Received: 11 November 2019 | Revised: 12 May 2020 | Accepted: 22 September 2020

DOI: 10.1002/acp.3748

RESEARCH ARTICLE

WILEY

The effects of collaboration and punishment on prospective memory performance in a group setting

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Summary

Remembering to perform a delayed intention is termed prospective memory (PM). Often delayed intentions are shared by more than one person; however, there is a dearth of studies examining PM in social settings. We aimed to investigate whether the potential consequences of one's behavior across diverse group settings influence PM performance in event- and time-based tasks. A total of 207 participants were randomly allocated to either an individual, collaborative, or collaborative plus penalty **motivation** condition and were tested in a 2- or 3-person setting. For the time-based PM task, participants responded less timely in the individual **motivation** condition, whereas there was no difference between the collaborative **motivation** conditions. No significant effects were found for motivation condition on the event-based task or for group size on PM performance. Analyses of ongoing task performance revealed that participants' attention allocation policies change depending on how individuals prioritize the ongoing and PM tasks.

1 | INTRODUCTION

Prospective memory (PM) involves remembering to perform planned actions at an appropriate moment in the future (Einstein & McDaniel, 1990), and has received increasing attention over the past three decades (e.g., Brandimonte, Einstein, & McDaniel, 1996; Cohen & Hicks, 2017; Einstein & McDaniel, 1990; Kliegel, McDaniel, & Einstein, 2008; Kvavilashvili, 1987; McDaniel & Einstein, 2007). PM can be distinguished into event-based and time-based tasks. In event-based PM, an individual needs to remember to initiate an action when a certain event occurs (e.g., remembering to give a message to a friend upon seeing them). In contrast, time-based PM involves remembering to execute an action based on a specific time (e.g., remembering to check the oven after 15 minutes have passed; Einstein & McDaniel, 1990). PM is of crucial importance for various aspects in our lives, such as maintaining independence (e.g., remembering to keep appointments; Woods, Weinborn, Velnoweth, Rooney, & Bucks, 2012), health (e.g., remembering to take medication on time; Zogg, Woods, Sauceda, Wiebe, & Simoni, 2012), and safety (e.g., pilot remembering to set the wing flaps of an airplane to takeoff position; Dismukes, 2010).

In typical laboratory PM studies, participants perform an ongoing task, such as a lexical decision task (e.g., deciding whether a letter string is a word or nonword), and, in PM conditions, they receive an additional PM instruction to respond differently if a pre-specified target event happens in the future during the lexical decision task or a certain time has elapsed. For example, participants would be instructed to press the spacebar if they see the word "QUEEN" presented or after 1 minute has passed. It is up to the participants to remember this intention as they are not given any further reminders once the lexical decision task begins. These paradigms are sensitive to participants' ability to encode an intended future action and to act on that intention at the appropriate time.

In terms of underlying cognitive processes, PM tasks mainly rely on retrospective memory and executive functions (Kliegel, Martin, McDaniel, & Einstein, 2002). Importantly, the extent to which executive control processes are involved in PM can vary depending on task characteristics, such as *cue focality* or the *importance* of the intention (Einstein et al., 2005; McDaniel & Einstein, 2000). PM cues may be considered *focal* or *non-focal* depending on whether or not target properties associated with the intention cue are in the focus of attention during ongoing task performance. For example, during a lexical decision task that involves deciding whether a presented letter string is a word or nonword, a focal PM cue would involve remembering to press the spacebar if the words “elephant, tiger, or horse” appear, whereas a non-focal cue would be remembering to press the spacebar if an animal word appears (see Einstein et al., 2005, for additional examples of focal and non-focal cues). According to the multiprocess framework of McDaniel and Einstein (2000), retrieval of the PM intention can be supported by strategic, executive control demanding processes, or rely on **relatively** automatic processes. For example, focal and non-focal cues differ in the extent to which the ongoing task directs attention to the PM cue. This, in turn, affects the degree to which strategic, executive control resources are needed to monitor the cue and switch from the ongoing task to performing the PM task.

