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PROSPECTIVE MEMORY IN THE NURSING ENVIRONMENT: EFFECTS OF TYPE OF PROSPECTIVE TASK AND PROSPECTIVE LOAD

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ABSTRACT

The nursing environment is replete with event-based and time-based prospective memory (PM) tasks (i.e. high prospective load). However, the effects of time-based prospective load, prospective load in naturalistic settings, and prospective load with unique retrospective components for each PM task remains unknown. To address this gap, the current study used a mockup patient room setting to examine the effects of PM type (event-based or time based) and prospective load (1 vs. 4 tasks) with unique prospective and retrospective components) on ongoing task and PM task performance. Registered nurses completed an ongoing documentation task while also remembering to perform 1 or 4 PM nursing tasks at a certain time (time-based) or certain patient name (event-based). Results indicated that having an event-based intention decreased performance on the prospective component of the PM task and slowed performance on the ongoing task. Having a time-based intention in the one load condition positively affected timeliness of performing the PM task and number of records completed. Performance on the retrospective components of the PM task was equal across groups, but post retrospective recall of tasks was worse in the high prospective load conditions.

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INTRODUCTION

Prospective Memory

Prospective memory (PM) is often defined as “remembering to remember” (Harris, 1984; Mäntylä, 1994). PM is a concept that describes our ability to remember to perform an activity in the future, sometime after we initially formed the intention to perform that activity. Common examples of PM tasks include remembering to take medications on-time or remembering to bring a textbook to school in the morning. Everyday examples of PM failure are getting home from work and realizing that you forgot to pick up the groceries you needed for dinner or return the movie that was due that day.

PM tasks are characterized by three major features (e.g., Ellis & Kvavilashvili, 2000; McDaniel & Einstein, 2000). First, there must be a delay between the time an intention is formed and the time when the intention is recalled and completed. Second, PM tasks require that there is no direct request or explicit prompting to remind the person to recall the task. The third feature of PM is that it requires a person to be doing some sort of ongoing (also called concurrent) task during the remembering period, which will be interrupted when it is time to perform the PM task.

PM intentions differ by the task demands: event-based and time-based (Einstein & McDaniel, 1990). Event-based PM tasks occur when a person forms an intention to complete a task in the future when a certain cue (e.g., person, object, location) appears; thus, event-based PM is said to be externally cued. Some nursing examples of event-based PM tasks are when a nurse must remember to tell the doctor about a patient’s blood test results next time she sees him or get more alcohol wipes next time she is in the supply room. Time-based PM tasks occur when a person forms an intention to complete a task at a specific time, or after a certain amount of time has passed. Contrary to the external cue provided in event-based PM, time-based PM requires clock monitoring and is internally cued (Ceci & Bronfenbrenner, 1985). Nurses often have to remember to check on a patient an hour after a surgical procedure has been completed or administer medication at 2:00pm.

All PM tasks consist of a prospective component and a retrospective component. The prospective component is remembering that you must perform a task when the appropriate cue (event or time) appears, while the retrospective component involves remembering the contents of that task (i.e. what it is you must actually do). For example, if a nurse had to remember to tell Dr. Lee about Mr. Smith's lab results next time she sees him, the prospective component would be interrupting her ongoing task when she sees Dr. Lee to perform a task and the retrospective component would be remembering the contents of the task (i.e. tell him Mr. Smith's lab results).

Prospective Memory in Nursing

A nurse's work environment places heavy demands on both time-based and event-based PM. Examples of such PM tasks include: remembering to communicate information to other staff members, giving medications at specific times, checking for new orders, attending meetings, bringing patients items they request, monitoring continuously changing information, and resuming interrupted tasks (Grundgeiger, Sanderson, MacDougall, & Venkatesh, 2009; Fink, Pak, Bass, & Johnston, 2010). *Prospective load* is a term used to describe the quantity of PM intentions one is trying to remember (Kidder, Park, Hertzog, & Morrell, 1997). For example, if a nurse had to remember to order a drug from the pharmacy for patient #3, call patient #4's spouse at 11am, and make sure Patient #5 ambulates for 10 minutes, her prospective load would be three.

Various aspects of a nurse's cognitively demanding work environment contribute to a high prospective load, and may hinder successful ongoing task or PM task performance. First, nurses perform a wide variety of tasks. One study found that nurses performed approximately 84 different types of activities during a typical shift (Tucker & Spear, 2006). These activities include direct patient care activities (e.g., patient assessment, administering treatment), indirect patient tasks (e.g., documentation, coordinating with other medical staff), and non-nursing tasks (e.g., housekeeping, bringing patients meals) (Cardona, Tappen, Terrill, Acosta, & Eusebe, 1997). In addition, nurses work long shifts (usually 8-12 hours), caring for 4-6 patients at a time (Institute of Medicine, 2004).

The nurse's prospective load is increased with the need to multi-task and frequent interruptions. Observational studies have found that nurses switch between patients on average every 6-7 minutes to 11 minutes per hour (Potter et al., 2005; Tucker & Spear, 2006). This creates a situation where nurses have tasks that are "stacked" or waiting to be performed. Wolf et al. (2006) found that 62% of the time nurses had at least 10 items in their stack and 17% of the time they had more than 15 items. Wolf et al.'s notion of "stack" is synonymous with the nurse's prospective load.

Reported rates of nursing interruptions vary from 6.3 interruptions per hour to 8 interruptions per shift (Tucker & Spear, 2006, Biron, Lavoie-Tremblay, & Loiselle, 2009). Inherent in an interruption is that the interrupted task is postponed until it can be resumed at a later time, thus forcing the individual to create a PM intention. Studies have shown that interruptions can negatively affect PM performance (e.g., McDaniel, Einstein, Graham, & Rall, 2004; Finstand, Bink, McDaniel, & Einstein, 2006).

It is possible that a high prospective load of both time-based and event-based tasks exceeds a nurse's capacity to remember and she forgets certain tasks; ongoing task performance may also be detrimentally affected. In the field of nursing, forgetting can have serious consequences and endanger the safety and well-being of patients. Indeed, PM failures have been suggested to be a contributing factor to nursing error (Leape, 1994; Rothschild, 2005).

Given the heavy PM demands placed on nurses, as well as the grave consequences for forgetting, it is surprising to find only one study (which was observational in nature) that has examined PM in nursing (Grundgeiger, Sanderson, MacDougall, & Venkatesh, 2009), though two have examined PM in a medical context (Dieckmann, Redderson, Wehner, & Rall, 2006; Grundgeiger, Liu, Sanderson, Jenkins, & Leane, 2008). Furthermore, given that nurses spend much of their day in a high *prospective load* situation trying to maintain different *types of prospective memory* tasks (event- and time-based), it is surprising to find only two studies on prospective load, both examining event-based load only using a typical laboratory paradigm.

