Introducing Wearables in the Kitchen: An Assessment of User Acceptance in Younger and Older Adults

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Abstract. Wearable computers allow users to record and access information at any time. The adoption and use of such devices is largely dependent on the users' acceptance of the technology. Previous studies investigated technology acceptance of wearables without having end-users directly trying the technology. The present paper aims at assessing the user acceptance of a wearable device to support cooking related activities, together with aspects of usability and experience of use. To this end, we developed a kitchen apron with embedded commands for navigating through the contents of a digital cookbook and asked a group of younger (N = 15, mean age 23.9 SD = 2.5) and older users (N = 15, mean age 30.3 SD = 7.6) to deploy it while preparing a recipe. Respondents' opinions were collected using questionnaires after they had accomplished the cooking task required. Overall, the kitchen apron was well received by both younger and older adults. Findings suggest that the perceived usefulness of the device and the compatibility of it with users' common activities accounted for the intention to adopt and use a wearable device in the kitchen.

Keywords: Technology acceptance · Wearable computers

1 Introduction

Wearable computers are fully functional and self-contained technological devices that can be worn or attached to user's body and that allow him/her to access information at any moment [23]. Given these characteristics, wearable devices are an ideal component for unobtrusively recording the users' state and for providing him/her constant access to commands and information, and they have been in fact extensively experimented in the healthcare domain and to support healthy lifestyles [5, 21]. Despite the advantages brought about by wearables in terms of continuous data recording, availability of

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information and networking possibilities, the users' willingness to adopt and use such devices is highly affected by the user acceptance of the technology itself [1, 23, 32].

User acceptance of technology has been investigated in different context of use, and a number of factors affecting the acceptance have been identified, e.g., age, gender, technology expertise and environment of use [10, 22, 31]. However, previous studies have mainly assessed technology acceptance without having users directly experience a functioning device before making their judgments, rather the presentation of scenarios has been preferred [e.g., 25].

In the present study we aimed at assessing the user acceptance of a wearable device to support cooking-related activities in younger and older adults. To this end a kitchen apron with embedded commands for navigating through the contents of a digital cookbook was developed and was used by participants to complete a realistic cooking task before assessing users' technology acceptance. The system considered in the present paper consists of a common kitchen accessory, i.e., a kitchen apron, and a simple keyboard for inputting commands. We thus hypothesize no differences pertaining the overall technology acceptance in younger and older adults. In addition, given the low level of complexity of the interface, no differences regarding system usability and the experience of use are expected between the two groups. We hypothesize a difference in the propensity of using technology, favoring younger adults.

The remainder of the paper is structured as follows. First, the concept of technology acceptance is introduced with reference to wearable computers. Then, the methods for assessing technology acceptance, usability and experience of use are presented. The experiment is then reported, including details regarding the materials devised, the equipment used, the experimental setting and procedure and the participants. The data analysis and the results are then described, and are discussed. Finally, concluding remarks are presented.

2 Background

Generally speaking, technology acceptance refers to a conscious intention by the user to adopt and use a technological device. However, the interaction with wearable devices entail peculiar characteristics as compared to traditional computers, e.g., the location of use [1]. A refined definition of technology acceptance is thus provided below, followed by the methods that are usually employed to investigate users' attitudes.

2.1 Technology Acceptance of Wearables

Considering the users' perspective is crucial for determining whether the interaction with a wearable device is efficient and satisfactory [16]. However, usability and user experience are not the only factors accounting for technology adoption. Highly technological features alone are in fact not determinant for the user to adopt the device and it is well-known that a poor acceptance of the technology is associated with the deny of adopting and using the device, regardless of the potential benefits [4, 17].

According to the Technology Acceptance Model (TAM) [7] and the Unified Theory of Acceptance and Use of Technology (UTAUT) [26], user acceptance is defined along two central factors: the perceived ease of use, that is the impression that operating the device is effortless, and the perceived usefulness of the technology, that is the impression that the technology can benefit the user supporting him/her in the unfolding of the task. A number of factors, including the technological features of the device and the characteristic of the user, have been identified as affecting the technology acceptance in a number of different application domain (e.g., the workplace [4], hedonic information systems [11], and mobile devices [13]).

