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Acting With the Future in Mind: Testing Competing Prospective Memory Interventions

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Prospective memory (PM) is a critical determinant of whether a person is able to lead an independent life. Because PM declines in late adulthood, an important question is therefore whether, and if so, which types, of PM interventions might lead to meaningful benefits. In the present study, we randomly assigned older adults to one of four conditions, in three of which participants received a structured PM intervention (Restorative, Compensatory, and Combined Restorative and Compensatory); the fourth was an Active Control condition. The results showed that there were significant gains on the PM training task used for both the Restorative and Combined conditions. We then analyzed change in PM tasks that were independent of the PM training task (Near Transfer). Only the Combined condition led to post-training improvement. Finally, we analyzed performance on measures of untrained cognitive abilities and everyday functioning: Far transfer effects were not evident for any intervention. These data align with prior literature in showing that interventions that target a single cognitive ability do not reliably generate far transfer effects, and additionally extend our understanding of these effects in two important ways. Firstly, they indicate that, even when the memory challenges that older adults are most concerned about are the direct target of restorative training, transfer effects to untrained cognitive domains may be difficult to achieve. Secondly, they indicate that for older adults whose primary goal is to enhance PM function, combining Restorative and Compensatory approaches is an effective approach.

Keywords: prospective memory, cognitive intervention, restorative, compensatory, transfer effects

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Prospective memory (PM), or "remembering to remember," involves the formation of an intention, followed by the subsequent execution of that intention after a delay. Successful performance on real life PM tasks is a critical determinant of whether a person is able to lead an independent life, and has been shown to partially mediate the association between age and the capacity to engage in a range of functional everyday activities (Hering et al., 2018; Sheppard et al., 2020). In light of the rapidly aging demographic, there is a growing need to identify effective ways to optimize older adults' autonomy. Because laboratory studies indicate that PM function declines in late adulthood (Henry et al., 2004; Haines et al., 2019), we designed the current study to directly test whether,

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and if so, which types, of structured PM interventions are beneficial for older adults.

The neurobiological basis for the notion that we can protect or enhance cognitive function by modifying experience is rooted in the concept of neuroplasticity, which refers to the capacity of the brain to change physical structure and function in response to environmental attributes or factors. Stern and others (Hertzog et al., 2008; Stern, 2009) argue that intellectually enriching activities throughout life could enhance the efficiency and capacity of existing neural pathways that are not typically used to accomplish a task. Structured cognitive training might confer similar benefits—and theoretically modulate the potential impact of age-related brain changes on cognitive performance. Consistent with a potential protective effect of cognitive training, auditory-based cognitive training has been shown to partially restore neural deficits in temporal processing (Anderson et al., 2013), and a recent systematic review concluded that cognitive training which targets executive functioning promotes both cognitive and neural plasticity in old age (Nguyen et al., 2019).

Moreover, a recent meta-analysis of more than 200 randomized controlled trials showed that cognitive training is modestly effective in improving older adults' cognitive function, with an overall small-sized net-gain in cognition for healthy older adults ($g = 0.28$; Basak et al., 2020). However, the effects of cognitive training were substantially smaller for untrained relative to trained cognitive abilities ($gs = .22$ and 0.38, respectively), and smaller still for measures of everyday functioning ($g = 0.19$). Basak et al. (2020) also showed that, although training a single cognitive ability (single-component training) reliably generated benefits on the trained cognitive ability (i.e., near transfer effects), only a few yielded far transfer effects (i.e., benefits in cognitive domains other than the trained one).

Current evidence therefore indicates that, at least for single-component training, the benefits differ markedly depending on the cognitive ability targeted, particularly with respect to far transfer effects. It is therefore surprising that, although memory represents one of the key cognitive domains typically targeted in training studies, the particular memory strategies that have conventionally been trained fail to align closely with the memory challenges that older adults are most concerned about, and which are in most need of assistance. Specifically, many prior training studies have focused on strategies that target episodic retrospective memory (McDaniel & Bugg, 2012). However, older adults report that lapses of intention are the most frequent and stressful memory problems experienced in daily life (Kliegel et al., 2007), and as McDaniel and Bugg (2012) note, "including PM in training interventions could have a significant impact on improving PM in everyday tasks that older adults care about." (p. 14).

Single-Component PM Training Studies

In contrast to much of the broader literature, of the training studies conducted to date that have tested whether targeting PM is beneficial, almost all have used a compensatory approach. This is a potentially important limitation, because compensatory approaches simply teach new ways to accomplish specific cognitive tasks by working around cognitive weaknesses. These approaches therefore align with Baltes and Baltes (1990) theoretical model of Selective Optimization with Compensation, in which some age-related losses are considered to be inevitable, with actualization of remaining strengths and resources (compensation) required to counter these losses. However, although compensatory training represents a potentially very effective approach for enhancing functionality in circumscribed cognitive domains, by failing to directly remediate the cognitive weakness, any broader effects are likely to be minimal. This contrasts fundamentally with restorative training approaches, which seek to directly strengthen areas of cognitive weakness in order to improve functional performance more generally. Restorative approaches therefore align more strongly with theoretical frameworks of cognitive reserve and principles of neuroplasticity. As noted earlier, it is now accepted that environmental and lifestyle factors can produce neural changes that have protective or damaging effects (positive and negative neuroplasticity, respectively (Hertzog et al., 2008; Stern, 2009). Because exposure to cognitively stimulating activities is considered to promote positive neuroplastic changes, such as increases in the number and strength of connections between neurons (for a review, see Cappa, 2017), restorative training should theoretically enhance cognitive reserve, and any benefits of restorative approaches should, by definition, be greater.

To date, a variety of different approaches have been used in the single-component PM training literature, including spaced retrieval, visual imagery, memory diaries, digital calendars, as well as metacognitive awareness training (see, e.g., Andrewes et al., 1996; Ozgis et al., 2009). However, most compensatory PM training studies conducted to date have focused on implementation intentions. While these studies show that use of this encoding strategy can meaningfully enhance older adults' PM (Brom & Kliegel, 2014; Bugg et al., 2013; Chasteen et al., 2001; Henry et al., 2020; Lee et al., 2016; Liu & Park, 2004; McFarland & Glisky, 2011; Schnitzspahn & Kliegel, 2009; Shelton et al., 2016), they do not lead to reliable far transfer effects. For instance, while Brom and Kliegel (2014) showed that implementation intention training led to gains in a real-world PM health behavior (blood-glucose monitoring), no transfer effects were identified for any untrained cognitive abilities.

As noted earlier, because the conceptual basis of restorative training is that training in one task might enhance the cognitive ability or abilities needed to perform similar tasks, or—ideally—also very different tasks such as activities of daily living, restorative approaches should theoretically have the potential to generate stronger far transfer effects than compensatory ones. However, only two studies to date have directly tested whether restorative training can enhance PM function in late adulthood (Brom & Kliegel, 2014; Rose et al., 2015) and in only one of these did the restorative training approach directly target PM (Rose et al., 2015). Thus, although Brom and Kliegel's (2014) study used a restorative training approach with the goal of enhancing PM, the target of their training was executive control (task-switching training). This means that although their study showed that a compensatory strategy condition focused on training implementation intentions generated stronger transfer effects than restorative training, it remains unclear whether this would also be true had the restorative condition also directly targeted PM.

