Designing for Task Resumption Support in Mobile Learning

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Abstract
Distractions and interruptions often disrupt mobile learners. Luckily, task resumption (memory) cues can support users in resuming a learning task. These cues can have multiple forms and designs, but their effectiveness depends heavily on their adaptation to the specific learning use case. This work explores the causes of interruptions during mobile learning and outlines designs for task resumption support. We report findings from two focus groups with HCI experts ($N = 4$) and users of mobile learning applications ($N = 3$). Finally, we discuss these findings by drawing on literature, and we derive a research agenda of currently unexplored concepts. We state limitations and open questions in the domain of task resumption support for mobile learning.

Author Keywords
Mobile Learning; Interruption Recovery; Task Resumption Support

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

Introduction
Smartphones are altering the face of modern education by making it possible to learn on the move [3]. This enables the design of new learning experiences (micro-learning) but

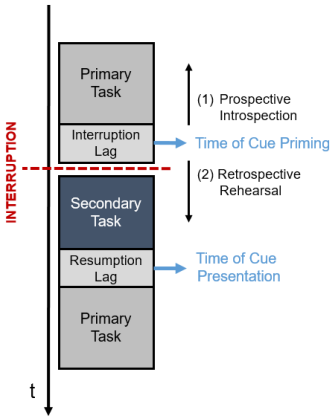

Figure 1: Based on [12]. An interruption occurs between a primary task and a secondary task. The priming of a cue happens during the interruption lag and the cue is then shown as task resumption support during the resumption lag. Cues can aim to foster (1) *Retrospective Rehearsal* or (2) *Prospective Introspection*.

also gives rise to considerable challenges. Mobile Learning Apps (MLAs) render learning ubiquitous – one can learn how to code[1] during a lunch break or how to speak Japanese[2] while waiting for a bus. Prior work has illustrated the variety of situations in which people use MLAs [11], in particular, outside of their home environment. However, learning in public spaces exhibits high distraction and interruption rates. Interruptions can be introduced by the user (e.g., mind-wandering), by the device (e.g., a message received), or by the environment (e.g., a distracting noise) [5]. Prior work suggested postponing or managing interruptions during human-computer interaction (HCI) [5]. However, in everyday life, many interruptions are unavoidable (e.g., changing trains on a commute), and thus task resumption techniques become increasingly relevant.

Regardless of its origin, an interruption increases the time needed to complete a primary task [5] as well as error rates [2]. Supporting users by shifting their attention back to the original task can help attenuating these negative effects. Task resumption support has been explored on various levels: from implicit color highlights (e.g., [10]), to complex auditory cues (e.g., [14]). However, research on task resumption support has hitherto focused primarily on desktop environments [8]. During mobile learning, the setting and situational context of the user varies and interruptions are very frequent and unpredictable. In this work, we delve into the design of task resumption support that addresses the special requirements of a mobile learning scenario. We present existing task resumption strategies and cues, as well as insights from two focus groups with HCI experts ($N = 4$) and users of MLAs ($N = 3$). Based on these results, we outline a research agenda that encompasses a set of worth-exploring research questions.

[1] SoloLearn: https://www.sololearn.com, last accessed May 17, 2019
[2] Duolingo: https://www.duolingo.com, last accessed May 17, 2019

Task Resumption & Memory Cues

We define an interruption as an intermission of a primary task such as that of mobile learning. A secondary activity disrupts the primary task and demands the user's attention (cf. Figure 1). The duration and required effort of a secondary task largely influence its disruptive effect. For example, changing trains may take several minutes and demand 100% of the user's attention, thereby disrupting a mobile learning task. On the other hand, a user may completely ignore an incoming e-mail notification on a mobile device and resume the primary task within milliseconds.