Prospective Load Research

The typical laboratory paradigm employed in prospective load studies (Einstein, Holland, McDaniel, & Guynn, 1992; Kidder, Park, Hertzog, and Morrell, 1997) asks subjects to engage in an ongoing computer task (e.g., rating the pleasantness of a word or lexical decision task), while also remembering to press a special key when an embedded target or targets (e.g., word, background) appear (first developed by Einstein & McDaniel, 1990). For example, participants may be told to press the letter 'M' anytime the word 'flower' appears. This paradigm can also be used to assess time-based PM by having subjects remember to press a special key at a certain time or time interval. In this paradigm, ongoing task performance is usually measured in terms of correctness and latency. PM performance is determined by the proportion of times the participant remembered to push the designated key when the appropriate target appears.

Einstein, Holland, McDaniel, & Guynn (1992) used this paradigm to study the effects of event-based prospective load (1 or 4 PM tasks), amount of delay after presentation of PM tasks (either 15 or 30 minutes), and age (young or old) on performance on an ongoing task and PM task(s). The ongoing task in the study had subjects perform a short-term memory task where they viewed a set of words, then repeated the set when the word RECALL appeared. The PM task(s) was to press the F20 key on a keyboard whenever the target word(s) *rake* (1 PM condition), or *rake*, *truck*, *nose* and *soap* (4 PM condition) appeared. All conditions were presented with a PM target word 3 times. Results showed that varying prospective load from 1 to 4 tasks did not significantly affect younger adults' performance, but did detrimentally affect older adults' performance. Einstein et al. also found that increasing the length of the retention interval from 15 to 30 minutes did not significantly affect PM performance for either young or older adults.

Kidder, Park, Hertzog, and Morrell (1997) examined the relationship between prospective load (1 or 3 targets), working memory load (low or high), and age (young or old). The ongoing working memory task was the same as Einstein et al. (1992), but the PM task was different. In this study, each word in the ongoing task was presented on a different background. For the PM task subjects had to remember to press the zero key when 1 or 3 (depending on condition) pre-assigned background patterns appeared. All conditions were presented with a target background six times. Like Einstein et al.'s results, this study found that only older adults showed significant performance decrements with increased prospective load. As far as working memory load, those in the low load condition performed significantly better on the PM task than those in the high load condition. Age differences were present, with older adults performing worse in both the high PM and high workload conditions.

The authors of both of these studies suggest that older adult's poorer performance on the high prospective load task was attributable to subjects not remembering what specific targets (i.e. 3 words, 4 background patterns) they were supposed to respond to, which they claim is the *retrospective* component of the task. However, it is plausible that this is not the actual retrospective component of the PM task (i.e. remembering what task is to be performed). Instead, remembering these targets is a retrospective aspect of the *prospective* component (remembering there is a task to be performed). The actual retrospective component would be remembering which button is pushed when the target word appears (the action to-be-performed).

A limitation of both of the previously mentioned studies is that the retrospective component was identical for all prospective load conditions (the same response button was used for all PM tasks). This limitation makes it difficult to determine if a person forgot to respond to complete a PM task because they forgot the target cues or because they forgot the content of the task. Furthermore, remembering multiple PM tasks with different prospective components but the same retrospective component appears to be a simpler task than remembering multiple PM tasks with unique prospective and retrospective components. Perhaps it is not an accurate representation of increased prospective load when the tasks do not have unique retrospective components.

Another limitation of these two studies is that subjects in the 1 prospective load condition were not performing just 1 PM task. In the Einstein et al. study, subjects in the 1 prospective load condition saw the same word three times, while in the Kidder et al. study subjects saw one background pattern six times or three patterns two times each. Not only is this an inaccurate representation of prospective load task quantity, but viewing the same word (or background pattern) multiple times can lead to repetition priming effects (Tulving & Schacter, 1990), or better memory due to multiple exposures.

A final limitation to existing prospective load studies is that they were conducted in highly controlled laboratory settings. These studies had college-aged students perform very novel tasks, in an unfamiliar setting, over very short time periods with short delay intervals between the time the PM intention was formed and the time the intention was to be recalled (only 1 to 2 minutes in Kidder et al.). The inherent limitations of lab-based studies seriously limit our ability to study phenomena such as prospective memory as it occurs in complex, operational settings (e.g., Graf & Uttl, 2001; Rendell & Craik, 2000). People are usually not performing one single, simple PM task over and over. Instead, they may have several PM tasks to remember, of varying levels of complexity and importance, which have to be remembered at different times throughout the day.

We addressed the limitations of previous prospective load studies in four major ways:

1) Unlike past studies that have been carried out in the laboratory, our study will be conducted in a naturalistic work environment where real workers perform familiar tasks.
2) Subjects in the 1 prospective load condition will only perform 1 PM task, eliminating potential repetition priming effects present in previous studies.
3) Subjects will have to perform more realistic, complex PM tasks with distinct prospective and retrospective components (e.g., not pushing F20 every time a PM cue appears, but rather performing a unique task for every PM cue).

4) Our study will examine both event-based and time-based PM tasks rather than exclusively event-based.

Although previous findings (Einstein et al., 1992; Kidder et al., 1997) have shown that only older adults experience performance decrements when prospective load is increased from 1 to 4 tasks, we believe that decrements in performance in other age groups (younger and middle-aged adults) are likely based upon current *monitoring* theories of PM (e.g., Smith, 2003). Monitoring theories of PM suggest that ongoing task performance is reduced when there is a PM task in memory because the act of monitoring the environment consumes resources (e.g., attentional resources) that would be used for the ongoing task. Monitoring theories posit that PM requires an executive attentional system that strategically monitors the environment for the target event. When the target event is encountered, this executive attentional system interrupts the ongoing activity and initiates the process for performing the intended task. Therefore, if one has multiple PM tasks in memory, the load on limited capacity resources would be high leading to decreased attentional capacity for another task.

Support for monitoring theories of PM comes from studies that have found having a PM intention in mind, versus no PM intention in mind, causes decrements to ongoing task performance (Guynn, 2003; Marsh, Hicks, Cook, Hansen, & Pallos, 2003; Smith, 2003; Einstein et al., 2005). The only support we can find for multiple PM tasks negatively affecting younger adults performance comes from a set of studies that found having both an event-based and time-based intention in mind, rather than just one or the other, caused significant slowing in ongoing task performance (Hicks, Marsh, & Cook, 2005). These findings should be interpreted with caution though because the results were obtained by comparing performance across two studies (rather than a single sample), one study where subjects remembered only a single intention and the other where they remembered both a time-based and event-based intention.

Research on Prospective Memory Type

Unlike event-based PM tasks that are cued by an external event, time-based PM tasks require a person remembers on their own to monitor the passage of time and perform a task at the appropriate moment (d'Ydewalle, Luwel, Brunfaut, 1999). Prior research has shown that this self-initiated process is more cognitively demanding than recognizing an external cue, and thus time-based tasks require more attentional resources than event-based tasks.

