*Psicológica (2001), 22,* 97-113.

# Dissociating prospective memory from vigilance processes

Maria A. Brandimonte*, Donatella Ferrante, Catina Feresin, and Raffaella Delbello

University of Trieste, Italy

In two experiments, we explored whether the retrieval processes underlying event-based prospective memory can be distinguished from those underlying vigilance. Participants performed an ongoing task (either a lexical decision task, Experiment 1 and 3, or a categorization task, Experiment 2) while at the same time they had to remember to stop performing the ongoing task whenever a particular target-stimulus appeared on the computer screen (background task). There were two target stimuli, each appearing 4 times across the ongoing task. Instructions and training induced participants to encode the background task either as a prospective memory task or as a vigilance task. Results revealed important processing differences between prospective memory and vigilance processes. The time to respond to the ongoing task was systematically slower in the vigilance than in the prospective memory conditions. However, prospective memory conditions did not differ from control (ongoing task only). Accuracy in the background task complemented RT data in the ongoing task in that more errors were observed in the prospective condition as compared to the vigilance condition. The differences were not due to a speed-accuracy trade-off between the ongoing and the background tasks, nor to the differences in training. Most important, repetition priming was observed across the four target presentations in the prospective memory condition but not in the vigilance condition. The results are consistent with the hypothesis that event-based prospective memory and vigilance processes differ as to the degree of conscious monitoring that they require, with prospective memory being based more on automatic retrieval of the cue-action association and vigilance being based more on active search for the target.

**Key words:** prospective memory, vigilance processes, automaticity.

---

* Correspondence to: Maria A. Brandimonte, Department of Psychology, Via Sant'Anastasio, 12, 34123 Trieste, ITALY e-mail: brandy@univ.trieste.it

Remembering to perform an action in the future (prospective memory, seeBrandimonte, Einstein, & McDaniel, 1996) has been often considered very similar to performing a vigilance task. For example, Meacham and Leiman (1982) suggested that over brief retention intervals "remembering to carry out an action...may be no different than the problem of maintaining one's vigilance" (p. 328). In a similar vein, Baddeley and Wilkins (1984) proposed a distinction between short and long-term intentions and suggested that short-term intentions may have to be maintained in "conscious awareness" during the retention interval in order to be successfully realized. However, the realization of longer term intentions may rely on different processes as to the degree of conscious monitoring that is required. It seems likely that intentions associated with actions that take either a few seconds, a few minutes or several hours will undergo different processing (Kvavilashvili & Ellis, 1996). For instance, if you have formed the intention to call a friend tomorrow evening, probably you will not "think of the intention" until the appropriate time approaches. Indeed, for intermediate and long-term intentions, conscious awareness may be relevant only during the period when the intended action should be retrieved (e.g., the performance interval, see Ellis, 1996; McDaniel and Einstein, 1993) or even irrelevant if all the parameters of the intended activity are sufficiently specified and the action can be realized by automatized routine skills (Goschke & Kuhl, 1996). In the latter case, simple actions can be triggered by the stimulus itself, without mediation of a conscious recollection of the intention (Neumann & Klotz, 1994). This type of readiness of procedural action schemas, termed procedural persistence (Goschke & Kuhl, 1996) qualifies those intentionsthat can be implemented in terms of activation of particular connections between execution conditions and action schemas. However, these actions cannot be considered automatic in the traditional sense in which the term "automatic" has been used in the literature (e.g. Schneider & Shiffrin, 1977). Although they are directly triggered by the stimulus, these types of actions depend on prior formation of an intention and, hence, they are not uncontrolled but controlled in a specific way (Goschke & Kuhl, 1996, 55).

The question of whether and, if so, in which extent retrieval processes underlying prospective memory can be distinguished by those underlying vigilance has not been systematically investigated. The present research is an initial attempt to explore this issue.

Before describing the general hypothesis that guided our research, it is worth considering some differences between the paradigms commonly used to study prospective memory and those used to investigate vigilance. In a typical laboratory-based prospective memory task, the participant is required to perform a ongoing task (e.g., memorizing a list of words, generating associations among words etc.) while at the same time he/she has to remember to do an action at the appropriate moment (background task, e.g., pressing a particular key on the computer keyboard every 10 min or on the appearance of a particular item). That is, the paradigm usually takes the form of a dual-task, with a primary, ongoing task that serves as a covering task for the prospective, background task (e.g., Einstein & McDainel, 1990). On the contrary, in a typical vigilance task, participants are required to monitor an information source for the occurrence of a specified target-event (e.g., listen actively and detect infrequent target tones); in so doing they attend to only one source for a prolonged, unbroken period of time (see Parasuraman, 1985). Another important difference is that a failure to detect a target in a vigilance task is regarded as attentional in its nature, whereas a failure in a prospective memory task is commonly considered a memory lapse (Maylor, 1996).

