Take Me Where I Was: Assisting In-vehicle Interruption Management with Peripheral Cues

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Abstract
Interruptions happen in driving context due to interacting with multiple in-vehicle information systems. Drivers are vulnerable to forget to resume the interrupted task. Remembering to resume these tasks increases mental workload. In this paper, we consider interrupted tasks as prospective memory tasks because they cannot be performed at the time their intentions are created. To assist resumption while driving, we propose using peripheral in-vehicle displays as cues to hint to the deferred intention. Later, we propose three approaches for using these cues.

Author Keywords
interruptions; prospective memory task; resumption cues; peripheral displays

ACM Classification Keywords
H.5.m [Information interfaces and presentation (e.g., HCI)]: User Interfaces

Motivation and Related Work
Interruptions happen everywhere. We experience different tasks interrupting each other frequently. Interruptions are more prone to occur in contexts that require users to deal with multiple tasks simultaneously. In recent years, due to the rise of in-vehicle information systems, driving has turned into a multi-tasking activity. These systems are

primarily meant to assist drivers with driving or performing secondary tasks more simply. However, when the number of the tasks and the workload required for handling them increases, they cause interruptions. These interruptions nevertheless, are not always disruptive; in cases where the interrupting task has a higher priority than the primary task, interruptions can be beneficial.However, the current work focuses on interruptions that are disruptive. Forgetting to resume an interrupted task is a problem, which has been addressed by many researchers [3, 7, 8]. People spend noticeable time and effort to remember interrupted tasks, and in cases they do, their workload is increased due to the mental effort they put into reconstructing the previous state of the interrupted task [9].

According to Dodhia and Dismukes [4] interrupted tasks become *prospective memory tasks*. When a secondary task interrupts a primary task, an intention for resuming the primary task is made. After the interruption is over, the intention for resuming the primary task has to be retrieved from memory. This act of retrieval is normally done without explicit prompting [6].

Interruption in driving context has been the topic of research in recent years [2, 11]. Switching the attention back and forth between driving and in-vehicle tasks increases drivers' cognitive workload [13]. According to Altmann et al. [1], when a task is interrupted, its goal which is the mental representation of its completion is suspended. After the interruption, this suspended goal is retrieved from memory, if its activation level passes a threshold called *interference level*. For example, the driver receives a phone call while receiving an up-coming turn instruction from the navigation system. In this case, the goal related to the turning maneuver is suspended until the phone call is finished and the driver can retrieve the stored goal. Altmann et al. [1] identified two factors which influence the activation of a suspended goal:

- frequency of retrieval and,
- presence of cues associated with the goal

As the frequency of retrieval of a goal depends highly on users experience with the task, we focus on the second factor, the retrieval cues.

The influence of cues in interruption management has been studied in several works [1, 2, 9, 12, 5]. However, most of these studies, except for [5] do not cover the role of cues in resumption and prospective memory task performance. In this work, we are going to discuss about the role of peripheral in-vehicle cues in supporting prospective memory tasks.

Prospective Memory Tasks and Peripheral Cues

In-vehicle interruptions can happen due to various reasons from in-vehicle infotainment system notifications to a passenger talking to the driver. The results of these interruptions are usually errors in time sensitive tasks, like taking a highway exit. Presence of cues associated with the interrupted task assist priming the information about the encoded intention.

In our approach, we decided to use peripheral cues for supporting task resumption. The reason for this decision was that we were inspired by an example happening in everyday life: imagine you want to post a letter, which is lying on a desk next to a green bag. Before you pick the letter up you receive a phone call. After the phone call is finished, you forget about the letter and leave the room. A while later, you enter another room where a similar green bag is lying on a chair. Seeing this green bag makes you think of the last time you saw it and reminds you of the letter. In this example, the green bag is not highly associated with the posting letter task, but it assists you to prime information about it.

Considering this example, we assume that human brain is capable of associating characteristics in one's periphery to intentions of tasks, although they are not highly associated. In our earlier work [10] based on this assumption, we suggested having peripheral in-vehicle cues before and after interruption. In this case,the driver can encode the intention of the prospective memory task before switching to the interrupting task to bookmark the context and encode the task intention. After the interrupting task is over, by providing the cues again she is able to prime the encoded intention.

Driving is a visual task where the focus of drivers' visual attention is normally on the road. Using peripheral cues for supporting interruption management and prospective memory tasks can assist drivers to prime information without being distracted from the road by using divided attention. We propose to use light displays for presenting resumption cues. We assume that having light displays in the periphery of drivers can attract their attention to an extent but not distract them from the road. We propose three different approaches to present these in-vehicle light cues:

- **Before and after interruption:** In this approach, as mentioned above, cues are presented before the interruption (e.g. from the time that the phone starts ringing, until the call is answered) to encode the intention, and then after interruption to retrieve the encoded information.
- **Based on task completion:** In cases where tasks are not time-sensitive, we suggest to have cues which remind drivers of an incomplete task.
- **Event based:** This approach can be applied more for time-sensitive tasks, like taking a highway exit. We suggest that when the time is approaching and the user is not taking a related action to the task (e.g. changing lane), cues are presented to remind users of a forgotten intention.

Conclusion

Peripheral in-vehicle displays can be a good solution for managing interruptions and prospective memory tasks in driving context. We can present cues for prompting information about the interrupted tasks and assist drivers at resumption. This paper discusses the characteristics of interruptions as prospective memory tasks and suggests using in-vehicle light displays as a solution. Three interaction concepts for these light displays are suggested. This work nevertheless, is still at a primary concept development stage and there is a lot room for research either in the concept development or design of in-vehicle peripheral cues.

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