Moreover, the importance of the PM task itself may affect the employment of executive control processes. When a task is perceived to be more important, additional strategic monitoring may be facilitated to ensure better performance (e.g., checking the time more often to be on time for a job interview than for coffee with a friend; Kliegel, Martin, McDaniel, & Einstein, 2001; Kliegel, Martin, McDaniel, & Einstein, 2004). Different methods have been used to manipulate the importance of an intention in studies of PM (cf. details Walter & Meier, 2014). For example, Cook, Rummel, and Dummel (2015) investigated the effects of monetary rewards and punishments as a way of manipulating the importance of an event-based PM task. They showed that the amount of correct event-based PM responses increased when paired with a monetary reward (positive frame), but PM performance was also enhanced when paired with a monetary punishment for failing to respond to PM cues (negative frame). Altgassen, Kliegel, Brandimonte, and Filippello (2010) used a laboratory time-based PM task to examine the effects of social importance on PM performance in younger and older adults. Social importance was manipulated by providing either standard task instructions or instructions that emphasized the social relevance of the task. Results showed that, although younger adults responded more accurately and outperformed the older adults overall, older adults performed better in the high social importance condition. This finding demonstrates that increasing the social value of a task can increase the performance of PM in an older adult population. More recently, the inducement of social importance also led to an increase in performance in event-based tasks among younger adults (Walter & Meier, 2017; also see Brandimonte & Ferrante, 2008; Brandimonte, Ferrante, Bianco, & Villani, 2010 for further studies investigating pro-social PM instructions). Taken together, these studies indicate that the perceived importance of a task is capable of altering participants' PM performance.

All studies mentioned above, which examined the influence of (social) importance manipulations on PM, focused on the performance of individuals (as is typically the case in studies of PM). It should be noted, however, that PM is just as critical in situations where multiple individuals are involved in the completion of a future task. As an illustration, imagine a group of three students who will be assessed for a presentation given at a symposium. Although all the students might be well prepared to give the presentation, it is important that someone remembers to bring the USB stick containing the slides for the presentation. In this collaborative PM situation, the implications of such a PM failure may only result in a negative effect on the students' grades. However, other areas in which forgetting future intentions can be harmful, or even fatal to other people, have adopted strict protocols to avoid such failures (e.g., in healthcare or aviation; Dieckmann, Reddersen, Wehner, & Rall, 2006; Dismukes, 2012).

To date, only three studies have investigated how the presence of others could affect the performance of PM. Johansson, Andersson, and Rönnberg (2000) compared the performance of PM in older adults between collaborative couples (elderly married or elderly couples who did not know each other) and non-collaborating control couples with naturalistic event-based and time-based PM tasks. The collaborating couples were assigned to work together on these tasks, whereas the non-collaborating couples completed the tasks on their own. The control couples outperformed the collaborative couples, which was interpreted to be the result of collaborative inhibition: the disruption of individual retrieval processes by the recall and utterances of others (Barber, Harris, & Rajaram, 2015; Basden, Basden, Bryner, & Thomas III, 1997).

Browning, Harris, Bergen, Barnier, and Rendell (2018) tested younger adults with “Virtual Week,” a computerized board game that simulates naturalistic PM tasks. Participants roll virtual dice and move their tokens around the board. When passing an event square, participants pick up a card and choose an activity (e.g., have cereal for breakfast) and can only move on once they roll a specific number. Into this ongoing task, event- and time-based PM tasks are embedded of which half are regular (i.e., repeat every virtual day) and half irregular (i.e., occur only once). In addition, time-check tasks have to be performed every virtual day after a certain time has elapsed. The performance of collaborating couples was compared with those of non-collaborating couples. The first experiment was conducted with couples who were strangers, and demonstrated that the collaborating couples performed worse on the time-check and regular event-based tasks. The second experiment investigated intimate couples and found no effects of collaboration on PM performance. Browning and colleagues explained this with the formation of a transactive memory system in intimate couples, which enables more similar information storage and, therefore, leads to decreased collaborative inhibition (Barber et al., 2015; Basden et al., 1997).

Taken together, both studies suggest that group settings, in which individuals actively work together on a PM task, may result in collaborative inhibition. Interestingly, simply working in the presence of others on a group task, without being exposed to each other's retrieval strategies, can also influence task performance. Social loafing is defined as the decrease of an individual's motivation and effort when working in a group task where individual outputs cannot be evaluated (Gilovich, Keltner, Chen, & Nisbett, 2013; Latané, Williams, & Harkins, 1979). As a consequence, individuals who work alone are capable of outperforming individuals in group settings. Social loafing may also take place during the performance of PM tasks as shown by D'Angelo, Bosco, Bianco, and Brandimonte (2012).

Participants were assigned to either an individual, collaborative, or competitive condition. In the collaborative condition, couples performed the computer-based task at the same time and were told that their correct responses would later be merged. In the competitive condition, the couples also performed the task at the same time, but, now, were asked to compete with each other as a winner would be selected based on the highest number of correct responses. In the individual condition, participants were tested one by one. Overall, the individual condition showed better PM performance than the collaborative condition, which was attributed to social loafing. The competitive condition did not differ from the individual condition.