While prospective memory paradigms and classical vigilance paradigms differ markedly as to their structure, it is widely accepted that there is an element of vigilance in every prospective memory task (see e.g., Dobbs & Reeves, 1996; Maylor, 1996). That is, once the intention to perform an action in the future has been formed, it must be checked occasionally and monitoring for the target must occur. However, as Dobbs and Reeves (1996) recently pointed out, in a prospective memory task, monitoring is never a continuous process filling the retention interval. One forms the intention, and only occasionally makes a check of it. Typically, people participating in an event-based prospective memory task claim not to have checked their intention, but to have simply waited for the occurrence of the target (Brandimonte, Bisiacchi, Pelizzon, 2000; Brandimonte, Ferrante, Delbello, in preparation; Brandimonte & Passolunghi, 1994). When monitoring becomes a continuous process, the prospective memory task may turn into a vigilance task. . In other words, we suggest that an important difference between prospective memory and vigilance processes may be that while the former requires retrieval the latter does not (see Logan, 1988). It is clearly difficult to decide upon an exact criterion for distinguishing between prospective memory and vigilance processes in a prospective memory task. However, we believe that this question is susceptible of empirical investigation.

The assumption on which the present research is based is that in an event-based prospective memory task, once the action has been planned, the intention is no longer present in conscious awareness until the opportunity of performing the action occurs. In contrast, if people encode the background task as a vigilance task, the planned intention to respond to a stimulus whenever it occurs has to be continuously maintained in consciousness. If so, this should be reflected in the RTs in the ongoing task, with the vigilance conditions being slower than the prospective memory conditions. An inverse pattern of results should be expected on accuracy in the background task, as a consequence of the difficulty, in the prospective memory conditions, to reactivate the intention from time to time. In addition, if our hypothesis that in the prospective conditions participants do not maintain continuously the intention in an active state is correct, then performance in these conditions should not differ from that in the baseline condition in which the participants perform a single task (i.e., when the prospective memory task is absent). In two experiments, participants performed either a lexical decision task (Experiment 1) or a categorization task (Experiment 2). A stopping paradigm (see Logan, 1990; 1991) was used to investigate memory for the intention. That is, participants were required to stop performing the ongoing task whenever a particular target-word appeared on the computer screen (background task). It should be noted, however, that the stopping paradigm used in the present research differs from traditional stopping paradigms (see e.g., Logan, 1988), in that in the latter a stop signal is commonly presented (e.g., a tone) which may occur at different delays after stimulus onset. In the present experiments, the same stimulus (the target) served as a stop signal so as to comply with the requirements of traditional event-based prospective memory paradigms in which the target stimulus serves as a cue which should prompt the action, without any other hint from the experimenter or the environment.

The decision to use a stopping paradigm was motivated by the observation that prospective memory performance commonly implies performing an action that is different from the just-performed action in the ongoing task. It is virtually unkown whether and how the action the participant executes during the ongoing task interacts with the prospective memory action. Though not necessarily problematic for other experimental paradigms, this might be a problem for our task, given the subtle frame within which we explore possible differences between prospective memory and vigilance processes. The stopping paradigm avoids those problems in that the two tasks - the ongoing task and the background task - are in opposition.

## EXPERIMENT 1

In this experiment, participants performed a lexical decision task - i. e., they had to decide whether or not a given letter string was a word or a non-word (ongoing task) while, at the same time, they had to remember to stop responding whenever a particular letter string appeared on the computer screen (background task). The "stop signals" were a word and a non-word, which appeared 4 times each. In order to induce prospective memory processing or vigilance processing of the two targets we manipulated instructions and training: one group of participants was given instructions and training intended to elicit prospective encoding (i.e., the target-word was not present among the items during training and no reminder of the previously formed intention was given); a second group of participants were induced to maintain sustained attention (i.e., during training the target-stimulus was present among the items and whenever participants failed to respond correctly they were reminded of the occurrence of the target). Finally, a control group performed only the ongoing task. Half the participants were presented with a target word and an illegal non-word while the other half were presented with the same target word as the first group and a legal non-word. Participants were required to perform the lexical decision task while at the same time they had to remember to stop responding whenever anyone of the two target-words appeared on the computer screen.

According to our hypothesis, the vigilance conditions should show slower RTs in peerforming the ongoing task than the prospective memory conditions. However, accuracy in the background task conditions should show an inverse pattern of results, with performance in the prospective memory conditions being less accurate than performance in the vigilance conditions. In addition, according to our model, performance in the prospective memory conditions should not differ from the baseline condition. Finally, accuracy in the ongoing task should be equally high, irrespective of conditions.

## METHOD

**Participants** One hundred participants took part in this experiment. Participants were assigned to three conditions: prospective memory, vigilance and baseline. In the prospective and vigilance conditions, 20 participants were presented with a word and an illegal non-word target, and 20 were presented with a word and a legal non-word target. In the baseline condition 20 participants performed only the lexical decision task.

