, since each of the 9 items can be scored from 0 (not at all) to 3 (nearly every day).

Digit Span Backward Task

The task is taken from the WAIS-R (Wechsler, 1981) and is a short working-memory test. Participants saw and immediately recall progressively longer sequences of single-digit numbers presented at a 1-s rate. Two trials for each sequence length were given, starting from

a 2-digit sequence, and testing continued until participants missed both trials within the given sequence length.

Shipley Institute of Living Scale: Vocabulary

This vocabulary task (Shipley & Burlingame, 1941) consists of 40 items where participants are instructed to select the one word out of four choices that is closest in meaning to a target word.

Procedure

After providing informed consent, participants were randomly assigned to one of the four experimental conditions. A short pre-screening questionnaire was used to check that they met the inclusion criteria (see the Participants section above). Half of the participants in each age group completed the metamemory questionnaires (MPMI-s, PRMQ, and MMQ) before performing the PM task, whereas the other half performed the PM task before completing the metamemory questionnaires (MPMI-s, PRMQ, and MMQ). The order of administration of the questionnaires was randomized to avoid presentation order effects. The PM task started with participants learning the instructions for the lexical decision task (ongoing task). They then completed a practice phase where they received feedback on whether their response was correct or incorrect and were asked to repeat any incorrect trial. Participants then completed 200 trials of the lexical decision task, with 100 words and 100 pseudowords. At the end of the lexical decision task, participants were presented with the PM instruction that if a word contained the syllable 'PER' they should press 'space' instead of making the word decision (i.e., pressing 'left' or 'right'). Participants then received a multiple-choice question to check whether they understood the instruction and were represented with it in case of a wrong answer. After confirming their understanding of the rules, participants completed a short practice phase which was repeated until they correctly identified the PM target syllable. Participants were then prompted to provide a confidence rating, according to the

experimental condition they were in (see the Measures section above). Participants then performed the Shipley Institute of Living Scale: Vocabulary (delay task). After completion of the task, they were told that they would complete the lexical decision task, without being reminded of the PM intention. The task consisted of 100 words and 100 pseudowords, presented in randomized order. Six additional words were presented as 33rd, 66th, 99th, 132nd, 165th, and 198th words as the PM target trials. The order of presentation of the PM target words was also randomized across participants. Each stimulus remained on screen until the participant had responded. Finally, participants completed the digit span backward task, a depression scale (PHQ-9), and a short questionnaire assessing age, sex, education, and collecting participants' impressions on the study. One question also checked once again that participants understood the PM instruction. At the end of the experiment, participants were thanked for their time, debriefed, and paid. (see Figure 1 for a schematic illustration of the task and visit <https://app.gorilla.sc/openmaterials/266311> for a demonstration).

Results

We followed our pre-registered analysis plan, with one additional analysis on the first block of the lexical decision task.

Objective accuracy and reaction times

We first performed some exploratory analyses on task performance to see if there was an effect of our manipulations and to check if we could replicate the age effects typically found in laboratory-based studies using similar experimental paradigms.

Lexicon Decision task

Accuracy at the first block of the lexical decision task (without the PM component) was examined with a 2 x 2 x 2 ANOVA with the between-participants factors age group (*younger* vs. *older*), test order (*questionnaires* → *PM task* vs. *PM task* → *questionnaires*), and metacognitive reference point (*peers* vs. *performance*). We found a main effect of age

group ($F(1,168) = 82.21, p < .001, \eta_p^2 = .33$). In line with previous literature, older adults ($M = 68.69, SD = 14.34$) performed significantly better than their younger counterparts ($M = 52.58, SD = 8.65$). We also found a significant main effect of test order ($F(1,168) = 3.93, p = .049, \eta_p^2 = .02$) such that participants completing the task before the questionnaires ($M = 62.40, SD = 15.00$) performed better than those who filled out the questionnaires before completing the task ($M = 58.88, SD = 13.44$). The effect of metacognitive reference point and the interaction terms were nonsignificant. A similar analysis was conducted on reaction times, but the results were nonsignificant ($F_s \leq 2.67, p_s \geq .104, \eta_p^2_s \leq .02$). We failed to replicate the standard age effect whereby older adults are slower than younger adults.