Support for this notion comes from one study that found older adults perform worse on an ongoing task and PM task when they concomitantly have to remember to perform a time-based task, but not an event-based task (Einstein, McDaniel, Richardson, Guynn, & Cunfer, 1995). Another study found that PM performance (not ongoing performance) was worse for older adults when remembering time-based, but not event-based intentions (Park, Hertzog, Kidder, Morrell, & Mayhorn, 1997). Furthermore, d'ydewalle, Bouckaert, and Brunfaut (2001) found that ongoing performance was worse for older adults in the time-based conditions than event-based conditions. If an older adult has limited resources and performance is worse only for time-based tasks, this suggests time-based tasks require more processing.

Additional support for time-based tasks taking up more attentional resources comes from a study that examined how frequently subjects thought about and performed an event-based and time-based intention (Sellen, Louie, Harris, Wilkins, 1997). The event-based PM task was to push a button on an electronic badge whenever a person was in a specific room; the time-based task was to press a button on the badge every two hours. Subjects also pushed a button any time they thought about an intention. Results showed that participants thought about the time-based task significantly more frequently than the event-based task, but remembered to perform the task less frequently than the event-based condition. So even though participants were thinking about the task more frequently, they forgot to perform the task more often. Taken together, these results suggest that time-based intentions occupy more mental resources than event-based intentions.

The purpose of this study was to investigate the effect of prospective load *and* PM type on the performance of a PM task and an ongoing task. Contrary to previous prospective load research we hypothesized that increased prospective load will detrimentally affect subject's performance. We also hypothesized that those in the time-based conditions would have worse performance because of the increased need for monitoring of the passage of time (and the increased need for self-initiated processing/reminding). Moreover, we predicted an interaction between prospective type and prospective load such that that performance in the event-based condition will be less detrimentally affected than performance in the time-based condition as the number of tasks increases. To investigate these research questions, we placed registered nurses in representative ongoing and PM tasks situations in a mock-up patient room environment.

METHODS

Design and Participants

The experiment was a 2 (PM type: event-based, time-based) x 2 (prospective load: 1, 4) between subjects factorial. Thirty-nine (3 male) registered nurses (M = 39.95 years, SD = 8.03 years) participated in the study and were randomly assigned to one of the four conditions. They each received \$50 compensation and a chance to be entered in a \$100 raffle for approximately 1 hour and 45 minutes of their time. Nurses were recruited from a local hospital through use of a mass email (from a coworker who had no knowledge of study details) and flyers posted on hospital bulletin boards directing nurses to contact a researcher to set up an appointment. Qualifications for participation included being between the ages of 22-55 and having at least 2 years hospital work experience.

Study Site

The study was conducted at a research warehouse located adjacent to Spartanburg Regional Healthcare System's Village at Pelham campus. The research facility is 4,480sq. ft. and contains three different variations of a full-scale patient room, one of which was used for the current study. The patient room included all of the components and equipment you would normally see in a hospital room like a headwall, sink, bed, etc.

There was a nurse work area to the right of the patient bed with a countertop and barstool. The countertop contained a laptop, mouse, mouse pad, and a stapled stack of 40 patient records to the left of the keyboard. A bedside table was located near the patient bed with supplies needed for one of the PM tasks (500mg Tylenol) as well as various other supplies (750mg Advil, gauze, ointment, syringe, yankeur catheter). A wheelchair (necessary for one of the PM tasks) and walker were located on the wall opposite the nurse work area. A vital signs machine (necessary for one of the PM tasks) was located to the right of the patient bed. A patient simulator with a bandage on his arm (necessary for one of the PM tasks) was situated in the patient bed to represent the patient. A high definition video recorder was set up to record each session. See Appendix A for a sample video frame from the study.

Tasks

Ongoing Task.

We chose a documentation task for the ongoing task because previous research has shown documentation is one of the most frequent tasks nurses perform (Buerhaus, Donelan, Ulrich, DesRoches, & Dittus, 2007; Battisto, Pak, Vander wood, & Pilcher, 2009). In our representative documentation task, nurses had one hour to transcribe information from a paper copy of a patient record into a computer-based form meant to replicate an *electronic* patient record management system. Both records were based on existing hospital forms and developed with the input of a nursing subject matter expert (a nursing professor). See Figure 1 for examples of each type of record.

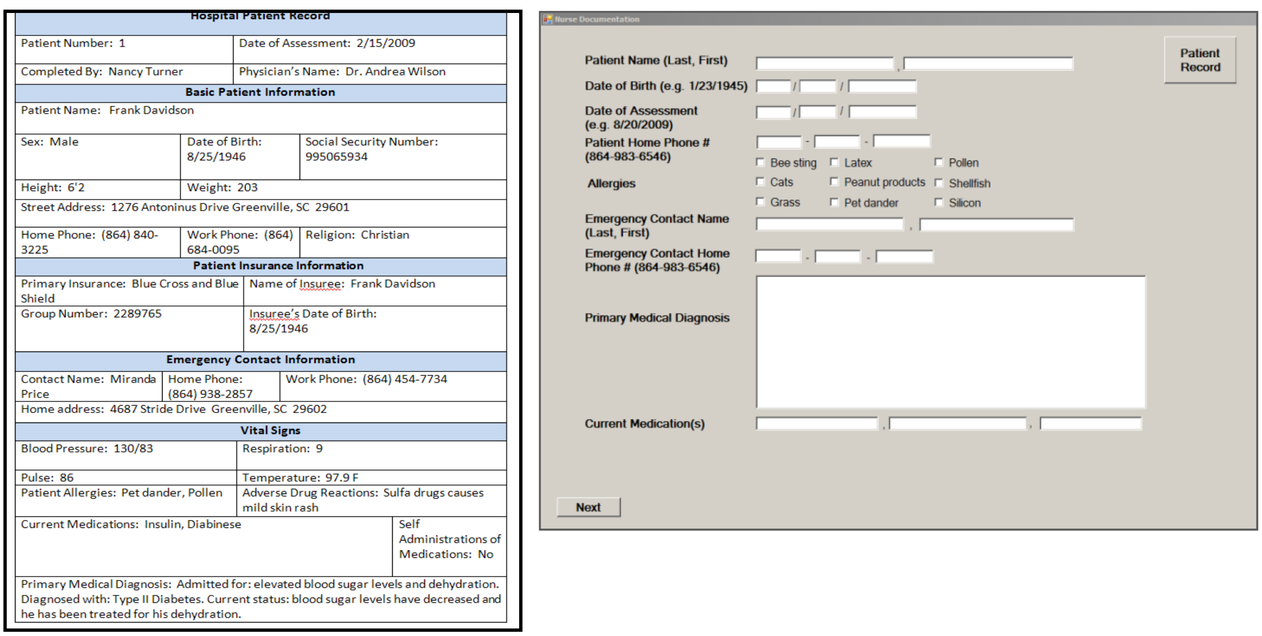

Figure 1. (left) paper patient record that subjects gathered information from and transcribed into the electronic patient record (right).