Indeed, the only study to date to target PM directly using restorative training identified significant far-transfer to real-world outcomes. In Rose et al.'s (2015) study, older adults were allocated to either a restorative single-component training condition that directly targeted PM ($N = 23$), or one of two control conditions:

a music control condition ($N = 14$) or a no-contact control condition ($N = 18$). The restorative training involved completing a specially adapted training version of the Virtual Week (VW) computer game in twelve sessions over a 1-month period. Encouragingly, the results showed that restorative PM training, but neither of the control conditions, produced far-transfer effects to real-world outcomes. This included improved performance on real-world PM and activities of daily living. Restorative training also led to small changes in the neural correlates of PM processing. However, there were a number of limitations in Rose et al.'s (2015) study. In addition to small sample sizes, the recruitment procedures prevented true random allocation to conditions, resulting in small but potentially important differences between groups. Concerns were also noted about the appropriateness of the musical control condition. Thus, although encouraging, these preliminary findings require further investigation in a larger, randomized controlled trial.

The Current Study

The present study substantially builds on and extends Rose et al.'s (2015) findings. An important consideration identified in this earlier study was that, at the beginning of training, most participants reported using either no strategy, or one that PM researchers would consider ineffective. Even after completion of the training program, which involved 4 weeks of three sessions per week, most participants still reported using ineffective strategies for prospective remembering. Ineffective strategies were broadly defined as strategies that lacked any elaborated, conceptual, or associative encoding, such as simple rote rehearsal. In the present study, in addition to including a restorative as well as a compensatory training approach, both of which directly target PM, we therefore also included a novel, combined intervention that involved both approaches. This combined intervention allowed us to directly test whether explicitly teaching participants effective strategies concurrently alongside restorative training is a particularly effective approach.

As noted, two of the three PM interventions (the Restorative and Combined conditions) involved use of the VW training task (the third PM intervention—the Compensatory condition—did not involve use of this task). The first key prediction was therefore that the two PM interventions that involved use of the VW training task (the Restorative and Combined conditions) would generate post-training effects, whereby there would be significant improvement on this task. Secondly, we anticipated that, for all three of the interventions that targeted PM (the Restorative, Compensatory, and Combined conditions), near transfer effects would be evident, whereby there would be significant post-training improvement for two PM outcome measures independent of the specific PM training task. However, of particular interest was to test the prediction that explicitly teaching participants' effective strategies while simultaneously providing the opportunity to practice these strategies when engaged in restorative training (i.e., the Combined approach) would be particularly beneficial for PM, and lead to the greatest near transfer gains.

Predictions with respect to far transfer effects were less clear. This is because, while both earlier PM intervention studies that have specifically targeted PM identified no transfer to untrained cognitive domains using a compensatory (Brom & Kliegel, 2014) or a restorative approach (Rose et al., 2015), the sample sizes in both were relatively small. Consequently, it remains unclear whether far transfer effects will emerge for untrained cognitive domains when a larger, better powered design is used. Theoretically, should any transfer to untrained cognitive domains be identified following completion of the PM interventions, these should be restricted to the interventions that included a restorative training component (because as noted earlier, only restorative training should directly promote positive neuroplasticity, and thereby increasing cognitive reserve). For this same reason, it was anticipated that any far transfer effects to measures of activities of daily living should be restricted to the interventions that included a restorative training component (either alone, or in combination, i.e., the Restorative and Combined interventions, respectively).

Method

Participants

In total, 124 adults aged 60 years or older participated in the study. Age ranged from 60 to 87 years ($M = 72.5$, $SD = 6.0$) and years of education from 7 to 31 ($M = 15.6$, $SD = 4.1$). To be eligible, participants had to be native English speakers or fluent in English, and to have normal or corrected-to-normal vision and hearing. Additional inclusionary criteria were the absence of any neurological or major psychiatric disorder, and all participants had to complete a cognitive screen (The Telephone Interview for Cognitive Status, TICS) prior to commencing the study. All participants scored above the recommended education adjusted cut-off (≥ 34) on this measure. Participants were recruited from the independent living clients of a retirement village and via community advertising. They provided written informed consent. Ethical approval was provided by the Human Research Ethics Committee of Australian Catholic University. Participants were randomly allocated to one of the four intervention conditions. The total number of participants initially enrolled were 37 (Restorative), 35 (Compensatory), 40 (Combined), and 36 (Active Control), with drop-out ranging from 4 (Active Control) to 9 (Combined). The reasons and timing of participants dropping out were diverse, but the most common reason provided related to the high time commitment required for participation. Other cited reasons included unanticipated personal or medical issues arising. The final numbers in each of the four conditions were as follows: Restorative ($N = 30$; 63% female), Compensatory ($N = 31$; 68% female), Combined ($N = 31$, 65% female), and Active Control ($N = 32$, 56% female).

Descriptive statistics for the background characteristics (age, years of education, TICS scores, and National Adult Reading Test scores) of participants in the four conditions are reported in Table 1. It is considered best practice not to report statistical tests of baseline differences in randomized controlled trials (see, e.g., de Boer et al., 2015), so these analyses have not been reported here, but are available as Supplementary Data (S1) for interested readers.

Design

This randomized controlled trial (RCT) involved 6 weeks of intervention for each of the four conditions and two assessment time points: Time 1 (baseline) and Time 2 (end of the 6 weeks of training). We used a randomly generated number chart to assign

Table 1
Descriptive Statistics for the Background Characteristics of Participants in Each of the Four Intervention Conditions

	Restorative (N = 30)		Compensatory (N = 31)		Combined (N = 31)		Active control (N = 32)	
Age	71.43	5.76	72.13	5.53	70.74	5.53	75.41	6.20
% male	36.72		32.33		35.54		43.78	
% community	80.00		90.30		80.70		81.30	
Years of education	15.53	3.40	15.74	5.18	15.27	4.16	15.62	3.51
TICS	38.97	2.92	38.37	3.32	37.93	2.78	37.09	2.48
NART	115.14	6.48	114.28	6.00	116.44	7.33	116.64	5.69

Note. TICS refers to The Telephone Interview for Cognitive Status. NART refers to the National Adult Reading Test. The NART is an extensively validated measure of verbal intelligence, from which it is possible to derive estimates of intellectual function; these estimates have been provided here.

each participant to one of the four conditions. Power analyses using G*Power (Faul et al., 2007) showed that a sample size of 23 per condition was needed to have appropriate power (>95%) to detect a large-sized effect size (f = . 40) using a frequentist approach, which was anticipated based on our pilot PM training studies (as detailed in Rose et al. (2015)), we identified large training-related gains in performance on all types of PM tasks on the unique virtual days for the training group relative to the control groups). Because of the 6-week time-period participants were required to be involved in the project, a minimum of 35 participants were recruited for each condition to allow for attrition.