Ongoing task

Accuracy at the second block of the lexical decision task (with the PM component) was examined with a $2 \times 2 \times 2$ ANOVA with the between-participants factors age group (*younger vs. older*), test order (*questionnaires $\rightarrow$ PM task vs. PM task $\rightarrow$ questionnaires*), and metacognitive reference point (*peers vs. performance*). We found a main effect of age group ($F(1,168) = 88.06, p < .001, \eta_p^2 = .34$) so that older adults ($M = 90.64, SD = 8.87$) performed significantly better than younger adults ($M = 77.14, SD = 9.92$). None of the other main effects or interactions were significant. This result was supported by a Bayesian analysis. We calculated Bayes Factors (against an additive Null model of the grand mean) for every possible combination of main and/or interaction effects to then selected the best fitting model using a model-comparison approach. A model with only the main effect of age group resulted in the highest Bayes Factor, $BF_{10} = 2.9e+14$. We thus conclude that our two manipulations (test order and metacognitive reference point) did not affect accuracy at the ongoing task.

A similar analysis was conducted on reaction times. We found a significant main effect of metacognitive reference point ($F(1,168) = 6.40, p = .012, \eta_p^2 = .04$) such that

participants in the *performance* condition ($M = 1708.22$, $SD = 780.48$) were significantly slower than those in the *peers* condition ($M = 1463.33$, $SD = 475.02$). The three-way interaction was marginally significant ($F(1,168) = 3.42$, $p = .066$, $\eta_p^2 = .02$). Subsequent follow-up tests conducted separately for the two metacognitive manipulations revealed that the older adults ($M = 1592.65$, $SD = 509.76$) were significantly slower than their younger counterparts ($M = 1334.01$, $SD = 403.06$) only in the *peers* condition ($F(1,84) = 6.89$, $p = .010$, $\eta_p^2 = .08$). The difference between the two groups was not significant in the *performance* condition ($F(1,84) = 0.05$, $p = .826$, $\eta_p^2 < .01$). Bayes Factors calculated against the null model separately for the two conditions showed that a model with only the main effect of age group resulted in higher Bayes Factors ($BF_{10} = 4.45$) than the null model in the *peers* condition, but not in the *performance* condition ($BF_{10} = 0.23$).

PM task

PM accuracy was calculated as the proportion of times that participants remembered to press the spacebar on the target trial or on the following trial. Given that PM trials were embedded within an ongoing task, age differences may be driven by differences in ongoing task performance. We therefore controlled for lexical decision task accuracy (see Marsh et al., 2002). Thus, a three-way ANCOVA was conducted with the between-participants factors age group (*young* vs. *older*), test order (*questionnaires*→*PM task* vs. *PM task*→*questionnaires*), and metacognitive reference point (*peers* vs. *performance*), after adjusting for performance at the ongoing lexical decision task. The results are summarized in Figure 2. [Insert Figure 2 approximately here] Against our original prediction, the main effect of age group was not significant ($F(1,167) = 0.04$, $p = .836$, $\eta_p^2 < .01$). There were a significant effect of accuracy at the ongoing task ($F(1,167) = 11.32$, $p < .001$, $\eta_p^2 = .10$) and a marginally significant interaction between test order and metacognitive reference point ($F(1,167) = 3.86$, $p = .051$, $\eta_p^2 = .02$). Exploring the interaction, subsequent follow-up tests

