Ambient Cues of Kitchen Counter in Guiding Cooking Activities for Alzheimer's Patient

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***Abstract*—Loss of memory is among the first symptoms reported by patients suffering from Alzheimer's disease (AD). The individual pattern of impaired memory functions correlates with functional brain integrity will result in the inability of the patient to complete a particular task. This research focuses on designing the ambient cues in the kitchen counter to guide Alzheimer's patient to complete cooking activities based on the concept of Stimulus-Response Compatibility (SRC) and whereas the activity is focus on the sequential workflow of cooking activities based on the Hierarchical Task Analysis (HTA). Wizard-of-Oz is used to simulate the behavior of theoretical intelligent ambient cues. The results show with the aid of ambient cues in the kitchen, patient be able to complete the task until the end even if there is confusing or disruption in the middle of the activity. The effectiveness of ambient cues show that patient can easily understood the cues of guiding the cooking flow when mistakes happened.**

Keywords—Ambient Assisted Living, Ambient Cues, Stimulus-Response Compatibility, Hierarchical Task Analysis, and Smart Kitchen,

I. INTRODUCTION

In Malaysia, it is estimated that there will be 50,000 of Alzheimer's patients by the year 2020. There is a high tendency that senior citizen aged 65 years old and above to suffer from Alzheimer's disease. The disease will cause a declining of cognitive abilities in where their attention levels are diminished. Thus, Alzheimer's patient may have difficulty remembering certain things and responds to their environment that they have known previously.

Therefore, number of pervasive computing technologies have been widely exploring into different human-computer interaction approaches to assist Alzheimer's patient, especially in the domestic kitchen. The domestic kitchen is one of an important area in the house where most of the daily living activities such as cooking, washing, baking, or cutting usually take place. Due to the declining memory of Alzheimer's patient, generally, activities in the kitchen may stop them to complete the task due to its complexity for them to remember and understand the relation between the tasks and the physical objects. MIT designed a Counter Intelligence Projects [1], a smart kitchen where the concept of a kitchen is based on Ambient Assisted Living (AAL) tools such as pervasive and ambient technologies that embedded into the kitchen space and equipment.

This research particular interest in the questions of how the potential of simple ambient cues could support guiding Alzheimer's patient when they did not be able to remember the tasks that need to be perform especially during cooking activities. These simple cues represent in this research is in a form of ambient lights which are designed based on classical approach of human-computer interaction; stimulus response compatibility (SRC).

Stimulus and response compatibility (SRC) play an important consideration of human action control in human-computer interface design. SRC studies the person's perception of the 'natural' interaction by considering relations between display (stimuli) and controls (response). When the relation between stimuli and response is direct, it is described as compatible by providing direct mapping manipulation. By contrast, when the relation is indirect and unnatural, it is described as incompatible as shown in Fig 1. The concept of SRC in this research shows how direct mapping of ambient cues in the cooking workflow can guide Alzheimer's patient to make a decision and act accordingly to complete the task.

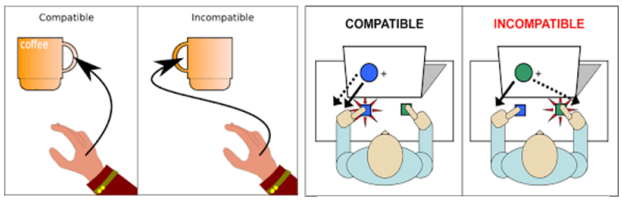

Fig 1: Illustration of compatible and incompatible Stimulus-Response Compatibility (SRC)

II. RELATED RESEARCH

Ambient Assisted Living (AAL) is an unobtrusive environment which encompasses technical system such as Ambient Intelligent (AmI) to support people in their daily routine which the environment be able to adapt and response toward human's actions and needs [2]. This condition provides a proactive service with the goal to allow an independent and safe lifestyle as long as possible. Keep in touch (KIT) uses smart objects and technologies such as NFC and RFID to facilitate telemonitoring process to elderly [3] while a personal device has been developed to assist in the insulin therapy dosage calculation in diabetes therapy management [4]. BackHome aims to study the transition from hospital to home for people with disabilities by implemented ambient intelligence which was design to adapt, personalize, alarm triggering and control over the environment [5]. On the other hand, [6] proposed a framework called RecAm, which enables the collection of

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contextual information and the delivery of resulted recommendation by adapting the user's environment using AmI.