Paper records contained 31 pieces of information related to a patient (e.g., physician's name, phone number, allergies). Subjects had to find and transcribe nine pieces of information from each paper record to each electronic record. Every electronic record was identical and contained nine data entry fields. Examples were provided next to every entry field to ensure subjects knew exactly what format in which to enter the information. The computer program automatically recorded the information entered into each field in a text-based comma separated values (CSV) file, then compared it to a master CSV file. The generated output files allowed us to capture total number of omissions per patient record (fields left blank), total number of commissions per record (fields with errors), average time per record, and total number of records completed.

A hidden clock, pause button, and next record button were also located on every electronic record and their functionality was explained to every subject, regardless of condition. The purpose of the clock was for participants in the time-based condition to monitor the time. It was hidden from view, but appeared for 3 seconds when the bottom right corner of the screen was clicked. We deliberately chose not to make the clock obvious to keep it from acting as an external reminder. Using an electronic clock (rather than one mounted on the wall) was beneficial because the computer program automatically recorded every time the subject checked the clock, and we were able to observe individuals clock checking behavior.

A pause button was located in the top right hand corner of the screen. However, in order to avoid the word ‘pause’ acting as an external reminder, the button was labeled ‘patient record.’ The computer program kept a time-stamp record of every time a subject clicked pause. As the participants finished each electronic record they would click a “next” button located on the bottom left corner, flip to the next paper record, and continue transcribing. The computer program automatically ended when the hour time period was up. Ongoing task performance was assessed along 4 measures: omissions (entries left blank), commissions (entries with errors), mean time per record, and total number of records completed.

Prospective Memory Task.

PM tasks were embedded in the ongoing documentation task and consisted of commonly performed nursing tasks (Battisto et al., 2009). We chose to use four PM tasks for our high load condition because it is similar to previous prospective load studies (which used loads of 3 and 4). The event-based PM task required subjects to push pause to perform a certain task when they saw a specific patient's name(s) (e.g., when you see patient record Lisa, bring walker to patient). The time-based PM task required subjects to push pause to perform a certain task at a particular time (e.g., during the ongoing task, at 10:12 AM bring walker to patient). See Appendix B for the four different task conditions a patient could have received. PM performance was assessed for both the prospective component of the task (getting up to perform a task at the appropriate time) and the retrospective components of the task (remembering to push pause and contents of nurse task).

Names in the event-based PM tasks were chosen from a list of the most common names from 4 different decades (Social Security Administration, 2010). We avoided very distinct names because distinctiveness can positively affect PM (McDaniel & Einstein, 1993). We did not include last names to minimize memory demands. Target names only appeared once in the ongoing task.

Times in the time-based PM tasks were chosen based on the following 4 criteria: 1) The time had to fall between 10:00:00 and 11:00:00 as that is what the computer program provided as a clock for each session. 2) The time could not be on any :00 or :05 minutes because that may be more memorable or distinct. 3) The minimum time was 10 minutes from start to ensure participants would get through a few records, and a maximum time of 47 minutes to ensure that slow participants in the 4 event-based PM task condition would get to that patient record before time runs out. 4) The times had to be more than 8 minutes apart from each other.

To roughly equate the delay interval between appearance and recall of target names and target times, we pilot tested 4 subjects and found the mean time to complete a patient record was 2.5 minutes. We then divided our target times (i.e. minutes) by 2.5 and put the event-based target names on those corresponding patient records. Table 1 displays how time-based and event-based conditions were matched.

Table 1

Displays how time-based times and event-based names were matched to the same approximate record

Time	Approximate Record	Name	Retrospective component of PM Task
10:12	5	Lisa	Bring walker to patient
10:23	9	David	Remove bandage from patients' arm
10:37	15	Carol	Assess patient's vital signs
10:46	18	Michael	Put 500mg Tylenol on patient bed

Procedure

Subjects first completed an informed consent form and demographics questionnaire. Before beginning the experiment, subjects were asked to remove their wrist watch if they were wearing one and set their cell phone to silent. The researcher then led the subject to the nurse work area in the mock-up patient room, pointed out the video camera, and told them our goal was to examine their performance on a nursing documentation task. Participants were further told that to make this documentation task more realistic, we were going to have them remember to perform other tasks while doing the documentation task. Subjects were directed to read the instructions on the computer and let the researcher know out loud when they were finished. These instructions describing the ongoing documentation task and are provided in Appendix C.

Once the subject finished reading the instructions, the researcher advanced the computer screen to a practice patient record and went through each of the nine fields, pointing out the necessary information on the paper record and where it was to be entered into the electronic record.

The hidden clock and next record buttons were explained next. The researcher then explained the pause button by saying, "Remember I said before that we are also going to have you remember to perform other tasks while doing documentation. Well, when you are ready to perform the other task, you will just click this button to pause the documentation task. When you click it, the screen will turn blank and this button will say resume task. Just click resume task to pick up where you left off." When the subject had no more questions remaining about any part of the documentation task, they completed a practice record on their own. The researcher checked it over to make sure it was correct, pointed out any errors, and then asked if the subject felt comfortable with the task or wanted to do another practice record (no one selected to do another practice).

Subjects were then introduced to the PM task(s). They were told that just like a typical day at work, they do not get to sit down and only do documentation, but have lots of other things to remember to do as well. They were told that we wanted them to remember to perform 1 (or 4) additional nursing tasks when they see a certain patient name (or it gets to a specific time); any necessary equipment is located around the bedside. Those in the event-based conditions were told to hit pause as soon as they saw the target patient name(s), before they began transcribing that record. Those in the time-based conditions were instructed to hit pause as soon as they realize it is the target time.

Subjects were then handed a sheet of paper that listed the 1 or 4 name(s) or time(s) and associated task(s). Appendix B contains the four different versions of the handout. Subjects were told to take as long as they needed to memorize the list of additional tasks, and let the researcher know out loud when they are finished so their memory could be tested. When the subject said they had the tasks memorized, they were handed the form from Appendix B, but this time there were blanks where the names/times and tasks had been and only the major heading name/time and task (see Appendix D). Once the subject completed the handout, the researcher checked it for 100% correctness. If it was not correct, the subject was handed the list of tasks again and the process continued until 100% was reached; no one ever needed more than 2 blank forms.