**Materials.** The stimuli were two and three-syllable words and non-words. The words were selected from the Bortolini, Tagliavini, and Zampolli (1972) norms for Italian language. They were chosen so as to be highly familiar (mean familiarity: 3.84 (max 4). Non-words were constructed by replacing two or three letters of each word and inverting the order of the remaining letters (e.g., canguro into cgsrntl). The legal non-words were formed so as to be highly pronounceable. Within each condition, half the stimuli were words and half were non-words. In the prospective memory and vigilance conditions, one of the words and one of the non-words (either legal or illegal) served as stop signals. The targets were "cintura" ("belt", word) "naloci" (legal non-word) and "vrstcb" (illegal nonword). There were 48 items which appeared 4 times (i.e., each item appeared as many times as the targets). Thus, overall, there were 192 trials, 8 of which were the targets that would serve as stop signals.

**Procedure.** The stimuli were displayed in uppercase in the center of the screen of a Macintosh computer. Each stimulus was viewed at a distance of about 40cm and subtended 1.14 x 5.72*ƒ* of visual angle.

Participants were tested individually in a session lasting about 20 minutes. They were given written instructions specifying that they would be asked to decide whether or not each item was a word and to stop responding if the item was one of the targets. In the vigilance conditions, instructions stressed the double nature of the task (i.e., press the appropriate key on most occasions and stop responding on few occasions); following the most common procedure in the literature on prospective remembering, in the prospective memory conditions, the background task was embedded in the ongoingtask. Namely, participants were asked to perform the lexical decision task and, as a secondary task, they should remember to stop responding on appearance of the appropriate targets.

In the training phase, participants performed the lexical decision task on 24 items which did not appear during test. In the vigilance condition, the two targets appeared two times each and if the participant failed to detect them he/she was given feedback and reminded to look for them. In the prospective memory condition, the targets never appeared during the training phase.

In the test phase, all participants took part in the lexical decision task and had to stop responding on appearance of the targets. A fixation point was presented for 500msec., immediately followed by the stimulus which remained in view for 500msec., with an ISI of l.5 sec. and a RSI of 500msec. Half the participants received the word and the legal non-word targets, and half received the word and the illegal non-word targets.

## RESULTS AND DISCUSSION

*Reaction Times.* A 3 (type of task; i.e., prospective, vigilance or baseline) by 3 (stimulus type; i.e.word, illegal non-word, legal non-word) by

4 (number of presentations) mixed ANOVA on the median RT values in the lexical decision task showed a main effect of type of task, $F$ (2, 97) = 8.99, p < .0003, MSe = 96093.51. Planned comparisons showed that performance in the prospective memory conditions differed significantly from that in the vigilance conditions, $F$ (2, 97) = 10.05, p < .002, MSe =966026.25, while not differing from that in the baseline condition (Figure 1).

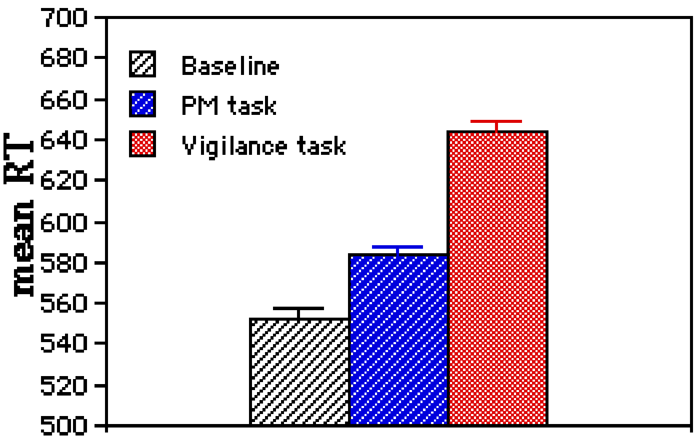


**Figure 1.** Mean RT as a function of Type of task in Experiment 1

There was also a main effect of stimulus type (word vs legal non-word vs illegal non-word): median RTs were faster for words and illegal non-words (570 msec and 574 msec, respectively) than for legal non-words (661 msec), $F$ (2, 194) = 200.59, p < .0001, MSe = 5673.36. A main effect of number of presentations, $F$ (3, 291) = 18.99, p < .0001, MSe = 2688.86, and an interaction between stimulus type and number of presentations, F (6, 582) = 5.75, p < .0001, MSe = 1154.17, were also found. The effect of number of presentations is due to the fact that repetition priming was observed across the four presentations. The interaction between stimulus type and number of presentations replicates previous results in the literature (Logan, 1990, 1991) showing that priming is stronger for legal non-words than for words and illegal non-words.

Further analyses showed an interaction between type of target in the background task (legal vs illegal) and stimulus type in the ongoing task, $F$ (2, 152) = 9.29, p < .0002, MSe = 5811.93. That is, RTs in the lexical decision task were affected by the type of target participants were responding to in the background task, with responses to illegal non-word being slower when the target of the background task was the illegal one rather than the legal one. Errors were analysed for both the ongoing task and the background task. Errors in the background task were the main measure of interest. An ANOVA on the total number of errors in the prospective memory and vigilance conditions showed an effect of type of task, $F$ (1, 78) = 11.55, p < .001, MSe = 5.002, with a lower error rate in the vigilance as compared to the prospective memory conditions. The effect was independent of the type of target (word, legal non-word, illegal non-word).