The context of use was found to play a relevant role in affecting technology acceptance of wearables, e.g., [31]. In particular, the healthcare scenario is in general associated to high acceptance rates among respondents [8] and was also found to be determinant in the acceptance of wearables, meaning that users would be willing to adopt the given technology for healthcare purposes but not for others, e.g., demanding job [23]. Regarding the domestic environment, the usage of wearables seems to be favored in the bedroom and living room, as compared to the kitchen [10, 31].

A number of demographic factors seem to play a role in the acceptance of technology, however results are mixed in this respect. Previous technology expertise seems to favor the adoption of wearable device [5, 22, 23, 25]. However, [10] showed that self-confidence in the use of technology does not affect respondents' judgments. Age seems not to affect the intention of use, even though older respondents were more concerned about the complexity of wearables than their younger counterparts [31]. In general, respondents' gender does not appear to affect their acceptance of technology [10, 31, 32]. The pressure made by friends and family members seems to the play a role, especially for older users [14].

Finally, the design and the appearance of the device plays also a determinant role: the wearable device should be comfortable and at the same time discreet [25, 28].

2.2 Assessing the Intention of Use of Wearables

To assess the willingness to adopt and use wearable devices, participants are usually asked to self-report their impressions and opinions regarding a device through a questionnaire. In the majority of the cases the completion of the questionnaire follows the presentation of a scenario, in which the respondents are illustrated the typical situations of use of the wearable device under examination [22, 25, 30]. Some studies had a more general aim to assess users' general attitude toward wearable technologies and a questionnaire alone was administered [10, 30, 31].

A more qualitative approach was also proposed. [3] investigated medical staff's attitude toward a wearable hand sanitizer system monitoring how much the user was effectively disinfecting his/her hands, by making participants first try a prototype in a laboratory setting and them let them discuss their impression in a focus group. Similarly, [24] investigated older adults' impressions of a wearable network of sensors by presenting them a prototype during a focus group session. Finally, [2] asked participants to try on two different wearable accessories, i.e., a backpack and an armband, which served different purposes according to the scenario presented to them. After, participants had made a series of movements following the experimenter's instructions, they were asked to complete a questionnaire.

3 Materials and Methods

In the present experiment, a total of three questionnaires were administered. A first questionnaire was devised to collect background information (name, age, gender and education) and aimed at assessing participants' habits in the kitchen and their cooking expertise. In particular, they were asked how often and for how many people they usually cooked and also if they were in the habit of consulting cookbooks and of which kind (i.e., paper book, digital cookbook via PC, tablet or smartphone). Regarding their cooking expertise, they were asked to indicate which recipe they would be able to prepare without consulting a cookbook. Participants could choose among six preparations of increasing difficulty: two options were easy to prepare, and were assigned a score of 1; two options were of intermediate difficulty, and were assigned a score of 2; and finally, two options were difficult to prepare without a cookbook and were assigned a score of 3. The higher the score gained by the user, the higher was assumed his/her expertise, and constituted a proxy of his/her cooking abilities.