An interruption can also be viewed as a suspension of the primary task's goal. *Priming* can serve as a reminder of a suspended goal: through the presentation of a memory cue [12], either as (1) retrospective rehearsal ("What was I doing before?"), or (2) prospective introspection ("What was I about to do?") [12] (cf. Figure 1). In this work, we focus on (1) retrospective rehearsal, since the lesson plans are in general defined by the MLA. However, further improvements in sensor capabilities of mobile devices could enable us to explore designs facilitating prospective introspection through context sensing. Task resumption cues using retrospective rehearsal have shown the potential to support reading being hindered by interruptions (e.g., via highlighting the last line of text a person was reading [10]). Additionally, auditory cues such as recording a verbal reminder about the task at hand before answering an incoming call can help to regain task context [14]. However, task resumption support is barely researched in MLAs. Therefore, we elicited potential resumption strategies and designs suitable for mobile context, as outlined below.

Study

We conducted two focus groups for deriving design ideas for task resumption support in MLAs. The 1st group in-

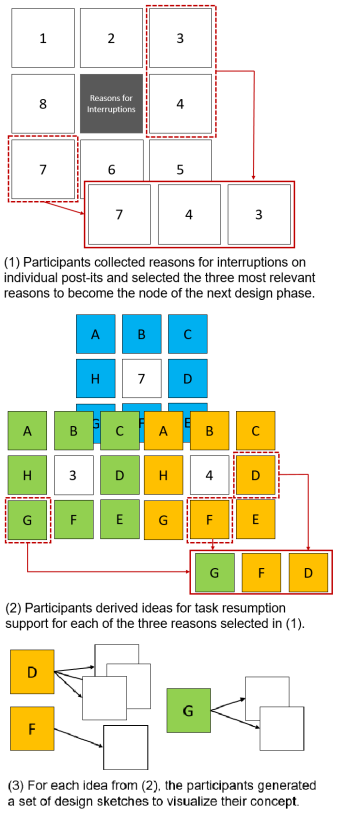

Figure 2: The three steps of the design process applied in both focus groups (cf. [6]).

cluded four HCI experts (3 female, 1 male) with a mean age of $M = 29.4$ ($SD = 1.0$). The 2nd group comprised three MLA users with little to no background knowledge in HCI (2 female, 1 male), and a mean age of $M = 25.7$ ($SD = 2.1$). All participants used MLAs such as *Duolingo*, *Phase 6*, or *Mondly* on their mobile devices in sessions of 10–30 minutes, on a daily to weekly basis.

To foster creativity and idea generation, we employed the "Lotus Flower" or "Lotus Blossom Method", a 3-step design ideation process for group brainstorming sessions as used in [6]. Ideas are gradually developed by choosing the most interesting or promising concepts of the current step to become the center of the next brainstorming phase (cf. Figure 2). We split the participants of the expert group into two smaller groups of two to facilitate the brainstorming process. The 3-step process was built bottom-up, we began by asking the participants to come up with *"Which are the reasons for interrupting a mobile learning session?"*

The participants then selected the three causes of interruptions they considered most relevant during mobile learning. In step 2, these reasons became the center of the new brainstorming nodes, asking *"How can we support the user in resuming a learning task after having been interrupted?"* Again, we asked the participants to pick the three most interesting solutions to be the center for step 3, the design phase. We asked the question *"How can resumption support be designed / implemented in an MLA?"* and let the participants sketch as many ideas as they liked. Next, we report our findings by numbering our participants consecutively, labeling with an "*E*" for *Expert* and a "*U*" for *User*.

Designing for Task Resumption Support

Participants came up with 27 (possible) causes of interruptions during MLA usage, based on introspection and prior experience. In the next sidebar, they are summarized and clustered into 3 main groups: *self*, *device-internal*, and *external interruptions* (cf. [5]). The substantial number of causes characteristic of mobile settings indicates that it is indeed meaningful to extend resumption strategies beyond desktop settings. Both groups sketched several ideas for supporting mobile task resumption, clustered as follows:

–**Increase Motivation for Task Resumption.** For situations in which the user is tempted to respond to an avoidable interruption (e.g., a social media notification), the user group participants described a gamification approach to keep the learner aware of the disruptive effect of interruptions. They designed an interface mock-up which includes a tree growing at the lower right corner of the screen. In case an interruption is detected (e.g., reacting to a notification), the tree shrinks, resulting in a loss of fruit / points. This idea combines the visual representation of Liu et al. [9], who could already show significantly lower off-task time through visual feedback in a desktop environment, with a gamification approach. A very similar concept is implemented in the Forest App[3]. Additional gamification elements are utilized in common MLAs (e.g., Duolingo), indicating that their design is suitable for small-screen devices such as mobile phones.