revealed that, in the *performance* condition, participants completing the metamemory questionnaires before the PM task ($M = 84.09$, $SD = 15.65$) were significantly more accurate than those who performed the task before the questionnaires ($M = 74.24$, $SD = 26.03$; $t(1,70.49) = 2.15$, $p = .035$, $d = 0.46$). There was no effect of test order in the *peers* condition ($t(1,86) = -0.24$, $p = .813$, $d = 0.05$). In order to assess the extent to which the data supported the presence and absence of these effects we also performed a Bayesian analysis. We computed Bayes factors against an additive Null model of the grand mean for every possible combination of main and/or interaction effects. Bayes factors for the model including the main effect of accuracy at the ongoing task were higher than any other model ($BF_{10} = 563.28$), more than three times the second-best model, which included the main effect of accuracy at the ongoing task and the main effect of test order ($BF_{10} = 174.12$).

A similar analysis was conducted on reaction times, calculated for accurate trials only (see Figure 2). In line with our prediction, younger adults ($M = 1519.20$, $SD = 504.37$) responded significantly faster than older adults ($M = 2130.15$, $SD = 922.44$; $F(1,168) = 31.70$, $p < .001$, $\eta_p^2 = .16$). The main effect of metacognitive reference point was also significant ($F(1,168) = 4.36$, $p = .038$, $\eta_p^2 = .03$), such that participants in the *performance* condition ($M = 1937.96$, $SD = 953.55$) were slower than participants in the *peers* condition ($M = 1711.39$, $SD = 599.03$). Furthermore, the results showed a significant three-way interaction ($F(1,168) = 8.81$, $p = .003$, $\eta_p^2 = .05$). Follow-up analyses revealed a significant main effect of age group in the *performance* condition (younger adults: $M = 1611.23$, $SD = 562.41$; older adults: $M = 2264.70$; $SD = 1142.32$; $F(1,84) = 11.97$, $p < .001$, $\eta_p^2 = .12$), whereas in the *peers* condition older adults ($M = 2236.09$, $SD = 669.18$) were significantly slower than younger adults ($M = 1324.45$, $SD = 390.83$) only when they completed the PM task after the metamemory questionnaires ($t(1,42) = -5.52$, $p < .001$, $d = 1.66$). A Bayesian ANOVA confirmed that the data are more likely under the model with the main effects of age

group and metacognitive reference point ($BF_{10} = 80444.24$) than under the model with the main effect of age group only ($BF_{10} = 72810.23$).

Predicted accuracy

We then moved to the main variable of interest, which was the metacognitive rating provided before performing the PM task. The analyses were conducted separately for the two metacognitive ratings (*performance* vs. *peers*). A 2 x 2 ANOVA with the between-participants factors age group (*young* vs. *older*) and test order (*questionnaires*→*PM task* vs. *PM task*→*questionnaires*) investigated the effect of age group on raw confidence ratings and whether this was affected by the administration of metamemory questionnaires before performing the PM task. In both conditions, the results did not detect an effect of aging on raw metacognitive ratings or an effect of the order of administration of the metamemory questionnaires ($F(1,84) \leq 2.52$, $p \geq .116$, $\eta_p^2 \leq .03$; see Figure 3a). [Figure 3 approximately here]

A Bayesian analysis aimed at selecting the best fitting model using a model-comparison approach showed that, in the *peers* condition, the data are 2.58 times more likely under the additive Null model of the grand mean than under a model containing the main effect of age group only and 18.26 times more likely than under a model also containing the interaction term. In the *performance* condition, the data are 1.51 times more likely under the additive Null model of the grand mean than under a model containing the main effect of age group only and 7.25 times more likely than under a model also containing the interaction term. This suggests that there was no reliable difference between the two groups.

These results are in line with our prediction of no difference in confidence ratings provided by younger and older adults. Nevertheless, we predicted higher raw confidence scores when participants solved the PM task before the metamemory questionnaires than after, but the effect of test order was not significant.