Repetition priming was also observed on accuracy in the background task across the four presentations. An ANOVA on the number of errors in the first versus the fourth presentation showed a significant decrement as the number of presentation of the same target increased, $F$ (1, 78) = 7.68, p < .007, MSe = .761. However, an interaction between type of task and number of presentations showed that repetition priming occurred for the prospective memory condition but not for the vigilance condition, $F$ (1, 78) = 5.57, p < .02, MSe = .324 (Figure 2).

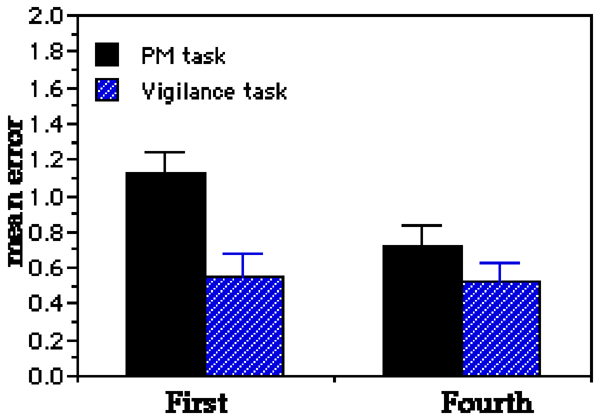


**Figure 2.** Mean number of errors in the background task as a function number of presentations (first versus fourth) and condition (prospective memory versus vigilance).

To rule out the possible alternative explanation that the difference observed between prospective memory and vigilance conditions was due to differences in training, we run a further analysis by contrasting the first 4 occurrences of the targets in the vigilance condition with the last four occurrences of the targets in the prospective condition. Indeed, if the difference in the number of errors in the background task was due to the fact that the participants assigned to the vigilance condition had already encountered the targets during training whereas the participants assigned to the prospective condition did not, then comparing the first four occurrences of the targets in the vigilance condition with the last four occurrences in the prospective condition should eliminate the difference. A 2 (type of task) by 4 (position of the targets) ANOVA showed that the effect of type of task was still present, $F$ (1, 78) = 5.42, $p < .02$, MSe = .133, with no interaction between task and position.

Finally, we analyzed the number of errors in the ongoing task. Error rate was low, averaging 4% in all three conditions, implying that the difference in the error rates observed in the background task was not due to a trade-off between RTs in the ongoing task and accuracy in the background task.

Taken together, the results of Experiment 1 support the hypothesis that, although there may be an element of vigilance in every PM task, performing an event-based PM task is different from performing a vigilance task. The difference we observed between prospective memory and vigilance conditions cannot be simply due to differences in the initial learning ofthe instructions and in the training phase. Rather, our results suggest that the observed differences can be plausibly attributed to the characteristics of the retrieval mode maintained by the cognitive system during the two types of task, with prospective memory relying more on spontaneous retrieval of the action on appearance of the targets and vigilance relying more on continuous monitoring for the targets.

## EXPERIMENT 2

Experiment 2 is essentially an attempt to replicate and extend the results of Experiment 1 by using a different task. Participants performed a living beings/non living beings decision task and again they had to stop responding whenever the PM target appeared on the computer screen. As in Experiment 1 each participant was presented with two PM targets that appeared four times each. In this experiment, at the end of the test phase, a brief questionnaire was administered which was aimed at getting information on the participant's awareness of the appearance of the targets.

## METHOD

**Participants** One hundred participants took part in this experiment. They were assigned to three conditions: prospective memory, vigilance and baseline. In the prospective and vigilance conditions each participant was presented with a living being (either an animal or a vegetable) and a non-living being targets. In the baseline condition all participants performed only the categorization task. The data from one of the participants assigned to the prospective condition and from one of those assigned to the baseline condition were not included in the analyses, because median RTs were higher than 1 sec. Thus, overall there were 98 participants: 40 in the prospective memory condition, 39 in the vigilance condition and 19 in the baseline condition.

**Materials.** The stimuli were two and three-syllable words selected from the Bortolini, Tagliavini, and Zampolli (1972) norms for Italian language. Within each condition, half the stimuli were living beings and half were non-living beings. In the prospective memory and vigilance conditions, one of the living beings and one of the non-living beings (either an animal or a vegetable) served as stop signals. The targets were "lampada" (lamp) "canguro" (cangaroo) and "sedano" (celery). There were 48 items which appeared 4 times (i.e., each item appeared as many times as the targets). Thus, overall, there were 192 trials, 8 of which were the targets that would serve as stop signals.