–**Adaptive Learning Modes.** The user group participants suggested learning modes within the MLA, with different learning content, structure and presentation of content, and type of task resumption support (cf. Figure 3). For example, a *home* learning mode would assume a quiet environment and therefore, would present tasks with increasing complexity and difficulty. A *commuting* learning mode would anticipate interruptions, and thus, schedule shorter units, while providing the option to repeat prior tasks. Resumption cues would then have to take the specific content and restrictions

[3]Forest App: https://www.forestapp.cc, last accessed May 22, 2019

Interruption Causes

Self-Interruptions:
Feeling tired (U2), hungry (U2+U3), cold (U2), or getting a headache (U2). In addition, mind-wandering (E4), cravings and needs (E4), sudden thoughts (E1) – such as the idea to look up something –, and the end of a self-assigned time slot reserved for learning (E2, E4).

Device-Internal Interruptions:
Instant messaging notifications (U3, E3+E4), incoming phone calls (U3, E3+E4), or distracting advertisements in the apps (U1). Also hardware-related problems, such as updates and device failures (E1), a low battery level (U1), missing network coverage (E3), or the sunlight making it difficult to read on the smartphone screen (U2).

External Interruptions:
The mail carrier ringing the doorbell (U2+U3), the neighbor being loud (U2), having to walk the dog (U1+U3), other people in the room (U2), or the TV running in the background (U1). People approaching (U2), being asked questions in the waiting room at the doctor's (U1), a bumpy metro ride (U2+U3), or switching trains (U2, E1+E2). The experts also listed more general external causes such as social interruptions (E3+E4) and daily chores (E1+E2).

of the current situation into consideration. With the improvement of devices' sensor capabilities, the differentiation of several learning modes seems feasible.

–**Reminders.** One suggestion was to send reminders to the learner after an interruption. This technique, in particular, would be applicable to unavoidable interruptions such as having to change trains on a commute. This reminder could be explicit, e.g., a notification as implemented in [3] or existing learning apps such as Duolingo, but could also be very subtle. For example, a simple vibration pattern could remind the user of an ongoing learning task.

–**Memory Cues.** E1 and E2 recommended showing an image upon the occurrence of an interruption. The MLA would present this image again as a mnemonic cue when the user resumes learning. A challenge, in this case, is the selection of a suitable image to serve as a memory cue. The experts also proposed embedding the learning content in a storytelling frame to make use of associative memory strategies.

–**Summary – "What happened so far?"** E1 and E2 came up with the idea of presenting a machine-generated summary of, for instance, the parts of a text the learner read before an interruption (cf. Figure 4). This is similar to plot summaries on TV shows. E3 and E4 proposed generating a set of questions that the learner would have to answer upon task resumption. Thus, the MLA guides the learner back to the topic and at the same time, can adapt the learning content automatically to the user's current knowledge state. The user group also suggested asking short questions on previously-seen learning content to get the user reacquainted with the topic, in particular after longer interruptions. In a pedagogical context, questions are already a common tool for re-activating specific memories [7], which could be easily implemented in an MLA.

–**Regaining focus.** E3 and E4 suggested to include a short meditation exercise. It would not be related to the learning content, but rather aid users to regain focus for upcoming tasks. This technique appears to be especially interesting to target self-interruptions, which root in the current inability to focus on the task, such as mind-wandering or sudden thoughts. Applying mindfulness meditation, even short-term, can improve the capability of sustaining attention [13].

Discussion and Limitations

The participants of the two focus groups were engaged and able to draw on their experiences with mobile learning, from an expert's and a user's perspective. They envisioned a set of realistic scenarios and the types of interruptions they consider likely. They also had many suggestions for what support they think learners would need, providing a basis for future designs. On the other hand, they did not discuss how severe the disruptive effect of the various interruptions is likely to be – an important factor for the design of task resumption strategies. Moreover, due to the limited number of participants, we cannot make general statements on the applicability of their suggestions. We believe that additional studies in real-life settings are needed, not only to assess resumption strategies but also to investigate actual MLA usage, disruptions, and their effect on learning performance. So far, existing work on task resumption support has been limited to stationary desktop settings, which do not reflect the fragmented use of MLAs in the wild [8]. In the following section, we delineate promising areas for future research.