Procedure

Baseline testing was conducted *prior* to the allocation of participants to different conditions, and therefore prior to participants commencing training. Separate and independent personnel were responsible for administering the intervention and for completing the post-testing assessments. This means that the researchers who conducted the phone calls and visits (and were involved in administering the interventions), never completed the follow-up assessments. The interventions in all four conditions were delivered via computer and completed in participants' homes. However, for each condition, there was first an initial introductory session to set up the intervention, with at least one follow-up phone call, and in some cases a visit to provide in-home support. The automated programs with phone support were extensively pilot tested prior to commencing. We also tried to minimize potential bias in communicating expectations to participants, with all four conditions presented to participants as plausible interventions. Thus, for each condition, a rationale was provided as to why it may be valuable, focusing broadly on how mental stimulation may be beneficial. With the initial Information Sheet inviting participants and all subsequent communications with participants we did not use the labels for each condition used in this report. Rather, we used terms such as Memory School for the Compensatory condition and Memory Coach for the Combined condition. The Active Control condition was not called a control group, but instead referred to as an equally valid intervention, Book Club.

Intervention Conditions

For the Restorative and Combined training conditions, an adapted computerized version of VW was the PM training task. VW is a measure of PM designed to more closely represent PM in daily life (Rendell & Craik, 2000) using an engaging, board game format. VW differentiates between PM multiple task parameters (time-based vs. event-based, regular versus irregular, time-based time-of-day vs. time-based time-interval) and provides a detailed error analysis. As with other PM measures, performance on VW is typically correlated with broader cognitive functioning, and in particular retrospective memory and executive control (Rendell & Henry, 2009). VW has excellent psychometric properties (Henry et al., 2007; Rose et al., 2010, and is very sensitive to the effects of normal adult aging, and prior studies that have used VW have consistently shown that older adults perform more poorly than younger adults (Haines et al., 2020; Henry et al., 2012; Rendell & Craik, 2000; Rose et al., 2010) and task performance is a key predictor of their functional independence (Hering et al., 2018).

Participants move around the VW board with the roll of a die, with each circuit of the board representing a virtual (waking) day. The selection of activity options, rolling die and moving the token constitute the ongoing activity for the PM tasks embedded in VW. Each day includes regular, irregular, and time-interval PM tasks. Regular PM tasks are tasks that need to be completed on multiple occasions; an equal number of these are event based (triggered by specific event cards) or time based (triggered by specific virtual times of day). Irregular PM tasks are not repeated; these also consist of an equal number of event-based and time-based tasks. Time-interval tasks are regular tasks that require participants to "break set" from the board game activity and monitor real time on the stop clock that is displayed prominently. Participants perform each PM task by clicking on the "perform task" button on the screen and selecting the appropriate action from the drop-down menu consisting of a list of target and distractor actions. Participants are encouraged to perform each PM task on time but even if they are late to remember a task, to still perform the task. Although VW was the training measure used in two of the PM training conditions, it was adapted to be appropriate for each of these conditions, as detailed below. For all four conditions, participants also attended an introductory session, although the exact content of these sessions differed, as noted next.

Restorative PM Intervention

For the VW training task developed for Rose et al.'s (2015) study, instead of the original seven virtual days, 24 virtual days were presented that allowed VW to be used for sustained practice. The training variant of VW also included adaptive difficulty (where the difficulty systematically increased in response to participants' performance), as well as feedback; both key features of restorative training studies (Jaeggi et al., 2008; Morrison & Chein, 2011). In the present study, we made two key further adaptions to the training VW task. Firstly, to allow in-home testing, we automated the VW training program to proceed through the difficulty levels of the training appropriate to each participant's performance, and to record and then send the results via the internet. Secondly, we extended the number of virtual days further to 48, to allow even greater sustained practice. Importantly, each of these virtual days continued to present unique activities and PM tasks, as is the case for the original VW. Piloting indicated that the adapted VW training program could be completed effectively by older adults in their homes, after receiving an initial introduction session with a research assistant, one follow up, and then phone support.

Thus, for the restorative training condition, we targeted PM via incremental computer-based training using the newly adapted training version of VW. After the initial introduction session, participants completed two virtual days per session, four times a week, for 6 weeks in their own homes, on an iPad provided to them. Because of the adaptive difficulty feature of the training version of VW, participants' own performance determined their game progress. Failing a day (defined as failing to complete at least 80% of tasks correctly) required the participant to complete their next circuit at the same difficulty level. After each virtual day, the computer provided the participant with feedback on their performance, but they were required to complete two circuits per session regardless of performance (passing or failing a particular day). However, participants had to "pass" each level twice before being moved up to the next level (i.e., two circuits at 80%+ accuracy).

Compensatory PM Intervention

This condition followed the PM intervention program used by McDaniel et al. (2014), and involved weekly video tutorials that focused on teaching various strategies to improve accuracy on PM tasks in daily life such as implementation intentions, monitoring strategies, use of external reminders, identifying types of PM tasks appropriate for each strategy. In addition, participants completed homework tasks that required application of the PM strategies they had learned as well as answering questions about the content of the tutorials. Participants were told to complete each of the four tasks (watching the video, completing the two homework tasks, and the online quiz), on separate days of each week. Each week had a different topic (Week 1: Getting to know your memory, Week 2: Types of PM tasks: Week 3: Two strategies: Converting cues, and the "When-Then" strategy: Week 4: Two strategies: creating cues and external aids: Week 5: Two strategies: stay put strategy, and mental to do list, and Week 6: Choosing and using strategies). Thus, across the 6 weeks, six distinct strategies were taught, and there were six homework activities dedicated to helping participants to learn each of these specific strategies in their everyday lives. The two key variations to McDaniel et al.'s (2014) protocol were that tutorial sessions were delivered via videos on a computer in participants' own homes, rather than face to face in a lab; and that the strategies only targeted PM: PM was one of several cognitive domains targeted by McDaniel et al. (2014).

Combined PM Intervention

As for both the Restorative and Compensatory conditions, participants in the Combined condition completed four intervention sessions per week. In the first session, they watched the same video tutorials that were used in the Compensatory condition. In each of the remaining three sessions, they played the training version of VW, which was adjusted for difficulty as per the Restorative condition protocol.

Active Control

Participants in the Active Control condition received the same frequency and duration of training sessions as the restorative condition. They selected an audiobook from four options and were instructed to listen to a chapter four times per week. After each audio session, they had to answer simple multiple-choice questions about the chapter in a booklet, which functioned as a fidelity check to ensure that they were completing their assigned reading. As for the PM intervention conditions, audiobooks were delivered via computer and involved the same level of support and contact with research personnel as the PM training conditions. The Active Control condition was included to control for any potential non-specific effects in the intervention conditions.

