# A Theoretical Framework to Understand and Engineer Persuasive Interruptions

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**Abstract**

Interruptions are often seen as distracting or sometimes devastating elements that need to be minimized or eliminated. However, interruptions are also used to increase efficiency, productivity, prevent errors, and even influence behavior. Existing theories and taxonomies of interruptions fail to account for the helpful aspects of interruptions. Therefore we propose a theoretical framework to help explain the positive aspects of interruptions. Warnings & alerts, reminders, suggestions and notifications are examples of interruptions that have beneficial outcomes by changing and influencing behavior. We propose a cognitive theory of interruptions based on the properties of the users, their tasks, and best presentations depending on the desired effectiveness of the interruption. Norman's 7-stage action model serves to explain how and why an interruption is accepted, and potential mismatches between the goal of the interruption and the user. Potential applications of this model include better understanding the effects of interruptions, and guidance to design effective and persuasive warnings and alerts, reminders, suggestions and notifications.

## Introduction

Interruption has been an active area in human-computer interaction research for some time. A comprehensive review was provided by McFarlane and Latorella (2002). Interruptions are typically defined as a change or disturbance in a process or in people's activities.(Cooper & Franks, 1993; McFarlane & Latorella, 2002) Interruptions are categorized along different dimensions by different researchers, such as source, effect, content, applicability, and duration by Cooper & Franks (1993) and individual properties, methods, meaning, source, channel, change, and effect by McFarlane and Latorella (2002).

Significant research has been expelled in determining how to classify, prevent, minimize, and provide tools to help users deal with interruptions. However, there is little understanding how interruptions can be exploited for positive outcomes, while at the same time minimizing some of their most disruptive properties. After all, interruptions are constantly used to help manage and complete important everyday tasks. Such interruptions also have the ability to influence and change behavior. In order to better understand and explain how interruptions can be engineered to be positive and persuasive we propose a theoretical framework and conceptualization. The theoretical framework may also guide designers on discovering factors to help develop appropriate interruptions.

## Effects of Interruptions

### Detrimental Effects of Interruptions

The effects of interruptions are generally described as negative Users perceive an interrupted task as being more difficult to complete than an uninterrupted task (Bailey, Konstan, & Carlis, 2000). An interruption is also thought to take longer to process and return back to task when it is unrelated to the task at hand (Cutrell, Czerwinski, & Horvitz, 2001). The added memory load seems to make it difficult for a task to be resumed. It also becomes difficult to remember what task was being processed before the interruption. (Burmistrov & Leonova, 1996; Dix, Ramduny, & Wilkinson, 1995). Further, the complexity of the task being interrupted effects the disruptiveness of an interruption. Interrupting complex tasks inhibits performance, and has no effect on simpler tasks (Burmistrov & Leonova, 1996). Interestingly, people can recall details about interrupted tasks better than uninterrupted tasks.(McFarlane & Latorella, 2002)

People also have individual differences in their ability to respond and manage interruptions (McFarlane & Latorella, 2002). Interruptions also affect performance. Users are thought in general to perform slower on interrupted tasks (Bailey et al., 2000), although some evidence exist that an interruption may actually speed up task completion (Zijlstra,

Roe, Leonara, & Krediet, 1999). However, the actual effect of an interruption will likely depend on the actual tasks being performed, and the interruption itself. There is conflicting evidence if similarity between the interrupted and interrupting tasks has any effect on performance (Bailey et al., 2000; Gillie & Broadbent, 1989).

Timing of interruptions may also have an effect. Interruptions coming early during a search task are described as likely to result in the user forgetting the primary task goal than an interruption arriving later on (Cutrell et al., 2001). The presentation of the interruption are also important. For example aurally presented interruptions are thought to be acknowledged more quickly than visual stimuli. Auditory ongoing tasks are more resistant to interruptions than visual ones (Latorella, 1996) Thermal interruptions have larger detrimental effect than light on disruptiveness and performance (Arroyo, Selker, & Stouffs, 2002). Motion as a notification system is effective compared with static items (Bartram, Ware, & Calvert, 2001). Traveling motions as a visual stimuli are more disruptive than anchored motions (Bartram et al., 2001)

Therefore much effort has been expended to determine the negative effects of various interruptions and their modalities. However there are also different perspectives from which the effects of interruptions may be viewed. Indeed an interruption may be devastating to the task in progress. But when looking at the individual performing various tasks, the interruption may not have a detrimental impact on the whole. Most research has focused on the task level, which may be an inappropriate level of analysis in some cases.