In summary, these findings demonstrate that PM performance can be influenced by motivation levels (e.g., the consequence of one's behavior), social factors (e.g., the group setting), and cognitive processes (e.g., the extent to which executive control processes are allocated to execute the PM task; Browning et al., 2018, D'Angelo et al., 2012; Johansson et al., 2000). Considering the fact that much of everyday life is experienced in collaborative settings, and only three studies have investigated PM in a social context, the present study set out to extend previous findings in an effort to further our understanding of the effect of motivation on PM in a social context.

2 | CURRENT STUDY

In this study, we manipulated motivation instructions by randomly assigning participants to either an individual, collaborative, or a collaborative plus penalty condition. Participants in the individual condition were informed that, despite them being tested together with others, each of them will perform the tasks alone. In contrast, those assigned to the collaborative, or collaborative plus penalty condition, were instructed that their answers will later be merged with other members of their group (cf. a similar approach, D'Angelo et al., 2012). Those in the collaborative condition were told that their performance can enhance the group's score as only their correct responses will be merged (positive frame), while those in the collaborative plus penalty condition were informed that their performance may negatively impact the group as their incorrect responses will be subtracted from the overall group score (negative frame). In addition, we manipulated group size with participants being tested in either groups of two or three. We know from studies from other fields that social loafing increases with group size and also occurs when individuals believe that their task performance will be merged with that of others (Karau & Williams, 1993; Latané et al., 1979). Previous studies only investigated the effects of collaboration on PM performance in dyads (Browning et al., 2018; D'Angelo et al., 2012; Johansson et al., 2000), and it is unclear how larger group size may affect PM performance. Highly sensitive event- and time-based tasks were administered, which involved high cognitive demands, which allowed us to examine how participants chose to allocate attentional resources.

We predicted that the collaborative only condition will result in lower PM performance compared to the individual condition, as participants would believe that their individual outputs cannot be evaluated, which has been known to elicit social loafing (Latané et al., 1979). We also expected that the collaborative plus penalty condition will lead to higher performance compared to the other two conditions, as participants may feel more social pressure and, therefore, devote more attentional resources to perform the PM task (Brandimonte et al., 2010). Considering the various group sizes, we expected that the groups consisting of three people will be outperformed by the groups consisting of two people, due to an increase in social loafing, when more individuals are present (Karau & Williams, 1993; Latané et al., 1979).

3 | METHOD

3.1 | Participants

A total of 207 participants took part in the present study. Participants were recruited via flyers and from the department's participant pool. Participants were randomly allocated to the couple or triple condition, as well as to one of the three motivation conditions (individual, collaborative, collaborative + penalty). Exclusion criteria were any presence or history of psychiatric or neurological disorders, as well as substance abuse. The study was approved by the local ethics committee and conducted in line with the Helsinki declaration. Before testing, all participants gave written informed consent. **Participants received course credit for taking part in the study**.

Details on participants' characteristics can be taken from Table 1.

Analyses of variance (ANOVAs) were conducted to test for any differences in age or education among the different motivation or group size conditions. With regards to age, there was no main effect of motivation ($F < 1.7$) and no significant interaction ($F < 1.1$); however, there was a significant main effect of group size ($F[2,201] = 9.31$, $p = .003$); with the triple samples being slightly older than the couples (on average about 2–4 years, which is not likely to affect performance). For years of education, there were no significant effects (group size $F(1, 200) = 3.56$, $p = .061$; motivation $F < 1$; interaction $F(2, 200) = 2.8$, $p = .063$).

3.2 | Materials and procedure

At the start of the experiment, the three motivation conditions received different instructions. Participants in the *individual condition* were informed that, despite them being tested together with others, each of them will perform the tasks alone. Participants assigned to the collaborative, or collaborative plus penalty condition, were told that their answers will later be merged with other members of their group (cf. a similar approach, D'Angelo et al., 2012). Those in the *collaborative only condition* were told that their performance can enhance the group's score as only their correct responses will be merged (positive frame), while those in the *collaborative plus penalty condition* were informed that their performance may negatively impact the group as their incorrect responses will be subtracted from the overall group score (negative frame). After these instructions, the ongoing and PM tasks were explained. The order of the event- and time-based PM tasks was counterbalanced across participants.