Open Research Questions

Drawing on the designs envisioned by our participants, we were able to infer the following open research questions:

(1) How generalizable is the effect of a certain task resumption strategy across different learning content or

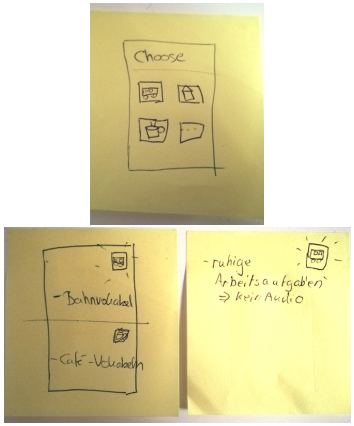

Figure 3: Sketch from the focus group on the design of *Adaptive Learning Modes* which include different features of task resumption in regards to specific situations.

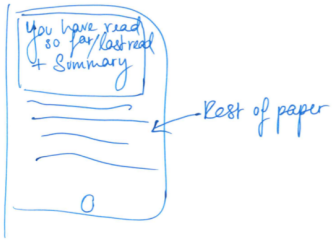

Figure 4: Sketch from the focus group on presenting a summary to support task resumption.

tasks? Task resumption cues and strategies are commonly evaluated using one task in a controlled environment. A strategy supporting one task in one environment may not support a different task in a different situation. Our participants mostly reflected on their experience with language learning applications. These MLAs commonly teach small learning units and apply a multiple-choice task approach with a high repetition rate (i.e., microlearning). By reducing the negative effect of interruptions with task resumption support, we might even be able to support the transition of MLAs from microlearning to more complex learning app designs. Therefore, future work needs to evaluate existing resumption strategies as well as new ideas for a diverse set of learning tasks and content complexity available in MLAs.

(2) How subtle can cues be for effectively supporting task resumption? Participants of the focus group discussed about designing cues with different levels of explicitness. For example, pictures (e.g., screenshots) as cues may be more effective in helping one recall where a learning task was paused, as opposed to reading summaries. The effectiveness of cues to support resumption with different levels of explicitness needs to be evaluated with regards to strength and cognitive demand of interruptions.

(3) What is the optimal amount of repetition / summary? Both experts and users proposed to repeat prior learning content after an interruption (e.g., using questions or summary texts). However, it remains unclear how extensive this repetition needs to be for the user to resume learning after an interruption.

(4) Which modality is most suitable for cue presentation in a specific type of learning task? Related work uses a variety of modalities for delivering task resumption cues, including visual, textual, and auditory, depending on the interruption context. For example, for urgent interruptions (e.g., phone calls), Yeung and Li (2016) propose auditory labels [14]. Audio cues can be quickly and easily generated and played back to remind one of the state of the task before an interruption. Especially in safety-critical situations like changing trains, designers need to carefully choose the modality of cues.

(5) How strong is the effect of context adaptation on the disrupting effect of interruptions? The participants suggested adapting learning topics and task to the context of the user, e.g. by presenting food vocabulary at a café. Thus, they expect to diminish the negative effect of interruptions happening in the same thematic context. Research has found that the similarity of primary and (interrupting) secondary task can actually increase the disruptive effect [4]). However, this aspect has not yet been evaluated in the context of learning and is influenced by a set of mediating factors such as associative strength of the primary task and the nature of task goals [1, 4].

Conclusion

In this work, we presented existing literature on task resumption support, while adapting methods for interruption recovery to the mobile learning domain. We further explored the design of task resumption methods and cues with two focus groups. We presented potential solutions for helping learners focus back on the learning activity, to regain context, and to remind them where they left off. Finally, we elicited a preliminary research agenda for task resumption support in mobile learning, an area hitherto under-explored.

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