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Relationship between Working Memory, Retrospective Memory and Strategic Monitoring with Prospective Memory Performance

Çalışma Belleği, Geriye Dönük Bellek ve Stratejik İzlemenin İleriye Dönük Bellek Performansı İle İlişkisi

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ABSTRACT

Working memory stands as a key influencer in prospective memory, encompassing elements of retrospective memory while strategic monitoring influences performance. Hence, this study delves into the interplay between strategic monitoring, retrospective memory, working memory, and prospective memory. A cohort of 120 participants (60 females and 60 males) underwent assessments utilizing the Beck Depression Inventory, n-Back tasks, and Virtual Week tasks. The results revealed that the performance in working memory significantly predicts prospective memory (β= .30; $p<.05$). As strategic monitoring and the burden of retrospective memory increase, there is a notable decrease in prospective memory performance ($p<.05$, $\eta p2$ =.45). A positive and significant correlation emerged between working memory and time-based tasks. However, no apparent relationship was observed between event-based tasks and working memory. Time-based tasks, demanding more strategic monitoring, appear relatively more challenging, suggesting a crucial role for working memory in these tasks. Notably, working memory's association with prospective memory remains irrespective of the load on retrospective memory. This study underscores the interaction of prospective memory with working memory, retrospective memory, and strategic monitoring. These findings align with the multiple processes perspective and the preparatory attention and memory processes theory.
Keywords: Memory, working memory, prospective memory

ÖZ

Çalışma belleği ileriye dönük bellek performansını etkileyebilecek önemli unsurlardan biridir. İleriye dönük bellek doğası gereği içerisinde geriye dönük bellek unsurları taşırken aynı zamanda stratejik izleme de performansı etkiler. Bu sebeplerle araştırmanın amacı stratejik izleme, geriye dönük bellek ve çalışma belleğinin ileriye dönük bellek performansı ile ilişkisini incelemektir. Araştırma 120 katılımcı (60 Kadın-60 Erkek) ile yürütülmüştür. Beck Depresyon Envanteri, n-Geri ve Sanal Hafta Görevleri katılımcılara uygulanmıştır. Elde edilen bulgulara göre çalışma belleği performansı ileriye dönük bellek performansını yordamaktadır (β= ,30; $p<,05$). Stratejik izleme ve geriye dönük bellek yükü arttıkça ileriye dönük bellek performansında düşüş görülmektedir ($p<,05$, $\eta p2$ =,45). Çalışma belleğinin zaman temelli görevlerle ilişkisi pozitif yönde ve anlamlı bulunmuştur. Ancak olay temelli görevler ile çalışma belleği arasında ilişki bulunmamıştır. Zaman temelli görevler stratejik izlemeye daha çok ihtiyaç duyan görece daha zor görevler olduğundan çalışma belleğinin burada kritik rol oynayabileceği düşünülmektedir. Çalışma belleği, geriye dönük bellek yükünden bağımsız olarak ileriye dönük bellekle ilişkili bulunmuştur. Bu çalışmada ileriye dönük belleğin çalışma belleği, geriye dönük bellek ve stratejik izlemeyle beraber işlediği gösterilmiştir. Bulgular çoklu süreçler görüşü ve hazırlayıcı dikkat ve bellek süreçleri kuramıyla tutarlı bulunmuştur.
Anahtar sözcükler: Bellek, çalışma belleği, ileriye dönük bellek

Introduction

Working memory is the type of memory that allows information to be retained and processed in memory and is considered to be at the midpoint of cognitive functions (Baddeley 2007). In complex cognitive tasks, which information will be accessed and which information will be retained and processed requires an organization, and it is thought that working memory is responsible for this organization (Ericsson and Kintsch 1995).