For the ongoing task, participants were presented with a picture-based two-back working-memory task (for similar procedures, see Altgassen, Kretschmer, & Schnitzspahn, 2017; Altgassen, Sheppard, & Hendriks, 2019). Colored versions of the Snodgrass and Vanderwart (1980) picture set (Rossion & Pourtois, 2004) were displayed one by one on a computer screen. Participants were requested to indicate via keypress whether or not the present picture had occurred two stimuli ago (i.e., green button for 2-back hit items and orange button for non-hit items). Items were presented for 1,500 ms with an interstimulus interval of 500 ms between trials. In the course of the n-back task, 25% of all the stimuli presented were hit items. Participants were first presented with a printout showing four ongoing task trials to illustrate the task and were then asked to complete a practice block consisting of eight trials. This was followed by 24 ongoing task trials (a single ongoing task block), after which the PM task was introduced.

For the event-based PM task, participants were asked to press a pink button whenever one of six target pictures appeared. Participants were shown a printout of the PM cues until they indicated that they had learned them. Thereupon, participants were asked to write down the prospective cues. This was repeated until the participants correctly reproduced all cues. Furthermore, participants were instructed—upon presentation of the PM cues—to first respond to the PM cues and then to perform the ongoing task. To ensure that participants had understood the instructions before starting the test, they were required to repeat what they were supposed to do within the PM and ongoing task. The PM instructions were followed by an approximate 10 minute filled delay, during which participants filled in several questionnaires. Subsequently, participants worked on the dual-task block, which involved 6 p.m. cues and 127 ongoing task trials (25% 2-back hits). The PM cues and n-back hit items never occurred at the same time. The dependent variables were event-based PM hits and correct ongoing task responses (both in proportion), as well as reaction times for correct responses for both task types.

For the time-based PM task, participants were asked to press a pink key whenever 1 minute had passed. Specifically, they were told to press the pink key as closely as possible to each minute, from the first to the sixth minute. To see how much time had already elapsed, they could press a white key upon which a digital clock was displayed for 1,500 ms. Again, to ensure that participants had understood the instructions before starting the test, they were required to repeat what they were supposed to do within the PM and ongoing task. The PM instructions were followed by an approximate 10 minutes filled delay, during which participants filled in several questionnaires. Subsequently, participants were engaged in the dual-task block, comprising 185 ongoing task trials (25% 2-back hits). Time-based PM-dependent measures were mean distance to target PM times (temporal PM accuracy; max. Distance +/− 2 s around the target times). Time monitoring (number of white button presses) was also measured (mean monitoring behavior collapsed across the four 15 s intervals preceding the six targeted times). Furthermore, correct ongoing task responses (in proportion) as well as reaction times for correct responses were assessed.

At the end of the experiment, the participants were asked to recall in writing what they had to do during the computer-based task. All participants were able to describe the n-back task, event- and time-based PM task. Participants were then requested to recall all prospective cues, followed by a recognition task in case not all event-based PM cues were remembered.

4 | RESULTS

4.1 | Performance on event-based prospective memory task

4.1.1 | PM accuracy

We analyzed event-based PM accuracy by conducting a 2 (Group Size: 2 person, 3 person) × 3 (Motivation Instructions: individual, collaborative, collaborative + penalty) factorial analysis of variance (ANOVA) with both variables as between-subject factors. The dependent variable was the number of times out of six that participants remembered to respond to the PM cue. Results revealed no significant main effects or interactions (all *p values* > .117). See Table 2.

TABLE 2 Mean PM accuracy in event-based PM task

	Group size	
Motivation instructions	**2 person**	**3 person**
Individual	3.39 (1.26)	3.00 (1.96)
Collaborative	3.82 (1.61)	3.45 (1.61)
Collaborative + penalty	3.52 (1.61)	4.00 (1.34)

Note: Standard deviations are in parentheses.