Baseline and Post-Testing Assessments

Participants completed a range of assessments, both at baseline prior to being randomly allocated to one of the intervention conditions, and then again 6 weeks later following completion of the intervention. These assessments allowed us to test the nature and magnitude of any gains and transfer effects across the four different conditions.

To test whether there was evidence of *training gains* on the specific task used for training in the Restorative and Combined conditions, participants completed the original version of VW.

To test whether there was evidence of *near transfer* effects to measures of PM not included in any of the interventions, all participants completed the Memory for Intentions Screening Test (MIST, Raskin et al., 2010) and the MEMO (Haines et al., 2020). The MIST is a laboratory measure of PM that has been shown to have good construct validity with healthy older adults (Kamat et al., 2014). The standard MIST is a validated non-computerized measure of PM, in which individuals are required to perform eight PM tasks over a period of approximately 20 min whilst engaged in an ongoing word search task. The MIST assesses both time-based and event-based PM and varies the delay interval (2-min or 15-min delay) and response type (verbal or action response). Time-based tasks are rated on a 3-point scale ranging from 0 to 2, where 0 equals an omission, 1 equals a correct response at the incorrect time, and 2 indicates a completely correct response. Event-based tasks are rated on a 2-point scale ranging from 0 to 2, where 0 is an omission error and 2 is a correct response. The key dependent measures of interest in the present study were the total scores for event-based PM and time-based PM tasks.

The MEMO provides a more ecologically valid measure of event and time-based PM in daily life. In the present study, the MEMO was provided to participants as an app which was uploaded on a dedicated Android LG smart phone (i.e., never onto the participants' personal phone; Haines et al., 2020). Participants completed the MEMO in their own homes over a 3-day period. Time-based measures involved scheduled quizzes each day at set times chosen by participant, and random quizzes which require the participant to open the app when they received an auditory notification and then again after a specific delay. Half of these time-based measures were time-of-day tasks, requiring completion at a particular time; the other half were time-interval tasks, requiring completion after a specific period of time had elapsed. Event-based measures required participants to take four photos each day when they encountered particular events. Some of these events were high-frequency events assigned by the experimenter, and others were selected by the participant from a list of options. For the present study, the three key dependent measures were total scores for event-based PM, time-based time-of-day PM, and time-based time-interval PM.

To test whether there was evidence of *far transfer effects* to *untrained cognitive abilities*, participants completed measures of episodic memory, executive control, working memory, and processing speed. To index episodic memory, the Hopkins Verbal Learning Test was used. Participants were asked to recall as many words as possible across three separate learning trials from a word list. The total number of words recalled provided an index of verbal learning. To measure delayed recall, participants were asked (about 20–25 min later) to recall these words again. To index the capacity to inhibit a pre-potent response (a core aspect of executive control), the Go-No-Go task was used. For this task, a series of letters were briefly presented one at a time on a computer screen, and participants were asked to press a particular key on the computer keyboard as quickly as possible for all letters (75% of all trials), *except* the letter X (appearing on 25% of all trials), for which no response was to be made. To measure working memory, The *N*-back task was used; this task required participants to watch a series of letters presented briefly one at a time on a screen, and to classify each one as either the same or different to the letter shown two letters prior to the current letter in the sequence (i.e., 2-back). The proportion of correct categorizations over all trials was used to index working memory. Processing speed was measured using a computerized Choice Reaction Task (CRT). In this task there were four blocks, with two simple stimulus presentations (a blue and a red square) alternating pseudo-randomly across trials within each block. Participants had to click on one side if they saw a red square and on the other side if they saw a blue square, as quickly as possible. The dependent measure for this task was mean latency for all correctly classified stimuli.

Finally, to test whether there was evidence of *far transfer effects* to a measure of *functional capacity*, participants completed a Timed version of the Instrumental Activities of Daily Living (TIADL). The TIADL required participants to complete a range of hands-on tasks such as sorting socks into pairs, and looking up a number in a phone directory, designed to index capacity for higher-order self-care activities (and consequently functional independence). Because of the timed nature of this assessment, this measure is sensitive to variation in functional capacity seen even in the context of healthy adult aging (see e.g., Hering et al., 2018).

Data Analysis

We conducted a series of 2×4 mixed ANOVAs with time (2: pre-test, post-test) as the within-subjects factor and training condition (4: Restorative, Compensatory, Combined, Active Control) as the between-subjects factors for each of the different outcome measures. For these analyses, the outcome measures were (a) VW, (b) the two PM tasks that were independent of the PM task used for training in the Restorative and the Combined conditions, (c) the cognitive tasks that tapped into untrained cognitive domains, and (d), the measure of functional capacity. Analyses were conducted with JASP (Version 0.13.1) created by the JASP team (2020) using frequentist (mixed) ANOVAs and *t*-tests and Bayesian (mixed) ANOVAs and Bayesian *t*-tests.

For the frequentist results, significant main effects and interactions were analyzed using post-hoc *t*-tests corrected using Bonferroni: all *p* values were multiplied by the number of comparisons made (indicated as *padj*). Alpha-level was set to .05. The aim of the present study was to compare different interventions for their efficiency to improve cognitive performance in different measures, therefore *post hoc* comparisons for the interactions focused only on the possible *change* within each training condition. For significant interactions of time by group, the change in performance from pre- to post-test was compared for each of the four groups using two-sided paired *t*-tests (multiplying the *p* value by 4 for *padj*). In case of at least moderate evidence for the interaction of time by group for the Bayesian analyses, we conducted Bayesian two-sided paired *t*-tests for each group to further analyze the change due to the intervention. For the Bayesian analyses, we used the default settings implemented in JASP. Models were compared to the null model. Interpretation of Bayes Factors (BF) was based on Schönbrodt and Wagenmakers (2018) and Keysers et al. (2020) guidelines. Here, with respect to level of support for the alternative hypothesis, a BF of 1 indicates an absence of evidence, BFs between 1 and 3 anecdotal evidence, BFs between 3 and 10 moderate evidence, BFs >10 strong evidence, and BFs >100 extreme evidence.