Metacognitive Bias

In order to study how well calibrated participants' performance predictions were to their objective accuracy, metacognitive bias was calculated as the discrepancy between predicted and objective accuracy. A positive value would indicate overconfidence and a negative value underconfidence. Figure 3b shows the results of one-sample t-tests comparing each metacognitive bias score against zero, separately for each condition and age group. The results pointed to a strong effect of our metacognitive manipulation. In the *peers* condition both younger and older adults showed overconfidence in their PM abilities, whereas in the *performance* condition both younger and older participants were generally underconfident.

These metacognitive bias scores were evaluated in an age group x test order ANOVA, conducted separately in the *peers* and *performance* conditions. The results did not detect an effect of aging on metacognitive bias or an effect of the order of administration of the metamemory questionnaires ($F(1,84) \leq 2.32, p \geq .131, \eta_p^2 \leq .03$). A Bayesian ANOVA confirmed that, in both conditions, the data are more likely under the null model than any other model included in the analysis (*peers* condition: $BF_{01} \geq 3.12$; *performance* condition: $BF_{01} \geq 2.54$).

Self-reported metamemory

Self-reported metamemory was examined in a 2 x 2 x 2 ANOVA, separately for each of the three questionnaires (MPMI-s, PRMQ, and MMQ), with the between-factors age group (*young* vs. *older*), test order (*questionnaires*→*PM task* vs. *PM task*→*questionnaires*), and metacognitive reference point (*peers* vs. *performance*). The results from the three questionnaires are generally in line with each other (see Table 1 for all inferential statistics). [Table 1 approximately here] We found a significant main effect of age group, so that older adults reported better everyday memory abilities than younger participants. The results revealed also a significant main effect of test. Participants reported better memory abilities

when completing the questionnaires at the beginning of the session than when they performed the PM task first. Finally, the main effect of metacognitive reference point was also significant, suggesting that participants in the *peers* condition reported better memory than those in the *performance* condition. For the MPMI, there was also a significant interaction between test order and metacognitive reference point, showing that participants in the *peers* condition ($M = 4.13$, $SD = 0.62$) reported significantly better memory abilities than those in the *performance* condition ($M = 3.78$, $SD = 0.54$) only when they completed the MPMI after performing the PM task; $t(1,86) = 3.20$, $p = .002$, $d = .68$.

A Bayesian ANOVA confirmed that the data are more likely under the model with the three main effects than any other model for the total score of the PRMQ ($BF_{10} = 135.98$) and the prospective memory subscale of the PRMQ ($BF_{10} = 718.79$). The best fitting model for the MPMI is that containing the interaction between testing order and metacognitive reference point ($BF_{10} = 10883.04$), whereas for the MMQ, the model with the main effects of age group and test order only ($BF_{10} = 24.70$) is more likely than the model with the three main effects ($BF_{10} = 22.87$).

These findings are only partially in line with our predictions as we expected to find a significant interaction between age group and test order. More precisely, we predicted older adults' self-reported metamemory to be lower than (or not significantly different from) younger adults when the questionnaires were administered before the PM task, and significantly higher than younger adults when the questionnaires were administered after the PM task.

Relationship between PM predictions and self-reported metamemory

An exploratory analysis was performed to test the existence of a significant relationship between the self-reported and online measures of metamemory. Correlations were conducted separately for younger and older adults, controlling for metacognitive

reference point (see Tables 2 and 3). [Tables 2 and 3 approximately here] The results indicated a significant positive correlation between PM predictions and self-reported metamemory at the MMQ in the *performance* condition, for both younger and older adults. A further investigation controlling for test order showed that for both age groups, the correlation was only (marginally) significant when the questionnaire was administered before the task (younger adults: $r(20) = .38, p = .077$; older adults: $r(20) = .42, p = .053$). For the younger adults, there was also a significant positive correlation between PM predictions and self-reported metamemory at the MMQ in the *peers* condition. Again, a further investigation controlling for test order showed that the correlation was significant only when the questionnaire was administered before the PM task; $r(20) = .64, p = .001$.

Discussion

The current study provided a systematic investigation of the role of metacognition in younger and older adults' PM performance. In particular, we manipulated A) the reference point used to form metacognitive judgments and B) the order of administration of the instruments.

