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Memory for future actions: The effect of prospective memory on an explicit and implicit memory task

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Abstract

Introduction: In the field of retrospective memory, an explicit and implicit memory are known to exist. This study analyses the effect of the prospective memory on a recognition task and a lexical decision task. **Method:** In experiment 1 (n = 78, of which 39 belonged to the experimental group and 39 belonged to the control group), a recognition task was followed by an intentional task, as well as an incidental free recall task. In experiment 2 (n = 74, of which 37 belonged to the experimental group and 37 belonged to the control group), repetition priming was studied during a lexical decision task, followed by an intentional task. The data were analysed using a mixed ANOVA. **Results:** Experiment 1 showed active monitoring of the prospective memory task accompanied by a recollective search process during the recognition task. The group which carried out the prospective task also showed better scores in the incidental free recall task. Experiment 2 showed active monitoring and repetition priming during the lexical decision task. **Conclusion:** While the prospective memory affects the performance in both concurrent tasks, it does not affect the recollective search process or repetition priming.

Keywords: Prospective memory, monitoring, recollective search, repetition priming.

Resumen

Recuerdo de acciones futuras: efecto de la memoria prospectiva en una tarea explícita e implícita de memoria. **Introducción:** en el campo de la memoria retrospectiva se conoce la existencia de la memoria explícita e implícita. Este estudio analiza el efecto de la memoria prospectiva en una tarea de reconocimiento y una tarea de decisión léxica. **Método:** en el experimento 1 (n = 78, de los cuales 39 pertenecían al grupo experimental y 39 al grupo control) una tarea de reconocimiento fue seguida de una tarea intencional, así como de una tarea de recuerdo libre incidental. En el experimento 2 (n =74, de los cuales 37 pertenecían al grupo experimental y 37 al grupo control) se estudió el priming de repetición durante una tarea de decisión léxica, seguido de una tarea intencional. Los datos fueron analizados con un ANOVA mixto. **Resultados:** el experimento 1 mostró una monitorización de la tarea de memoria prospectiva junto a procesos de búsqueda recolectiva durante la tarea de reconocimiento. Asimismo, el grupo que llevó a cabo la tarea prospectiva mostró mejores puntuaciones en la tarea de recuerdo libre incidental. El experimento 2 mostró monitorización y priming de repetición durante la tarea de decisión léxica. **Conclusión:** mientras que la tarea de memoria prospectiva tiene un efecto sobre el desempeño en ambas tareas concurrentes, no afectó a los procesos de búsqueda recolectiva y priming de repetición.

Palabras clave: memoria prospectiva, monitorización, búsqueda recolectiva, priming de repetición.

The scientific literature has shown the explicit and implicit nature of the long-term memory (Milner, Squire, & Kandel, 2009; Schacter & Tulving, 1994; Squire, 2004). The explicit memory refers to the conscious and voluntary search for information associated with the past, while the implicit memory is related to the unconscious and voluntary access to this information (Caballero, Reales, & Ballesteros, 2018; Schacter, Cooper, Delaney, Peterson, & Tharan, 1991; Schacter, 1987; Barrera, Arellano, Avilés, & Ballesteros, 2012).

However, most studies have essentially focussed on the memory of past events, with studies on the memory of future events being less common. In this context, the prospective memory refers to the capacity to remember to do actions which will take place in the future (Anderson, McDaniel, & Einstein, 2017). Ellis and Freeman (2008) highlighted two components of this: the retrospective and the prospective. The retrospective component involves the content of the intention, while the prospective component requires self-initiated recall in a previously determined recall context.

In this regard, Kliegel and Martin (2003) describe how the prospective memory is divided into the following phases:

Phase 1: Forming the intention: this corresponds to intentional behaviour encoding.

Phase 2: Retention interval: this refers to the time that elapses from the encoding until the recall phase. The individuals carry out distraction tasks which simulate the interferences of daily life.

Phase 3: Self-initiated recall for the future event: this refers to remembering the intention in a specific context and place.

Phase 4: Carrying out the intentional action: this is when the delayed behaviour takes place.

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In relation to the cognitive processes which take place during the retention interval, and which therefore favour success or failure in a prospective task, the experimental findings have indicated the plausibility of the multiprocess theory (Anderson & McDaniel, 2019; Anderson et al., 2017; Einstein et al., 2005; Scullin et al., 2013). According to this model, the success of a prospective memory task depends on various factors: the presence and relevance of the external signal, the duration of the retention interval, the demands of the concurrent task, the cognitive burden of the intentional task, and the subject's expectations and motivations.

