A Literature Review on Positive and Negative Effects of Interruptions and Implications for Design

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Abstract. The relevance of interruptions in human-computer interaction has increased over the last decades in both private and working life. Research from a multitude of disciplines has addressed interruptions. However, the literature is dispersed. In particular, no balanced collection of literature on interruptions looking at the negative as well as at the positive effect is lacking. In this paper, we present a literature review on the positive as well as negative effects of interruptions. We analysed studies on how interruptions affect individuals, collaborative work, and social relationships. We derive implications for design.

Keywords: Interruptions; Positive Effects; Negative Effects; Literature Review; Survey.

1 Introduction

Information and communication technology (ICT) allows for continuous connectivity between individuals and provides benefits for organisations, but it also leads to work interruptions [2, 6, 10, 25, 32, 39].

We define interruption—similar to many authors in HCI—as an event that leads to a halt of a user's activity. Typically, a user is disrupted from a primary task, temporarily performs a secondary task, and later upon completion of the secondary task, resumes the primary task [44]. Research has shown that after an interruption, time is required to recover and continue the interrupted task. Two major factors determine the time required to complete an interrupted task: interruption lag and resumption lag [43]. Interruption lag is the time necessary to redirect attention towards the interruption. Resumption lag is the time used to determine what has been done in the primary task and what needs to be done next.

Literature reviews have targeted on various aspects of interruptions and the effects of interruptions (e.g. [10, 12, 22, 25, 39]). However, the predominant perspective in the existing literature has been negative—focusing on the challenges caused by interruptions. A balanced view is missing. As Puranik et al. put it: "We call for a more balanced approach to studying interruptions that focuses on … the positive, in addition to the negative, outcomes of interruptions." [39, p. 829].

This paper has three main contributions: It provides a systematic compilation of interruptions and their negative as well as positive effects on users. It covers literature from multifarious domains. It provides implications for the design of HCI systems.

We first glance at related work. Then we explain the method of our thorough literature review. We present our literature review of the positive as well as negative effects of interruptions. We draw conclusions for the design of future HCI concerning interruptions.

2   Related Work

Several literature reviews provide great compilations of previous research (e.g. [10, 12, 22, 25, 39, 40]). However, they mainly focus on the negative side of interruptions.

Interruptions are a multidisciplinary issue, and literature is spread across various research domains such as HCI (e.g. [5, 32]), psychology [10], medicine [26, 40], and management [22, 39]. The scope of research varies across research domains. Medical publications often analyse interruptions within a specific healthcare setting [18, 33]. Psychological research is addressed across domains, in literature reviews within psychology [10], and beyond [12, 39].

Despite the diversity of domains and perspectives, some common themes and findings on interruption effects appear in most available scientific literature, independent of users' tasks and situations. For instance, interruptions consuming time and delaying primary tasks is a finding that is present in most literature reviews (e.g. [10, 18, 25, 39]). Studies reported in literature reviews often aim to quantify the implications of interruptions on specific performance metrics, either on the performance of the task (e.g. [1, 4]) or on the condition of the individual being interrupted (e.g. [1, 13, 30]).

Literature reviews acknowledge that interruptions can have benefits, such as fostering creativity or increasing the speed of simple tasks [10, 25]. Still, most publications view interruptions negatively, referring to effects like errors [10, 15, 26, 39], memory loss [10, 18, 35], stress [12, 15, 22, 25], and negative emotions [10, 12, 22, 39].

3   Method

Our systematic literature review process is grounded in general recommendations on doing literature reviews as well as specific methods of literature reviews on interruptions (e.g. [19, 24, 34, 36]). Since we aimed to collect relevant literature from multifarious disciplines, a multi-level, multi-step approach (cf. [24]) was required.

Multi-level approach: (1) we searched for literature reviews on interruptions with the search terms "interruption", "interruptions", "notification", "notifications", and "interruptibility" combined with terms like "literature review", "survey", or "literature study". We searched several scientific databases (ACM DL, Web of Knowledge, and Google Scholar). Our research goal was to include literature on the effect of disruption of users by technology. We excluded publications that did not fit this goal (e.g. interruption of enteral nutrition [45] or electricity consumer interruption [11]). Then (2) we searched for specific studies on individual interruption effects mentioned in the surveys—independent of their positive or negative results. We used the search terms "interruption", "interruptions", "interruptibility", "notification", and "notifications" combined with search terms like "study" and "user study" to identify those publica-

tions. We used the same databases as before. We used these findings to (3) identify interruptions' specific positive and negative effects and searched for each of them.