The questionnaire investigating the user's acceptance of wearable devices validated by [23] was administered. It consists of 26 items in total, assessing 10 factors. A first factor measured the respondent's overall reaction toward technology, namely Attitude Toward Technologies (ATT) [27]. A second factor pertained the feelings of apprehension when using a technological device (3 items), i.e., Technology Anxiety (TA) [26]. Three items assessed the extent to which the user had the impression that using the device is compatible with his/her current habits and with the tools at his/her disposal, i.e., Facilitating Conditions (FC) [27]. The fourth factor pertained the respondent's impression that the device could enhance his/her performance, namely Perceived Usefulness (PU) [7]. Four items assessed the extent to which respondents perceived that using the device would be effortless, i.e. Effort Expectancy [26]. Behavioral Intention, i.e., the degree to which the respondent is able to formulate conscious plans to deploy the device for carrying out certain actions, was assessed by four items (BI) [7]. Two items assessed the extent to which users would be willing to use the technology as a consequence of social influence, namely Psychological Attachment (PA) [15]. Two items referred to the extent to which the user perceived that the information collected by the system would be safely stored and handled, i.e., Perceived Privacy (PP) [20]. Perceived Enjoyment (4 items) assessed the degree to which the respondent perceived that using the system would be pleasant, regardless of the consequences of the usage [26]. Finally, three items assessed the Perceived Comfort (PC) [12] of wearing the wearable system. Participants were asked to indicate their level of agreement on a 6-point Likert scale.

An additional questionnaire was devised to assess the experience of use with the system and to investigate aspects related to the usability of the system. Such post-experience questionnaire consisted of 20 items, to which the respondent was asked to mark his/her level of agreement on a 6-point Likert scale. In order to evaluate to which extent the system was perceived helpful in the unfolding of ordinary cooking activities, namely Usefulness [9], 4 items were included. The Ease of Use of the system, that is the degree to which users found the wearable simple to use, was assessed by 3 items [9]. A total of 5 items investigated the extent to which respondents had the impression that it was easy to navigate through the system, namely Navigability [9]. The Satisfaction of use, that is the extent to which users were happy of their interactions with the system, was assessed by a single item [9]. Again, a single item investigated the effort associated in learning how to operate the system, that is called Learnability [9]. The quality of the experience, namely Pleasantness, was investigated by 4 items [29]. Finally, 3 items evaluated to which extent the user had the impression that the system would interfere with the user's established practices [23].

3.1 Equipment

A kitchen apron with embedded commands was purposefully created for the study. On the left side of the apron was attached a plastic plaque holding five buttons. To simplify the interaction, only three of them were used in the present study to navigate through the pages of a digital cookbook: the one on the right side served to proceed to the next page, the one on the left side allowed to go back to previous page and the central one had an enter function (Fig. 1).

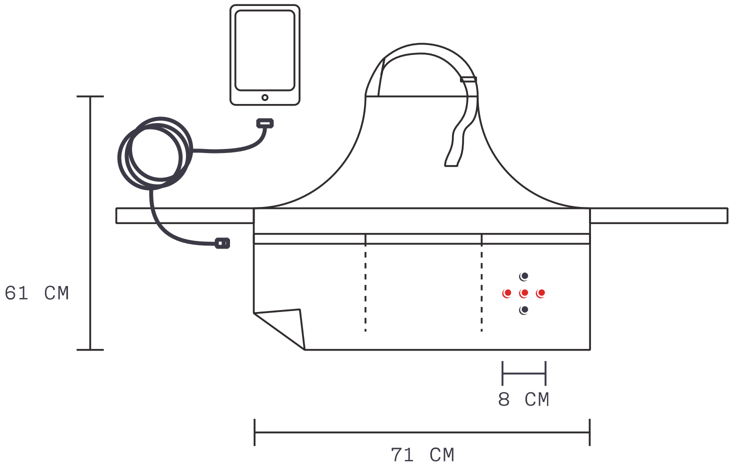

Fig. 1. A schematic representation of the kitchen apron connected through a USB cable with the tablet. The buttons used in the present experiment are highlighted in red. (Color figure online)

The digital cookbook was presented on a Microsoft Surface Pro 2 tablet (10.6"). The buttons on the apron were connected to a hardware schedule using Arduino IDE (Makey Makey 1.2). The schedule was connected to the tablet through an USB cable that was arranged in order not to interfere with users' actions.

3.2 Experimental Setting

The experiment took place in the kitchen of the lab facilities that was properly arranged to serve research purposes. A large table was placed in the middle of the room and served as the main working top. On the table participants found the utensils and the ingredients needed to prepare the requested recipe. Participants were asked to use the oven, which was placed closed to the main working top. Next to the oven, there was a secondary working top that participants could use. The setting was maintained the same for all participants (Fig. 2).