## Beneficial Effects of Interruptions

Types of interruptions that may serve beneficial purposes include warnings and alerts, reminders, notifications and suggestions. Of course warnings and alerts etc., may not always be interruptions. We define a warning and alert etc. as an interruption when it causes a change or disturbance in a person's activity or behavior. Table 1 summarizes the characteristics of these interruptions. We provide examples in a healthcare context, although these types of interruptions would also exist in other domains. Our examples are also technologically focused and include persuasive interruptions embedded into computer systems, mobile devices, and medical equipment which are increasingly being used in healthcare.

**Warnings & Alerts** are usually a sign or signal of something negative occurring, or a notice to be careful. They are intended to make people aware of an impending danger or difficulty. For example, drug interaction warnings embedded into drug prescribing systems warn doctors and pharmacists about dangerous drug-drug interactions when prescribing or filling a prescription. These warnings are designed to interrupt the current task, and alert the clinician to a potential adverse event. Although such warnings may be critical in preventing errors, it is found that in practice such warnings are often ignored or overridden (Wilson, 2003), suggesting the need for better designed warnings. Hospitals are increasingly 'buzzing' with auditory alerts from a variety of medical equipment (Meredith & Edworthy, 1995). The purpose of such devices are to monitor patients and alert physicians or nurses when they need to take action. However, there is rarely any synchronization or awareness between the large number of standalone medical equipment emanating various alerts and tones; resulting in many ignored warnings.

Warnings and alerts are often urgent and need to be handled quickly. Warnings and alerts may either have an explicit or implicit action associated with them. For example a drug interaction warning may indicate explicitly that there is a potential interaction with a drug and provide a list of medications that may be suitable replacements. An audible alert may be more implicit, simply indicating an off nominal state, without providing any explicit instructions or actions.

**Reminders** are a form of interruption that cause an individual to remember or recall an event. Clinical decision support systems often remind physicians of standard tests or procedures that conform to clinical practice guidelines. (Bates et al., 2003) Such reminders are deemed important as they provide a mechanism to foster uniformity in treatment and to assist in managing the burgeoning costs of healthcare. These reminders often occur while the physicians is documenting or ordering the tests and procedures. Medication reminders may also assist patients in adhering and complying with their medication regimens (Bennett & Glasziou, 2003). Although the urgency or importance of reminders may vary, many will include an explicit associated action. For example a medication reminder may announce the time, dose and route for the drug.

**Suggestions** are ideas or proposals that are propagated to individuals. Patients often receive suggestions and recommendations from their care-givers. For example diabetics are urged to exercise more and eat healthier. Physicians may be informed that their patient may be eligible for a particular clinical trial. Pharmaceutical companies also engage in suggestive practices to prescribers when they promote their particular brand of medication. Such suggestive interruptions can be from face-to-face encounters with a pharmaceutical sales representative or through the use of sponsored drug reference databases. Suggestions are unlikely to be of high urgency or importance. But effective suggestions may explicitly state associated actions that are recommended.

**Notifications** are usually described as the process of informing. Notifications are defined as the most generic type of interruption, with the least degree of importance or urgency. A notification may purely be informational in purpose with no explicit instruction for action. For example

a notice stating the availability of a patient's lab results informs a physician that their requested order is ready. However, notifications may lead to actions implicitly without specific instructions. For example the lab test may indicate that a particular patient needs an immediate surgical procedure. Therefore notifications may lead to implicit actions.