Results

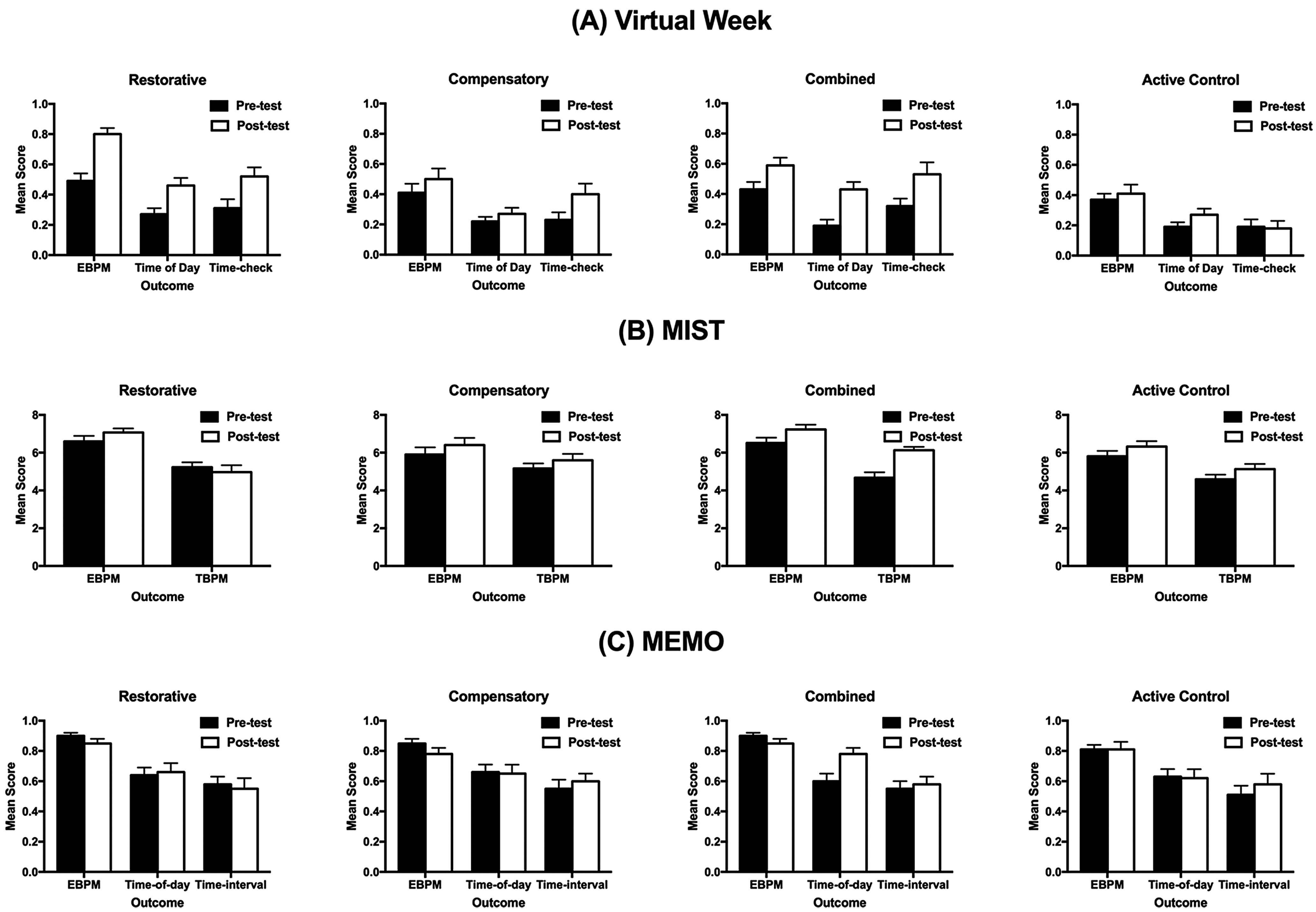
VW Training Gains

To analyze the effectiveness of the VW training approach used in the Restorative and the Combined conditions, we conducted mixed ANOVAs on the outcome measures of VW including the performance scores for all event-based tasks (event-based PM), all time of the day tasks (time-based PM), and all time-interval tasks (another index of time-based PM; see Figure 1).

For performance on the *event-based tasks*, we found main effects of condition ($F(3, 108) = 5.87$, $p < .001$, $\eta p^2 = .14$, $BF_{incl} = 155.04$ indicating extreme evidence) and time ($F(1, 108) = 29.22$, $p < .001$, $\eta p^2 = .21$, $BF_{incl} = 70{,}301$ indicating extreme evidence) as well as an interaction between condition and time ($F(3, 108) = 4.29$, $p = .007$, $\eta p^2 = .11$, $BF_{incl} = 22.24$ indicating strong evidence). The Bayesian mixed ANOVA showed that the full model including the two main effects and the interaction was the best model ($BF_{10} = 2.755 * 10^6$, compared against the null model). Post hoc paired *t*-tests showed, that only participants in the Restorative and Combined conditions improved their performance from pre-test to post-test (Restorative: $t(27) = 5.62$, $padj < .001$, $BF_{10} = 3{,}485$ indicating extreme evidence; Combined: $t(27) = 3.09$, $padj = .020$, $BF_{10} = 8.82$ indicating moderate evidence). There were neither significant changes nor evidence for changes over time for the Compensatory ($t(27) = 1.24$, $padj = .908$,

Figure 1

Performance of Participants on the Measures of Prospective Memory at Pre-Test and Post-Test for Each of the Four Intervention Conditions. Data Are Reported Separately for (A) Virtual Week Data, (B) the Memory for Intentions Screening Test (MIST) Data, and (C) MEMO Data. Error Bars Depict Standard Error of the Mean



$BF_{10} = 0.40$) or Active Control conditions ($t(27) = 1.15$, *padj* > .999, $BF_{10} = 0.37$).

For performance on *time-of-day tasks*, we again found main effects of condition ($F(3,108) = 3.72$, $p = .014$, $\eta p^2 = .09$, $BF_{incl} = 6.27$ indicating moderate evidence) and of time $F(1, 108) = 43.88$, $p < .001$, $\eta_p^2 = .29$, $BF_{incl} = 5.58 * 10^6$ indicating extreme evidence), as well as an interaction between the two ($F(3, 108) = 3.21$, $p = .026$, $\eta_p^2 = .08$, $BF_{incl} = 5.15$ indicating moderate evidence). The Bayesian mixed ANOVA showed that the full model including the two main effects and the interaction was the best model ($BF_{10} = 1.785 * 10^7$, compared against the null model). Post hoc paired *t*-tests showed, that only participants in the Restorative and Combined conditions improved their performance from pre-test to post-test (Restorative: $t(27) = 4.20$, *padj* < .001, $BF_{10} = 110.45$ indicating extreme evidence; Combined: $t(27) = 4.53$, *padj* < .001, $BF_{10} = 242.98$ indicating extreme evidence). There were neither significant changes nor evidence for changes over time for the Compensatory ($t(27) = 1.66$, *padj* = .432, $BF_{10} = 0.68$) or Active Control conditions ($t(27) = 2.38$, *padj* = .100, $BF_{10} = 2.18$ indicating only anecdotal evidence).

However, for performance in the *time-check tasks*, we found main effects of condition ($F(3, 108) = 5.67$, $p = .001$, $\eta_p^2 = .14$, $BF_{incl} = 28.41$ indicating strong to very strong evidence) and time, $F(1, 108) = 21.71$, $p < .001$, $\eta_p^2 = .17$, $BF_{incl} = 1{,}538$ indicating extreme evidence), but no interaction between the two, $F(3, 108) = 2.22$, $p = .090$, $\eta_p^2 = .06$, $BF_{incl} = 2.28$ indicating anecdotal evidence). The Bayesian mixed ANOVA showed that the model including the two main effects was the best model ($BF_{10} = 37{,}289$, compared against the null model).