PM Performance

Although the paradigm conformed to the traditional Einstein and McDaniel (1990) laboratory assessment of PM, the current study failed to observe the age differences in PM typically found in event-based PM tasks conducted in the laboratory (Kliegel et al., 2008; but see Reese & Cherry, 2002). One possible explanation may be a selection bias, so that older adults registered on Prolific show a somewhat higher general performance level; yet data on fluid and crystallized intelligence were not in line with such a selection bias. Another possible factor that might explain why this finding departs from the typical age decline observed in laboratory studies may be the home setting in which it was conducted, meaning that participants performed the task from a physical location of their choice, possibly, a

familiar environment. This opens to the possibility that this online PM task shares some features with the naturalistic tasks that often lead to an age advantage and are commonly discussed within the framework of the age-PM paradox (Schnitzspahn, Ihle, et al., 2011). Overall, this result opens the way to further research systematically comparing online, naturalistic, and laboratory-based PM tasks.

If older adults did not perform worse than younger adults, they were however significantly slower, in line with previous literature (e.g., O'Connor et al., 2021). Furthermore, the results indicated that participants in the *performance* condition were slower than participants in the *peers* condition. This result is in line with previous research showing that nonfocal PM performance increases after making PM predictions (Meier, 2011) and is accompanied by slower reaction times at the ongoing task (Rummel et al., 2013). Taken together, these findings suggest that estimating the upcoming performance via a confidence judgment may lead to the allocation of additional resources to the detection of the PM targets. Nevertheless, the lack of differences in PM performance between the *peers* and *performance* conditions and the absence of correlation between predicted and actual PM performance suggest that the engagement of additional resources for PM processing does not translate into an enhancement in performance.

Predictions of Future PM Performance

Our first hypothesis concerned age differences in participants' predictions about their upcoming PM performance. In line with previous literature, we originally predicted that older adults would be overconfident when rating their upcoming PM performance, and this metacognitive bias would be stronger in the *performance* than in the *peers* condition. We found that, in both conditions, younger and older adults did not differ in their confidence ratings. Nevertheless, when looking at the discrepancy between predicted and objective accuracy, we found that, against our expectations and previous laboratory-based experiments

(Cauvin et al., 2019; Scarampi & Gilbert, 2021), younger and older participants were both underconfident in the *performance* condition and overconfident in the *peers* condition.

Although it seems plausible to conclude that younger and older adults' PM predictions are not well calibrated, it is important to point out that the PM task used in the experiment may be quite unusual for the participants. Therefore, as discussed by Higham and colleagues (2016), it may be difficult to translate metacognitive beliefs and confidence into a percentage or percentile rank. Overall, the finding contributes to the scarce literature on how participants make predictions about PM performance, by showing that variability in metamemory may be driven by differences in the chosen reference point to evaluate one's own abilities.

Our second hypothesis concerned the effect of the order of administration of the instruments on metacognitive predictions. We expected a stronger bias toward overconfidence when the PM task was administered before the metamemory questionnaires than after them. Against our prediction, neither raw performance predictions nor metacognitive bias were affected by test order. This result suggests that online metamemory estimates are not affected by the administration of questionnaires asking participants to reflect on their everyday memory failures before performing a PM task, and indicate a potential dissociation between online and self-reported metacognitive measures.

Self-reported metamemory

Our third hypothesis concerned the effect age group and test order on self-reported metamemory. We predicted that older adults would report lower PM abilities before the PM task, in line with the literature on memory complaints in the elderly, but significantly higher PM abilities than younger adults when the questionnaires were administered after the PM task, in line with previous laboratory-based experiments. We found a significant effect of both factors, but not an interaction between the two. At the group level, older adults reported significant better everyday memory than younger participants. This finding is consistent with

recent studies showing that older adults tend to overestimate their PM abilities (Cauvin et al., 2019; Scarampi & Gilbert, 2021). The lack of interaction with test order goes against the literature documenting age-related memory complaints and concerns. This, again, raises questions regarding the representativeness of the online older adult samples and the comparability with studies based in different settings.