At this point, subjects were told that they are to complete as many patient records as quickly yet accurately as possible, spelling and punctuation are important, capitalization is not, while also remembering to perform their other task(s). The need to simultaneously do the ongoing documentation task and PM task(s) was explained again to ensure the subject understood what they were supposed to so (i.e. documentation, pause when you see target, perform associated task, click button to resume documentation). Subjects were asked if they had any questions about any part of the task. Any uncertainties were answered, and subjects were told to hit the start button once the researcher turned on the video camera and said, “begin study.”

Upon completing the hour long documentation task, subjects were given the same blank form as before (Appendix D) to test their post-retrospective recall of the PM tasks we had asked them to complete. This exercise was done as a check to assess if PM task errors could be attributed to forgetting the contents of the prospective or retrospective component. Subjects then completed a questionnaire unrelated to the current study, and were debriefed, compensated, and dismissed.

RESULTS

Data from two nurses were eliminated from analysis due to not understanding the instructions or an inability to complete the task. The remaining data from 37 nurses (See Table 2 for distribution among conditions) were used in analysis. There were no significant differences ($p > .05$) between the four groups in age, work experience, length of computer usage, frequency of computer usage, experience with computers, typical work shift, and amount of time spent on the computer during a typical work shift.

Table 2
Number of participants per condition

	Prospective Load	
PM Type	One	Four
Event-based	9	9
Time-based	10	9

The results are organized by the two tasks: PM task and ongoing task. Within the PM task results, we examined performance on both the prospective component (remembering intention to perform task) and retrospective components (contents of PM task and pause task), as well as latency and retrospective recall of tasks. Ongoing task performance was assessed along 4 measures: omissions (entries left blank), commissions (entries with errors), mean time per record, and total number of records completed. Significance was set at an alpha level of .05.

Many of our dependent measures were very skewed because participants were scored as either correct or incorrect (i.e. 1 or 0). Prior research has suggested that a skewness statistic ± 2 is severe enough to bias the results of the analysis (Cohen, Cohen, West, & Aiken, 2003;

Tabachnick & Fidell, 2007). Thus, for data sets with a skewness statistic ± 2, a binary logistic regression was performed where data was coded as either 1 (correct) or 0 (incorrect).

Prospective Memory Task

Prospective component.

The prospective component of the PM task required remembering to interrupt the ongoing documentation task at the appropriate moment to perform the PM task. The prospective component was scored as the proportion of times that an individual correctly got up to perform the PM task(s). A response was counted as correct and received a score of 1 as long as it occurred on the correct patient record (event-based) or within a 2 minute window of the target time (time-based). A response was considered incorrect and received a score of 0 if it was outside of those boundaries.

Because the data was not normal (evidenced by a skewness of -2.3), we performed a binary logistic regression in which the data were coded as either 0 (did not initiate the PM task) or 1 (did initiate the PM task). We tested the main effects of PM type and prospective load, as well as their interaction. The Omnibus tests of model coefficients chi square statistic revealed a significant main effect for PM type, χ^2 (1, N = 37) = 8.04, p = .005, such that participants in the event-based conditions were less likely to perform the PM task than those in the time-based conditions. Table 3 displays the predicted probability of correctly initiating the PM task in each condition based on the logistic regression equation. These data suggest a ceiling effect with almost perfect performance for the time based condition, and poorer performance for the event-based condition. This significant effect was in the opposite direction from our prediction. There was no significant main effect for prospective load, χ^2 (1, N = 37) = .30, $p > .05$, and no significant interaction, χ^2 (1, N = 37) = .70, $p > .05$.

Table 3
Predicted probability (based on linear regression model) of performing the PM task as a function of prospective load and PM type

	Prospective load	
PM type	1	4
Event-based	77%	67%
Time-based	99%	99%

Retrospective components.

Our PM task had two distinct retrospective components: remembering to push pause before performing the nurse task and remembering the contents of the nurse task. For both retrospective components, we only analyzed participants who got up to perform the PM main task (though it was acceptable if they got up at the wrong prospective component). This selective analysis was due to the nature of the task; if a participant did not even attempt the PM task it was impossible for them to correctly (or incorrectly) perform the retrospective components. These more stringent criteria led four participants to be excluded, leaving 33 in the subsequent analysis (see Table 4 for distribution).

Table 4
Number of participants per condition once those who did not perform the PM task were excluded

	Prospective Load	
PM Type	One	Four
Event-based	7	7
Time-based	10	9

Pause task.

The first retrospective component of the PM task was for participants to remember to push pause on the ongoing task before they got up to perform the PM task. We examined the computer output to see if a subject clicked pause on the appropriate target name(s) or within 2 minutes of the target time. Performance was scored as the proportion of times that a participant hit pause before performing the main PM task. The mean proportion of times that subjects clicked pause was 1 in the event-based 1 load condition, .86 in the event-based 4 load condition, .8 for the time-based 1 load condition, and .78 in the time-based 4 load condition.

Due to high skewness in the pause data (-2.2), we performed a binary logistic regression where all of the data were coded as either 0 (did not push pause) or 1 (did push pause). We tested the main effects of PM type and prospective load, as well as their interaction. The Omnibus tests of model coefficients chi square statistic revealed no significant main effects of PM type, χ^2 (1, N = 33) = .60, $p > .05$, prospective load, χ^2 (1, N = 33) = .004, $p > .05$, or their interaction, χ^2 (1, N = 33) = .10, $p > .05$.

Contents of PM task.

Video data from each nurse's session was examined to determine if they performed the correct task (i.e. at 10:12 or at patient record Lisa did they bring the walker to patient). Correct responses received a score of 1 and incorrect responses received a score of 0. Performance was scored as the proportion of times that a participant performed the correct task. Thus, like the prospective component, in the 1 load condition subjects could score either a 0 or 1 and in the 4 load condition they could score a 0, .25, .5, .75, or 1.

When participants attempted a PM task, they were very accurate at performing the correct task. A ceiling effect was evident with only 2 participants not performing the correct PM task(s).

Both participants were in the time-based 4 load condition and incorrectly performed one and two of the four tasks. We performed a binary logistic regression to test the main effects of PM type and prospective load, as well as their interaction. The Omnibus tests of model coefficients chi square statistic revealed no significant main effects of PM type, χ^2 (1, N = 33) = .05, p > .05, prospective load, χ^2 (1, N = 33) = 3.033 p > .05, or their interaction, χ^2 (1, N = 33) = .99, p > .05.

Latency.

This dependent variable measured the proportion of times that an individual was on-time (not delayed) when performing the PM task. Participants were considered on-time and received a score of 1 if they performed the PM task as soon as they saw the correct patient name before they began typing (event-based), or within 15 seconds of target time (time-based). Participants were considered delayed and received a score of 0 if they performed the PM task on the correct patient record, but after they started typing (event-based), or within 15 seconds to 2 minutes after the target time (time-based). Video data were again analyzed in the event-based conditions to determine if nurses were on-time or delayed. We were able to tell once they turned to a new paper record if they immediately clicked pause and/or got up to perform the task, or if they started typing before getting up to perform the task. For the time-based conditions, if the subject clicked pause it was easy to determine if they were on time or delayed. If the subject did not click pause, we watched the video and used the video program clock to determine if a subject was on time or delayed.