Near Transfer Effects

For near transfer effects, we analyzed the change from pre-test to post-test in two other PM tasks that were independent of the training task used in the Restorative and Combined conditions: MIST and MEMO (see Figure 1).

MIST

For the *event-based tasks*, we found main effects of condition ($F(3, 117) = 3.40$, $p = .020$, $\eta_p^2 = .08$, but $BF_{incl} = 1.41$

indicating only anecdotal evidence) and time ($F(1, 117) = 10.80$, $p = .001$, $\eta_p^2 = .08$, $BF_{incl} = 15.74$ indicating strong evidence), but no interaction between the two ($F(3, 117) = .073$, $p = .974$, $\eta_p^2 < .01$, $BF_{incl} = 0.13$). The Bayesian mixed ANOVA showed that the model including the two main effects was the best model ($BF_{10} = 45.00$, compared against the null model).

For performance in the *time-based tasks*, we found a main effect of time ($F(1, 117) = 11.38$, $p = .001$, $\eta_p^2 = .09$, $BF_{incl} = 28.24$ indicating strong evidence) and an interaction between condition and time ($F(3, 117) = 4.41$, $p = .006$, $\eta_p^2 = .10$, $BF_{incl} = 4.25$ indicating moderate evidence), but no main effect of condition ($F(3, 117) = 1.28$, $p = .283$, $\eta_p^2 = .03$, $BF_{incl} = 0.93$). The Bayesian mixed ANOVA showed that the full model including the two main effects and the interaction was the best model ($BF_{10} = 25.60$, compared against the null model).

Following up on the interaction using post hoc paired *t*-tests showed that only participants in the Combined condition improved performance from pre-test to post-test ($t(29) = 5.55$, $padj < .001$, $BF_{10} = 3{,}671$ indicating extreme evidence). For participants in the three other conditions, there were neither significant changes nor evidence for changes over time (Restorative: $t(29) = 0.72$, $padj > .999$, $BF_{10} = 0.002$; Compensatory: $t(29) = 1.37$, $padj = .724$, $BF_{10} = 0.45$; Active control: $t(30) = 1.63$, $padj = .452$, $BF_{10} = 0.63$).

MEMO

For performance changes in the MEMO task, we analyzed total scores for the event-based tasks, the time-of-day time-based tasks, and the time-interval time-based tasks. Regarding the *event-based tasks*, there was a main effect of time ($F(1, 100) = 6.54$, $p = .012$, $\eta_p^2 = .06$, $BF_{incl} = 2.79$ indicating anecdotal evidence), but was neither main effect of condition ($F(3, 100) = 1.44$, $p = .235$, $\eta_p^2 = .04$, $BF_{incl} = 0.17$), nor any interaction between condition and time ($F(3, 100) = .86$, $p = .463$, $\eta_p^2 = .03$, $BF_{incl} = 0.09$). The Bayesian mixed ANOVA showed that the model including time was the best model ($BF_{10} = 4.04$, compared against the null model).

For the *time-of-day tasks*, there was an interaction between condition and time ($F(3, 98) = 5.08$, $p = .003$, $\eta_p^2 = .14$, but $BF_{incl} = 0.71$), but no main effects of condition ($F(3, 98) = 0.49$, $p = .691$, $\eta_p^2 = .02$, but $BF_{incl} = 0.19$) or time ($F(1, 98) = <0.01$, $p = .977$, $\eta_p^2 < .01$, BFincl = 0.24). The Bayesian mixed ANOVA showed that the null model was the best model. For completeness, we reported the post hoc analyses following the frequentist approach. However, given the results of the Bayesian mixed ANOVA, these results have to be treated with caution.

Following up on the interaction revealed that only participants in the Combined condition improved their performance from pre-test to post-test ($t(24) = 3.94$, $padj < .001$). No changes were identified for the other conditions (Restorative: $t(26) = 1.55$, $padj = .536$; Compensatory: $t(26) = 1.06$, $padj > .999$; Active control: $t(22) = .280$, $padj > .999$).

Finally, for the *time interval tasks*, no main or interactions effects were identified (all $ps \geq .814$, all $BF_{incl} < 0.107$). The Bayesian mixed ANOVA showed that the null model was the best model.

Far Transfer Effects

For far transfer effects to untrained cognitive domains, we analyzed performance on measures of episodic memory (Hopkins Verbal Learning Test [HVLT] total immediate and delayed recall), inhibitory control (Go-No-Go mean reaction time for correct trials), working memory (*N*-Back accuracy), and processing speed (Choice Reaction Time task mean reaction time for correct trials). To test for far transfer effects to a measure of functional capacity, we assessed performance on the TIADL total time, adjusted for errors. Data contributing to these analyses are reported in Table 2. The analyses did not reveal any interactions of group by time for any of these measures. There was only one main effect of time for the *N*-Back performance ($F(1, 91) = 11.35$, $p = .001$, $\eta_p^2 = .11$, $BF_{incl} = 19.07$ indicating strong evidence), with performance higher at post-test, consistent with practice effects. The Bayesian mixed ANOVA showed that the model including the time was the best model ($BF_{10} = 27.92$, compared against the null model).

For completeness of reporting, data for all interactions tested are as follows: HVLT total immediate recall: $F(3, 116) = 1.84$, $p = .143$, $\eta_p^2 = .05$, $BF_{incl} = 0.13$; HVLT delayed recall: $F(3, 116) = 1.40$, $p = .247$, $\eta_p^2 = .04$, $BF_{incl} = 0.04$; Go-No-Go: $F(3, 93) = 0.29$, $p = .833$, $\eta_p^2 < .01$, $BF_{incl} = 0.01$; *N*-Back: $F(3, 91) = 1.07$, $p = .365$, $\eta_p^2 = .03$, $BF_{incl} = 0.09$; Choice Reaction Time: $F(3, 94) = 0.51$, $p = .679$, $\eta_p^2 = .02$, $BF_{incl} = 0.03$; TIADL: $F(3, 116) = 0.95$, $p = .418$, $\eta_p^2 = .02$, $BF_{incl} = 0.01$. These data therefore provide no evidence for any far transfer effects for any of the four different interventions.

Discussion

The current study provides the strongest test to date of the potential value of single-component interventions that directly target PM. As noted, to date all but one of the prior PM intervention studies have tested compensatory approaches (Brom & Kliegel, 2014; Bugg et al., 2013; Chasteen et al., 2001; Henry et al., 2020; Lee et al., 2016; Liu & Park, 2004; McFarland & Glisky, 2011; Schnitzspahn & Kliegel, 2009; Shelton et al., 2016), or a restorative approach that did not directly train PM (Brom & Kliegel, 2014). The one exception had a number of methodological limitations which meant that, although Rose et al. (2015) found that directly targeting PM via restorative training led to far transfer effects, these findings were acknowledged to be preliminary. By including both an RCT design and a more appropriate Active Control condition, the present study provided a critically needed, rigorous test of whether restorative training that directly targets PM elicits reliable transfer gains.

