COOKING GUIDE: DIRECT AND INDIRECT FORM OF INTERACTION IN THE DIGITAL KITCHEN ENVIRONMENT

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ABSTRACT. This paper explores the potential of ambient cueing in assisting cooking activities in the digital kitchen environment. An application has been developed which given the opportunity to receive feedback and guidance related to cooking tasks through ambient displays. This challenge of balancing the need to incorporate feedback and guidance with the cooking tasks is addressed through the development of two forms of user interface; *direct* and *indirect.* The results of this study suggest that the indirect form of interaction produce a *physical* distraction in task performance but more interestingly produces *cognitive* disruptions. Meanwhile, direct form of interaction provides a standard and natural cooking interface that contributes more advantages in terms of cooking performance and accessing digital information.

Keywords: ambient assisted living, digital kitchen environment, user awareness, human-computer interaction, ubiquitous computing

INTRODUCTION

Ubiquitous computing (UbiComp) offers implicit interaction which means technologies embodied in the environment, intuitiveness, anticipating of the user's intent, affordance and peripheral awareness. As computers are starting to migrate into the domestic space, it is expanding the horizons of UbiComp's interest in daily life including a wider range of user population, activities and space. One of the examples is the kitchen environment. The idea of smart kitchen has been pioneered by MIT in their CounterIntelligence Projects (Bonanni, Lee, & Selker, 2005) and there have been numerous follow-ups in the last decade such as Smart Kitchen Minoh Labrotary (Hashimoto et al., 2008), Nutrition-Aware Cooking in Smart Kitchen (Chen, Chi, Hao-Hua Chu, Chen, & Huang, 2010), smart kitchen from Newcastle Culture Lab(Olivier, Xu, Monk, & Hoey, 2009), and other ranges of research works (Blasco, Marco, Casas, Cirujano, & Picking, 2014; Grossi, Bianchi, Matrella, Munari, & Ciampolini, 2014). The concept of smart kitchen is designed to make activities in the kitchen more convenient through the implementation of ubiquitous and ambient technologies which are embedded into the kitchen space, equipment and utensils. The technologies are introduced to support the cook's activities at the precise time based on the user needs by recognizing the cook's behavior, and skills. Moreover, the dynamic kitchen environment that lead to the technology ability to decides whether user needs support or not and which kind of support is suitable for the situation is also required. The implicit interaction has been applied which occurs without the explicit awareness of users by employing interactive or smart devices to do what they want whenever users are physically, socially or cognitively engaged. One way is to display a continuous representation of cues of interest in the environment using ambient display which defined as *direct manipulation.* Direct manipulation ideally involved continuous representations on the objects of interest and rapid, reversible, and incremental actions and feedback. In contrast, *indirect* manipulation require users to points to received information on the specific items that eventually require users to stop one task in order to do a new task i.e. move their hand from the keyboard to move the mouse, thus interrupting typing.

This paper explores the approach of the potential ambient cueing in the smart kitchen. It is suggested that by increasing the amount of information could enhance performance as long as there was no incompatibility in the provided cues. Thus, redundancy in cueing could be beneficial under some condition. However, when the cues did not agreed with each other, the performance was far worse when there were multiple cues. Taking this point further, it is proposed that if the cues do not agreed with the expectations or knowledge of the users, then performance could be equally compromised. Evaluating the benefits of ambient cueing through user trials will help to better understand the behavior of users in order to produce a 'problem list' which will be valuable in improving of the usability of the ambient displays in the near future.

DESIGN AND HYPOTHESES

A functional prototype (with information presented using PowerPoint) was designed to 'assist' user perform cooking in the kitchen. This is projected on top of the table by a LCD projector. Figure 1 shows the arrangement of equipment used in this paper. Before the task, the ingredients are placed in small, ceramic containers and arranged on the table. This layout provides a convenient structure for the projections. It is not suggested that a 'real' kitchen would be so regimented (although, of course, cooking on television programs is often performed with all the ingredients prepared and placed around the TV Chef). However, the layout meant that all participants were confronted with exactly the same arrangement with all ingredients and utensils positioned in the same places prior to the start of the trials. This meant that the arrangement of the work surface was consistent across all trials.

Interaction Interface

Three different types of user interface were designed to test the user performance in the cooking task in this paper; *ambient* and *smartChalk* with *recipeBook* as the control condition. Similar to a traditional cookery book, the *recipeBook* is a printed document which contains step-by-step cooking instructions, required and quantities of ingredients. *Ambient* is a recipe book that is projected on top of the table. It provides step-by-step instructions as a guided digital information cook book through ambient display.