**Procedure.** Procedure was the same as in Experiment 1, with the exception that in this experiment categorization was used as an ongoing task. In addition, at the end of the test phase, participants were asked to fill a brief questionnaire, aimed at getting information on their awareness about the presence of the targets. Namely, participants were required to report: 1) whether they thought they made any error; 2) how many errors they thought they made; 3) whether and at which point in the test phase they were aware they made an error. This set of questions was repeated three times (i.e., for the ongoing task, for the living being target (either animal or vegetable) and for the non-living being target. Results and discussion

*Reaction Times.* A 3 (type of task; i.e., prospective, vigilance or baseline) by 2 (stimulus type; i.e., living beings/non living beings) by 4 (number of presentations) mixed ANOVA on the median RT values in the categorization task showed a main effect of type of task, $F (2, 95) = 7.10$, $p < .001$, $MSe = 45624.79$. Once again, RTs in the categorization task under prospective memory conditions were faster than RTs under vigilance conditions, $F (2, 95) = 6.40$, $p < .01$, $MSe = 292329.83$. However, RTs under prospective memory conditions did not differ from RTs in the baseline condition.

There was also a main effect of stimulus type (living vs non-living beings): median RTs were faster for living beings (639.80 msec) than for non-living beings (658.74 msec), $F (1, 95) = 37.02$, $p < .0001$, $MSe = 2186.33$. There was a main effect of number of presentations, $F (3, 285) = 72.47$, $p < .0001$, $MSe = 1307.41$. The effect of number of presentations is due to the fact that repetition priming was observed on RTs across the four presentations.

*Errors.* A one-way ANOVA on the total number of errors in the prospective memory and vigilance conditions showed an effect of type of task, $F (1, 77) = 19.00$, $p < .0001$, $MSe = 3.94$, with a lower error rate in the vigilance as compared to the prospective memory conditions. A 2 (type of task) by 2 (type of target) ANOVA on the number of errors for each target showed that the effect of task was independent of the type of target, in that the interaction was not significant. Repetition priming was also observed on accuracy in the background task across the four presentations. An ANOVA showed a significant decline in the number of errors in the fourth presentation as compared to the first presentation of the target, $F (1, 77) = 21.16$, $p < .0001$, $MSe = .606$. However, repetition priming occurred in the prospective memory condition but not in the vigilance condition, as qualified by an interaction between type of task and number of presentations, $F (1, 77) = 5.69$, $p < .02$, $MSe = .279$.

As in Experiment 1, we contrasted the first 4 occurrences of the targets in the vigilance condition with the last four occurrences of the targets in the prospective condition to rule out the hypothesis that the difference in the number of errors in the background task was due differences in the training phase. A 2 (type of task) by 4 (position of the targets) ANOVA showed that the effect of type of task was still present, $F (1, 77) = 9.33$, $p < .003$, $MSe = .288$, with no interaction between task and position.

The analysis on the number of errors in the ongoing task showed that error rate was low, averaging 3.5%, implying, once again, that the difference in the error rates observed in the background task was not due to a trade-off between speed in the ongoing task and accuracy in the background task. Finally, the results from the questionnaire showed that, when participants were questioned about their estimate of the errors they made in the background task, the percentage of "I was not aware I missed the target" responses was higher in the prospective memory (.19) than in the vigilance condition (.04). However, there was no difference between the two conditions when participants were asked about their errors in the ongoing task; i.e., no participants reported to have not been aware of making an error during the categorization task (.04 in the prospective memory condition and .0 in the vigilance condition). These outcomes are consistent with the notion that a fundamental difference between prospective memory and vigilance processes refers to the amount of monitoring that is required in order to detect the target.