Like the analysis of retrospective components, only 33 participants were included in this analysis once individuals who did not complete the PM main task were excluded. A 2 (PM type) x 2 (prospective load) between participants ANOVA revealed no significant main effects for PM type, $F(1, 29) = .04$, p > .05, or prospective load, $F(1, 29) = .87$, p > .05, but a significant interaction between PM type and prospective load, $F(1, 29) = 5.147$, $p = .03$, $\eta_p^2 = .15$. Follow-up tests revealed that participants were on-time when performing the PM task significantly more often in the 1 PM task conditions than in the 4 PM task conditions, but only in the time-based condition ($M = .90$ and .47. respectively). The effect of load was not significant within the event-based condition ($M = .57$ and .75). See Figure 2. Thus, increasing PM load decreased timeliness in initiating the PM task, as predicted, but only for time based tasks.

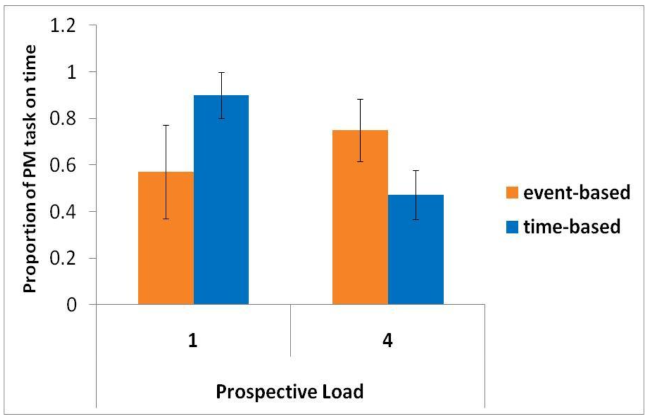

Figure 2. Proportion of times participants were on-time when they got up to perform the PM task as a function of PM type and prospective load. Error bars represent a 95% confidence interval around the mean.

Retrospective recall of tasks.

Performance on the post-retrospective recall questionnaire was scored as the proportion of times a person correctly answered the task recall questions. Correct responses received a score of 1 and incorrect responses received a score of 0. Thus, participants in the 1 prospective load condition (with 2 responses) could receive a score of 0, .5, or 1, while participants in the 4 prospective load condition (with 8 responses), could receive a score of 0, .125, .25, .375, .5, etc.

A 2 (PM type) x 2 (prospective load) between subjects ANOVA with data from the 33 nurses that completed the prospective component of the PM task revealed a significant main effect of prospective load, $F(1, 29) = 5.03$, $p = .03$ $\eta_p^2 = .15$, such that participants answered significantly fewer post-recollection questions correctly in the load 4 conditions ($M =$ .875) than those in the load 1 conditions (*M* = .975), as predicted. See Figure 3. There was not a significant main effect for PM type, $F(1, 29) = .109$, $p > .05$ or the prospective load by PM type interaction, $F(1, 29) = .49$, $p > .05$. The same analysis with all 37 participants yielded the same result, with a significant main effect only for prospective load, $F(1, 33) = 5.36$, $p = .03$.

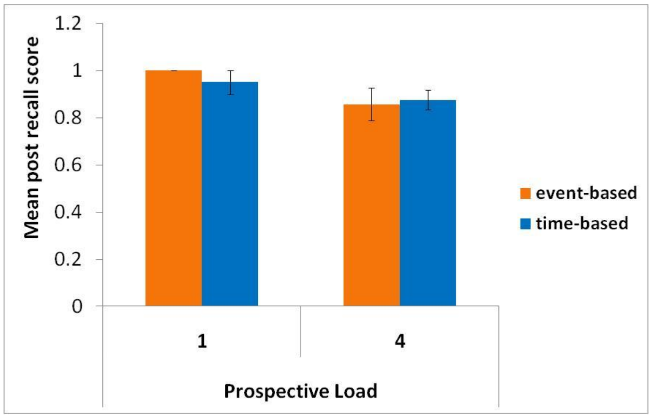

Figure 3. Mean score on post-retrospective recall questionnaire as a function of PM type and prospective load. Error bars represent a 95% confidence interval around the mean.

Ongoing Task

Omissions.

The computer program automatically recorded any entry field left blank on the electronic record as an omission. Performance was scored as the average number of omissions per subject. Data were severely skewed (4.77) so a traditional 2 x 2 ANOVA was not appropriate. However, performance was so close to ceiling that other significance tests did not prove useful. Thus, there were no significant differences among conditions on the average number of omissions made (*M* = .02, .00, .00, and .00).

Commissions

Commission performance was scored as the average number of commissions per subject. A response was considered a commission if it had any spelling or grammar errors in it; spacing and punctuation differences were not considered errors. A 2 (PM type) x 2 (prospective load) between subjects ANOVA revealed no significant main effect for PM type, $F(1, 33) = .959$, $p = .33$, prospective load, $F(1,33) = .39$, $p = .54$, or their interaction, $F(1, 33) = 1.36$, $p = .25$. Thus, there were no significant differences among conditions on the average number of commissions made (M = 1.87, 1.25, 1.13, and 1.31).

Mean time per patient record.

This dependent variable was calculated by dividing the total amount of time spent on the records by the total number of records completed. A 2 (PM type) x 2 (prospective load) ANOVA of mean time per record revealed a significant main effect of PM type, $F(1, 33) = 9.31$, $p = .004$, $\eta_p^2 = .22$. Contrary to predictions, participants took longer to complete records in the event-based condition (M = 157.2 sec) than in the time-based conditions (M = 125.4 sec). See Figure 4. There were no significant effects of prospective load, $F(1,33) = .26$, $p > .05$, or interactions of PM type and prospective load $F(1, 33) = 2.89$, $p > .05$.

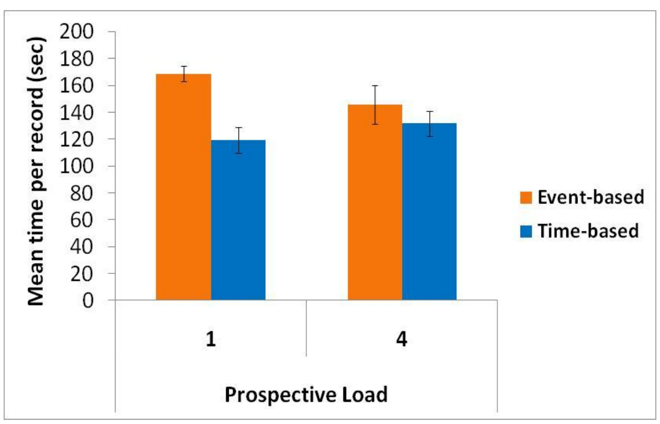

Figure 4. Average time it took participants to complete a single patient record as a function of PM type and prospective load. Error bars represent a 95% confidence interval around the mean.

