Ambient Notifications and the Interruption Effect

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***Abstract*—**The technology of mobile devices has changed our daily lives. Since smartphone have become a multi-functional device, many people spend unnecessary time on them, and could be interrupted by inappropriate notifications such as unimportant messages from social media. Notifications from smartphone could draw people's attention and distract them from their priorities and current tasks. This research investigated that if the users were notified by their surroundings instead of smartphone, would it create less distraction and keep their focus on the present task. The experiment was a simulation of a lamp and door notification. Notifications related to work will be embedded in the lamp such as an email from a colleague. A notification that is useful when going outside such as weather information, traffic information, and schedule reminder will be embedded in the door. The experiment was conducted by sending notifications to the participant while he or she was working on a primary task and the working performance was measured. The results show that the lamp notification had fewer interruption effects than the smartphone. For the door notification, it was simulated in order to gain opinions and insights on ambient notifications from participants. Many participants agreed that the ambient notifications are useful and being informed by them could lessen the usage of their smartphone. The results and insights from this research could be used to guide the design process of ambient notifications.

***Keywords*—**HCI, Interaction, Interaction design, Usability testing.

I. INTRODUCTION

THIS study focuses on the human behavior towards notifications from their digital devices in their daily life and introduces a method in displaying the notification in the ambience. Instead of being notified by smartphone, people could be notified with appropriate notifications within their environment. Notifications inform and keep people updated; however, notification could affect user's attention and harm their tasks. Due to earlier research, most studies involved the interruption effect of the notification from smartphones and personal computers on user's task interruption. This study would like to compare the existing notifications with the new way of notification display and prove which one has more effects on user's attention. The study covers user studies on how users perceive existing notifications, ambient notification designs, usability testing and interruptions from the notifications.

II. RELATED WORK

Notifications generally inform people of various useful important pieces of information, by nature, it is meant to inform users by interrupting them, which acts as a double-edged sword. Notification systems could also be called Interrupting Technologies [1]. Before smartphones emerged there were fewer notifications, mainly coming from desktop computers. They often only showed in email and specific applications such as anti-virus notifications. Since then, many more and various types of notifications are conceived and produced by many applications inside smartphones. Notifications can come from phone calls, emails, instant messaging (IM), a calendar system, software and device status and social networks. Even though users are able to customize their notifications, they would not put in any effort into customize the settings. Distractions from notifications impact users strongly when users change their current activity, resulting in failure to finish their primary task in the expected time. Therefore, it is possible to designate notifications when to be interrupted at a desirable time, such as a break times. As more and more notifications are generated by different applications, researchers try to find a ways to prioritize how important or urgent a message is and then find a suitable time to release the notifications to users [4]. In order to not interrupt users with notifications, information could be sent during a change of an activity. For a message that is not so urgent, it could be postponed to interrupt during the user's break time.

The knowledge from the cognitive psychology that must be implied is to understand what happens after a person is interrupted. The resumption lag is the time needed to "collect one's thoughts" [2] and restart the primary task after the interruption. Leiva et al. [3], studied interruption by incoming phone call, switching applications, and the resumption lag in using a smartphone. They proved that it took users 40 seconds longer to finish the primary task when they were interrupted. Suggestions for further design were mentioned that giving out notifications with light interfaces could give time for users to be prepared from being interrupted and could also help the users to decrease their resumption lag time and get back to their primary task easily. From the knowledge of resumption lag, if the notification system could be designed to avoid or reduce the resumption lag, the system could be improved.

Since the smartphone are now commonly used in people's everyday lives, many approaches were suggested to solve the problem of interruptions and user's attention. One of them is to be able to manage their attention. Designers and developers have created an interface, called Attentive User Interface (AUI), which prevents users from losing their attention from their primary task. The AUI is an interface managing the user's attention [4]. It dynamically prioritizes the information to its users, thus information-processing resources of both user and system are optimally distributed across a set of tasks. AUI could be selected to inform users of new information, so users could be least interrupted. AUI, by notifying only the relevant

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information, and can be used in particular to display information in a way that increases the effectiveness of the interaction [5].

III. Method

The study has been arranged into two phases, the primary user research and the main research that will lead to the answer to the hypothesis. From the primary user research, insights and interesting points were developed and user requirements were designated. From the requirements, the ambient notifications should be set in a working environment. From the design process the selected object was a "task light" or a "lamp". The lamp design included the physical form, interactions, and interface. The physical form was designed to create a flow of light from the task light to the notification light. When the user was notified, the light would run from the task light to the notification panel, which was at the base of the lamp. The base of the lamp should have enough space to be able to display the notification that users would receive.