## GENERAL DISCUSSION

The assumption on which the present research was based is that in an event-based prospective memory task, once the action has been planned, the intention is no longer present in conscious awareness until the opportunity of performing the action occurs. In contrast, if people encode the background task as a vigilance task, the planned intention to respond to a stimulus whenever it occurs has to be continuously maintained in consciousness. The results of Experiment 1 support the hypothesis that, although there may be an element of vigilance in every PM task, performing an event-based PM task is different from performing a vigilance task. The difference we observed between prospective memory and vigilance conditions cannot be simply due to differences in the initial learning of the instructions and in the training phase. Rather, our results suggest that the observed differences can be plausibly attributed to the characteristics of the retrieval mode maintained by the cognitive system during the two types of task, with prospective memory relying more on spontaneous retrieval of the cue-action association on appearance of the targets and vigilance relying more on continuous monitoring for the targets. A stronger version of this view would be that whereas prospective memory requires retrieval of the intention, vigilance does not. Results from Experiment 2 allowed us to extend the above conclusions to a different task and to add some refinements to the picture emerging from this research. Once again, in the ongoing task, the vigilance conditions were slower than the prospective memory conditions. In the background task, performance in the prospective memory conditions was less accurate than performance in the vigilance conditions. The latter result was not due to a speed/accuracy trade-off between the two tasks (the ongoing and the background) because accuracy in the ongoing task was equally high, irrespective of conditions, nor to the differences in the training phase. In addition, performance in the prospective memory conditions did not differ from the baseline condition (i.e., when the prospective memory task was absent), suggesting that performing an event-based prospective memory task does not elicit continuous conscious "rumination" of the intention, but rather relies on automatic retrieval of the cue-action association (McDaniel, Robinson-Riegler, & Einstein, 1998). The data from the post experimental questionnaire support this hypothesis. In fact, participants systematically reported to have been aware of making an error a) during the ongoing task and b) during the background task under vigilance conditions. However, most participants reported they never realized to have missed the target during the background task under prospective memory conditions. If one accepts the assumption that the ongoing task requires conscious recollection of the stimulus meaning to be performed, then the results from the questionnaire can be taken as indicating that event-based prospective memory retrieval plausibly relies on more automatic processing of the target (McDaniel et al., 1998). Recent research on the processes underlying prospective remembering specifically addressed the question of how event-based prospective memories are retrieved (Einstein & McDaniel, 1996; McDaniel et al., 1998). In particular, McDaniel and collaborators proposed a model of prospective memory retrieval in which the type of prospective memory tasks known as event-based prospective memory tasks is aligned with direct associative episodic memory tasks (McDaniel et al., 1998). This model is based on the Moscovitch (1992a, 1992b; see also Moscovitch, Goshen-Gottstein, & Vriezen, 1994) systems theory of memory which holds that associative episodic memory tasks are mediated by a memory module that rapidly and mandatorily delivers to consciousness the information associated with the presented cue. The module is activated when the cue receives full conscious attention. If the cue automatically interacts with a memory trace (i.e., the intended action), then the product of that interaction (i. e., the cue-action association) is obligatorily delivered to consciousness. If the cue does not interact with a memory trace, then the information is not retrieved unless another memory component (a prefrontal one, Moscovitch, 1992a, 1992b) initiates a strategic memory search (McDaniel et al., 1998). The idea is that it is this reflexive associative memory system that mediates prospective remembering, that supports retrieval of the intended action and that is responsible for those spontaneous memories that "pop into mind", apparently without any act of will. In the present research, the effects of repetition priming systematically observed on the error rate in the prospective memory task but not in the vigilance task add weight to the view that the retrieval of an intention under event-based prospective memory conditions is mostly automatic. Indeed, recent theories of automaticity consider repetition priming as a marker of automatization (Logan, 1988, 1991) and relate automatic processing to memorial aspects of attention, rather than to resource limitations (Craik, Govoni, Naveh-Benjamin, & Anderson, 1996; Logan, 1988; 1991; Logan & Etherton, 1994; Logan, Taylor, & Etherton, 1996). For example, the Instance Theory of Automatization (ITA) proposedby Gordon Logan in 1988 is based on the assumption that automaticity is a memory phenomenon governed by the theoretical and empirical principles that govern memory (Logan, 1991, 347). Automaticity-as-memory theories account for the properties of automaticity in terms of the properties of memory retrieval, that is, it is suggested that the process underlying automatic processing is memory retrieval . The instance theory of automatization assumes that memory performance depends on the outcome of a race between an algorithm for performing the task and a memory process that retrieves past solutions. Performance becomes automatic when the memory process wins the race. In this theory, instances are separate representations of co-occurrences, they represent processing episodes. It is attention that determines what is an instance and which co-occurrences are remembered. According to the ITA, repetition priming is viewed as the first step toward automatization. On the first exposure, the subject relies on some general algorithm. Obligatory encoding causes a representation of the item to be stored in memory; on the second exposure the subject can engage the algorithm or rely on memory retrieval of the episode: Whichever of the two processes finishes first determines performance. Repetition priming can be viewed as a shift from algorithmic processing on the first presentation to a mixture of algorithmic and memory-based processing on the second, and so on till performance becomes fully automatic. Our data on repetition priming can therefore be interpreted as indicating that while some kind of automatization process is at work when people encode the task as a prospective memory task, this is not the case under vigilance conditions. Taken together, the results from the present research are in good accordance with the hypothesis that prospective memory and vigilance processes differ as to the degree of monitoring that they require. However, it remains to be established whether "automaticity" can be considered a determinant of prospective memory retrieval. We believe that, although most results (including the present ones) seem to converge on this conclusion, one must be cautious before accepting the claim that automaticity is the major determinant of event-based prospective memory retrieval, as there are still some caveats that require attention and suggest that the picture may be more complex than commonly believed. For example, recent research addressed the issue of whether prospective memory retrieval is sensitive to interference from concurrent tasks (divided attention, Einstein, McDaniel, Smith, & Shaw, 1998; Marsh & Hicks, 1998; see also Hicks & Marsh, 2000; McDaniel & Einstein, 2000). Results showed that event-based memory can be susceptible to the effects of divided attention (Einstein, McDaniel, Smith, & Shaw, 1998), however, this is particularly true when the concurrent task is resource demanding (Marsh & Hicks, 1998). The conclusion is that event-based prospective memory may rely on both automatic and controlled processing, depending on the nature of the ongoing task and on its relation to the cue. Such a conclusion, however, is compelling only on the assumption that the detrimental effects of divided attention represent a reliable marker of controlled processing. In fact, while the common idea underlying resource theories is that automaticity does not suffer interference from concurrent tasks, automaticity-as-memory theories predict that automaticity, rather than being immune to interference, will suffer interference from those tasks that require memory retrieval (Logan, 1988, 1991). According to this view, the detrimental effects of divided attention on prospective remembering cannot be taken, per se, as reflecting the activity of controlled processing in prospective memory; rather, they might indicate that remembering an intention at some point in the future relies on retrieval-based automaticity. Automaticity-as-memory theories provide new and promising avenues for disentangling prospective memory from those cognitive processes (i.e., vigilance) which does not require retrieval to be completed. Such a hypothesis, which is currently under study in our laboratory (Brandimonte, Ferrante, & Delbello, in preparation), may open new directions for the study of the processes underlying memory for intentions.