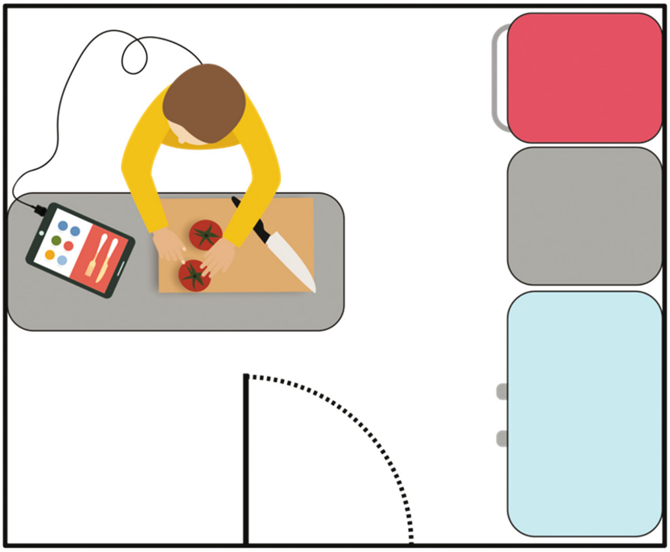

Fig. 2. A sketch of the experimental setting. On the left side, there was the main working top used by the participant. On the right side there was the kitchen furniture, that is the oven (on the top right corner), the secondary working top (in the middle) and the refrigerator (on the bottom right corner).

3.3 Participants

We recruited 30 participants in total. The overall sample was divided into two subgroups based on participants' age.

The first group was composed of 15 younger adults (7 women), with a mean age of 23.9 years old (*SD* = 2.5). The group of younger adults received on average 16 years of education (*SD* = 1.3). Regarding their habits in the kitchen, 8 participants out of 15 declared to cook once a day, 6 reported to cook more than once a day and only 1 was in the habit of cooking more than once a week but not on a daily basis. When cooking, 9 participants out of 15 reported to cook for more than one person. The expertise level in cooking was assessed by asking participants which recipes they would be able to cook without consulting a cookbook. A score ranging from 0 (no expertise at all) to 12 (high expertise) was assigned, according to the complexity of the recipes indicated by participants. We found that 5 participants had a low level of expertise, 7 had an intermediate level and 3 had a high expertise level in cooking. Regarding the use of cookbooks, only seven participants reported to use it while cooking, among those only one consulted paper cookbook, the others reported to consult recipes on the PC or on the smartphone. About their habits of using technologies, all younger participants affirmed to use the smartphone every day, 10 out 15 reported to also use the PC on a daily basis, and 5 reported to use it weekly. The tablet was used by 8 respondents and the smart TV by 7 than once a week.

The group of older adults was composed of 8 women and 7 men. The average age of the sample was 70.3 years old (*SD* = 7.6). They received on average 9.3 (*SD* = 3.8) years of education. Concerning participants' usual practices in the kitchen, 10 participants out of 15 reported to cook more than once a day, one reported to cook once a day, three affirmed to cook more than once a week, but not on a daily basis, and one said to cook less than once a week. Furthermore, among the subgroup of ten participants cooking most often, six reported to cook for more than one person. Regarding the level of expertise, all participants but one had an intermediate or a high level of expertise in cooking. Regarding the use of cookbooks, 6 participants out of 15 reported not to use cookbooks. Among those who did, eight reported to consult paper book recipes, five consulted the PC and one the tablet. About technologies employment, in the second group 6 out f 15 reported to use smartphone daily, 9 affirmed to use PC, of which only 6 reported a daily usage.

All participants were recruited by word of mouth and received no compensation for taking part in the experiment (Fig. 3).

Fig. 3. An older and a younger participant during the experimental session.