TABLE 1 Participants' characteristics

		Individual	Collaborative	Collaborative + penalty
N (gender)	Couple	28 (7 men)	38 (13 men)	31 (11 men)
	Triple	30 (12 men)	38 (14 men)	42 (9 men)
Age	Couple	21.75 (2.0)	22.08 (1.7)	22.13 (2.1)
	Triple	22.70 (1.9)	24.61 (8.9)	26.14 (9.1)
Education	Couple	16.46 (1.4)	17.24 (1.5)	17.00 (2.0)
	Triple	16.72 (1.6)	15.84 (2.7)	16.52 (2.2)

4.2 | Ongoing task accuracy in n-back picture task during event-based PM task

To analyze accuracy performance in the ongoing task, we conducted a 2 (Group Size: 2 person, 3 person) × 3 (Motivation Instructions: individual, collaborative, collaborative + penalty) factorial ANOVA with accuracy in percent as the dependent variable. There was a main effect of Motivation Instructions, F (2, 200) = 3.81, p = .024, η_p^2 = .037. Pairwise comparisons revealed that those in the collaborative plus penalty condition (M = 93, SE = 1.21) performed significantly more accurately (p = .007) than those in the collaborative condition (M = 89, SE = 1.17). No other main effects or interaction were significant. See Figure 1.

4.2.1 | Reaction time performance on ongoing n-back picture task trials during event-based PM task

A 2 (Group Size: 2 person, 3 person) × 3 (Motivation Instructions: individual, collaborative, collaborative + penalty) between-subjects factorial ANOVA was conducted. Given that we observed more accurate performance in the collaborative plus penalty condition in the previous analysis, we wanted to examine whether that higher accuracy came at a cost. Although the overall main effect of motivation was not significant (p = .092), we were most interested in examining the pairwise comparisons between the collaborative plus penalty condition compared to the other motivation conditions. Inspection of pairwise comparisons revealed that reaction times were significantly slower (p = .033) for those in the collaborative plus penalty condition (M = 658 ms, SE = 10.31) compared to the individual condition (M = 625 ms, SE = 11.53). See Figure 2.

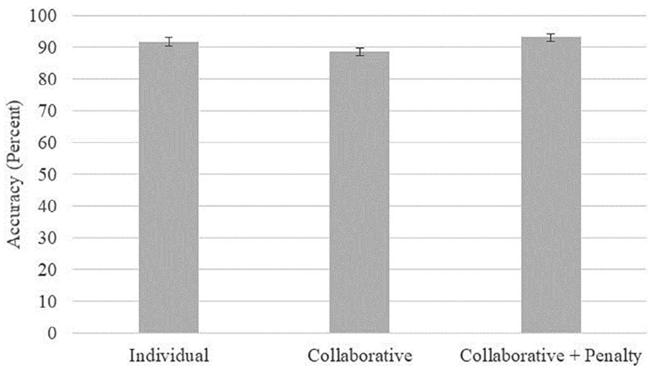

FIGURE 1 Mean accuracy performance in the ongoing n-back picture task during the event-based PM task. Error bars represent standard error

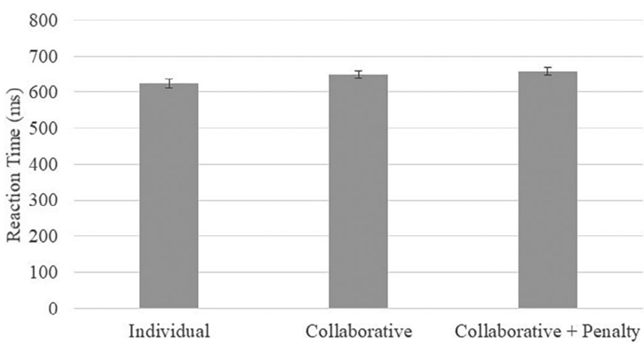

FIGURE 2 Mean reaction time performance on ongoing n-back task during event-based PM task as a function of motivation instructions. Error bars represent standard error

4.3 | Performance on time-based prospective memory task

PM accuracy is based on the average difference, in milliseconds, between time-based PM response and PM target. We conducted a 2 (Group Size: 2 person, 3 person) × 3 (Motivation Instructions: individual, collaborative, collaborative + penalty) factorial ANOVA on the reaction time difference between a participants' PM response and the actual time-based PM target. Results revealed a significant main effect of Motivation Instructions, F (2, 184) = 3.20, p = .043, η_p^2 = .034. Analysis of pairwise comparisons indicated that those in the collaborative plus penalty condition were significantly (p = .029) more accurate in their time-based PM response, showing a shorter time interval between their PM response and the target time (M = 613 ms, SE = 38.57), compared to those in the individual condition (M = 741 ms, SE = 43.22). There was also a significant difference (p = .024) between those in the collaborative only condition (M = 610 ms, SE = 37.87) and the individual condition (M = 741 ms, SE = 43.22). See Figure 3.