A key additional goal of the present study was to establish whether any transfer effects differed as a function of the *type* of PM intervention used, particularly in light of the critical distinction made in the broader intervention literature between compensatory and restorative approaches. Consequently, the present study directly compared performance across three different PM interventions: Restorative, Compensatory, and—quite uniquely—a Combined condition that integrated these approaches. To test for VW training gains and transfer effects, we analyzed change in performance from pre-test to post-test on the VW training task used in the Restorative and Combined conditions, two measures of PM that were independent of all four interventions (MEMO and MIST), untrained cognitive abilities, as well as a measure of functional capacity.

Table 2
Means and Standard Deviations for the Far Transfer Outcome Measures, Separately for Each of the Intervention Conditions

	Restorative				Compensatory				Combined				Active control			
	Pre-test		Post-test		Pre-test		Post-test		Pre-test		Post-test		Pre-test		Post-test	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
HVLT																
Total Immediate	27.57	3.57	27.55	4.31	26.10	4.80	26.47	5.36	26.29	4.66	28.17	4.47	25.34	4.65	25.77	4.65
Delayed	9.97	1.38	9.79	1.78	8.97	2.70	9.47	2.83	9.52	1.95	10.30	1.64	9.13	2.35	9.06	1.93
Go-No-Go	457.67	116.86	452.96	121.14	451.76	72.19	454.61	75.66	460.00	91.54	449.40	65.75	464.03	69.70	476.84	84.73
N-back	0.80	0.09	0.83	0.07	0.78	0.13	0.81	0.12	0.77	0.12	0.83	0.06	0.80	0.07	0.80	0.07
CRT	554.63	157.05	568.25	171.50	525.41	91.21	547.09	85.91	512.02	72.93	536.60	80.62	532.56	67.63	527.94	77.96
TIADL	562.33	228.14	532.26	227.69	592.23	245.94	610.08	317.69	637.55	275.51	550.33	262.53	671.87	267.52	577.00	255.43

Note. HVLT refers to The Hopkins Verbal Learning Test. CRT refers to Choice Reaction Time. TIADL refers to The Timed Assessment of Instrumental Activities of Daily Living.

Taken together, the results indicated that for participants who completed the compensatory intervention, there were no transfer effects. For participants who completed restorative training (either alone, or in combination with a compensatory approach), there were training gains on the VW task that was used for training in both of these conditions, with performance on event-based and time-of-day PM tasks significantly improved at post-test. However, restorative training, when completed by itself, generated no further gains. Specifically, for the Restorative condition, there was neither evidence of near transfer to the PM measures that were not included in training (MIST and MEMO), nor any far transfer to untrained cognitive abilities, or the TIADL. Only the Combined condition that integrated restorative and compensatory approaches led to transfer effects, but these gains were restricted to PM. Thus, although participants in this condition improved in aspects of their time-based PM as indexed by the MIST (and according to the frequentist, but not the Bayesian analyses, the MEMO), as for the other training conditions, no far transfer effects were evident.

Compensatory PM Intervention

Although these findings were not as predicted, they have direct implications for our understanding of when and why PM training might, and just as importantly, might not be, beneficial for older adults. In particular, a surprising finding was the absence of significant gains for participants who completed the compensatory intervention. Even after engaging in an intensive 6-week program that taught participants to use compensation strategies directly targeting PM, no gains emerged. This null effect runs contrary to considerable prior literature that has identified beneficial effects of compensatory approaches for enhancing PM, including prior work in our own labs (Brom & Kliegel, 2014; Bugg et al., 2013; Henry et al., 2020; Schnitzspahn & Kliegel, 2009).

There are a number of potential interpretations of this null effect. One possibility is that the non-specific effects of engaging in regular computerized activities incorporated into all four conditions may have been greater than anticipated, with the compensatory intervention providing little additional benefit over and above these broader effects. However, this explanation seems unlikely, as the simple main effect of time was not significant for the Active Control condition for any of the outcome measures.

Instead, it seems more likely that, at least in relation to compensatory PM interventions, computerized administration (video tutorials) may be less effective relative to face-to-face and/or group format administration. As noted, one of the key ways in which the current study's compensatory approach deviated from the (successful) program used by McDaniel et al. (2014) was that, instead of tutorials being administered face-to-face in group-format, participants completed tutorial sessions individually in their own homes. Indeed, a recent study that compared memory skills group training with individualized computerized cognitive training found that only the former was associated with significant memory gains post-stroke (Withiel et al., 2019). Thus, although the two interventions in Withiel et al.'s (2019) study differed in a number of respects, a key distinction was the format of delivery: participants completed the computerized training tasks individually whereas the memory skill intervention involved face-to-face, group-based delivery.

Broader literature also shows that face-to-face group-based administration is the default method of administering compensatory training; indeed, in the aging literature, the current study appears to be one of very few to use a computerized approach that is completed individually in participants' own homes. This approach was an important strength of the current design, as it ensured that we were able to equate as many background characteristics of the four intervention conditions as possible. However, given that the results show that, for the compensatory intervention, this approach did not lead to significant benefits, it speaks to potential mechanisms by which compensatory approaches are typically able to deliver benefits. Specifically, it suggests that at least part of the reason why this type of training may typically be successful is because of its format of delivery.

One potential reason why format of delivery may be so important for compensatory interventions is individual differences in the types of PM memory failures experienced as well as the specific compensatory strategies that are optimally effective. Older adults potentially rely on at least eleven distinct types of compensatory strategy (Weakley et al., 2019), and the need to consider the potential role of personality variables in understanding the efficacy of specific interventions for cognitive aging has also recently been highlighted (Marr et al., 2020). Face-to-face delivery can presumably be more readily adjusted and sensitive to individual requirements and preferences.

However, given the many advantages associated with self-administration (including lower cost outlay and therefore potentially greater up-take in the wider community), future work is needed to test whether customized compensatory training programs that are more closely calibrated with an individuals' needs lead to greater benefits than the generic intervention approach used in the present study. In addition, to test whether the success of prior compensatory training interventions in this literature derives partially from its group-based method of delivery, future studies should endeavor to make use of recent advances in virtual reality and other immersive techniques (see e.g., Sokolov et al., 2020).

Restorative PM Intervention

With respect to the Restorative condition, although gains were identified on the VW training task, the finding of no further post-training gains on any of the other outcome measures indicates that restorative training that directly targeted PM, generated no transfer effects. These data deviate from the earlier findings reported by Rose et al. (2015) in which restorative training led to significant far transfer effects, but as noted this earlier study lacked a RCT design, and questions were raised about the appropriateness of the protocol used in the control condition. The current results suggest that these methodological differences were important, and that much of the benefit identified in Rose et al.'s study may have been an artefact of method-specific factors. Instead, the data align with much of the broader cognitive training literature, which show that for single-component cognitive training, far transfer effects are the exception rather than the norm.