Total number of patient records completed.

This measure represents the total number of patient records that nurses completed. A 2 (PM type) x 2 (prospective load) between subjects ANOVA revealed a main effect only for PM type, $F(1, 33) = 11.46$, $p = .002$, $\eta_p^2 = .26$, not prospective load, $F(1, 33) = .05$, $p > .05$, There were significantly fewer records completed in the event-based conditions than the time-based conditions. Type of PM interacted with prospective load ($F(1, 33) = 4.82$, $p = .04$, $\eta_p^2 = .13$, such that participants completed significantly more records in the time-based conditions than in the event-based conditions, but only in the low prospective load condition (M = 30.0 and 20.5 records, respectively). See Figure 5.

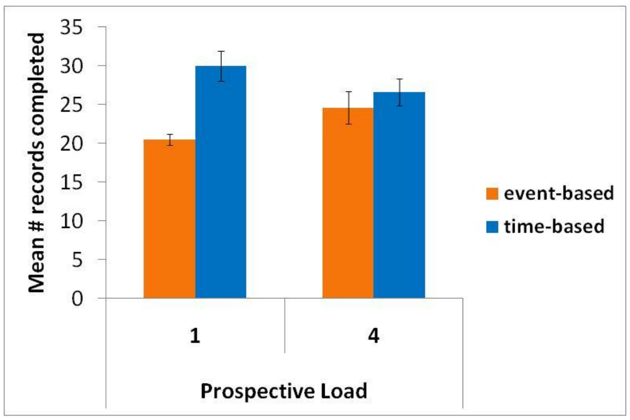

Figure 5. Mean total number of records completed by participants as a function of PM type and prospective load. Error bars represent a 95% confidence interval around the mean.

DISCUSSION

The purpose of this study was to examine the effects of PM type and prospective load on nurses ongoing and PM task performance in a representative nursing environment. Based on previous literature, we hypothesized that participants in the time-based conditions and high prospective load conditions would perform worse on all measures of the ongoing and PM tasks. Several interesting (and statistically significant) findings emerged from this study, many of which were contrary to our hypotheses:

1) PM performance was worse in the event-based than the time-based condition, but only for the prospective component of the PM task, not the retrospective component.

2) Ongoing task performance as measured by accuracy (commissions and omissions) was the same across conditions. Ongoing performance as measured by latency revealed that those in the event-based conditions took longer per record and (for low PM load) completed fewer records than those in the time-based conditions.

3) Participants in the 1 prospective load were more prompt (on-time) in attempting the PM task, but only in the time-based condition.

These findings are now discussed in more detail along with theoretical propositions for why these results may have occurred.

The first two findings above suggest that having an event-based intention in mind detrimentally affects performance compared to a time-based intention. First, participants in the event-based conditions forgot to perform the PM task more often than those in time-based conditions. In fact, prospective PM performance was almost perfect for the time-based condition. Hence, remembering to perform a task when a specific patient name appeared was harder than remembering to perform a task at a specific time. This result was not the result of people in the event-based condition allocating more effort to the ongoing task than the PM task. Those in the event-based conditions also completed fewer ongoing patient records and performed slower on each patient record than those in the time-based conditions. Taken together, these results are inconsistent with our hypothesis and suggest that event-based intentions can consume a greater amount of attentional resources than time-based intentions for both ongoing and PM tasks.

Summarizing, our hypothesis that people in time-based conditions would perform worse than event-based conditions was not supported. One potential explanation of this finding was the poor performance on the ongoing task in the event-based condition could have been due to a speed-accuracy tradeoff (i.e., these participants may have prioritized accuracy over speed). However, given that ongoing task accuracy (as measured by omissions and commissions) was not significantly different across conditions, it appears that a speed-accuracy tradeoff is not a suitable explanation.

There is also the question of whether PM failure in event-based conditions is attributable to forgetting the prospective component (remembering to perform task) or the retrospective component (remembering contents of task) of the PM task. We found retrospective performance was consistent across conditions. This suggests that participants' difficulty with event-based PM tasks had to do with the prospective component of the PM task. A potential explanation for the poor performance on the prospective PM task in the event-based condition has to do with the nature of the PM cues in our event-based tasks. Seeing a patient's name on a patient record is probably not as salient or natural of a cue as those in the typical nursing environment (e.g. seeing a patient's face). In contrast, remembering to perform a task at a certain time is a typical prospective cue for nurses.

Our finding of poor ongoing task performance in the event-based condition is consistent with Jäger and Kliegel (2008), who found that ongoing task accuracy was the same across time and event-based conditions, but latency measures revealed the event-based conditions were slower. Other studies have similarly found ongoing task accuracy was worse for event-based than time-based conditions, but they did not measure latency (d'Ydewalle et al., 1999; Park et al., 1997).

Recall that the basis of our original hypothesis for better performance with event-based PM tasks was that monitoring the passage of time would be a more resource-demanding task than monitoring the environment for an event-based cue. We will now consider other plausible explanations for why time-based tasks would show less detrimental effects to ongoing task performance than event-based tasks. Before considering these explanations, it is helpful to understand a common theoretical paradigm for time-based PM tasks: the test-wait-test-exit model (Harris & Wilkins, 1982). This model suggests that when a person has a time-based PM task in mind, they will initially check the clock to determine the current time. If it is too early to perform the task they will wait a period of time before checking the clock again. This action cycle continues until it is the appropriate time to perform the task, at which point the person exits the loop and performs the intended action.

While monitoring the clock for the appropriate time has been suggested to exact an attentional cost and would support our original hypothesis (McDaniel & Einstein, 2007), Park et al. (1997) propose that monitoring a clock and just checking it once in a while allows an individual to experience decreased working memory demands for periods of time, allowing them to focus more on the ongoing task. Thus, in time-based tasks individuals have a period of attentional disengagement right after the clock check where they can focus mainly on the ongoing task. On the other hand, in event-based tasks individuals are constantly monitoring the environment for the appropriate cue and thus ongoing task performance is more negatively impacted. A related explanation for why event-based intentions can cause slower performance on an ongoing task compared to time-based intentions is that event-based targets (e.g., patient name) are a feature of the ongoing task, while time-based targets are not. Thus, an individual is always assessing the ongoing task to see if an event-based cue is present, but can choose the optimal moment for them to assess if it time to perform a time-based task (d'Ydewalle et al., 1999; Jager & Kliegel, 2008). In brief, these two explanations assume that event-based PM tasks can sometimes require more effortful attentional engagement, while time-based PM tasks can sometime use easier, automatic processes.