Table 1: Beneficial Interruptions and their Characteristics

| Interruption Type | Importance / Urgency | Action |
|---|---|---|
| Warnings & Alerts | High | Implicit or Explicit |
| Reminders | High-Low | Explicit |
| Suggestions | Medium – Low | Explicit |
| Notifications | Low | Implicit |

### Persuasive Interruptions

Fogg (1998) suggests computers and technology can be persuasive (change attitudes or behavior) as tools, social actors and/or media. We suggest that technology-based interruptions can be designed so they too can influence behavior and attitudes in order to achieve positive outcomes. In fact beneficial interruptions described earlier as warnings and alerts, reminders and suggestions disrupt a person's current task, and may cause them to change their behavior. Of course not all positive interruptions need to change or influence behavior. The persuasiveness of interruptions may be directly linked to the interruption type and their corresponding importance to deliver a particular message. For example warnings may be high in importance, and need to influence a change in behavior immediately and therefore very persuasive. While a notification, which is just informational in content, may not influence behavior and therefore may not be particularly persuasive.

## Theoretical Framework

We propose a theoretical framework for interruptions (figure 1) to help explain the different dimensions that are involved in making an interruption persuasive and beneficial. Table 2 shows the details of the framework in a form of taxonomy.

### User Properties

Individuals or users that are affected by interruptions are likely to have unique characteristics and properties. Therefore it is important to identify key features that may impact the effectiveness of interruptions and how they respond and deal with them. For example a physician has different characteristics than a nurse. A challenge in producing effective interruption are to deliver them when most opportune and least detrimental. Therefore a users location, environment, time of day (or week or year), or schedule (in Outlook for example) may be exploited to establish if they can be interrupted. Horvitz et al have explored the use of subtle clues in design of attentive user interfaces to discover the attention of users combined with user preferences in design of notification platform to intelligently route messages (Horvitz, 1999).

### Task Properties

In addition to determining user characteristics, it is also important to determine properties of the interrupted and interrupting tasks. Certain tasks may be particularly susceptible to the detrimental effects of interruptions. However, determining a user's current task is challenging. Computer based tasks may be more amenable to discovering current task or workload. But in more complex, dynamic or distributed domains, it is likely that the users will interact with a multitude of (unlinked) devices including phones, pagers, PDA's, among others.

Various methods to determine user interrupt-ability have been explored. Instant messaging applications allow users to indicate their current availability. Alternatively, task complexity may be automatically measured. The number and type of applications the user has open, or number of key strokes, or mouse clicks within a certain time period may indicate the user's workload. The user's contextual information may also be exploited, such as time of day or week. A user may conduct certain tasks at certain times of a week. However, many users do not follow a rigid schedule and may elect to make changes. Another approach has been to discover "activity awareness" between groups which take into account situational, group, task and tool factors and subsequently provide a notification system to indicate availability. (Carroll, Neale, Isenhour, Rosson, & McCrickard, 2003) However, further work is needed to discover how best to determine current task properties in order to present an interruption at the most optimal time.

### Presentation

In addition to user and task properties, the presentation of an interruption may be critical. The presentation of an interruption involves two stages. First, the interruption must alert the user of its presence. Heat, light, sound, vibration, and motion may capture attention differently with different efficiencies. Second, a message representation must be delivered. Analysis of the user, task and priority of the interruption context will help determine the appropriate mode of interruption. The presentation may also differ depending on type of interruption and on the device used to interrupt. A visual pop-up may effectively capture a users attention while using a computer, but may be ineffective on a cell phone stowed in coat pocket.

In addition to being effective and minimally disruptive, the message of the interruption can also be engineered to be persuasive. In a multi-tasked environment, users are presented with a multitude of interruptions and are constantly deciding whether to act upon the interruption. If