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Prospective memory is responsible for remembering whatever needs to be done in the future (Khan et al. 2008). Keeping in mind the tasks we need to do in the future and remembering them at the right time is as important as remembering past information (Tenenboim-Weinblatt 2013). Thus, it is necessary both to perform an action that is currently being performed and to remember another action that is planned to be performed in the future in the prospective memory tasks. At this point, retrospective memory is responsible for the content information of whatever will be remembered in the future. While the load of retrospective memory is low in repeated events in daily life, its load increases in non-routine one-time events. It has been suggested that when retrospective memory components need to be kept in mind and attention needs to be shifted between tasks, working memory resources are used (Smith 2003, McDaniel and Einstein 2007). The use of cognitive capacity may differ according to task types (Einstein and McDaniel 2005). According to the multiple processes view proposed by McDaniel and Einstein (2007), recall of the planned action is achieved through automatic or controlled processes depending on the nature of the ongoing task or the relevant cue. In automatic processes, spontaneous retrieval is common and the use of cognitive resources is relatively less. However, the use of cognitive resources increases in prospective memory tasks due to the involvement of multiple processes. The fact that when the working memory load of the ongoing task is increased, both time-based prospective memory and event-based prospective memory performance decreases indicates that working memory plays an active role in the retention of what is planned to be done (Logie et al. 2004). The theory of preparatory attention and memory processes suggests that retention of another planned action during the ongoing task will require resource utilization (Smith 2003). Successful performance of prospective memory is achieved by the combination of preparatory attention and retrospective memory processes (Smith and Bayen 2005). Working memory influences both processes and plays an active role in the performance of prospective memory (Smith and Bayen 2005).

Event Related Potentials (ERPs) have been found to show different patterns during the performance of a working memory task and a prospective memory task (West et al. 2006). On the other hand, other studies have shown that working memory and prospective memory exhibit similar patterns in terms of ERPs (Rose et al. 2010). Rose et al. (2010) measured working memory performance on procedural span tasks. They found that working memory was predicted only when on prospective memory tasks with a high need for strategic monitoring. Strategic monitoring requires more resources when the cue is time, while resource utilization decreases when the cue is an event. The multiple processes view emphasizes the matching strength of the cue and the planned action and the focalness of the cue (McDaniel and Einstein 2007). In this context, the fact that working memory is associated with performance on a prospective memory task with a high need for retrospective memory, and strategic monitoring seems to be consistent with the multiple processes view. It is well known that laboratory-based prospective memory tasks are generally weak in terms of representing real-life events (Mioni et al. 2015) and that the reliability of most prospective memory tasks is low (McDaniel and Einstein 2007). In addition, the insufficient number of prospective memory tasks can be seen as the reason for the lack of difference between the groups in terms of the number of correct responses. In the laboratory task developed by Rendell and Henry (2009), called the Virtual Week, which assesses the prospective memory, daily life activities were well represented and had sufficient number of prospective memory tasks. This task also provides the opportunity to manipulate strategic monitoring and retrospective memory. In this context, this research aims to examine the relationship between strategic monitoring, retrospective memory, and working memory with prospective memory. The hypotheses of the study are that Virtual Week is a reliable tool to measure prospective memory, working memory predicts the performance of prospective memory, the higher the need for strategic monitoring, the lower the performance of prospective memory, and the higher the retrospective memory load, the lower the performance of prospective memory.

The present study contributes to the literature by showing the relationship of working memory, retrospective memory, and strategic monitoring with prospective memory and their differences according to types of prospective memory

Method

Sample

According to the G*Power analysis, it was found sufficient to collect data from 115 participants with a power of 95% and a margin of error of 0.05. It was aimed to reach 160 participants due to possible participant losses during the research. The average age of the participants was 21.51 (2.85) and participants between the ages of 18 and 30 were included in the study. Depression is thought to be a confounding variable in both time-based and event-based prospective memory tasks (Zhou et al. 2017). People with depression have difficulty remembering tasks that need to be done in the future (Zhou et al. 2017). For this reason, the data of 23 participants who scored 17 or above on the Beck Depression Inventory were removed before analysis. The data of 16 participants who were currently using psychiatric medications that could affect cognitive processes, or those who had used such medications for a long time, and those who had a history of neurological or psychiatric disorders were excluded from the analysis. Participants were selected from students studying in different faculties of Hacettepe University.

Procedure

The study was conducted with a total of 120 volunteer participants at the Behavioral Psychopharmacology Research Laboratory (DAPSAL) of Hacettepe University, Department of Psychology. Among those who agreed to participate in the study upon the announcement, those who met the inclusion/exclusion criteria were given an appointment and the applications were carried out under the coordination of the 1st author. Approval was obtained from the Hacettepe University Ethics Commission on March 8, 2016, with the decision numbered 35853172/433-664 detailed information about the purpose of the experiment and the procedures involved was given, and written consent (Informed Consent Form) was obtained from the participants. Then, a demographic information form was given to the participants and then the Virtual Week and n-back task were administered via desktop computer. Finally, the study was completed by applying the Beck Depression Inventory.

Data Collection Tools

Demographic Information Form

It is a form prepared by the researcher to obtain information about the participants' characteristics such as age, gender, educational status, visual and auditory health status, smoking and alcohol use, and the history and pattern of use of neurological and psychiatric drugs that may affect cognitive processes.