Our final explanation assumes that participants make the opposite assessment of whether event-based or time-based tasks require more effort. Hicks et al. (2005) suggest that participants form mental predictions at the time instructions are given as to how much attention they must devote to each task, then delegate their attention based on what they think they need to focus on more. This theory provides another explanation of why participants in time-based conditions performed better. Perhaps at the time of instructions, participants in time-based conditions thought the task would be hard so they focused more attention to it, while those in the event-based conditions relied on automatic processing to notice the cue.

Our hypothesis about participants in the low prospective load conditions performing better than those in the high prospective load conditions was not completely supported. We found no main effects of PM load on ongoing task or PM task performance. Instead, we found better on-time performance on the PM task with low than high load, but only for the time-based condition. It is possible that the high prospective load conditions did not show overall worse performance than low prospective load conditions because of the interactive effect of PM type. That is, being in the event-based condition was exacting such a detrimental toll that a participants' performance was negatively affected whether they were in the 1 or 4 load condition.

Although we did not find overall worse performance in the high prospective load conditions, it is possible that a high prospective load can still negatively affect performance. Even though we took numerous measures to create a representative nursing environment, it may be that complex phenomena like high prospective load are not able to be effectively measured outside of actual job settings. Real-world nursing environments entail higher prospective loads, over longer periods of time, with more varied and complex ongoing and PM tasks, and with triggering events that vary from subtle to conspicuous. Furthermore, research has shown that factors such as importance of PM task and rehearsal can affect PM performance (Kliegel, Martin, McDaniel, & Einstein, 2001; Kvavilashvili & Fisher, 2007).

Our study differed from previous studies on prospective load in that we had a unique prospective component and retrospective component for each of the 1 or 4 PM tasks. Results revealed that there were differences between groups, with event-based performing worse than time-based on only the prospective component of the task, but not the retrospective component. To our knowledge, only one previous study has used a PM task that can be analyzed based on both its prospective and retrospective components. This was done by asking participants to press the number '9' when they say saw the letter 'B' or push the number '7' when they saw the letter 'D' (Cohen, Dixon, Lindsay, & Masson, 2003). Future studies should separate the prospective and retrospective component of the PM task in order to determine what is causing forgetting—missing the appropriate cue or forgetting the contents of the task. Our results suggest that in a more representative job setting, PM failure is caused more by missing a PM cue than by forgetting the contents of the task.

One limitation of this study is the small sample size, although small sample sizes are common when using expert participants. A within subjects design would have allowed for more participants per condition, but there were several drawbacks that led us to choose a between subjects design. First, a within subjects design would have increased the possibility of practice effects; we did not want participants to perform better on the second trial because of practice in the first trial. Second, we wanted nurses to have the longest amount of time possible to perform the tasks, thus increasing the delay interval between the time the intention was formed and the time it is recalled and executed, more like a real nursing PM task. Future research may want to replicate our study with a larger sample size or a control condition that receives no PM tasks. Seeing how nurses often must remember 10 or more PM tasks at once, it would be interesting for future studies to examine if prospective loads higher than four detrimentally affect performance. It would also be useful to examine if the salience or realness of the event-based cue influences performance (i.e. see a real patient rather than just a name).

Another possible limitation of our study is that the clock may have acted as an external reminder every time it was checked, thus increasing the likelihood a person would remember to perform the PM task. We intentionally hid the clock to try and keep this from happening, but just the act of monitoring may have reminded participants about the task. Future research may want to examine different versions of a clock including a watch, PDA, or wall mounted clock.

Our study differed from most time-based studies in that we had participants perform a task at a specific time, rather than a time interval (e.g., every 4 minutes). We chose a specific time because we thought it was most similar to the prospective component of the event-based tasks, remembering solitary chunks of information. Future research should examine time-based prospective load using time intervals, as well as time widows (i.e. between time x and y).

CONCLUSION

Examining factors that affect PM in naturalistic settings can help us explain inconsistencies in existing theories of PM. Understanding the role that prospective load and PM type have on performance on ongoing and PM tasks is crucial not just in the field of nursing, but in many critical work settings where PM load is high and forgetting can lead to tragic consequences (e.g. aviation). Our results suggest that event-based PM tasks are harder to remember to perform than time-based PM tasks. Unfortunately, an examination of existing memory aids (Fink & Pak, 2010) revealed that most aids to date are time-based in nature. If we are able to determine under what situations performance declines, we can inform the design of usable environmental aides to assist with PM demands.

APPENDICES

Appendix A

Sample video frame from study

Appendix B

The four boxes diplay the four different conditions and associated tasks that participants could have received.

Additional Nursing Tasks

Carol = Assess patient's vital signs

Additional Nursing Tasks

Lisa = Bring walker to patient

David = Remove bandage from patients' arm

Carol = Assess patient's vital signs

Michael = Put 500mg Tylenol on patient bed

Additional Nursing Tasks

10:37 = Assess patient's vital signs

Additional Nursing Tasks

10:12 = Bring walker to patient

10:23 = Remove bandage from patients' arm

10:37 = Assess patient's vital signs

10:46 = Put 500mg Tylenol on patient bed

Appendix C

Instruictions on computer that described the ongoing documentation task

Welcome to the Pelham Research Laboratory! Today we are interested in examining your performance on a common nursing task: documentation. Please read the instructions below carefully and let the researcher know when you are finished.

You will find a booklet of hard-copy patient records to your left; please flip to the first page. Your task is to transcribe select information from the hard-copy patient records into an electronic patient record form.

Each hard-copy patient record will go on an individual electronic patient record. The computer will show you 9 entry fields of patient information (e.g., patient name, allergies) that you need to fill in. Your job is to find that information on the hard-copy patient record and enter it as quickly yet accurately as possible into the computer.

Spelling matters, so try your best to type the information exactly as you see it on the hard copy record.

You will have an hour to enter as many patient records as possible. The researcher will guide you through the first record and then you will have an opportunity to complete a practice record on your own. Please ask any questions you have before starting the task, for we will not be able to answer any questions once the hour time period starts.

We thank you very much for participating in our research study today! Please let the researcher know when you are ready to begin the practice record.

Appendix D

Blank handout given to subjects to test master memory and post retrospective recall of PM tasks

Additional Nursing Tasks

	Name		**Task**
1.	____________	=	______________

Additional Nursing Tasks

	Name		**Task**
1.	____________	=	______________
2.	____________	=	______________
3.	____________	=	______________
4.	____________	=	______________

Additional Nursing Tasks

	Time		**Task**
2.	____________	=	______________

Additional Nursing Tasks

	Time		**Task**
1.	____________	=	______________
2.	____________	=	______________
3.	____________	=	______________
4.	____________	=	______________

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