# RESUMEN

**Disociación entre memoria prospectiva y procesos de vigilancia.** En dos experimentos se explora si se puede distinguir entre los procesos de recuperación que subyacen a la memoria prospectiva basada en eventos y aquellos que son responsables de la vigilancia. Los sujetos realizaban una tarea de forma continua (decisión léxica en el Experimento 1 y categorización en el Experimento 2), pero al mismo tiempo (tarea de fondo) debían recordar que siempre que apareciese en la pantalla un determinado estímulo objetivo, debían dejar de realizar la tarea continua. Había dos estímulos objetivo que aparecían 4 veces a lo largo de la tarea continua. Mediante las instrucciones y la práctica se inducía a los sujetos a codificar la tarea de fondo como una tarea prospectiva o como una tarea de vigilancia. Los resultados mostraron importantes diferencias entre memoria prospectiva y vigilancia. El tiempo de respuesta en la tarea continua fue sistemáticamente más lento en las condiciones de vigilancia que en las de memoria prospectiva. Sin embargo, las condiciones de memoria prospectiva no diferían de las de control (la tarea continua sola). Los datos de precisión en la tarea de fondo fueron complementarios a los de tiempo de reacción ya que se observó un mayor número de errores en las condiciones prospectivas que en las de vigilancia Estas diferencias no se debieron a un intercambio de velocidad y precisión entre las tareas continua y de fondo ni tampoco a las diferencias en entrenamiento. Aún más importante fue que en las condiciones de memoria prospectiva se observaron efectos de facilitación (priming) a través de las cuatro repeticiones de los objetivos y que esto efectos no aparecieron en las condiciones de vigilancia. Estos resultados son consistentes con la hipótesis de que las tareas de memoria prospectiva basada en claves y las de vigilancia difieren en el grado en que requieren monitorización consciente. La memoria prospectiva depende más de la recuperación automática de la asociación clave-acción, mientras que la vigilancia depende de procesos de búsqueda activa del objetivo.

**Palabras clave:** Memoria prospectiva, vigilancia, automaticidad.

# REFERENCES

Baddeley, A. D. & Wilkins, A. (1984). Taking memory out of the laboratory. In J. E. Harris & P. E. Morris (Eds.), *Everyday memory actions and absent-mindedness*. London: Academic Press, 1-17.

Bortolini, U., Tagliavini, C. & Zampolli, A. (1972). *Lessico di frequenza della lingua italiana contemporanea*. Milano, Garzanti

Brandimonte, Bisiacchi, Pelizzon, L. (2000). Perceptually-driven memory for intentions: A study with children and adults. *Cognitive Technology, 5* (1), 20-25.

Brandimonte, M. A., Einstein, G. O., & McDaniel, M. A. (Eds.) (1996). *Prospective memory. Theory and applications*. Hillsdale, NJ: Erlbaum.

Brandimonte, M.A., Ferrante, D., & Delbello, R. (in preparation). *Differential effects of divided attention on prospective memory and vigilance processes: A retrieval-based account of automaticity of prospective remembering*.

Brandimonte, M.A., & Passolunghi, M.C. (1994). The effect of cue-familiarity, cue-distinctiveness, and retention interval on prospective remembering. *Quarterly Journal of Experimental Psychology, 47*, 565-587.

Craik, F. I. M., Govoni, R., Naveh-Benjamin, M., & Anderson, N. D. (1996). The effects of divided attention on encoding and retrieval processes in human memory. *Journal of Experimental Psychology: General , 125*, 159-180.

Dobbs, A. R., & Reeves, M. B. (1996). Prospective memory: More than memory. In M. A. Brandimonte, G. O. Einstein, and M. A. McDaniel (1996). *Prospective memory. Theory and applications*. Hillsdale, NJ: Erlbaum. (pp.199-221).

Einstein, G. O., & McDaniel, M. A. (1990). Normal aging and prospective memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 16*, 717-726.