Beck Depression Inventory

Beck Depression Inventory, developed by Beck et al. (1961), is a scale consisting of 21 items that measure depression symptoms through self-assessment. Spearman-Brown split-half reliability coefficient was found to be 0.93. Each item of this 21-item scale is evaluated between "0" and "3" points, and a high score on the scale is an indicator of high depression symptoms. The highest score for each item is "3"; The lowest score is "0" and the lowest score that can be obtained from the scale is "0"; The highest score is "63". The Turkish adaptation of the second form of the original scale was made by Hisli (1988). The Spearman-Brown split-half reliability coefficient was found to be 0.74.

Working Memory Task: n-Back

The symbol "n", which gives its name to the task, is the number that determines which stimulus should be responded to among the consecutively presented stimuli. For example, the 2-back task is a task that requires responding to consecutively presented stimuli when the presented stimulus is the same as the 2 previous stimuli. The n-Back task, which is known to measure the performance of working memory, which allows both storing and modifying information "online", causes activation in the dorsolateral prefrontal cortex (DLPFC) (Kane and Engle 2002). n-Back task software created with Brain Workshop 4.8.1 was used to measure the working memory performances of the participants (Hoskinson and Toomim 2008). The program was translated into Turkish by Altun and Çevik (2012). Özbozdağlı et al. (2018) measured working memory by studying auditory and visual spatial n-Back tasks separately. In the current study, a different combination of the 2-back task mentioned above was used, and the necessary permissions were obtained from the aforementioned researchers to modify and use the software of the n-back tasks. By evaluating the pilot study data, relevant literature, and reliability values together, it was decided to use the auditory 2-back task. The Spearman-Brown split-half reliability coefficient of the correct response rate in the auditory 2-back task was found to be .62 (Jaeggi et al. 2010). Auditory n-back tasks were performed via headphones, presenting a desktop computer screen without any visuals. During the practice phase, 1-back and 2-back tasks were applied to ensure that the participant became familiar with the tasks. In each trial, the stimuli (letters) were adjusted to come audibly and randomly through the headphones, as used in the study of Özbozdağlı et al. (2018). The total response time was determined as 3.5 seconds, the duration of the stimulus being voiced through the headphones was 0.5 seconds, and inter-stimulus interval was 3 seconds. The 2-back task consists of 90 stimuli in a total of 3 trials. Unlike the task used in Özbozdağlı et al.'s (2018) study, in the current study, instead of saying the stimulus loudly, participants responded by pressing the 'l' key if the stimulus they heard 2 stimuli ago was the same as the stimulus they heard at that moment. Due to the length of the task duration, 30 stimuli were used in each trial instead of 60. The correct response rate in the

2-back task, which measures working memory, was calculated.

Prospective Memory Task: Virtual Week

The Virtual Week was first designed as a task that involves rolling dice on a game board to measure prospective memory performance (Rendell and Craik 2000). Within the scope of the current study, the computerized version of the Virtual Week, which was later developed by the same researchers (see Figure 1 for a sample screenshot) (Rendell and Henry 2009), was used and the necessary permission was obtained from the aforementioned researchers for the use of the task.