The door notification is another ambient notification that was designed for this research. This notification was created to stimulate and give the participant and idea on how the ambient notification will be like and could give an opinion in the interview that was conducted. The door notification that was created for the simulation gave only three categories of notifications; that is, the weather, a reminder, and traffic notifications. They were derived from the information that users might want to know before leaving their homes.

Following the notification design, the design would be tested by simulating the notification design through the observation of a set of users. The usability testing must be done for both the lamp and the smartphone for comparison. Participants did both the usability testing for the lamp notification and smartphone. Data were analyzed using paired t-test, and certain factors related to the user's behavior toward notifications were searched for. Owing to the fact that the researcher wanted to compare the performance from the same set of participants, between having been notified by the lamp notification and smartphone, the paired t-test was the chosen method to analyze the data. The usability testing was set in an architect's office and was tested with architects, employees, and interns. Overall, there were 11 participants: seven men and four women. The participants' age ranged from 18 years to 30 years. All use digital devices in their daily lives and are familiar with notifications.

The variable that the test would like to control would be the notifications generated both for the lamp and the smartphone, considered independent variables. The amount, type, and time in releasing the notifications were controlled to be the same for each user. The notifications generated for which participants would have to perceive, were their secondary task. The dependent variables that the test measured were: primary task performance on accuracy, primary task performance on the amount of time, and the notifications that are noticed (secondary task performance). The primary task must require a large amount of attentional resource, which was calculating math problems without using a calculator. The task was to do a simple set of math problems, which was summing a set of numbers.

The secondary task was to comprehend the simulated embedded notifications. The notification would be separated into important content that users would have to take action, such as phone calls, and non-important notifications. The amount of information that was used to notify was also divided into three types. First, the notification that shows only the icon from the application. Second, the notifications are the icon of the application and sender's name. Third, the notifications were the icon of the application, name of sender, and brief message. For the notification on the smartphones, the ability to control the notification was different. A controlled specific amount of notifications were simulated. On the other hand, there were also participants' actual notifications, which were not considered independent variables. Some of the participants received many actual notifications and some received a smaller amount. In this case, it is impossible to control the simulation to be the same for every participant. Not being able to control the amount of notifications on participant's device could also bias the research results; however, this set of data was excluded.

The environment was set up similar to the working office. The lamp was arranged on a desk, along with only the mathematical problems and the necessary stationery. Two cameras were also set in place to record the usability testing. The room had a quiet environment so the participants had no other distractions than the variables given in the simulation. The primary task was in front of the participants and the secondary task was at the left top corner of the table, where each participant could see by glancing. The test monitor sat beside the participants, as seen in Fig. 1.

After the test, participants were interviewed. Questions were asked to investigate if there were any design problems with the lamp notifications, gain information on their behavior, experiences, and opinions. The one-sample t-test was used to determine whether the answers reached the specific mean (3) out of the five-rating scale.

For the door notification, participants were asked to observe and interact with the door notification that was simulated. The simulation was set in an environment similar to a home (Fig. 2). The notification was set 150 cm from the ground on the inside of the door, which was the same level as the eyesight for the average height. By setting this stimulation, the participants could imagine the situation of receiving notifications or standing at the door before leaving home. After the participants had read all of the notifications on the door, they were asked to complete a questionnaire and were interviewed about the simulation.

To summarize the method for this research, the overall process was firstly undertaken with the primary user research by sending out a questionnaire. Secondly, the ambient notification prototype was created based on the primary user research data. Lastly, the usability testing, questionnaire, and interview about the ambient notifications were conducted and then the data was analyzed for the results.