Ambient allows participants to request information by tapping the icons and when the participant touches (i.e. places their hand on or next to) an ingredient or utensil, a colored disc is projected on top of the object. This projected disc indicates whether the ingredient is right or wrong. If is the right ingredient, a green disc will projected on top of the ingredient (red when the ingredient is wrong). If the correct ingredient is selected, the name of the ingredient will change to green text at the same time. For the purpose of this trial, the action of the participant is monitored by the experimented whose cues the appropriate information (thus following a standard *Wizard of Oz* approach to prototyping).

Figure 1. Arrangement of Experiment Set-Up

The *smartChalk* interface uses the same display as *Ambient*. However, *smartChalk* requires participants to interact with the interface by using a small handheld LED-torch. The participants points the LED at the digital information needed. A webcam captures the position of the light and the *smartChalk* software links this to the information required. Thus, while the *ambient* display provides a form of direct interaction (albeit mediated by the 'wizard'), the *smartChalk* represents a form of indirect interaction which is an off-the-shelf solution supplied by researchers from the *Moscow State Institute of Electronics and Mathematics*. The interaction interfaces of this paper are illustrated in Figure 2.

Figure 2. Experiment's Interface Interaction from (l) Recipebook, (c) Ambient and (r) Smartchalk

Cooking Recipes

This study involved simulated cooking activity of two Malaysian recipes: *Fish Curry* and *Pandan Chicken*. Each recipe is broken down into two sub-tasks: *prepare curry paste and cook fish* for Fish Curry and *prepare chicken* and *cook chicken* for Pandan Chicken. The purpose of using two different cooking tasks is to test the effect of level of complexity for each experiment conditions. Complexity of the tasks is defined by the number of steps, number of different actions, number of ingredients and number of different tools. Preparing curry paste and cooking fish show a general increase in the number of steps, number of ingredients and number of cooking tasks. Meanwhile, in the *Pandan Chicken* recipe, the complexity of preparing chicken shows a slight increase in the number of steps but a reduction in the number of ingredient and tools.

Hypotheses

The work in this paper looked into the impact of the conditions towards user performance and was measured by cooking times and completed number of steps. Therefore, the following hypotheses were made.

- Hypothesis 1 – The amount of times spending in cooking activities are faster for both 'skilled' and 'unskilled' participants, given the interface provided a direct mapping manipulation.
- Hypothesis 2 – Direct interactions provided an ease and natural way of interaction given both group of participant performance better in the cooking activities.

Participants and Procedures

Twenty participants were involved in this study. Ten participants were from Malaysia and aged between 22 to 35 (6 female and 4 male) and rated themselves as both familiar with the recipes and good at cooking. Another 10 participants were drawn from different cultures aged between 19 and 27 years old (8 male and 2 female) and rated themselves as not good at cooking and unfamiliar with the recipes. Malaysian participants were defined as an 'expert' group while the non-Malaysian participants were defined as a 'non-expert' group.

Each participant was given a standard set of instructions at the beginning of the experiment regarding how to perform the cooking activity. Each participant was required to complete the cooking task within five minutes where each of them needed to perform all four cooking tasks for each interaction interface giving a total of 12 consecutive trials individually. The cooking tasks were tested on different days with at least a one day gap between the tasks. The orders of cooking activities were randomized across participants. A high resolution digital camera was used to record the cooking activities. Following the cooking tasks, the video-recording was coded and annotated using the ELAN – Language Archiving Technology Software.

RESULTS

The results analyze the difference between expert and non-expert in terms of time to complete the task, and number of steps completed on each cooking tasks. Two-tailed statistical has been applied with respective *p-value* divided into two in the T-Test to meet the one-tailed condition.

Cooking Times

A three-way analysis of variance (ANOVA) has showed that there was a significant main effect of *participant* [$F(1,18) = 4.509$, $p < 0.05$]. This indicates that cooking times differed between expert and non-expert participants. There was also a significant main effect of *interface* [$F(2, 36) = 9.357$, $p = 0.001$] indicating that cooking times were different between interaction interface. There was also a significant main effect for task [$F(2,36) = 12.001$, $p < 0.001$]. A further T-Test on average cooking times for each interaction interface between expert and non-expert was conducted. In terms of interaction interface and expertise, the T-Test revealed significant differences between expert and non-expert participants in *recipeBook* [$t(74.61) = 3.019$, $p < 0.001$] and the *ambient* [$t(66.25) = 2.987$, $p < 0.001$] but not difference for *smartChalk* [$t(78) = 0.594$, $p = 0.2777$). These results are shown in Figure 3.