4.3.1 | Ongoing task accuracy in n-back picture task during time-based PM task

To analyze accuracy performance in the ongoing task, we conducted a 2 (Group Size: 2 person, 3 person) × 3 (Motivation Instructions:

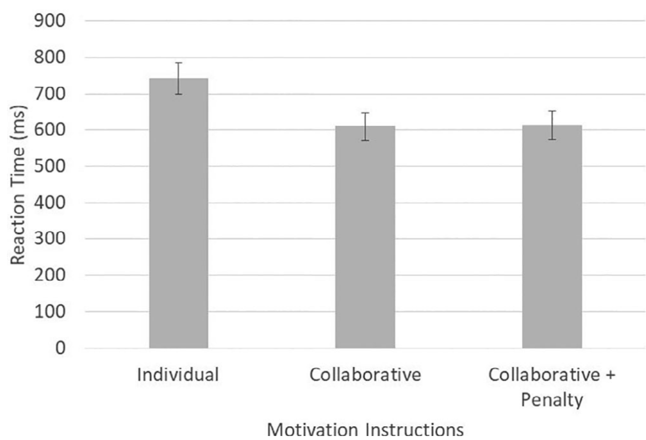

FIGURE 3 Mean reaction time difference between a participants' prospective memory response and the actual PM target as a function of Motivation Instructions. Error bars represent standard error

individual, collaborative, collaborative + penalty) factorial ANOVA with accuracy in percent as the dependent variable. There were no significant main effects or interactions (all *p values* > .11).

4.3.2 | Reaction time performance on ongoing n-back task trials during time-based PM task

A 2 (Group Size: 2 person, 3 person) × 3 (Motivation Instructions: individual, collaborative, collaborative + penalty) between-subjects factorial ANOVA was conducted with reaction times on the ongoing n-back task as the dependent variable. Results revealed a main effect of Motivation Instructions, F (2, 194) = 5.16, p = .007, η_p^2 = .051, which showed that reaction times were significantly slower (p = .002) for those in the collaborative plus penalty condition (M = 643 ms, SE = 7.71) compared to the individual condition (M = 606 ms, SE = 8.74). Reaction time performance was also significantly slower (p = .043) in the collaborative condition (M = 629 ms, SE = 7.58) relative to the individual condition (M = 606 ms, SE = 8.74). See Figure 4.

4.3.3 | Number of clock checks in four 15 s intervals leading up to time-based PM target response

A 2 (Group Size: 2 person, 3 person) × 3 (Motivation Instructions: individual, collaborative, collaborative + penalty) × 4 (Interval 1:0–15 s, Interval 2:16–30s, Interval 3:31–45 s, Interval 4:46–60s) mixed factorial ANOVA was conducted with Group Size and Motivation Instructions as between-subject variables, and Interval as a within-subjects factor. The dependent variable was the number of clock checks divided into four 15 s intervals leading up to the time-based target response. There was a significant main effect of Interval, F (3, 582) = 460.01, p < .001, η_p^2 = .70, revealing that participants significantly increased their clock checks from Interval 1 to Interval 4. Pairwise comparisons revealed significant differences in clock checks between all four intervals (all p values < .001; Interval 1: M = .325, SE = .029; Interval 2: M = .526, SE = .040; Interval 3: M = .801, SE = .039; Interval 4: M = 1.852, SE = .070). There was a marginally significant effect of Group Size, F (1, 194) = 3.72, p = .055, η_p^2 = .02, showing that participants in the two-person condition made marginally more clock checks (M = .95, SE = .055) compared to participants in the three-person condition (M = .80, SE = .053).

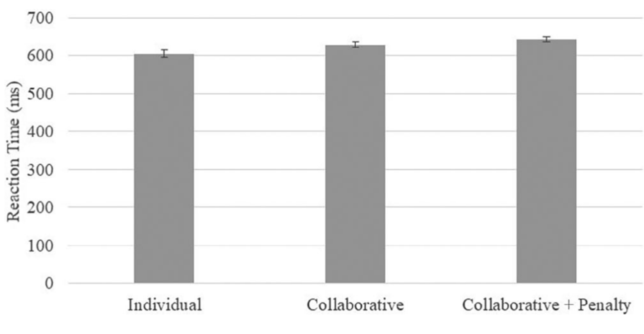

FIGURE 4 Mean reaction time performance on ongoing n-back task during time-based PM task as a function of motivation instructions. Error bars represent standard error

5 | DISCUSSION

In the current study, we examined the effects of motivation instructions in group settings that varied by size. Previous studies indicated that negative effects of group settings, such as social loafing or collaborative inhibition, on PM performance may be influenced by an interaction of social, motivational, and cognitive processes (Browning et al., 2018; D'Angelo et al., 2012; Johansson et al., 2000). To our knowledge, this was the first study to investigate the effects of collaboration on PM performance not only in dyads but also in groups of three.