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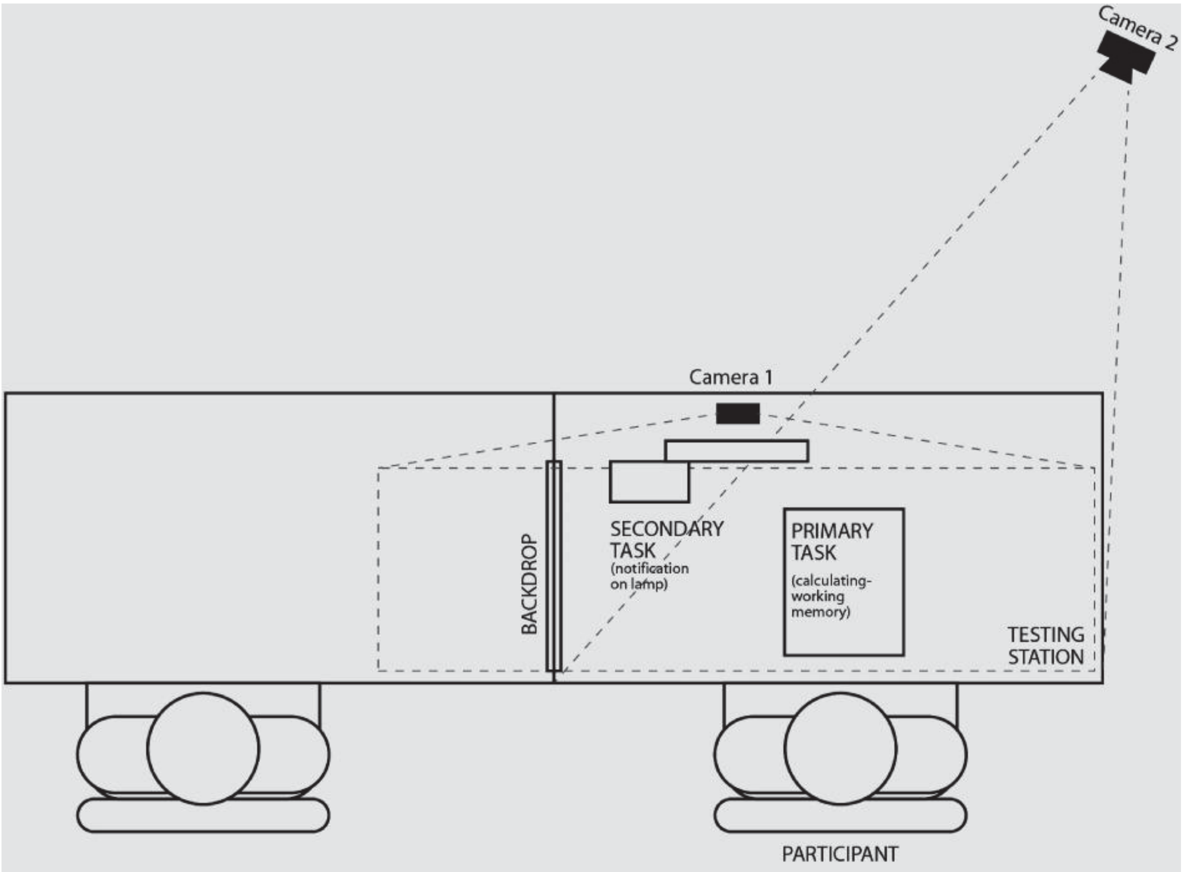

Fig. 1 Usability testing setting

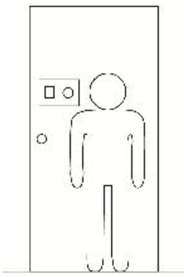

Fig. 2 Door notification settings

IV. Results

A paired-sample t-test was conducted to compare the scores from the math problems while being interrupted by the lamp notifications and by the smartphone notifications. There was a significant difference in the scores for being interrupted by lamp notifications (M=3.82, SD=1.25) and by smartphone notifications (M=3.18, SD=1.08) conditions; t (10)=2.28, p=0.046. These results suggest that the smartphone notifications interrupted users more than the lamp notification. Specifically, when participants had been interrupted by the smartphone notifications, the math score of the participants decreased more than that of the lamp. From measuring the accuracy performance of the two different methods by the same participants, the results reject the null hypothesis that there was no significant difference between the primary task's performance when being interrupted by the lamp and the smartphone device.

A paired-sample t-test was also conducted to compare the length of time in doing the math problems while being interrupted by the lamp and smartphone notifications. There was a significant difference in the length of time in doing the math problems while being interrupted by lamp notifications (M=6.61, SD=2.19) and being interrupted by smartphone notifications (M=11.45, SD=3.13) conditions; t (10)=-11.23, p=0.000001. These results suggest that the difference between being interrupted by notifications from the lamp or smartphone really does have an effect on the time spent on the primary task. Specifically, users being interrupted by the smartphone notifications take longer to complete the math problems than those interrupted by the lamp notifications. The average time consumption for users who did the math problems with the lamp was 6.61, and for the smartphone this figure was 11.45. From measuring the time performance of the two different methods by the same participants, the results reject the null hypothesis that there is no significant difference between the primary task's performance when interrupted by the lamp and the smartphone device.