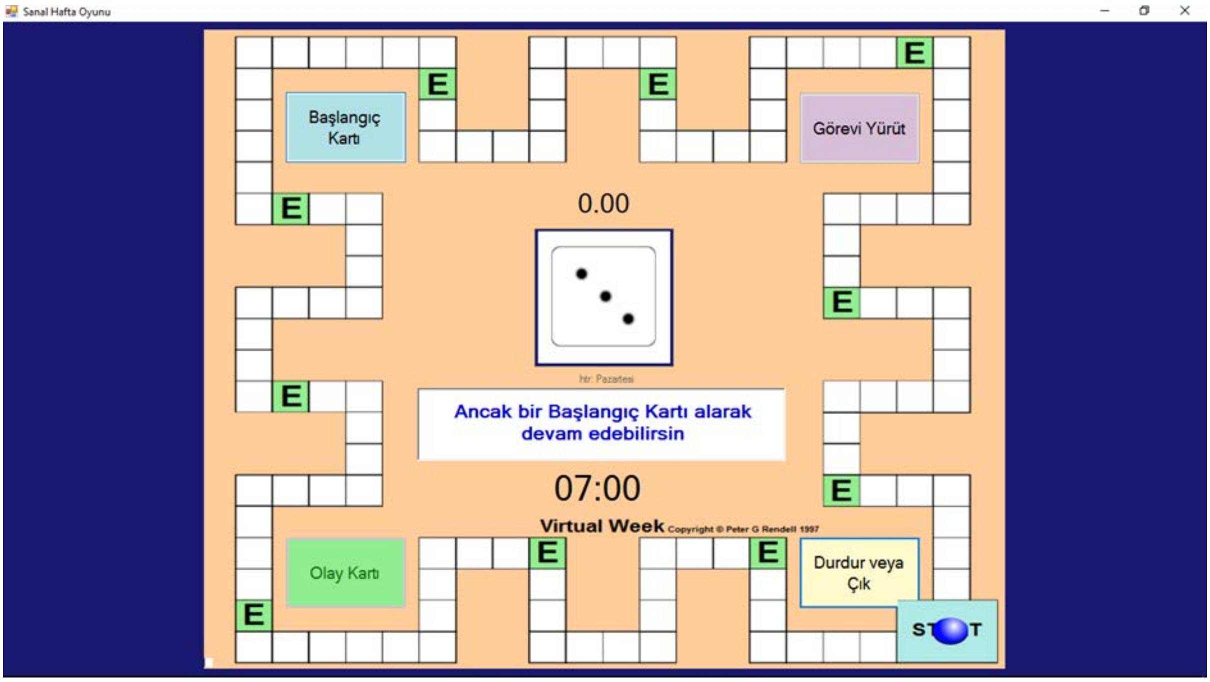

Figure 1. Main screen display of the Virtual Week task

Virtual Week is a version of daily life transformed into a computerized game format. There are some daily tasks (e.g. taking medication), situations (e.g. having bronchitis), and events (e.g. plumbing breakdown) that are determined in advance every day and occur during the day. These tasks need to be done just like in daily life and remembered when the time and place come. Participants first learn the introduction and rules of the task by reading the instructions through the relevant software program on a high-resolution (1366x768 pixels), 18-inch LG desktop computer screen.

Virtual Week consists of two types of tasks: regular tasks, which are performed routinely every day, and irregular tasks, which are performed only for that day and at that time. Regular tasks are also called health tasks that need to be done every day, such as taking medication at breakfast and dinner, regular time tasks that taking asthma medication at 11:00 am and 9:00 pm, and time control tasks that must be done every day, such as taking lung function tests at the 2nd minute and 4th minute after the virtual day starts. Irregular tasks are specific to each day, two of them are given on the starting cards (one event task, one time task) and the other two are given on the event cards (one event-based task, one time-based task).

Although the original task consists of 7 virtual days, there are also shorter versions of 5 days or 3 days. In the current study, versions consisting of one practice day and 3 virtual days were used. The version used includes a total of 10 prospective memory tasks every day, including 4 regular (two event-based, two time-based), 4 irregular (two event-based, two time-based), and 2 time control tasks. A total of 30 prospective memory tasks are used throughout the actual experiment.

When the main visual of the Virtual Week in Figure 1 appears on the screen, the participant must click on the start card. There are two tasks in the start card that need to be done that day, one event-based and one time-based. The game is then continued by rolling a virtual dice on the main game image in Figure 1 and moving leftward on the squares. In the lower right corner, there is a box with the word Event Card written in green. The participant is asked to read all that is written on the event card out loud and choose the option that is most likely to be done in real life. An example screenshot of the event card is presented in Figure 2.