In contrast to our expectations, for the *time-based* task, participants in the individual condition showed the least timely PM responses. That is, they pressed the PM button, on average, less closely to the target times, while there were no performance differences between the two collaborative conditions. Possibly, the fact that participants in both collaborative conditions were told that they would be working together as a team increased their motivation to perform well, and this led to more timely PM responses. Thus, similar to the results by Cook et al. (2015), both positive (i.e., the collaborative only condition) and negative framing (i.e., the collaborative + penalty condition) led to more accurate time-based PM performance. A result that is also in line with previous research, showing increased time-based PM performance in older adults following a social importance manipulation as compared to standard instructions (Altgassen, Kliegel, et al., 2010). Group size did not influence time-based PM performance. To better understand the underlying processes of time-based PM, we further analyzed participants' time monitoring behavior. Overall, all three motivation conditions strategically increased their clock checks in each 15 s interval as the target time approached; with the mean number of clock checks in each interval being significantly higher than the previous interval. There were no significant differences between the three motivation conditions with regards to their clock checking behavior. There was a marginal effect of group size (p = .055), with participants in the two-person condition checking the elapsing time more often than participants in the three-people condition. Although this effect did not reach significance, this trend may support the assumption that larger groups are associated with more social loafing given that individual responsibility is less clear and individual contributions can be more easily hidden within a group.

In contrast to our expectations and previous studies (e.g., Brandimonte et al., 2010; Cook et al., 2015; Walter & Meier, 2017), there were no effects of motivation condition or group size for event-based PM. The means for the event-based PM hits ranged between 3.0 and 4.0 (out of 6 p.m. targets) for all conditions, which neither point to a ceiling nor a floor effect. It seems as if the event-based PM task was not sensitive to our manipulation. Possibly, the lacking effects are due to the fact that focal PM cues (i.e., specific pictures embedded in a 2-back working-memory task) were employed. Focal cues depend less on strategic executive control resources, such as monitoring, as cues may be automatically detected while working on the ongoing task. Thus, the PM task is spontaneously triggered, leading to retrieval of the intended action (McDaniel & Einstein, 2000). In contrast, non-focal cues that are not part of the information, which is being processed for the ongoing task, require more strategic monitoring to be detected and might have been more sensitive to our experimental manipulations. This assumption is in line with earlier studies by Kliegel et al. (2001, 2004) where perceived task importance only had a positive effect on performance when the employed PM task puts high demands on monitoring, but not when it relied on rather automatic processing. Nevertheless, the present results may support models arguing that event-based PM tasks provide fewer opportunities for applying strategic monitoring approaches than time-based tasks (Altgassen, Schmitz-Huebsch, & Kliegel, 2010; Einstein, McDaniel, Richardson, Guynn, & Cunfer, 1995; Kvavilashvili & Ellis, 1996). Time-based tasks have clearly defined time intervals in which clock checking is more important, in order not to miss the target time (i.e., the last interval before the target time), and individuals who keep this in mind show better PM performance (Einstein & McDaniel, 1996). In contrast, in event-based tasks, the prospective target can appear any moment and there are no clear times in which monitoring is more important.

Analyses of ongoing n-back task performance revealed an interesting pattern of results. When the *event-based PM* task was active, ongoing task accuracy was significantly higher in the collaborative plus penalty condition. Accordingly, analysis of reaction time performance revealed significantly slower response times in the collaborative plus penalty condition relative to the individual condition. This shows that this increased accuracy came at a cost, demonstrating a speed/accuracy trade-off. Interestingly, this speed/accuracy trade-off for ongoing task performance was not observed when the *time-based PM* task was active. That is, there was no significant effect of motivation instructions on accuracy in the ongoing n-back task, but there was a significant effect of motivation on reaction time latencies; with responses being slower for those in the collaborative plus penalty and collaborative only condition as compared to the individual condition. This lack of a speed/accuracy trade-off when the time-based PM task was active may be explained by the different nature of the event-based versus time-based PM instructions. As indicated above, the event-based PM task employed focal PM cues that probably put lower demands on strategic executive control resources than the time-based PM task in which no external cue was present, and participants had to keep track of the elapsing time. Therefore, it may be that the instructions for the event-based task elicit attention allocation policies that result in increased focus on the ongoing task stimuli, leading to a benefit in accuracy in the n-back task when participants were especially motivated. In contrast, increased motivation, when the time-based PM task was active, did not yield this benefit to ongoing task accuracy. These findings demonstrate how participants' attention allocation policies can change depending on how they prioritize the ongoing and PM tasks. Much research (e.g., Cohen, Jaudas, Hirschhorn, Sobin, & Gollwitzer, 2012; Lourenco and Maylor, 2014; Marsh 2006) shows that allocation of attention and executive control processes can change flexibly according to task instructions.