3.4 Experimental Procedure

On the day of the test, participants were first welcomed in the laboratory and were debriefed regarding the activity and the goals of the experiment. Once participants had signed the informed consent, they were asked to fill in the pre-test questionnaire collecting background information. The experimenter then walked the participant to the kitchen, where s/he was first illustrated how the it was set up. Then the experimenter showed the kitchen apron and helped users to wear it and explained them how to navigate through the digital cookbook contents using the buttons on the apron. When the user was able to operate autonomously the device, the experimenter asked the participant to prepare a pre-selected recipe following the instructions provided by the digital cookbook and the experimental session started. The experiment ended when the participant told the experimenter s/he had finished. At this point, participants were helped to take off the apron and were accompanied in another room, where they filled in the questionnaires assessing user acceptance and the experience of use with the system. Finally, the experimenter greeted and thanked the participant, who was also given the dish s/he had prepared to take away.

4 Results

First, we used a Pearson's correlation test to assess whether and how the variables under examination correlated with each other. We found that Attitude Toward Technology was weakly correlated with the expectancy of the technology being difficult to use, i.e., Effort Expectancy, and negatively correlated with the age, indicating that the older the respondents the lower was their Attitude Toward Technology. Technology Anxiety was moderately correlated with the presence of factors enabling the adoption of the device, namely Facilitating Conditions, and with the Perceived Usefulness of the device. Furthermore, Technology Anxiety correlated moderately with the Behavioral Intention and with the Psychological Attachment. Facilitating Conditions, was moderately correlated with Effort Expectancy and more strongly with Behavioral Intention. In addition, Facilitating Conditions was negatively correlated with Age. Perceived Usefulness correlated moderately with the intention of use the device, i.e., Behavioral Intention, and more strongly with Psychological Attachment. Effort Expectancy was moderately correlated with Perceived Comfort and more strongly with the Perceived Enjoyment. Behavioral Intention was moderately correlated with Perceived Enjoyment and Psychological Attachment and negatively correlated with Perceived Privacy. Psychological Attachment was moderately correlated with Perceived Enjoyment. Finally, we found that Perceived Comfort was strongly correlated with Perceived Enjoyment (Table 1).

A Spearman's correlation test was run to assess whether the gender correlated with any of the factors assessed by the user's acceptance questionnaire. The analysis revealed no significant correlation between the gender and any of the factors investigated (Table 2).

Table 1. The Pearson's correlation matrix. *p < .05; **p < .001

	ATT	TA	FC	PU	EE	BI	PA	PP	PE	PC	Age
ATT	–										
TA	.065	–									
FC	.158	.402*	–								
PU	−.006	.347*	.164	–							
EE	.029*	.027	.321*	.123	–						
BI	.128	.429*	.605**	.485*	.233	–					
PA	−.022	.418*	.224	.625**	.208	.453*	–				
PP	−.020	−239	−.251	−.172	.103	−.438*	.136	–			
PE	-.016	.288	.227	.483	.601**	.311*	.326*	.107	–		
PC	.079	.042	.254	.321	.415*	.212	.148	.331	.645**	–	
Age	−.50*	−.13	−.401*	.097	−.052	−.111	−.007	.038	.175	−.027	–

Table 2. The Spearman's correlation matrix. *p < .05; **p < .001

	ATT	TA	FC	PU	EE	BI	PA	PP	P	PC	Age
Gender	.20	−.359	.008	−.202	−.076	−.23	−.248	.076	−.118	−.118	.222

Next, a multiple linear regression was run to test whether the factors assessed by the user acceptance questionnaire predicted the intention of use of the device, i.e., Behavioral Intention. A significant regression equation was found $F_{11,18} = 2.731$, $p = .028$, with an R^2 of .625. In this model, respondents' Behavioral Intention was predicted only by the factor Facilitating Conditions $\beta = .46$ $t = 2.352$ $p = .03$.