The manipulation of test order also had a significant effect on self-reported metamemory, so that the administration of the PM task before the questionnaires reduced participants' confidence, regardless of the age group, and made them report more memory failures than those participants who filled out the metamemory questionnaires at the beginning of the experimental session. This finding has important implications for future studies intended at measuring PM metamemory as it shows that the order in which different instruments are administered may affect the variables of interest. Unfortunately, the current study was unable to disentangle whether this result was due to participants performing a PM task just before assessing their metamemory – and therefore using it as a proxy of their PM abilities – or to participants being asked to reflect on their PM performance when providing metacognitive judgment – and therefore making them more cautious in their evaluations. Future studies could be designed to disentangle the effect of task performance from the effect of the metacognitive judgment.

The manipulation of metacognitive reference point also had a significant effect over self-reported metamemory, with participants in the *peers* condition reporting better everyday memory than those in the *performance* condition. Whereas the administration of the metamemory questionnaires did not affect predicted accuracy, it seems that reflecting on the upcoming performance may impact upon general self-reported metamemory. One potential explanation for the difference between the two metacognitive conditions is that reflecting on one's own performance without comparing it to others might make participants more

cautious and this wariness may then translate into a ‘more underconfident’ update of general metamemory beliefs. This is partially supported by the significant interaction between test order and metacognitive reference point found for the MPMI. Future studies should be conducted with a more powerful design to study the interaction between the two factors and shed further light on this tentative hypothesis. It is also possible that the online and self-reported measures capture different aspects of metamemory. As speculated by Smith et al. (2011), metamemory questionnaires refer to beliefs regarding memory in a series of everyday scenarios, whereas performance predictions tap into newly acquired metacognitive knowledge.

Overall, the above findings suggest that knowledge about PM-task demands and performance predictions tend to be inaccurate in a laboratory-based task for both younger and older adults. This has relevant practical implications as decisions on metacognitive control strategies such as attention allocation or reliance on external aids will be based on biased expectations and might therefore result in the adoption of maladaptive strategies. This points to the importance of designing guidelines and interventions aimed at promoting optimal strategizing about memory intentions in order to meet everyday life challenges and support behavioral independence across the lifespan. Interventions can be designed to restructure metacognitive knowledge about one’s own memory abilities by helping individuals discriminate between easy-to-remember and easy-to-forget intentions and use this information to adopt effective strategies.

In summary, the findings of this study point to reactive effects of metamemory to metacognitive reference point and order of administration of the instruments, and highlight the importance of taking these aspects into account when designing metamemory studies and interpreting the results. Furthermore, the findings add to the literature showing that both

younger and older adults have limited metacognitive insights, which might lead to lack of allocation of resources to facilitate remembering.

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Table 1

F-values, significance levels and partial eta-square for self-reported metamemory.

	MPMI-s		PRMQ						MMQ	
	PMA		Total score		PM		RM		Ability	
	<i>F</i> (1,168)	η_p^2	<i>F</i> (1,168)	η_p^2	<i>F</i> (1,168)	η_p^2	<i>F</i> (1,168)	η_p^2	<i>F</i> (1,168)	η_p^2
Age group (younger vs. older)	21.03***	.11	8.27**	.05	12.16***	.07	3.52 [#]	.02	9.50**	.05
Test order (<i>questionnaires</i> → <i>PM task</i> vs. <i>PM task</i> → <i>questionnaires</i>)	5.10*	.03	10.46**	.06	8.60**	.05	10.06**	.06	5.79*	.03
Metacognitive reference point	7.87**	.04	4.58*	.03	6.46*	.04	2.12	.01	3.83 [#]	.02
Age group x Test order	0.57	< .01	0.76	< .01	0.27	< .01	1.30	.01	0.32	< .01
Age group x Metacognitive reference point	0.68	< .01	1.29	.01	1.09	.01	1.22	.01	1.90	.01
Test order x Metacognitive reference point	4.22*	.02	1.60	.01	1.45	.01	1.38	.01	0.16	< .01
Age group x Test order x Metacognitive reference point	2.93 [#]	.02	0.05	< .01	0.09	< .01	0.02	< .01	0.19	< .01