Multi-step approach: on all three levels we respectively did the following: define the scope and select sources and keywords, search in databases, select relevant publications, perform a backward search based on the relevant publications' references, make a selection of relevant literature (cf. [24, 46]). We searched for publications from the last twenty years—since 2002 when McFarlane and Latorella published their seminal paper on human interruption in HCI [32]. It became apparent during the research that many relevant publications we discovered originated from other areas beyond HCI. Some of their findings are necessary to explain specific interruption effects, and some provide essential background knowledge. For instance, we will present findings from the field of medicine with effects that apply to HCI settings (e.g. in healthcare, the interruption effects on prospective memory [14], the effect of interruptions on prospective memory).

The work was done by both authors (except for searching and collecting the results, which the second author did).

4   Understanding the Effects of Interruptions

The literature reviews and studies we found helped us to discover several positive (cf. Table 1) and negative (cf. Table 2) interruption effects. We sorted both positive and negative effects based on the scope of their implications. We started with effects only affecting the individual task (e.g. increased completion time or errors). Then we listed effects that can affect the interrupted person beyond a single task (e.g. incubation, stress, negative emotions). Then we present effects that can affect other individuals beyond the interrupted person, such as others in the same team (e.g. the interruption of third parties).

Literature shows several positive effects of interruptions. Simple tasks are sometimes completed more quickly following interruptions [10, 25, 26]. Interruptions are also significant for distributing relevant information to individuals [15, 22, 41]. Interruptions can also lead to a moment of incubation [10, 22, 25], thus fostering creativity. Interruptions can improve social connections between individuals [37, 48, 50] and provide awareness [21, 28, 47].

At the same time, literature also has negative interruption effects. They impact the performance of a single specific task (e.g. interruptions entailing errors [10, 26, 33]) or time consumption (e.g. the increased completion time for a singular task, the accumulated time consumed due to multiple interruptions over a day [25, 39, 43]). Interruptions can also affect the individual being interrupted beyond the current task by causing memory loss [15, 18, 35], inducing stress [12, 22, 25], and evoking negative emotions. Interruptions may also affect others (e.g., delaying collaborative processes [16, 32]).

Interruption effects are often dependent on the circumstances in which they occur. Some effects apply to individuals in diverse situations (e.g. incubation, errors). Others are more likely to occur in a collaborative setting in which different actors are de-

pendent on each other (e.g. information delivery and awareness [8, 21]) or settings with non-work social connections (e.g. social connectedness [37, 48]).

Table 1. Positive interruption effects and literature sources.

Positive Effect	Sources
Simple Task Performance Increase	[10, 25-27]
Information Delivery	[15, 22, 25, 40, 41]
Incubation	[10, 22, 25]
Social Connectedness	[37, 38, 48, 50]
Awareness	[8, 20, 21, 28, 47]

Table 2. Negative interruption effects and literature sources.

Negative Effect	Sources
Time consumption	[10, 18, 25, 26, 29, 35, 39, 43]
Errors	[5, 10, 15, 18, 25, 26, 29, 32, 33, 39, 40]
Stress	[5, 12, 15, 22, 25, 27, 32]
Negative emotions	[10, 12, 15, 22, 25, 39]
Memory loss	[10, 15, 18, 25, 35]
Interruption of third parties	[16, 17, 32]

5 Conclusions

We have presented a literature review on interruptions' positive and negative effects. We compiled positive interruption effects in simple task performance, information gain, incubation, social connectedness, and awareness. We compiled negative interruption effects like time consumption, errors, stress, negative emotions, memory loss, and interruption to third parties.

In the future, it would be interesting to look at the implications for design from those findings. For instance, further research on awareness systems could lead to better mutual information on each user's interruptibility, where availability information can either be measured automatically by sensors (e.g. [42, 51]) or can be provided explicitly by the user (e.g. [7]). Better negotiation systems could allow users to find an interruptibilty compromise—they provide information to the users that an interruption is about to occur and provide them multiple options of responding towards the interruption (e.g. [31, 49]). Advanced mediating systems could use algorithms to optimise mutual interruptiblity, for instance, via an autonomous broker to intelligently time interruptions based on interruptibility [3, 9, 23].

Acknowledgements

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