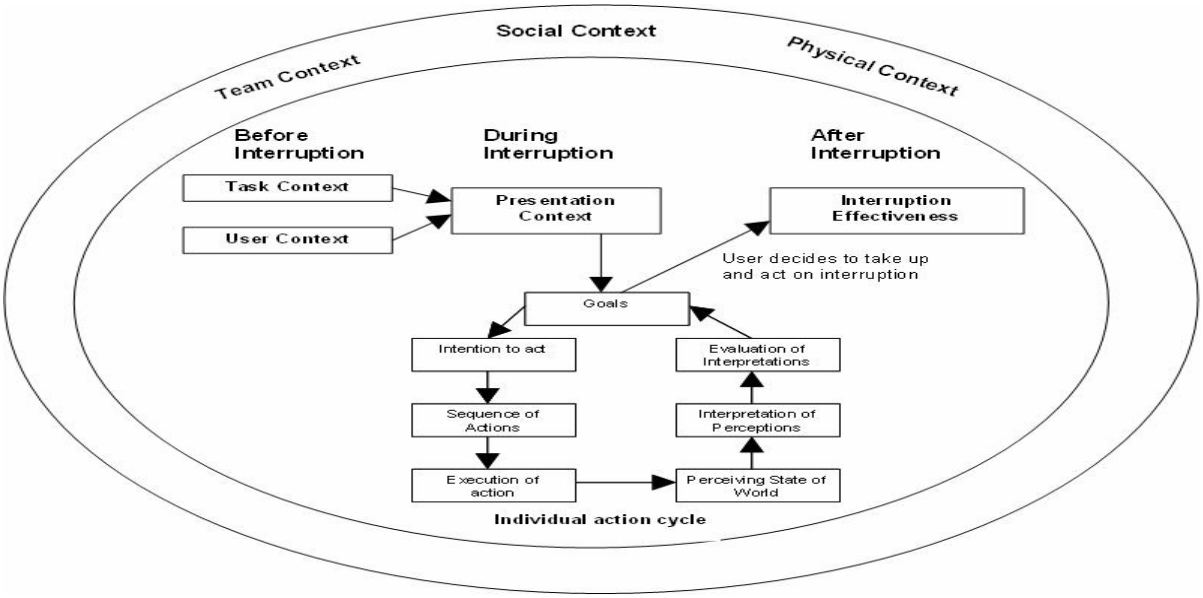


Figure 1: Cognitive theory of persuasive interruptions

different interruptions (such as a warning or notification) are presented with the same degree of persuasiveness they may be handled in the same manner. However, persuasive elements such as positive reinforcement, personalization, and social cues amongst others can also be used to enhance the persuasiveness of an interruption when appropriate. Currently there is little research on how modifying the persuasiveness of a message of an interruption effects its acceptance.

## Individual Action Cycle

Norman's 7-stage action model has been incorporated into the cognitive theory in order to help explain at the individual action level why an interruption is accepted and acted upon (Norman, 1988). The seven stages are divided into three categories, one for goals, 3 for stages of executions and 3 for evaluation. The goal stage may be particularly important because an individual's perceptions or intentions may need to be related to intention of the interruption itself as personified by its presentation. The stages of execution are also useful in determining if the suggested interruption can be acted upon. The evaluation stage where the individual perceives the state of the world after executing an action may also assist in determining the success of an interruption. Therefore the 7-stage action model provides a useful perspective in helping to explain how modifying the presentation of an interruption impacts discrete stages of individual action.

## Interruption Effectiveness

The effectiveness of an interruption will largely depend upon the original goal and perspective used. A drug interaction warning that interrupts a physician while inputting order entry may be effective if it results in a change of medication; as it may avoid a hospitalization for the patient. However, it may also cause the physician to lose focus and forget the original task. Therefore it is important to clarify the perspective from which effectiveness is judged. In our model we propose cognitive, perceived value and performance based measures to evaluate and engineer interruptions once the perspective has been defined. Cognitive factors may include loss of memory or disruptiveness of interruptions. Perceived value factors such as annoyance and anxiety are often associated with interruptions. Interruptions affect performance, by changing time to complete tasks, providing opportunities for errors, and forgetting to resume previous tasks.

Similarly they may effect financial performance or result in a more favorable outcome (such as prevention of hospitalization) In our model, information from the context of the user, tasks and presentation can be exploited in order to find an optimal balance between cognitive, perceived value and performance measures depending on the perspective and desired outcomes.

## Assessing Context

The surrounding conditions or circumstances that make up the environment around an individual may provide important information in order to successfully deliver an interruption. The dynamics of interruptions in team environments are different than those of single individuals. In team environments, a team member can intercept an interrupting activity for another team member who is already engaged in a previous task. An audible interruption targeted to one team member may interrupt the work of colleagues nearby. Or an interruption for one individual may result in a cascade of interruptions for others.