The expert participants completed cooking activities faster than non-expert participants, as one would expect. However, when cooking activities were performed using *smartChalk*, their performance was significantly reduced. This suggests that participants who know the ingredients and recipes could be slowed down by 'indirect' interaction with the information that supports these tasks. Interestingly, in the *ambient* condition, Malaysian participants performed better than in the *recipeBook* condition (which suggests that the differences could be attributed to the interference in task performance that the *smartChalk* introduced rather than the provision of information that they might be expected to already know). In contrast, the non-expert participants took roughly the same time using *ambient* and *smartChalk.* Despite not knowing the recipes and ingredients, the performance by non-expert participants was still better in the *ambient* condition, compared to using the *recipeBook*. This suggests that the *ambient* interaction, providing it does not interfere with cooking tasks, need not hinder the 'expert' and can assist the 'non-expert.'

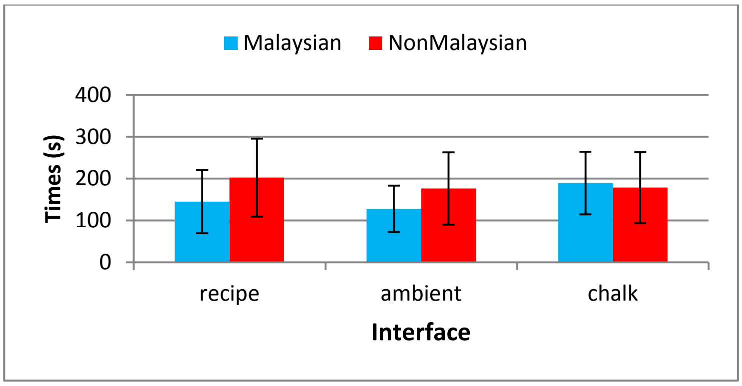

Figure 3. Average cooking times taken to Complete the Cooking Tasks Using Different Interface Between Malaysian and Non-Malaysian

Number of Steps Completed

A three-way analysis of variance (ANOVA) has showed that there was no significant main effect of *participant* [F (1, 18) = 0.914, p = 0.352]. This indicates that the percentages of steps completed did not differ between expert and non-expert. Results also show that there was a significant main effect of *interface* [F (1,32, 23.69] = 52.982, p < 0.001]. This indicates that the percentages of completed steps differed among the *recipeBook*, *ambient* and *smartChalk* interface. Post-hoc, pairwise comparison, using a T-Test revealed no difference in percentage of steps completed between the recipeBook and ambient conditions for either the expert or the non-expert participants. However, expert participants completed significantly fewer steps using smartChalk, compared to recipeBook [T (39) = 9.038, p < 0.001], or ambient [T (39) = 9.722, p < 0.001]. For non-expert participants, there was a significant difference between smartChalk and ambient condition only. Another T-Test was conducted to test the percentage of the number of steps completed without considering the differences in expertise. The results revealed significant differences in recipeBook and ambient conditions but no difference in the smartChalk condition. Even though cooking times for non-expert in *ambient* condition were not significantly different to those using *smartChalk*, the percentages of steps completed are higher in *ambient* conditions on all the cooking tasks. For Malaysian participants, both *recipeBook* and *ambient* conditions have a higher percentage of steps completed than in *smartChalk*.

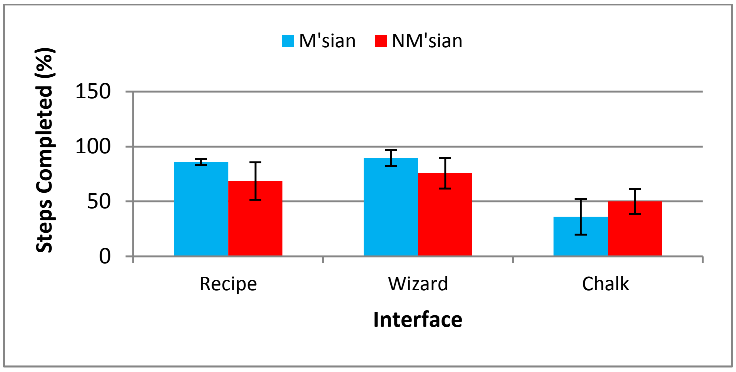

Figure 4. Percentage of steps completed for overall tasks in different interactions

CONCLUSION

This paper reported a study using a simulated cooking task employing three types of user interface; *recipeBook, ambient* and *smartChalk*. As well as comparing user interfaces, the study compares two levels of expertise in cooking specific Malaysian recipes. The main conclusion from this study is that direct interaction such as *ambient* interaction supports and provides a 'natural' form of interaction in the digital environment but indirect interaction causes a delay in the cooking activities as two different actions are required to be performed simultaneously: pointing and cooking. That the indirect interaction interrupted primary task performance, which was disruptive, raises the next question to be addressed in the future: How do people cope with ambient cueing when they have to deal to interruptions?

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