Note. [#] $p < .1$; * $p < .05$; ** $p < .01$; *** $p < .001$. MPMI-s = Metacognitive Prospective Memory Inventory; PRMQ = Prospective and Retrospective

Memory Questionnaire; MMQ = Multifactorial Memory Questionnaire; PMA = Prospective Memory Ability scale; PM = Prospective Memory scale; RM = Retrospective Memory scale.

Table 2

Correlations between measures in the peers condition. Results from the older group are shown in the panels above the diagonal (upper right) and results from the younger group are shown in the panels below the diagonal (bottom left).

Variable	Peers Condition														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. LDT RTs	—	-.10	.68***	-.29 [#]	.29 [#]	-.35*	.05	.31*	-.09	-.13	-.10	-.15	-.25 [#]	-.13	-.28 [#]
2. LDT Accuracy	.38*	—	-.21	.57***	-.29 [#]	.31*	-.01	-.18	-.05	-.13	-.14	-.12	.08	.69***	.20
3. OG RTs	.54***	.17	—	-.28 [#]	.49***	.00	.07	.06	-.19	-.17	-.13	-.21	-.31*	-.19	-.28 [#]
4. OG Accuracy	.09	.40**	-.09	—	-.03	.27 [#]	.03	-.25	.09	.22	.24	.18	.43**	.69***	.30 [#]
5. PM RTs	.33*	-.05	.43**	.05	—	-.29 [#]	.23	.29 [#]	-.32*	-.29 [#]	-.27 [#]	-.29 [#]	-.32*	-.09	-.29 [#]
6. PM Accuracy	.11	.15	.08	.35*	-.12	—	.01	-.79***	.03	.20	.20	.19	.22	.23	.28 [#]
7. Predicted Accuracy	.06	.08	.17	.05	.09	.27 [#]	—	.44**	-.28 [#]	-.09	-.09	-.09	-.09	.13	.07
8. Metacognitive Bias	-.00	-.07	.11	-.21	.18	-.60***	.46**	—	-.15	-.24	-.20	-.26 [#]	-.26 [#]	-.11	-.21
9. MPMI	-.17	.00	-.02	.18	.01	.08	.20	.08	—	.76***	.76***	.70***	.67***	.01	.19
10. PRMQ-TOT	.05	.05	-.16	-.04	.08	-.01	.29 [#]	.25 [#]	.37*	—	.96***	.96***	.83***	.03	.20
11. PRMQ-PM	-.04	-.08	-.17	-.10	.07	-.02	.28 [#]	.24	.34*	.93***	—	.86***	.82***	.04	.21
12. PRMQ-RM	.15	.08	-.11	.04	.07	.01	.25 [#]	.21	.33*	.89***	.66***	—	.79***	.01	.18
13. MMQ	.08	.27 [#]	-.12	.25	-.03	.13	.31*	.15	.48**	.71***	.65***	.66***	—	.20	.29 [#]
14. Vocabulary	.17	.36*	-.13	.35*	-.02	.27 [#]	.07	-.16	.18	.02	-.07	.12	.15	—	.16
15. DigitSpan	.08	.19	.10	.21	-.09	.40**	.20	-.13	-.12	.00	-.01	.02	.14	.11	—

Note. [#] $p < .1$; * $p < .05$; ** $p < .01$; *** $p < .001$. MPMI-s = Metacognitive Prospective Memory Inventory; PRMQ-TOT = Prospective and Retrospective Memory

Questionnaire, total score; PRMQ-PM = Prospective and Retrospective Memory Questionnaire, prospective memory scale; PRMQ-RM = Prospective and

Retrospective Memory Questionnaire, retrospective memory scale; MMQ = Multifactorial Memory Questionnaire.