Aiming to obtain a more parsimonious model, we replicated the analysis considering only the factors having values of $\beta > .20$, being Facilitating Conditions, Perceived Usefulness and Perceived Privacy. A significant regression equation was found $F_{3,26} = 11.92$, $p < .001$, with an R^2 of .58. In this model (Table 3), Behavioral Intention was predicted by the factors Facilitating Conditions $\beta = .48$ $t = 3.63$ $p = .001$ and Perceived Usefulness $\beta = .36$ $t = 2.78$ $p = .01$.

Table 3. The final regression model. The unstandardized coefficients, the standard errors and the standardized coefficients.

	B	*SE B*	***β***
Facilitating Conditions	.393	.108	.48**
Perceived Usefulness	.356	.128	.36*
Perceived Privacy	−.325	.169	−.25

A further analysis was run to investigate whether there were specific differences between younger and older adults in the average scores of the factors assessed by the user acceptance questionnaire (Table 4). A Mann-Whitney test revealed a statistically significant difference only for Attitude Toward Technology $U = 38$ $p = .001$, with younger adults having a more positive attitude ($M = 5.44$, $SD = .61$, $Mdn = 5.67$) as compared to their older counterparts ($M = 4.35$, $SD = 1.14$, $Mdn = 4.33$).

Table 4. The means and standard deviations values of the scores gained for each factor of the user acceptance questionnaire for younger and older adults and the Mann-Whitney test. *$p < .05$

Factor	Younger adults		Older adults		*U*
	M(SD)	*Mdn*	*M(SD)*	*Mdn*	
Attitude Toward Technology	5.44 (.61)	5.67	4.35 (1.14)	4.33	38*
Technology Anxiety	3.77 (.44)	4	3.71 (.67)	4	108.5
Facilitating Conditions	4.9 (1.19)	5	3.8 (1.71)	4	66.5
Perceived Usefulness	3.91 (.99)	3.67	4.15 (1.56)	4.33	90
Effort Expectancy	5.56 (.79)	6	5.43 (.72)	5.5	95
Behavioral Intention	4.08 (1.02)	4.33	3.78 (1.49)	3.77	96
Psychological Attachment	4.16 (.79)	4	4.16 (1.27)	4.42	105.5
Perceived Privacy	4.06 (.56)	4	6.02 (2.12)	4	110.5
Perceived Enjoyment	5.17 (.54)	5	5.35 (.69)	5.67	92
Perceived Comfort	4.86 (.67)	5	4.71 (1.06)	5	109

Regarding the post-experience questionnaire, we first investigated whether there were differences between the two groups of users using a Mann-Whitney test, but the analysis revealed no significant difference between the groups for any dimension tested (Table 5).

Table 5. The means and standard deviations values of the scores gained for each factor of the post-experience questionnaire for younger and older adults and the Mann-Whitney test.

Dimension	Young adults			Older adults			*U*
	M(SD)	*Mdn*	*t*	*M(SD)*	*Mdn*	*t*	
Satisfaction	4.66 (1.54)	6	2.92*	5 (.65)	5	8.87**	109.5
Learnability	5.6 (.48)	6	17.19**	4.6 (1.44)	5	3.12*	67.5
Ease of Use	4.9 (.79)	5	6.9**	4.84 (.82)	5	6.31**	111.5
Navigability	5.54 (.52)	5.8	15.06**	5.4 (.5)	5.6	14.51**	92
Pleasantness	4.76 (.82)	4.75	5.93**	5.08 (.7)	5.25	8.69**	88
Practice	4.73 (.92)	5	5.17**	4.8 (.86)	4.25	5.84**	109
Usefulness	4.98 (.62)	5	9.22**	5.11 (.58)	5.25	10.76**	93.5

After that, we compared the average score of each of the dimension assessed by the post-experience questionnaire against the mid-point of the response scale, i.e., 3.5, which indicates a neutral attitude (Fig. 4). A one-sample t-test highlighted that for both groups all the dimensions received an average score that was significantly above the mid-point of the response scale (Table 5).