Einstein, G. O., & McDaniel, M. A. (1996). Retrieval processes in prospective memory: Theoretical approaches and some new empirical findings. In M. A. Brandimonte, G. O. Einstein, and M. A. McDaniel (1996). *Prospective memory. Theory and applications*. NJ, Lawrence Erlbaum Ass. (pp. 115-138).

Einstein, G. O., McDaniel, M. A., Smith, R. E., & Shaw, P. (1998). Habitual prospective memory and aging: Remembering intentions and forgetting actions. *Psychological Science, 9*, 284-289.

Ellis, J. (1996). Prospective memory or the realization of delayed intentions: A conceptual framework for research. In M. A. Brandimonte, G. O. Einstein, and M. A. McDaniel (1996). *Prospective memory. Theory and applications*. NJ, Lawrence Erlbaum Ass. (371-376).

Goschke J., & Kuhl, T. (1996). Explicit and implicit intention memory. In M. A. Brandimonte, G. O. Einstein, and M. A. McDaniel (1996). *Prospective memory. Theory and applications*. NJ, Lawrence Erlbaum Ass. (53-91).

Hicks, J. L., & Marsh R. L. (2000). Toward specifying the attentional demands of recognition memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 26*, 1483-1498.

Kvavilashvili, L., & Ellis, J. (1996). Varieties of intention: Some directions and classifications. In M. A. Brandimonte, G. O. Einstein, and M. A. McDaniel. *Prospective memory. Theory and applications*. NJ, Lawrence Erlbaum Ass. ( 23-51).

Logan, G. D. (1988). Toward an instance theory of automatization. *Psychological Review, 95*, 492-527.

Logan, G. D. (1990). Repetition priming and automaticity: Common underlying mechanisms. *Cognitive Psychology, 22*, 1-35.

Logan, G. D. (1991). Automaticity and memory. In W. E. Hockley, & S. Lewandowsky (Eds.), *Relating theory and data: Essays on human memory in honor of Bennet B. Murdock* (pp. 347-366). Hillsdale, NJ: Erlbaum.

Logan, G. D., & Etherton, J. L. (1994). What is learned during automatization? The role of attention in constructing an instance. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 20*, 1022-1050.

Logan, G. D., Taylor, S. E., & Etherton, J. L. (1996). Attention in the acquisition and expression of automaticity. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 22*, 620-638.

Maylor, E. A. (1996). Age-related impairment in an event-based prospective-memory task. *Psychological Aging, 11*, 74-8.

Marsh R. L., & Hicks, J. L. (1998). Event-based prospective memory and executive control of working memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 24*, 336-349.

Marsh R. L., Hicks, J. L., & Hancock, T. W. (2000). On the interaction of ongoing cognitive activity and the nature of an event-based intention. *Applied Cognitive Psychology, 14* (7), S29-S41.

Meacham, J. A., & Leiman, B. (1982). Remembering to perform future actions. In U. Neisser (Ed.) *Memory observed: Remembering in natural contexts* (pp. 327-336) San Francisco: Freeman.

McDaniel, M. A., & Einstein, G. O. (2000).Strategic and automatic processes in prospective memory retrieval: A multiprocess framework. *Applied Cognitive Psychology,, 14* (7), S127-S144.

McDaniel, M. A., Robinson-Riegler, B. & Einstein, G. O. (1998). Prospective remembering: Perceptually driven or conceptually driven processes?. *Memory and Cognition, 26* (1), 121-134.

Moscovitch, M. (1992a). Memory and working-with-memory: A component process model based on modules and central systems. *Journal of Cognitive Neuroscience, 4*, 257-267.

Moscovitch, M. (1992b). A neuropsychological model of memory and consciousness. In R. L. Squire & N. Butters (Eds.). *The neuropsychology of memory*. NY, Guilford Press.

Moscovitch, M. , Goshen-Gottstein, J., & Vriezen, E. (1994). Memory without conscious recollection: A tutorial review from a neuropsychological perspective. In C. Umiltý & M. Moscovitch (Eds.). *Attention and Performance, XV*, 619-660.

Neumann, O. & Klotz, W. (1994). Motor responses to nonreportable, masked stimuli: Where is the limit of direct parameter specification? In Umiltý, C. and Moscovitch, M. (Eds); *Attention and performance: Conscious and nonconscious information processing, XV*, 123-150.

Parasuraman, R. (1985). Sustained attention: A multifactorial approach. In M. I. Posner & O. S. M. Marin (Eds.), *Attention and Performance, XI*, Hillsdale, N. J.: Erlbaum.

Shiffrin,R. M., Schneider, W. (1977). Controlled and automatic human information processing: II. Perceptual learning, automatic attending and a general theory. *Psychological Review, 84*(2): 127-190.

Tulving, E. (1983). *Elements of Episodic Memory*, Oxford University Press, New York.

Tzelgov, J. (1997) Automatic but conscious: That is how we act most of the time. In Wyer, Robert S. Jr. (Ed.) *The automaticity of everyday life: Advances in social cognition*, Vol. 10. (pp. 217-230), Mahwah, NJ, Erlbaum.