Likewise, when a future task is established, there are two types of help for recall. The first consists of attention processes for monitoring and memory. This results in longer reaction times and a higher number of errors or omissions when performing the distraction task which takes place in the retention interval (Smith & Bayen, 2005). The second refers to spontaneous recall, in which automatic access to the desired memory trace occurs when perceiving the external signal. As such, this signal will have longer latencies of response than the rest of the distraction material. The multiprocess theory accounts for the flexibility and dynamism of both strategies at different moments in time (Ball et al., 2015; Gonen-Yaacovi & Burgess, 2012; Shelton & Scullin, 2017).

The methodology has shown that the monitoring processes occur, among other factors, because the working memory must retain the prospective memory task at the same time as it resolves the distraction tasks. However, this monitoring is more likely when the future task has a high attentional burden (Kliegel et al., 2004).

Taking into account this theoretical framework, our aim was to evaluate whether a high-complexity prospective memory task affects the performance of two concurrent tasks: one on explicit memory and the other on implicit memory, favouring monitoring processes in both tasks and, as a result, a cost associated with the intention. We also evaluated the effect of the prospective task on an incidental free recall task.

Experiment 1

We investigated whether the presence of a future task affects the reaction times and success rates in a recognition task. Finally, we evaluated the effect of the intention on the success rates of an incidental free recall task. We decided to add this task to evaluate the impact of future behaviour on the encoding processes for the study material.

Method

Participants

A group of 78 university students (age range: 17-31 years, M = 20.9, SD = 3.8, 73% women) were randomly assigned to the experimental group (n = 39) and the control group (n = 39). All students took part voluntarily in exchange for an academic credit.

Instruments

The study materials were selected based on the study by Schult and Steffens (2013). In this study, they presented a five-step script. However, with the aim of increasing the complexity of the prospective task, a new ten-action script was designed in Spanish. Each action consisted of a transitive verb and a common noun, with a total of 20 words.

The recognition task was made up of 40 words: 20 were part of the script and the other 20 were distraction stimuli. Finally, 10 were semantically related to the script and the other 10 were unrelated. All the words were selected from the SUBTLEX-ESP (Spanish word frequencies based on film subtitles) word list (Cuetos, González-Nosti, Barbón, & Brysbaert, 2011). Finally, the script stimuli were equal to the distractors in terms of frequency, $t(19) = 0.053$, $p > 0.05$, and word length, $t(19) = 0.271$, $p > 0.05$ (see script and distractors in Table 1).

Procedure

The procedure was based on the studies by Goschke and Kuhl (1993) and Freeman and Ellis (2003). The participants were assessed individually. Each of them was informed that the session would begin with a practice phase followed by an experimental phase (see Table 2). At the start of the practice phase, and regardless of the group variable, three instructions appeared on the computer screen and the subjects had to read them aloud. The first instruction was to memorise a script, which consisted of a title and five actions, followed by a memory task. The study protocol was as follows: first of all, the title appeared (preparing dinner), followed by the corresponding actions, in order and in sequence, for four seconds each, with a total learning time of 20 seconds. To help with script retention, the presentation was repeated. Subsequently, the subjects carried out a distraction task which consisted of counting down in threes from a given number for 45 seconds. They then carried out a recognition task, which included four practice words. Each test began with a fixed point of 250 milliseconds, followed by the corresponding verbal stimulation

Table 1
Stimuli used in the recognition task

The stimuli are script and distraction words separated into verbs and nouns

Verbs of script	Nouns of script	Verbs of distractor	Nouns of distractor
Quitar	Florero	Tragar	Mesa
Extender	Mantel	Beber	Horno
Repartir	Cubiertos	Degustar	Vasos
Poner	Copas	Oler	Azucar
Traer	Jarra	Cocinar	Cuchillo
Colocar	Salero	Limpiar	Playa
Encender	Velas	Abrir	Tragedia
Servir	Platos	Guardar	Fogata
Cortar	Pan	Cerrar	Templo
Brindar	Comida	Doler	Metro

Table 2
Procedure Experiment 1

Experimental group	Control group
With prospective instruction	Without prospective instruction
Learn script	Learn script
Distractor task	Distractor task
Recognition task	Recognition task
With prospective recovery	Without prospective recovery
Incidental free recall task	Incidental free recall task

in the centre of the screen until the participant gave an answer. Once the answer was given, a blank screen appeared for 500 milliseconds and a new test would then start.

The recognition task consisted of pressing "YES" when the subjects believed that the word on the monitor had been present in the script they had previously studied. Otherwise, they had to press "NO". They had to carry out this task as quickly and accurately as possible while the words were shown randomly. Finally, the phrase "end of task" appeared in the centre of the monitor.