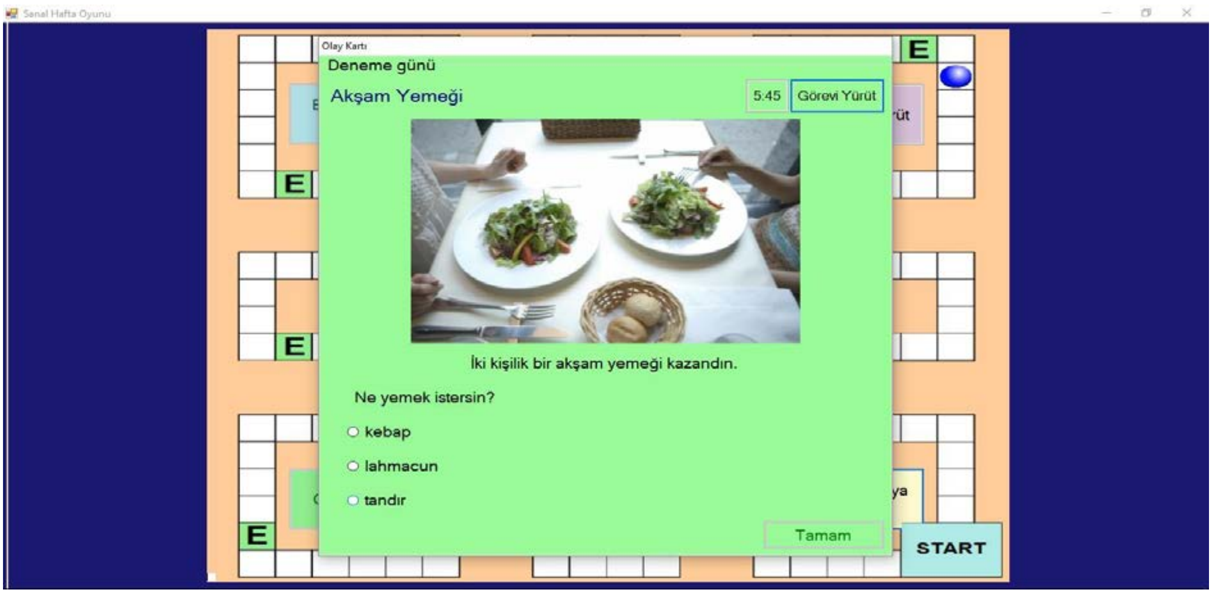

Figure 2. Example screenshot of an Event Card on a Trial Day

After decision-making, rolling the virtual dice again and reading the event cards corresponds to ongoing tasks in the prospective memory paradigm (Foster et al. 2013). After reading the event card and choosing the action that is most likely to be taken in daily life, the participant rolls the virtual dice again and continues to progress through the day. Virtual days start at 7.00 in the morning and end at 22.30. As seen on the main screen in Figure 1, participants draw 10 event cards during the day, read these cards out loud, and choose the option they are most likely to do in their daily lives among the 3 options. Moving two squares in the task equates to 15 minutes of virtual time being passed. Regardless of the tasks, there is a real-time digital stopwatch on the main screen, and tasks are given according to this stopwatch.

The task is carried out by clicking on the purple "Execute Task" box at the top right of the screen. Participants press the "Execute Task" button at the appropriate time or place and choose the task they need to do from a list of distractor options.

At the end of each virtual day, participants are asked to perform a Recognition Test to assess their retrospective memory performance during various prospective memory tasks. The Recognition Test involves matching the planned action (e.g., buying colored pencils) with a cue (e.g., while shopping). The actions presented to the participants include distractors (e.g. buy a birthday present for your niece). Since the tasks were created according to Western culture, Virtual Week was updated by changing some of the tasks and options according to Turkish culture, and the Spearman-Brown two-half reliability coefficient was found to be 0.74 in young sample (Pakyürek and Cangöz-Tavat 2023).

Statistical Analysis

The research findings were analyzed using the licensed version 23.0 of the Statistical Package for Social Sciences (SPSS). First of all, necessary data cleaning procedures were performed to test the suitability of the data for statistical analysis; then descriptive analysis of demographic information was carried out. To test the reliability of the Virtual Week, Cronbach's alpha and Spearman-Brown two-half reliability coefficients were calculated. Correlation and regression analysis techniques were used to determine the relationship between working memory and prospective memory. Then, a 2 (Task Regularity: Regular-Irregular) X 2 (Task Type: Event-Based-Time-Based) repeated measures ANOVA was used to see the effects of strategic monitoring and retrospective memory on prospective memory.

Results

Demographic information about the participants and the mean scores obtained from the scale and tasks are presented in Table 1. To test the reliability of the Virtual Week used for the prospective memory measurement, Cronbach's alpha and Spearman-Brown two-half reliability coefficients were calculated. Respectively, the Cronbach's Alpha of the Virtual Week was 0.75 and the Spearman-Brown two-half reliability coefficient was 0.72

for all tasks. The correlation values between Virtual Week, and the 2-back task were also analyzed. The correlation matrix for these analyses is presented in Table 2.