There were number of researchers that focus on designing a smart kitchen environment for elderly or Alzheimer's such as [7] by presenting the hardware architecture for cooking-safe system that targets safety in the kitchen. Meanwhile, [8] designed a remote assistive system to guide elderly to find and recognize hidden objects in a kitchen by utilizing sensing and light projection. Shadow Cooking guides users with situated, step-by-step information projected on a kitchen counter if users lose their current position in the recipe [9] whereas the Smart Cueing Kitchen [10] focused on how to assist the Traumatic Brain Injury (TBI) patient to the cooking independently by providing a kitchen appliances in safe state.

III. Ambient Cues Kitchen Design Concept

In this research, a kitchen counter is designed to assist an Alzheimer's patient in completing one cooking sequential workflow which is to make a glass of fruit juice. The cooking workflow is based on the hierarchical task analysis (HTA). The task executes by using the idea of plans to show when sub-goals need to be carried out. HTA give straightforward understanding to achieve the stated goal. The strength of HTA flow is consisting sequential arrangement of sub-tasks, the user's actions can be monitored and traced consistently until complete as shown in Fig 2.

In the case of making a glass of fruit juice, the HTA breaks down the task into a tree structure, consists root-goal that represent the main task and break down of the main task is called sub-tasks [11]. The root goal is "*Make a glass of juice"*, which is composed of five sub-tasks representing 5 steps to prepare juice. One of the sub-tasks which (#2) is furthered broke down into four more of which (#2.4) decomposed into two more. Meanwhile, another sub-tasks which (#3) is furthered broke down into four more of which (#3.4) decomposed into four more. The second last sub tasks which (#4) and the last sub-task (#5) are broke down into three more respectively.

The structure of HTA is labeled with numbering for each task which give a clear illustration of the task that need to be executed. The root goal starts with number "0" and sub-tasks "1" to "5". The hierarchical structure of HTA has plans at every level. The plans represent rules and order in which sub-task should be carried out. HTA is executed by completing one goal at the time, for example if the task involve *'clean fruit',* the other goals should remain latent. HTA provides a flexible, exhaustive and systematic means of identifying the behaviours that occur during a task.

IV. Implementation

There are two ambient cues that been implemented in this research's kitchen counter which are red and green ambient lights. The green light acknowledges patients as the correct actions or items been used; while the red light shows the wrong item or wrong actions have been performed. This is proven from the previous work that the colour interpretation of Alzheimer's patients is similar to normal people's interpretation [12].

Four green LEDs and four red LEDs were embedded around the utensils/item as shown in Fig 3. The purpose of these LEDs are to give attention and affordances for a user to use the correct utensils or performed the correct action. The LEDs also acted as a stimulus to stimulate alertness of the subject to choose the right utensils with green ambient light. Contrast, if they are wronged, the red ambient light will be displayed as a warning. Kitchen utensils in this cooking activity had been pre-identify earlier and placed on top of the kitchen counter which includes peeler, knife, cutting board, glass, juicer and also included fruits and a sink. The ambient cues and instruction of cooking operation provides to subjects based on the Wizard-of-Oz (WoZ) approach; which subjects believe to interact with autonomous computer system but actually the system being operated or partially operated by an unseen human controller (instructor).

User's actions will be monitored by the instructor through the installed camera which located at the top view of the kitchen counter to avoid sight's block. The web camera is controlled by a program from OpenCV that enable to record and save the video from the camera automatically. Besides, the camera represents a visual surveillance system for the caretakers or family members to observe and monitor the patient's actions in the process of making a juice. This is very useful as precautions to avoid any unwanted accidents happened to the patient while carrying out cooking activities.