The experimental phase began immediately after the practice phase, using the same procedure mentioned above, with the difference being that the participants had to learn a script consisting of ten actions. Furthermore, before starting this final phase, the participants in the experimental group were instructed to run the script (manually) immediately after completing the recognition task. The experimenter advised them that they would have all the materials available (it should be highlighted that the participants did not run the script at any time, as the theoretical interest consisted of creating expectations of future action).

When the participants from the experimental group proceeded to run the script and the participants from the control group completed the recognition task, the investigator went ahead with the incidental free recall task. The instructions consisted of remembering the whole script, with its respective verbs and nouns in any order.

Data analysis

For all the statistical analyses, the type I error was set at $\alpha < .05$. The first and second dependent variables were reaction time and the success rate in the recognition task. The third dependent variable was the number of successes in the incidental free recall task. The first independent variable was inter-subject and corresponds to the instruction type (experimental and control). The second independent variable was intra-subject and corresponds to the type of words used in the recognition task (words from the script, words semantically related and unrelated to the script). The statistical test used was the mixed ANOVA. It was essential to assess whether the participants fulfilled the inclusion criteria set forth: achieving a minimum proportion of correct answers in the recognition task of over 0.5; a total average in reaction times for the script which did not exceed two seconds; and correctly remembering the prospective memory task. After analysing the data, no participants were excluded from the sample.

Results

The results are shown in Table 3.

Latencies of response in the recognition task: There is an effect of the word type on the recognition task, $F(1,78) = 35.514$, $p < 0.05$, $\eta^2p = 0.324$. There is no interaction between the word type and the instruction type variable, $F(1,78) = 0.257$, $p > 0.05$, $\eta^2p = 0.003$. Finally, an effect was observed for the instruction type, $F(1,78) = 6.812$, $p < 0.05$, $\eta^2p = 0.084$, with the experimental group being the one which showed higher reaction times compared to the control group.

In an attempt to assess the influence of previous knowledge on learning the script, the mixed ANOVA showed an effect for the word type (words from the script and words semantically related to it), $F(1,78) = 11.942$, $p < 0.05$, $\eta^2p = 0.139$, and no interaction, $F(1,78) = 0.132$, $p > 0.05$, $\eta^2p = 0.002$, meaning that both groups have statistically significant differences in both word types.

Success rate in the recognition task: The mixed ANOVA showed an effect for the word type (script and distractors), $F(1,78) = 51.513$, $p < 0.05$, $\eta^2p = 0.410$, and no effect for the instruction type $F(1,78) = 2.312$, $p > 0.05$, $\eta^2p = 0.030$. No effect was observed for the interaction between the word type and the instruction type, $F(1,78) = 3.696$, $p > 0.05$, $\eta^2p = 0.048$. However, when breaking down the words from the script into nouns and verbs, the data show an effect for the interaction between the two variables mentioned, $F(1,78) = 9.226$, $p < 0.05$, $\eta^2p = 0.111$. Specifically, there are statistically significant differences in the script verbs between the experimental group and the control group, $F(1,78) = 8.298$, $p < 0.05$, $\eta^2p = 0.101$, but this is not the case for the nouns, $F(1,78) = 0.322$, $p > 0.05$, $\eta^2p = 0.004$. This pattern is not observed in the case of the distractor verbs and nouns. Finally, the false-positive rate was 7.5% in the control group and 7.11% in the experimental group.

Incidental free recall: The mixed ANOVA showed an effect for the word type, $F(1,78) = 189.176$, $p < 0.05$, $\eta^2p = 0.719$, and a marginal effect for the interaction between the word type and the group, $F(1,78) = 3.140$, $p = 0.046$, $\eta^2p = 0.041$. Finally, an effect was observed for the instruction type, $F(1,78) = 30.456$, $p < 0.05$, $\eta^2p = 0.292$.

Table 3
Results Experiment 1

Mean and standard deviation (SD) between the experimental and the control group: reaction times and percentage of correct answers in the script and the distraction words during the recognition task. Success rate in the incidental free recall task.