Table 1. Demographic information and mean scores from scales and tasks

Variable		**n=120**	**%**
Gender	Female	60	50
	Male	60	50
Marital Status	Single	113	95
	Married	7	5
Job Status	Working	0	0
	Unemployed	120	100
Education Level	University student	120	100
Smoking Use	Smoker	60	50
	Non-Smoker	60	50
Alcohol Use	Alcohol User	56	47
	No Alcohol Use	64	53
		Ort	SS
Age		21,51	2,85
BDI		9,64	4,86
PM Regular Event-based		.78,5	.20
PM Regular Time-based		.73,3	.25,2
PM Time Check Task		.68,5	.28,3
PM Irregular Event-based		.85	.17
PM Irregular Time-based		.54,3	.26,2
WM 2-Back		71,14	17.33

BDI: Beck Depression Inventory; PM: Prospective Memory; WM: Working Memory

Table 2. Correlation matrix of prospective memory tasks and working memory task

Task Type	**1**	**2**	**3**	**4**	**5**	**6**	**7**
1. PM Regular Event-based	1.00	.328**	.229*	.426**	.284**	.622**	.118
2. PM Regular Time-based	.328**	1.00	.394**	.233*	.431**	.742**	.238**
3. PM Time-Check Task	.229*	.394**	1.00	.191*	.383**	.700**	.244**
4. PM Irregular Event-based	.426**	.233*	.191*	1.00	.250**	.540**	.157
5. PM Irregular Time-based	.284**	.431**	.383**	.250**	1.00	.732**	.199*
6. PM All Tasks	.622**	.742**	.700**	.540**	.732**	1.00	.295**
7. WM (2-Back Task)	.118	.238**	.244**	.157	.199*	.295**	1.00

PM: Prospective Memory, WM: Working Memory; *p<.05; ** p<.01

While a positive and significant correlation was found between working memory and the time-based prospective memory ($p<.01$), no significant correlation was found between working memory and event-based prospective memory ($p>.05$). In addition, a positive and significant relationship was found between time control task and working memory ($p<.01$). There is a significant positive correlation between the types of the prospective memory tasks ($p<.01$). Then, a simple linear regression was applied to reveal the relationship between 2-back task and Virtual Week and to test whether working memory predicts prospective memory. The mean percentage of correct answers in the working memory and the total percentage of correct answers in the prospective memory task were included in the regression. As a result of the regression analysis, it was shown that working memory performance predicted prospective memory performance at a statistically significant level ($F(1,118)= 11.25$, $p<.05$; $R2 = .09$). Accordingly, 9% of the prospective memory performance is explained by working memory. Working memory performance positively predicts prospective memory performance ($\beta= .30$; $p<.05$).

A 2 (strategic monitoring: time-based-event-based) X 2 (retrospective memory: regular-irregular) repeated measures ANOVA was applied to see the effects of strategic monitoring and retrospective memory on prospective memory. According to the results of repeated measures ANOVA, the main effect of strategic monitoring ($F(1,119)= 8.56$, $p<.05$, $\eta p2 =.07$), the main effect of retrospective memory ($F(1,119)= 62.68$, $p<.05$, $\eta p2 =.35$), and interaction effect ($F(1,119)= 97.56$, $p<.05$, $\eta p2 =.45$) are significant respectively. The number of correct responses given to regular tasks (Mean=.76, SD=.22) is significantly higher ($p<.05$) than irregular tasks (Mean=.70, SD=.20). The number of correct responses given to event-based tasks (Mean=.82, SD=.17) was significantly higher ($p<.01$) than time-based tasks (Mean=.64, SD=.27). The interaction effects, according to the comparisons made on the basis of task type, more correct responses were given in event-based regular tasks (Mean=.78, SD=.21) than in time-based regular tasks (Mean=.73, SD=.25) with a significant difference ($p<.05$). Similarly, more correct responses were given in event-based irregular tasks (Mean=.85, SD=.13) than in time-based irregular tasks (Mean=.54, SD=.21) with a significant difference ($p<.01$). According to the comparisons made on the basis of task regularity, event-based regular tasks (Mean=.78, SD=.21) had significantly fewer correct responses than event-based irregular tasks (Mean=.85, SD=.13) ($p<.05$). Time-based regular tasks (Mean=.73, SD=.25) had significantly more correct responses than time-based irregular tasks (Mean=.54, SD=.21) ($p<.01$). Graphs of task type and regularity are given in Figures 3 and 4.