The overall design and paradigm of the present study were most similar to that of D'Angelo et al. (D'Angelo et al., 2012). While Johansson et al. (2000) and Browning et al. (2018) required their collaborative couples to actually work together, participants in both the D'Angelo et al. (2012) study and the current study worked individually on the PM task. However, in contrast to D'Angelo's study, the present study not only tested participants as couples, but further manipulated group size by also testing three people at the same time. Moreover, we tested all our participants in a two or three people setting (even those in the so-called individual condition, which were tested one by one in D'Angelo's study). While D'Angelo and colleagues' participants in the competitive condition performed at a similar level as those in the individual condition in both the PM and ongoing task, the collaborative condition performed more poorly in both tasks compared to the individual condition. In contrast, in the present study, both collaborative conditions showed more accurate time-based PM than those in the individual condition. Possibly, the mere presence of others in the room (e.g., listening to their keyboard presses) led to a type of interference that negatively influenced the performance of the participants in the individual condition. The decrease in performance may be due to collaborative inhibition (i.e., being distracted by hearing others) or to social loafing (i.e., realizing that more people are concurrently participating in the study, which may diffuse individual responsibility; see D'Angelo et al., 2012, for a similar argument). In the current study, both collaborative conditions involved (allegedly) merging the scores of participants for both the positive and negatively framed conditions. In contrast, in the D'Angelo et al. (2012) study, the competitive condition did not suggest to participants that they were working together, but motivated them to be better than their counterpart, which probably explains the lacking difference between their individual and competitive conditions. The interpretation of PM performance in group settings is clearly complex and is influenced by various social, motivational, and cognitive factors that probably interact with each other (see also Brandimonte et al., 2010; D'Angelo et al., 2012). Future studies should consider adding another testing session, in which all participants are tested by themselves, to have a true comparison condition, and to be able to disentangle the effects of collaborative inhibition and social loafing.

The present study has several limitations. Overall, it seems the present paradigm (and the group setting) was not suitable to elicit strong positive or negative effects. There are several explanations for the lacking effects of motivation and group size. First, the motivation instructions were only given once at the beginning of the testing session, and thus the potential consequences of one's behavior may have been forgotten over time. Relatedly, at the end of the testing session, no manipulation check was conducted to clarify whether participants actually believed the experimental manipulation that (for the collaborative conditions) they were part of a group and that their performance may have consequences on the entire group. Future studies should repeat motivation instructions before each test block, and later assess participants' belief in them. Second, the potential positive or negative consequences of one's behavior may have had no personal relevance for the participants, and were thus not suited to affect participants' motivation to do well (or slack behind), and consequently their performance. Future studies should make sure to relate group's performance to a reward that is motivating for participants (e.g., best team will receive a monetary reward). Third, with regards to the missing effects of group size (except for clock checks), it seems that the difference between 2 or 3 people in a team was probably not large enough to lead to differential effects. Future studies should compare couples with groups of at least 5.

The present study is one of the few empirical studies to investigate how the presence of others can affect PM performance. Taken together, both positive (i.e., the collaborative only condition) and negative framing (i.e., the collaborative + penalty condition) in a group setting led to more accurate time-based PM performance, but did not affect event-based PM performance. Future studies should use PM tasks that put high demands on strategic, executive control resources to ensure that tasks are sensitive to experimental manipulations of motivation. The present results showed that, also in group settings, participants' attention and executive control allocation policies change depending on how they prioritize the ongoing and PM tasks. Even though the vast amount of literature shows that group settings have detrimental effects on (prospective) memory performance, this study indicates that motivation may be a critical component to increase PM performance in group settings. More research is needed to better understand the underlying mechanisms of PM performance in groups.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

DATA AVAILABILITY STATEMENT

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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How to cite this article: Altgassen M, Cohen A-L, Jansen MG. The effects of collaboration and punishment on prospective memory performance in a group setting. *Appl Cognit Psychol*. 2021;35:160–168. https://doi.org/10.1002/acp.3748