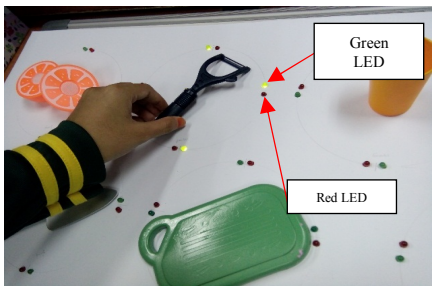

Fig 3: The utensils are surrounded by green and red LED.

V. Test Operation

There are a total of 32 subjects participated in this experiment with, 16 of the subjects are Alzheimer's subject (AS) and another 16 subjects are elderly that does not have any serious sickness; normal subject (NS). Most of the AP's subjects suffer a mild stage of Alzheimer with an average aged of 63 years old. The subjects are selected randomly from three old folks care centers in Kedah, Malaysia. Several important criteria are consider for the subject to participate in the experiment which are (i) they can move by themselves, and (ii) have a clear sight and hearing in order to response towards an ambient lights and listening to the instructions delivered. The instructions deliver by instructors for making a glass of juice are stated in Table 1. The instructions consist of 13 steps and are generate to be as simple as that both of the subject's group can understand and at the same time lessen the difficulties faced by the Alzheimer's patients. The experiment conditions with the subjects at the old folks care centers are shown in Fig. 4.

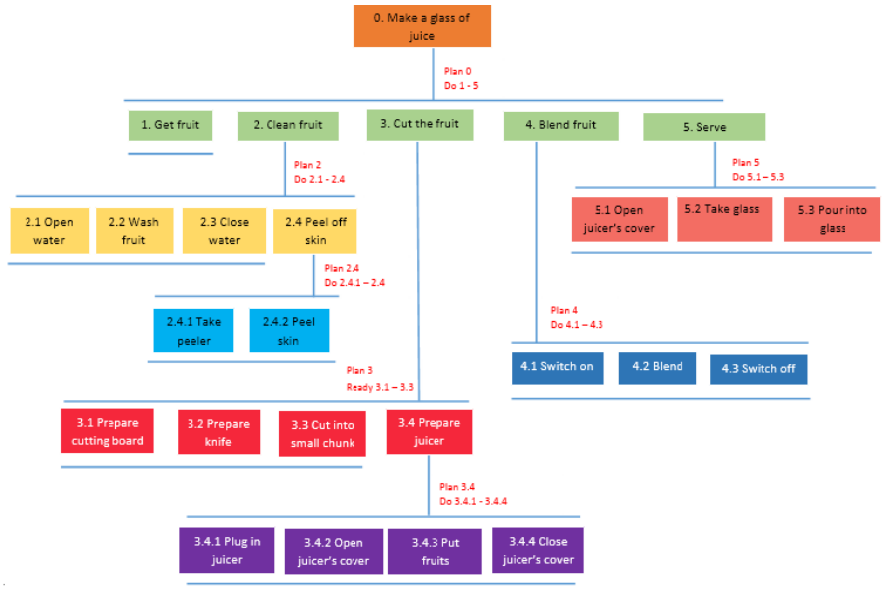

Fig 2: Hierarchical Task Analysis (HTA) of making juice.

Table 1: List of instructions according to the steps of making juice.

Step	Instructions
1st	Please take fruits.
2nd	Wash the fruit in the sink.
3rd	Then, take a peeler to peel the fruit's skin.
4th	Next, take the cutting board and put on the counter.
5th	Next, take a knife.
6th	Cut the fruits into a small chunk.
7th	In order to blend the fruit, use the juicer.
8th	Once finish cutting put the fruit into the juicer.
9th	Close the juicer with juicer's cover
10th	Then, blend the fruits until smoothie.
11th	Prepare a glass.
12th	Then, open the juicer's cover and pour the juice into a glass.
13th	Finish. Enjoy your juice.

Fig 4: Experiment conducted at old folks care center.

VI. Result

The effectives of ambient cues were measured by looking at the errors that been made by both the subject's group (AS and NS). In this particular experiment, the observation is based on their understanding and responds towards the corrected ambient cues when mistakes happened. For the purposed of this experiment, Fisher's Exact test will be conducted on the utensils which associated with the instruction.