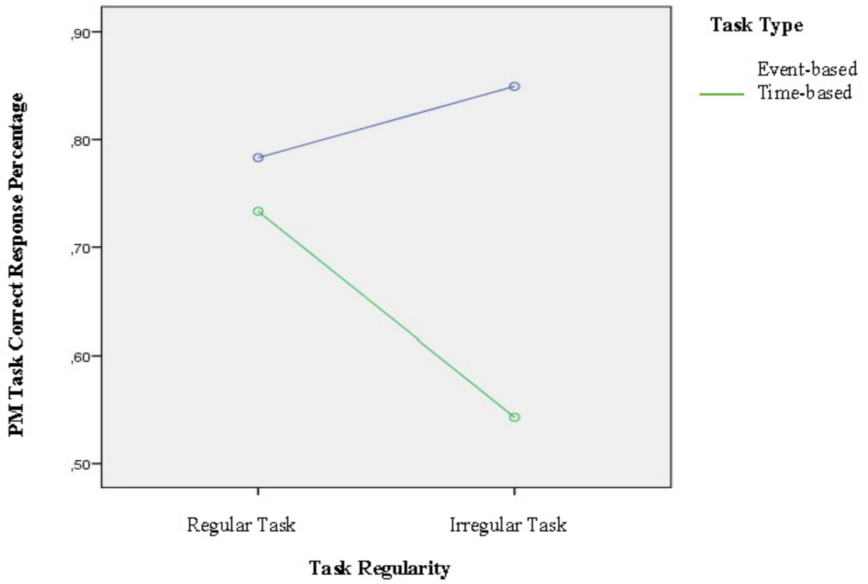

Figure 3. Prospective memory correct response percentage by task type according to task regularity

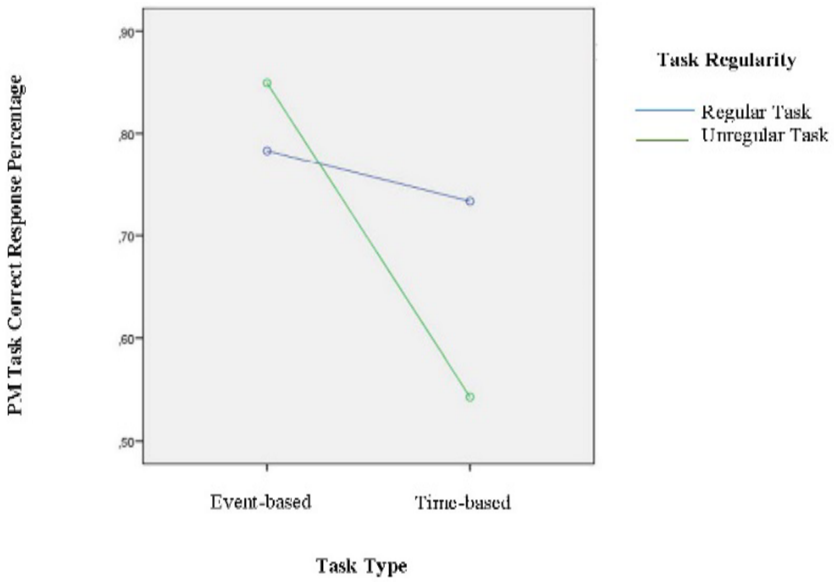

Figure 4. Prospective memory correct response percentage by task regularity according to task type

Discussion

There was a relationship between working memory and prospective memory in the present study. It is also stated that working memory may be one of the important factors that can affect the performance of prospective memory (Smith 2003, Logie et al. 2004, Smith and Bayen 2005, Rose et al. 2010). Prospective memory tasks require retention of the planned action and it is thought that working memory also plays a role in this process (Rose et al. 2010). It has been suggested that the processes of retrospective memory and preparatory attention and memory are necessary for the performance of prospective memory and that working memory contributes to the performance of prospective memory by influencing both processes (Smith 2003). In this context, the findings of the present study are consistent with the theories of preparatory attention and memory processes.

There was no relationship between working memory and regular and irregular event-based tasks, but a significant positive relationship was found with time-based and time-control tasks. This is consistent with the multiple processes view. Time-based and time-control tasks are relatively more difficult and require more strategic monitoring. Working memory is thought to play an important role in this process (McDaniel and Einstein 2007). In event-based tasks, on the other hand, automatic processes are activated as the cue is visible, and the role of working memory is less in event-based tasks. Although Logie et al. (2004) found a relationship between both time and event-based tasks and working memory, they found that this relationship was stronger in time-based tasks. Fronda et al. (2020) found a relationship between working memory and time-based tasks when the cognitive load was increased, but not in event-based tasks. In this context, it is suggested that there is a task-specific differentiation of the relationship between prospective memory and working memory.