Combined PM Intervention

The results for the condition that combined compensatory and restorative approaches were the most encouraging. Here, not only were gains seen on the VW training task, but there was also evidence for transfer gains to time-based measures of PM that were independent of the training task. The format of these independent PM tasks differed considerably from the computerized VW training task. Specifically, the MIST involved the completion of PM tasks using physical cues in a social context, and the MEMO was a naturalistic task completed in participants' everyday lives (although as noted, this latter finding needs to be interpreted cautiously, given that a significant effect emerged only for frequentist, but not the Bayesian analyses). Although no far transfer effects emerged, these data provide encouraging preliminary support for the possibility that, for older adults' whose primary concern is to enhance PM function, combining Restorative and Compensatory interventions may have considerable value.

The potential value of an integrated approach would also align with other evidence from the broader training literature that points to greater benefits for broader, as opposed to more specific approaches. Basak et al. (2020) reported that only for multiple component cognitive training (i.e., where multiple cognitive operations were targeted) but not single-component cognitive training did far transfer effects reliably emerge. Moreover, Park and Park (2018) showed that non-specific computer training (using Nintento Wii) led to stronger benefits for both cognitive function and health-related quality of life relative to cognition specific cognitive training. The current data extends this concept of "generality" to encompass the type of training approach, and specifically, points to the potential value of integrating both restorative and compensatory approaches.

With respect to why the Combined approach led to significant near transfer gains, we believe that this effect may have emerged for two key reasons. Firstly, this approach provided participants' opportunities to *spontaneously* practice the compensatory strategies that they had learned. Secondly, these opportunities were provided in conjunction with feedback on errors. Thus, although the Compensatory condition also provided opportunities for participants to practice the compensatory strategies they had learned, this was in the context of specific homework exercises where they were explicitly instructed to use them, and no feedback on errors was provided. By contrast, participants in the Restorative condition did obtain feedback on errors but were never taught how to use effective compensatory strategies.

We would therefore cautiously suggest that, at least in relatively high functioning older adult cohorts of the type included in the present study, it may be valuable to provide spontaneous opportunities to practice compensatory strategies, in combination with feedback on errors. This is because our collective experience from many years working in this research field indicates that, when participants receive error feedback, they are typically very motivated to improve, and provision of effective compensatory strategies provides them with the skillset required to do this. However, clearly future studies are needed to directly test whether these proposed mechanisms do in fact underlie the transfer effects seen in the Combined condition.

In addition, an important next step is to establish whether our Combined intervention approach is also beneficial for other groups, including the many clinical disorders known to present with PM impairment (Henry, in press; Henry et al., 2016). For the reasons suggested here, it may be that this Combined approach has greater efficacy than many existing clinically focused interventions, which typically provide restorative or compensatory training in isolation. However, if our reasoning here is correct, it also seems likely that these benefits may be restricted to only certain clinical populations.

In particular, groups that present with prominent deficits in executive control, or that have avolitional disturbances, may gain greater value from a more structured, directive approach.

Limitations and Future Directions

By comparing multiple interventions that directly target PM, this study provides novel evidence that a single-component computerized intervention can be beneficial when compensatory and restorative approaches are integrated. The results are also important in highlighting the potential importance of delivery format for compensatory approaches. However, several limitations must also be acknowledged.

Firstly, with hindsight, we believe that our initial aim to demonstrate far transfer effects to untrained cognitive abilities may have reflected a theoretical overreach. As noted, the conceptual basis of restorative training is that training in one task might enhance the cognitive ability or abilities needed to perform similar tasks, or—ideally—also very different tasks. Because the process of prospective remembering is considered to impose substantial demands on both executive control and retrospective memory, a clear case can be made for why training either of these abilities might then also lead to gains in PM. However, theoretical models do not regard PM as a critical determinant of either executive control or retrospective memory, and it is interesting to note that both earlier PM intervention studies that targeted PM also identified no transfer to untrained cognitive domains (Brom & Kliegel, 2014; Rose et al., 2015).

By contrast, a strong theoretical argument can be made that improving PM function should lead to meaningful transfer on activities of daily living. This is because, as noted, older adults report that lapses of intention are the most frequent and stressful memory problems experienced in daily life (Kliegel et al., 2007), and failures of PM have been consistently linked to difficulties engaging in a range of functional everyday activities (Hering et al., 2018; Sheppard et al., 2020). In this regard, the failure to identify any far transfer effects to the measure of functional independence in the present study was the most disappointing finding, and we believe highlights the biggest limitation of this study. Specifically, in retrospect, the TIADL may not have been the optimal tool to measure everyday functional capacity. This is because none of the tasks in the TIADL required application of PM—tasks such as reading nutrition information on the back of a can, sorting socks and looking up a phone number are unlikely to impose demands on PM, and therefore may not be sensitive to changes in PM ability. This points to our most important recommendation for future research in this area, particularly for studies seeking to cross validate and extend our finding of benefits for a Combined approach. Specifically, future studies should include real-world indicators of functional capacity that impose demands on the process of prospective remembering, such as medication adherence, preparing a meal, and attending appointments. Although this recommendation deviates with some conceptualizations of far transfer effects (which define far transfer narrowly in relation to untrained cognitive domains), it fits with our groups' broader view of far transfer effects, which is of gains that generalize beyond the training environment (and which is ultimately the primary goal of any cognitive intervention).

Finally, an important limitation is that, while the present study was sufficiently powered to detect the large-sized effects that had been anticipated based on our earlier pilot study (Rose et al., 2015), power to detect small and even moderate-sized effects was low. This is important, particularly when considered in the context of Basak et al.'s (2020) meta-analysis, which revealed that none of the aggregate training effect sizes for healthy older adults approached large, or even moderate-sized effects. Thus, although these data allow us to confidently conclude that only the Combined condition generated significant near transfer effects, more subtle gains may have been evident (but not detected) in the other conditions. An important issue for future research is to establish the minimum level of PM improvement that is needed to be functionally meaningful in the context of healthy adult aging.

Related to this issue, as a group, the participants included in the present study consisted of older adults with relatively high levels of education and recruited from inner city areas that are generally associated with higher socioeconomic status. Whilst this is quite typical of the broader cognitive intervention research field as a whole, future research is also needed to establish the acceptability and efficacy of PM interventions in more culturally and socially diverse groups of older adults. We see this as an important and very achievable future goal in light of the rapidly emerging field of telehealth methods of cognitive assessment and treatment delivery.

Conclusion

The current study aligns with prior literature in showing that interventions that target a single cognitive ability do not reliably generate large far transfer effects. However, they also show that, for older adults' whose primary goal is to enhance PM function, combining both Restorative and Compensatory approaches can be effective. The potential value of this integrated training approach is an important avenue for future investigation, particularly in light of literature highlighting greater benefits for broader as opposed to more specific types of cognitive training.

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