The result showed that subject does not need ambient cues to assist them in most of cooking flow except in the instruction no 3, *"Then, take a peeler to peel fruit's skin"*. From the observation also, twelve (12) subjects from Alzheimer's subject (AS) and two (2) subjects from normal subject (NS) make mistakes at this cooking flow. This is may due to the confusion between peeler and knife. When they make a mistakes, such as take different utensils than a peeler, a red ambient cues will be blinking showing that they perform a wrong action. Then the system will assist them to take the right action by showing green ambient cues at the correct utensil. Table 2 shows ambient cues is significantly applied on the peeler as 43.75% of Alzheimer's subject tends to make the wrong responds. It also shows that there is no significance of the effectives of the ambient cues on other utensil.

Table 2: Significance of ambient cues between Alzheimer and normal subjects.

Alzheimer vs normal	fruit	sink	peeler	knife	Cutting board	juicer	Juicer's cover	glass
Fruit	n.s							
Sink		n.s						
Peeler			14 (43.75%)					
Knife				n.s				
Cutting board					n.s			
Juicer						n.s		
Juicer's Cover							n.s	
Glass								n.s

Additionally, Chi-square test was used to measure relation between numbers of completed actions with these two population subjects. The result shows that there was significant difference on number of completed actions between Alzheimer and normal subject with $p < 0.05$. This indicates that Alzheimer's subject take more actions to complete the task compare to normal subjects as shown in Fig 5. It can be concluded that the more actions that been taken, the more time is require to complete the task. Thus, the result shows an alignment with previous research that

the effect of Alzheimer to the patient does impact their responds to complete the task.

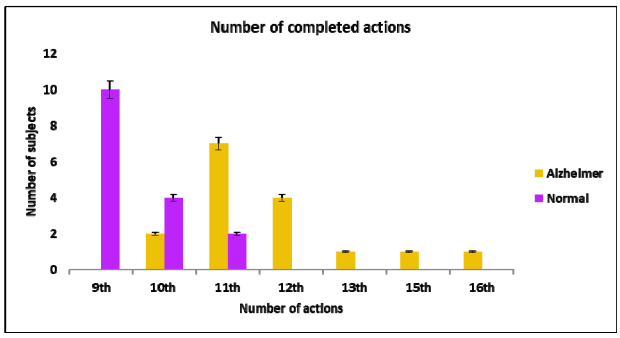

Fig 5: Number of completed actions between Alzheimer and normal subject.

There was also a t-test has been conducted to observe the relationship between number of errors and gender within Alzheimer's subject. The test is conducted between two populations, male and female subjects. In this observation, the number of errors are based on the number of times the subjects taking a wrong utensils or items.

To analyses the hypothesis (i), the t-test was conducted by using SPSS and the result is shown in Fig. 6. The p-value of Levene's test stated 0.239 is greater than the significance level, α=0.05 ($p>0.05$) therefore, the null hypothesis is accepted. From this test, it can be concluded that there is no significant difference in the relationship between numbers of errors that is done by patients within the gender populations.

		Levene's Test for Equality of Variances			
		F	Sig.	t	df
Number of did wrongly	Equal variances assumed	1.511	.239	-.424	14
	Equal variances not assumed			-.396	8.878

Fig 6: Independent sample test gender vs. number of errors

VII. Conclusion

In summary, it is believed that the work conducted in this research offers an approach of designing ambient cues for the smart kitchen environment. The approach shows and provide the framework of integration between modelling stimulus-response compatibility (SRC) and Hierarchical Task Analysis (HTA). It was claimed this research provides the user with visual cues information which can be easily understood and responded to by both of the Alzheimer and normal population for cooking sequential workflow.

The present study shows that ambient cues can give an optimum guidance towards users in completing the cooking activities. Though the users have difficulty to complete the task, ambient cues does help them in guiding to perform the task correctly regardless of the time taken. Therefore, a simple ambient cues in this study has provided an effective and direct interaction between users and the environment.

Acknowledgement

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