The average percentage of correct responses was higher in regular tasks than non-regular tasks. While less retrospective memory resources are needed when performing regular prospective memory tasks, more retrospective resources are needed in non-regular prospective memory tasks (Rendell and Henry 2009). The retrospective memory manipulation was made by dividing the prospective memory task into regular and irregular tasks according to whether it is routine or not. Thus, regular tasks provide an encoding advantage over irregular tasks (Mioni et al. 2015). While regular tasks include a single health-related topic such as "taking antibiotics" and "taking asthma medication", irregular tasks consist of different topics such as "stopping by the dry cleaners on the way to shopping", "putting the food in the oven at 17.00" and "taking your brother's sports club membership card when you go to the pool". In this context, irregular tasks require relatively more cognitive effort because they require more retrospective memory resources. It is seen that regular tasks are more successful than irregular tasks, as expected in both healthy and patient groups (Rose et al. 2010, Henry et al. 2012, Foster et al. 2013, Mioni et al. 2015, Niedzwienska et al. 2016, Fronda et al. 2020, Bozdemir and Cinan 2021). It is noteworthy that similar results were obtained in patient groups (Henry et al. 2012, Foster et al. 2013). According to the theory of preparatory attention and memory processes, the findings were found to be consistent with the theory, as the use of resources in regular tasks compared to irregular tasks will be allocated more to the prospective memory task rather than the ongoing task (Smith 2003).

The main effect of task type on prospective memory performance was also significant. Event-based tasks were significantly more recalled than time-based tasks. Strategic monitoring manipulation was also made according to whether the cue was a time or an event. Tasks such as "When you see your friend, Berke, invite him to dinner" or "When you go shopping, buy paper" contain event-based cues that facilitate the recall of the task at the right time with little need for strategic monitoring, whereas tasks such as "Meet your friend for coffee at 4:00 p.m." or "Get a haircut at 1:00 p.m." contain time-based cues that require intrinsic cues for task recall with a high need for strategic monitoring. In the present study, participants were more successful on event-based tasks than on time-based tasks. This finding is consistent with the multiple processes view. In addition, in previous studies using the Virtual Week, participants were more successful in event-based tasks than in time-based tasks (Jager and Kliegel 2008, Rose et al. 2010, Henry et al. 2012, Foster et al. 2013, Mioni et al. 2015, Niedzwienska et al. 2016, Zuber et al. 2016, Fronda et al, 2020, Bozdemir and Cinan 2021, Yörük and Cangöz-Tavat 2022, Pakyürek and Cangöz-Tavat 2023). Jager and Kliegel (2008) suggested that this difference increases with aging because the internal functioning of time deteriorates with aging. In addition, it is thought that executive functions are more efficient in time-based tasks and decrease in performance because they utilize resources in relatively difficult prospective memory tasks (Zuber et al. 2016).

One of the limitations of the current study is that although the Virtual Week was found to be successful in terms of representing everyday life, the behavioral measurement taken on the computer in the laboratory environment differs from naturalistic prospective memory tasks (Schnitzspahn et al. 2020). In addition, only the auditory 2-Back task was used as a working memory task in the study. There are studies in the literature that find the use of the n-Back task in the measurement of working memory controversial (Miller et al. 2009). Finally, the current study was conducted only on university students. Increasing the external validity by studying with larger samples will contribute to the literature.

Conclusion

The relationship between working memory, retrospective memory, and strategic monitoring with prospective memory is examined and it is explained which types of prospective memory are related to which prospective memory task performance. Virtual Week was shown to be a reliable tool for measuring prospective memory. Working memory was found to predict prospective memory. It has been shown that the performance of prospective memory is affected by strategic monitoring and retrospective memory. Working memory was found to be related to time-based and time-controlled prospective memory tasks, but not to event-based tasks.

Future studies may seek to answer the question of how the performance of prospective memory may change according to the subsystems of working memory. The use of more extensive working memory tasks may increase the validity of the results and examine differences between working memory functions. In addition, studies by creating naturalistic prospective memory tasks may be more representative of everyday life. Recent smartphone applications (MEMO) can be used to design prospective memory tasks with high ecological validity and variables associated with the prospective memory can be found (Haines et al. 2020). With aging, there is generally no decline in the performance of the natural prospective memory task, but there is a decline in laboratory-based tasks and this is called the age-prospective memory paradox (Pakyürek and Cangöz-Tavat 2023). In future studies, comparing the role of working memory in the age-prospective memory paradox with younger and older participants and showing the differences in the process will contribute to the literature. Lastly, prospective memory errors are one of the earliest symptoms in mild cognitive impairment and Alzheimer's disease (Scullin et al. 2022). Maintaining and enhancing the performance of the prospective memory with smartphone applications will be one of the goals of science in the future.

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