	Experimental (Mean, SD)	Control (Mean, SD)
Reaction times		
Script	1181 (201)	1086 (192)
Nouns	1066 (201)	1003 (227)
Verbs	1296 (260)	1168 (177)
Distractors	1089 (195)	977 (157)
Related		
Nouns	1118 (249)	1020 (247)
Verbs	1121 (225)	999 (172)
No related		
Nouns	959 (218)	837 (144)
Verbs	1160 (285)	1052 (203)
Success rate		
Script	83 (8.46)	87 (7.68)
Nouns	92 (7.6)	91 (8.5)
Verbs	74 (13.5)	82 (11.07)
Distractors	92 (4.13)	92 (3.8)
Related		
Nouns	74 (12)	73 (12)
Verbs	98 (5)	98 (5)
No related		
Nouns	99 (3)	100 (0)
Verbs	98 (4)	98 (7)
False positives	7.11	7.5
Free recall		
Actions	6.16 (1.43)	4.32 (2.00)
Verbs	7.26 (1.11)	5.84 (1.62)
Nouns	8.55 (1.08)	6.55 (1.60)
Intrusions	0.42 (0.80)	0.64 (0.78)
Perseverations	1.50 (0.90)	1.18 (0.98)

Conclusion

The results show that the participants from the experimental group were monitoring the prospective memory task during the retention interval, which results in longer reaction times, both for the words from the script and for the distractors. The fact that the participants showed longer latencies of response in the words from the script than in the distractors indicates that they used a recollective search process, which is very commonly associated with high-complexity explicit memory tasks.

Additionally, the fact that the experimental group showed a higher number of errors in the verbs than in the nouns from the script highlights a cost associated with the intentional action, as well as a dissociation between these two linguistic elements.

Finally, the participants from the experimental group showed better scores in the incidental free recall task, which demonstrates that the actions which have to be carried out favour deep and elaborate encoding in sensory-motor terms.

Experiment 2

In experiment 2, we investigated whether the intentional task from the previous study affects the reaction times and the success rate for a lexical decision task, which is very commonly associated with the field of implicit memory, thereby demonstrating monitoring and repetition priming.

Method

Participants

A group of 74 new university students (age range: 18-31 years, M = 21.2, SD = 3.2, 89% women) were randomly assigned to the experimental group (n = 37) and the control group (n =37). The students took part voluntarily in exchange for an academic credit.

Instruments

The same script was used as for experiment 1. The lexical decision task consisted of showing a series of verbal stimuli on the screen one by one. In this case, the aim was to decide, as quickly and accurately as possible, whether or not these stimuli were Spanish words. The task was made up of 40 stimuli: 20 were words from the script and the other 20 were distractors. Of the distractors, 10 were Spanish words which were not semantically related to the words from the script and the other 10 were not words from the test battery for assessing aphasic disorders (BETA) (Cuetos & González-Nosti, 2009) (see Table 4). As with experiment 1, all the verbal stimuli were selected from the SUBTLEX-ESP word list (Cuetos, González-Nosti, Barbón, & Brysbaert, 2011). Finally, the script stimuli were equal to the distractors in terms of frequency of use, $t(9) = 0.344$, $p > 0.05$, and word length, $t(19) = 0.295$, $p > 0.05$.

Procedure

The procedure was similar to that of experiment 1, with the difference being that the recognition task was replaced with a lexical decision task.

Data analysis

The first and second dependent variables were reaction times and the success rate in the lexical decision task. As with experiment 1, the first independent variable was inter-subject and corresponds to the instruction type (experimental and control). The second independent variable was intra-subject and corresponds to the type of stimuli used in the lexical decision task (words from the script and distractors). It was necessary to assess whether the participants met the inclusion criteria for the statistical analysis: achieving a minimum proportion of correct answers in the lexical decision task of over 0.5; a total average in reaction times for the script which did not exceed two seconds; and correctly remembering the prospective memory task. After analysing the data, two participants were excluded from the sample.

Results

Table 5 shows the results obtained.

Latencies of response in the lexical decision task: The mixed ANOVA showed an effect for the stimulus type, $F(2,78) = 163.786$, $p < 0.05$, $\eta^2p = 0.695$, and no effect for the interaction between the stimulus type and the instruction type, $F(2,78) = 0.229$, $p > 0.05$, $\eta^2p = 0.003$. In fact, the data show that both groups have shorter latencies of response for the words from the script than for the distractor stimuli. Furthermore, an effect was observed for the instruction type, $F(1,78) = 8.543$, $p < 0.05$, $\eta^2p = 0.106$, with the experimental group being the one which had longer latencies of response compared to the control group.