Overall, answers to the questionnaire as seen on Figs. 3 and 4 were on the positive side but there were no significant difference between the neutral attitude and the positive attitude. It could be assumed that the lamp notification is not necessary, but still useful. Most participants thought that the

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ambient notification was in between being unnecessary and being useful. The location of the notification was appropriate. However, the results rejected the null hypothesis that there was no significant difference between the satisfaction of having the ambient notifications and not having the ambient notifications. Moreover, most of the answers from the participants show the positive attitude toward the door notification.

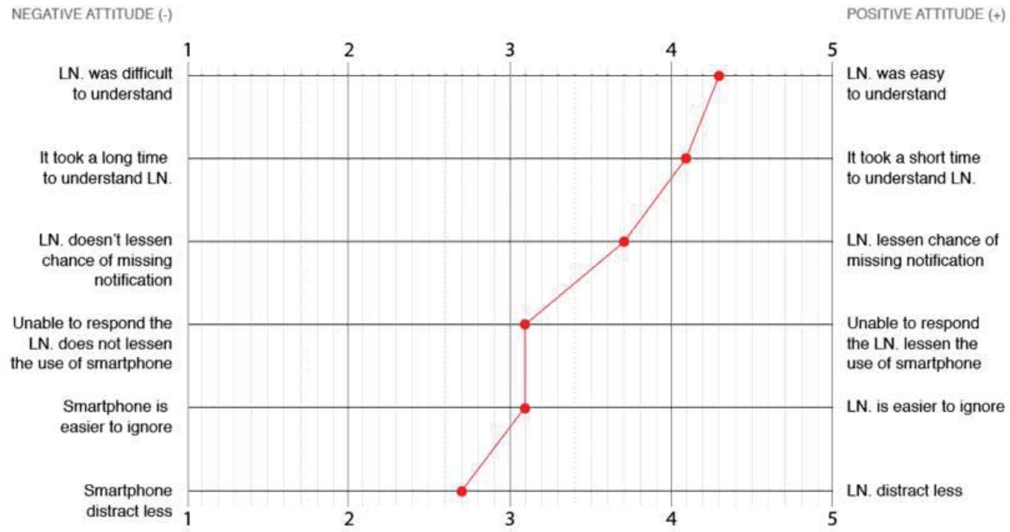

Fig. 3 Results for the lamp notification questionnaire

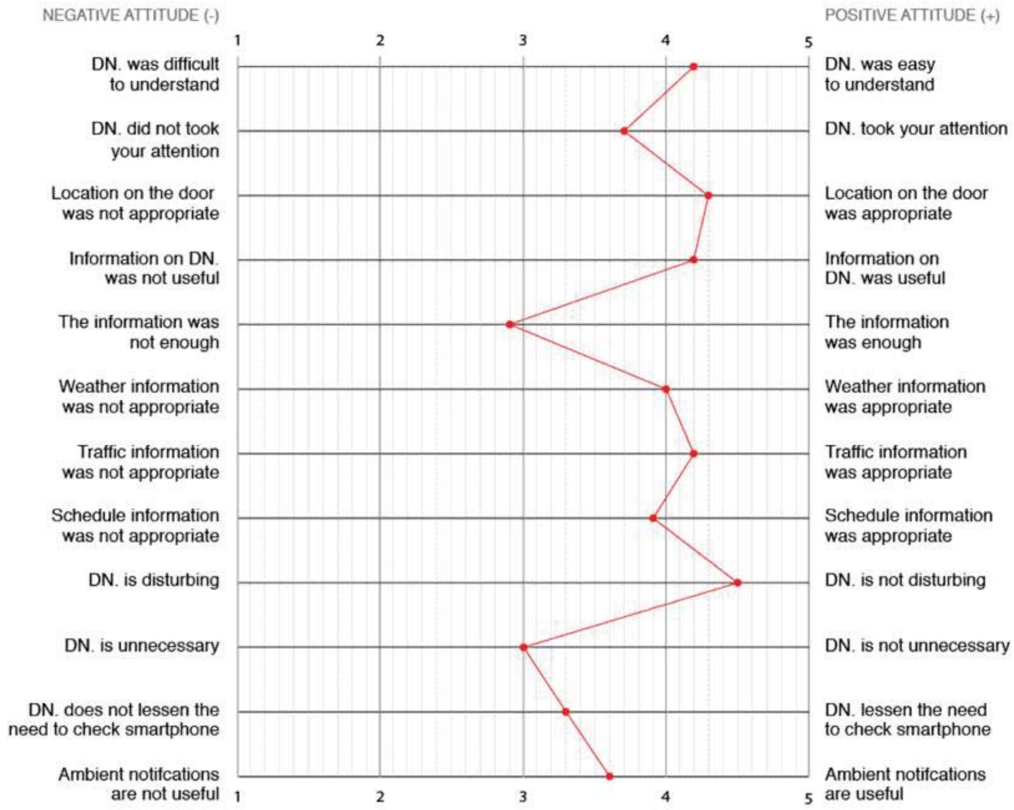

Fig. 4 Results for the door notification questionnaire

To summarize, results from the usability testing of the lamp notification and the smartphone showed that notifications from the smartphone interrupt more than the lamp. Moreover, the results from the questionnaire showed that most of the participants were satisfied with the ambient notifications.