Table 3

Correlations between measures in the performance condition. Results from the older group are shown in the panels above the diagonal (upper right) and results from the younger group are shown in the panels below the diagonal (bottom left).

Variable	Performance Condition														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. LDT RTs	—	.15	.68***	.13	.72***	.13	.06	-.05	-.18	-.12	-.06	-.18	-.08	.07	-.11
2. LDT Accuracy	.36*	—	-.04	.48**	.05	-.11	-.03	.06	-.01	-.07	-.11	-.02	-.14	.74***	-.02
3. OG RTs	.82***	.27 [#]	—	.13	.68***	.37*	.17	-.15	-.01	.01	.07	-.05	.11	-.09	-.13
4. OG Accuracy	-.20	.33*	-.15	—	.05	.16	.25	.07	.07	-.14	-.14	-.12	-.12	.73***	.07
5. PM RTs	.32*	-.01	.56***	-.36*	—	.05	.03	-.01	-.20	-.13	-.04	-.21	-.06	.01	-.22
6. PM Accuracy	.13	.03	.00	.23	-.49***	—	.09	-.68***	.19	.11	.10	.11	.11	-.15	.01
7. Predicted Accuracy	.10	.02	.20	-.20	.13	.11	—	.67***	.26 [#]	.26 [#]	.27 [#]	.23	.34*	.03	.21
8. Metacognitive Bias	-.03	-.02	.14	-.33*	.49***	-.72***	.61***	—	.05	.11	.13	.09	.17	.13	.15
9. MPMI	-.02	-.19	.14	-.02	.11	.09	.04	-.04	—	.80***	.78***	.73***	.77***	-.05	-.03
10. PRMQ-TOT	.22	.22	.35*	-.37*	.26 [#]	.00	.20	.14	.50***	—	.95***	.94***	.91***	-.24	.00
11. PRMQ-PM	.14	-.16	.31*	-.31*	.24	.01	.24	.16	.53***	.96***	—	.78***	.93***	-.22	.06
12. PRMQ-RM	.29 [#]	-.05	.36*	-.40**	.26 [#]	-.01	.14	.10	.41**	.96***	.84***	—	.78***	-.22	-.06
13. MMQ	.18	-.05	.25	-.17	.20	-.02	.34*	.25	.33*	.69***	.62***	.71***	—	-.30*	.06
14. Vocabulary	.13	.48***	.19	.44**	-.23	.15	.02	-.11	-.12	-.16	-.18	-.14	.05	—	.12
15. DigitSpan	.15	.26 [#]	.14	.20	-.09	.11	.23	.08	-.06	.15	.10	.19	.15	.22	—

Note. [#] $p < .1$; * $p < .05$; ** $p < .01$; *** $p < .001$. MPMI-s = Metacognitive Prospective Memory Inventory; PRMQ-TOT = Prospective and Retrospective Memory

Questionnaire, total score; PRMQ-PM = Prospective and Retrospective Memory Questionnaire, prospective memory scale; PRMQ-RM = Prospective and

Retrospective Memory Questionnaire, retrospective memory scale; MMQ = Multifactorial Memory Questionnaire.

Figure 1

Schematic illustration of the PM task

Figure 2

Results from the prospective memory task: accuracy and reaction times

Note. A) Accuracy was calculated as the proportion of times that participants remembered to press the spacebar on the target trial or on the following trial. B) Reaction times were calculated for accurate trials only. Error bars indicate standard error of the mean.

Figure 3*Results from the PM task: metacognitive measures*

Note. A) Predicted accuracy corresponds to the raw metacognitive ratings provided by participants before performing the PM task. B) Metacognitive bias was calculated as the discrepancy between predicted and objective accuracy at the PM task. Error bars indicate standard error of the mean.