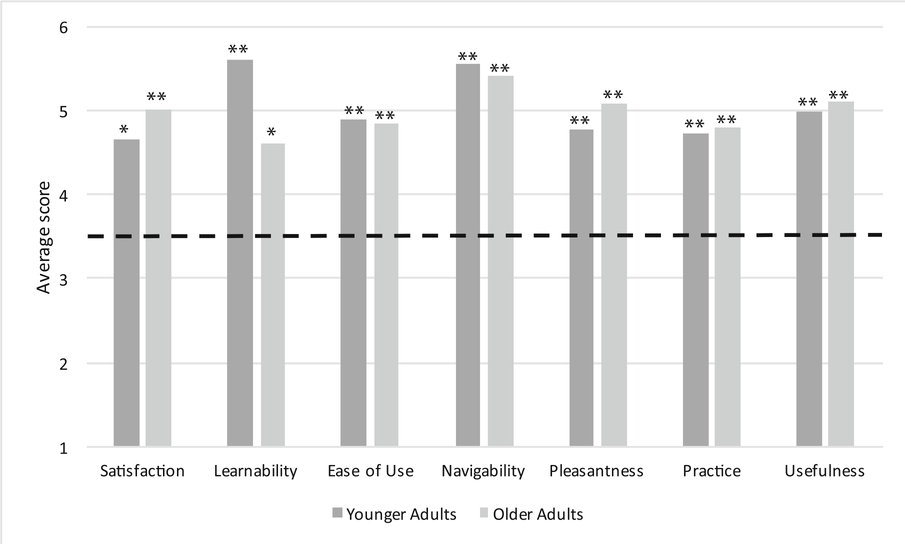

Fig. 4. The average scores of the post-experience questionnaire. *p < .05, **p < .001 for the one-sample t-test

5 Discussion

In the present research paper, we investigated the user acceptance, the usability and the general experience of use of a wearable device aiming to support cooking activities, namely a kitchen apron, which was conceived to be very simple. Differently from previous studies, in which technology acceptance was assessed after asking respondents to read a scenario or after trying a prototype in a simulation, e.g., [2, 31], we asked participants to use the kitchen apron to complete a realistic cooking task before collecting their opinions. We found that both younger and older adults received positively the device, both in terms of user experience and of usability, supporting our hypothesis regarding the uncomplexity of the interface. This finding is in line with previous research based on a scenario, where it was found that smart wearables are generally perceived positively [32]. Notably, previous studies [10, 31] reported that the use of smart wearables in the kitchen was considered less useful by respondents as compared to other scenarios of use, e.g., the bedroom. However, we found that all participants involved, i.e., both younger and older adults, praised the kitchen apron as a useful tool. This suggests the importance of providing users with a realistic and concrete experience with the prototype under examination before collecting their opinions, especially with older adults, who may struggle to grasp the idea of a new technology [19].

Regarding the user acceptance of the technology, we found that only two factors predicted the intention of use the kitchen apron: Facilitating Conditions and Perceived Usefulness. This model suggests that the adoption of the kitchen apron would depend on the compatibility of the device with the users' typical practices and activities in the kitchen and with their belief that the apron could support them in the unfolding of the cooking tasks, in line with the seminal model of technology acceptance by [7]. Interestingly, it did not seem that users' technical expertise affects the intention of use, contrary to what previous studies suggested [22, 25]. However, we did find that younger adults had a more positive attitude toward technology as compared to older adults. In addition, our findings suggest that respondents' age did not affect the technology acceptance, in line with previous research [31].

6 Conclusions

Taken together our findings suggest an overall positive attitude toward the deployment of wearable computers in the kitchen by both younger and older adults. In addition, our findings confirmed that age is not a decisive factor affecting the intention to use a wearable computer. Whereas, technology acceptance seems to depend on the extent to which the device fits well with the users' already exiting practices and with the tools at their disposal, and with the belief that the wearable would be helpful to accomplish the activity.

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