V. DISCUSSIONS

A. Performance

Assumption on how the accuracy and time performance increased is due to the lower level of interruption from the

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lamp notification. Therefore, when participants were completing the math problems their working memory used in calculating could be interfered. The working memory is in charge of processing, retrieval of information, and manipulating the information. However, working memory has a limited capacity and is linked with our attention. If our attention shifts, an amount of unnecessary information will take place in our working memory. By this, mistakes could occur while calculating the math problems resulting lower accuracy in user performance.

Having more distractions decreases the performance of the primary task. It has also been mentioned together with the resumption lag in Böhmer's research. The research by Böhmer et al. [6] on the interruptions from phone calls looks at resumption lag, which is a process that occurs after being interrupted. This process takes time and opens the possibility for errors. Lamp notifications display only the notifications and do not have a function for replying. This feature reduces the resumption lag and refers back to the results of how the primary task could be improved by decreasing the interruptions.

B. Benefits of Ambient Notifications

Some participants mentioned that they felt that the lamp and the smartphone was the same, but most opinions suggest having ambient notifications could lessen the use of the smartphone and that they would only go back to the smartphones to make a call or read important messages.

For the door notification, participants thought that it was useful but unnecessary. The type of information that could remind users seemed to be the most preferable, but then that information might have to be customized to each person who passed the door, in which case the users' privacy should be a concern.

C. Design Implications

In the experiment, many findings about improvements were found and could be used to improve the lamp and door notifications themselves, or can be considered in other notification designs. The aim of this research was focusing on how to notify users without impairing or distracting from their main task and encourage them to depend less on their smartphones. The crucial component of designing the ambient notifications is the location and the appropriate information.

Selecting the locations or objects within the environment could be challenging. Different locations have different characteristics such as how the users interact with this type of object or space. For instance, users might spend more time in front of the bathroom mirror than their front door. Different locations also refer to different types of activities that take place and the characteristics of the environment. For example, at a bus stop where the environment is very noisy, notifying users by sound might not be a suitable choice. However, for the kitchen space where users should focus visually on their primary task, the proper notification should be sounds. Different activities could refer to many hints on the appropriate design and how users could interact with the space they are in. As a result, the points given should not be neglected.

Privacy is also an issue that was mentioned by some participants. Therefore, the content of the information and the sender of the notification should be carefully considered if it should be embedded to the location or object. Perhaps more general content could be embedded in a location that has the sense of a public space and private content could be embedded in the private space such as the user's bedroom.

The non-verbal signal is also another design implementation for notifying users that should be studied. The ambient notification could alert users by light, color, and sound. They are assumed as calmer stimuli and less distracting. However, users might need more verbal information from the notification and further research could be done and iterations for the ambient notifications prototype should be developed for improvements and validated again.

VI. Conclusion

This experiment aimed at alerting people to notifications through ambient means and test whether the method is effective or not. The research compared an alternative way of notifying users of smartphone notifications. From the testing, the results suggest that the smartphone notifications interrupt users more than the lamp notifications, proven by the performance of the primary task. The percentage of the participants who scored higher in receiving the lamp notifications than the smartphone notifications was more than half. The results were also supported by the amount of time that the participants were spending on the primary task. Being interrupted by the smartphone notifications lead the participants to spend more time in finishing the primary task math problems. From the questionnaire, the one sample t-test in the lamp notification questionnaire results showed that there were no significant differences in the positive attitude and negative attitude, but showed a significant difference for the door notification. However, results showed that the participants were overall satisfied with the ambient notifications and presented a positive attitude toward the two notifications.

From the research, a possibility in changing the way people are notified by technology could shift to another dimension, into the spaces we inhabit. In order to change that, the designers must be aware of the interruption and distraction that the ambient notifications could cause. If the ambient notifications are well designed, the notifications could benefit people's lives. The results and insights from this research could be used to guide the design process of the ambient notifications later on in future works in interaction design.

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