Table 2: Taxonomy of Persuasive Interruptions

| | | Examples |
|---|---|---|
| **User Properties** | Individual characteristics of users, their contextual situations and preferences | |
| Context | Where is the individual? Where can an individual be interrupted? Is an interruption more appropriate at a certain location or time | Hospital, Emergency Room (ER), Attending to critical patient, etc. |
| Characteristics | What are the individual characteristics of users? What are their strengths and limitations? | Expertise, skills, knowledgebase, age, education, cognitive capacities and limitation |
| **Task Properties** | The properties of the interruption itself and the task it will interrupt | |
| Interruption Type | What is the intent of the interruption? | Warning, alert, reminder, suggestion or notification |
| Interrupted Task Type | What task will be interrupted? | Work related (computer based, meeting etc.), Social (lunch, sleep etc.) |
| Task Interrupt Scale | How important is the task to be interrupted? | Low, Medium, High |
| Stage of Interruption | What is the stage of the current task? | Goals, Intention to Act, Sequence of actions, Execution of action sequence, Perceiving state of the world, Interpreting the perception, Evaluation of interpretations |
| Broadcast or Single Interruption | Is the interruption in the context of team or collaborative environment, or individual environment? | Individual, small team, large team, etc. |
| **Presentation** | Factors addressing how the interruption can be presented to the user | |
| Customization | To what degree is the presentation customized? | Generic, Personalized, Targeted or Tailored |
| Mode of Interruption | How will the user be alerted of the presence of the interruption? | Heat, lights, sound, vibration, and motion |
| Display type | How will the message be communicated? | Prompt, pop-up, voice alert |
| Device | What device will be used to convey the message of the interruption | Personal Computer (PC), Personal Digital Assistant (PDA), Telephone, Cell phone, Pager |
| Persuasive elements | What types of persuasive techniques are incorporated into the interruption? | Media, Tool, Social Actor, Positive reinforcement, personalization, credibility etc. |
| Interruption frequency | How often will the interruption be presented? | Once only, more than once, every hour etc. |
| Resumption method | How will the individual be assisted to resume their original task? | Log of previous tasks, reminder of previous task, screenshot of previous state etc. |
| **Interruption Effectiveness** | Assessing the effectiveness of the interruption | |
| Perspective | Who is the intended beneficiary of the interruption? What is the net benefit? | Physician being interrupted, Patient, Healthcare system |
| Cognitive | What is the cognitive impact of the interruption on the individual? | Loss of memory, disruptiveness, number of errors |
| Perceived value | What are the individual perceptions of the interruption? | Annoyance, anxiety, interest, boredom, curiosity |
| Performance | How does the interruption effect the performance of the interrupted task? To what degree is the task associated with the interruption completed? | Completion of tasks, time to complete task, number of errors, dollars saved |

## Benefits of Persuasive Interruption Model

Other models of interruptions have been developed in an attempt to eliminate, minimize or manage the detrimental effects of interruptions. However, these models fail to describe the positive effects of interruptions. Latorella's (1996) Stage Model of interruption management is a detailed description of how people may manage an interruption and how it effects a current task in terms of detection, distraction, disturbance and disruption. The model of persuasive interruptions is more concerned with dimensions of the user, task and presentation properties and how that influences the effectiveness of the interruption. We suggest Norman's 7-stage action model can explain how and why an individual receives an interruption. McFarlane

(2002) has also proposed a taxonomy of human interruptions that includes elements such as source, individual characteristics, method of coordination etc. Our model incorporates features of McFarlane's taxonomy but is more operationalized and detailed. For example McFarlane suggests looking at the individual characteristics of users, while we expand this view to also consider other relevant contextual features, such as time, location and environment.

## Conclusion

In this work we identify and discuss four types of beneficial interruptions: warnings and alerts, reminders, suggestions and notifications. We then propose a theoretical framework and taxonomy in order lay the foundation to develop guidelines for persuasive interruption design.

Future work will improve the framework by experimentally testing and validating the model of persuasive interruptions. We are particular interested in discovering the effects of various persuasive techniques when applied to the message of an interruption. Potential applications of this model include better understanding the effects of interruptions, and guidance to better design effective and persuasive interruptions.

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