Table 4
Stimuli used in the lexical decision task

The stimuli are script words and distractors (words and no words)

Script words	Script words	Spanish words	Non words
Quitar	Florero	Limpiar	Suritano
Extender	Mantel	Abrir	Soflete
Repartir	Cubiertos	Guardar	Traicora
Poner	Copas	Cerrar	Robesto
Traer	Jarra	Doler	Gratunto
Colocar	Salero	Playa	Musco
Encender	Velas	Tragedia	Lura
Servir	Platos	Fogata	Conso
Cortar	Pan	Templo	Aneo
Brindar	Comida	Metro	Mabio

Table 5
Results Experiment 2

Mean and standard deviation (SD) between the experimental and the control group: reaction times and percentage of correct answers in the script words and the distractors during the lexical decision task.

	Experimental (Mean, SD)	Control (Mean, SD)
Reaction times		
Script	744 (117)	661 (78)
Distractors	860 (141)	787 (104)
New Words	776 (130)	699 (96)
No words	944 (183)	877 (129)

Success rate in the lexical decision task: An effect was observed for the stimulus type, $F(2,78) = 15.249$, $p < 0.05$, $\eta^2p = 0.175$. There was no effect for the interaction between the stimulus type and the instruction type, $F(2,78) = 2.399$, $p > 0.05$, $\eta^2p = 0.032$, and no effect was observed for the instruction type, $F(1,78) = 2.573$, $p > 0.05$, $\eta^2p = 0.035$.

Conclusion

As with experiment 1, the results from experiment 2 show that the participants from the experimental group monitored the prospective memory task during the retention interval. However, the fact that the participants showed shorter latencies of response for the words from the script than for the distractors shows a repetition priming effect.

Discussion

In both studies, the participants from the experimental group had to carry out the study material, which created a significant effect for this instruction on the latencies of response, promoting a monitoring process during the retention interval and retaining the content of the intentional task in the working memory at the same time as they carried out the distraction task.

On analysing the reaction times during the recognition task (experiment 1), it was observed that the participants from both groups had longer latencies of response in the words from the script than for the distractors. This finding is consistent with the classic study by Atkinson, Herrman and Westcourt (1974), who asked their participants to learn a list of words. Subsequently, they carried out a recognition task which included measuring reaction times. The results showed that, the longer the list, the longer the latencies of response for the words studied, which were shorter for the distraction stimuli. To this end, it is worth highlighting that the study material for both experiments is an extension of the study by Goschke and Kuhl (1993), who designed a five-action script, showing shorter reaction times for the study material than for the distractors. With this information, it is implied that, as the length of the list is increased, the familiarity is decreased and the subjects initiate conscious and deliberate search processes. However, given that in the subsequent study (experiment 2) the participants carried out a lexical decision task, these search processes were blocked, showing longer reaction times for the distractors than for the words from the script. In other words, this shows a repetition priming effect in a prospective memory context.

The study has shown that the demands of the prospective memory task and the monitoring processes create effects in the concurrent tasks (Smith & Bayen, 2005). However, this premise does not apply to all the tasks which take place during the retention interval. In other words, the concurrent tasks with a high attentional burden are affected by the content of the intentional task (Kliegel et al., 2004). To this end, the complexity of the prospective task had an effect on the recognition task and not on the lexical decision task. Specifically, experiment 1 showed a cost in the accuracy of the concurrent task, although not for all the words from the script. This cost was clear in the case of the verbs and not in the case of the nouns from the script, showing a higher number of errors (pressing “NO” for an item that had been studied).

The reason for this result could be attributed to the type of task used during the retention interval. In the case of the recognition task, the verbs, unlike the nouns, are usually more poorly remembered, possibly due to the lack of any semantic context which would facilitate voluntary access to this type of word (Earles et al., 1999; Kersten & Earles, 2004). However, as the lexical decision task is an indirect measure of implicit memory, it does not require voluntary and conscious access to the information stored. As such, there are no differences in the percentage of correct answers for the verbs between the two groups.

The results from experiment 1 showed that the experimental group had a better incidental free recall than the control group. To this end, the instruction for the prospective task could create different levels of processing, from the most superficial levels to the most profound, elaborate and semantic (Craik & Lockhart, 1972). In the case of the control group, the lack of prospective instruction favoured a more superficial processing (possibly based on the physical or sensory properties of the stimuli) and with it a poorer performance in the subsequent free memory.

Therefore, the previous instruction, the demand of the intentional task and the concurrent task could shape the cognitive processes used by the participants in both experiments. These results open up the debate regarding a continuous processing in the field of intentional behaviours. In other words, if the scientific literature has revealed a continuous processing between the explicit and implicit measures of retrospective memory, the prospective memory is not exempt from this phenomenon. As such, once the subject forms a future action plan in the encoding phase, the external and internal factors will determine the direction of the cognitive processes during the retention interval.

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