Promoting Older Adults' Independent Living with Assistive Technology: Emotional Requirements, Technostress and Formal

Promoting Older Adults' Independent Living with Assistive Technology: Emotional Requirements, Technostress and Formal Caregivers Perspective

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***Abstract*— Assistive technology has the potential to promote the independent living of older adults. To ensure adoption, the user experience and investigation of user needs should be meticulously assessed. One factor that can influence acceptance and adoption of innovative technology is the emotional aspect. Despite this understanding, the examination of how emotions and other demographic factors play a role technology perception are not thoroughly examined. This study evaluated emotional requirements and stress toward technology in a monitoring and socialization service after 6 months of use by 64 older adults. The perspective of 25 formal caregivers was also considered. Monitoring service showed higher 'stay informed' requirement but similar emotional aspects compared to socialization. Overall, although not significantly, the monitoring scenario scored higher in the emotional requirements and elicited lower stress towards technology, aligning with formal**

caregiver's perception of its technical superiority. Future guidelines for long-term studies should consider the emotions and needs of the OA and the system's technical reliability to maximize the efficacy.

Keywords— active aging, healthcare providers, assistive technology, emotional requirements, socialization, monitoring.

I. INTRODUCTION

The rise of older demographic [1] is highlighting the growing need for assistive technologies in both healthcare and social systems. Moreover, the worsening of medical conditions resulting in motor and sensory impairments underscore the demand for technologies that support older adult (OA)'s independent living. Numerous assistive devices – including robots - have been created to tackle these pressing challenges. However, a plethora of these technologies are burdensome to operate by the users, largely because they were designed without the involvement of the target population [2]. In order to provide well-accepted devices, the system should offer exceptional user experience that starts with the investigation of user needs. To meet the users' requirements, the needs should be analyzed and translated into functional and technical requirements that can guide the design and development of a technological solution. In this context, several methodologies such as the action research (AR) [3], the user centre design [4] and the co-creation [5], aim to give a pivotal role to the end-users. However, to achieve a great user experience, the identified technical requirements should extend beyond basic specifications encompassing human factors such as emotions and values. Emotions contribute on the acceptance and adoption of innovative technology, especially by OA [6], [7], [8], [9], [10], and thus should be considered when designing a study and technologies to foster long-term user experience and use. Therefore, considering emotions into the design process can lead to a more effective long-term user experience promoting the actual use of the technology. Nevertheless, as highlighted by [6], [7], despite people expressing emotions, it persists uncertainty in how to interpret and translate these emotions into specific technical requirements, given the ambiguous, unstructured, and subjective interpretation of emotional needs. Hence, it is crucial, at a particular point in the long-term interaction with the devices, to come back to the initial emotional requirements and evaluate whether they were fulfilled. According to [7] this validation represents a valuable challenge since, as stated in the review, most of the studies employed illustrative case studies, without validating the effectiveness and efficiency. Additionally, [7] remarked that factors like demographics, environment, digital skills and social influences can alter emotions, so models should

Pilots for Healthy and Active Aging (Pharaon) Project founded by the EU Horizon H2020 R&I Programme (GA 857188).

incorporate these factors. Consequently, it could be valuable to compare the emotional goals with other factors observing which of these can influence technology perception.

In this context, the present study employes the AR approach, which intends to bring change to the research process through "*a spiral of steps, each of which is composed of a circle of planning, action and fact-finding about the result of the action*" [11], to investigate the achievement of emotional requirements. Particularly, the aim was to provide a perspective on a monitoring and socialization service after six months of use in terms of i) compliance with the identified emotional requirements; ii) evolution of the OA perceived stress related to the technology; iii) caregivers' perception and evaluation of the service, and factors that can influence the service perception. These three aims can help to write guidelines for other researchers and health professionals that want to design a similar long-term and real-life experimentation.

II. Material and Methods

This study was conducted in the context of "Pilots for Healthy and Active Ageing" (Pharaon) project that focused on developing integrated and customizable interoperable open platforms to promote healthy and active ageing (www.pharaon.eu). The project encompasses six large-scale pilots across five European countries (i.e. Italy, Spain, The Netherlands, Portugal and Slovenia). The Italian pilot, of which the results are reported in this article, consists of two pilot sites in the Apulia and Tuscany regions. In the first phase of the project, functional, quality and emotional requirements were outlined for OA and their caregivers thanks to a needs analysis conducted in 2020 involving 473 participants across Europe [10]. Particularly, in deep interviews with OA and their caregivers five Italian emotional requirements were identified in the context of assistive technologies for promoting independent living (See *Evaluation tools*). Starting from these requirements, two services were established and deployed with the purpose of addressing the identified needs: "health management and monitoring" (from now on "monitoring") and "socialization and inclusion support" ("socialization" from here onwards) [12].

The monitoring scenario consisted in the monitoring of the OA's physical activity and sleep through a FitBit Versa2 smartwatch (FitBit, USA), and environmental movement, humidity and/or temperature sensors (Shelly, Bulgary; QingPing Air Quality Monitor, China) connected to IoTool (Senlab, Slovenia) and ThingsBoard (ENT, Croatia). As for the functions, the OA could keep track on the total number of steps and movements performed as well as the quality of the air. The caregivers could access the dashboard (Ascora, Germany) to observe the OA's data over time. The socialization scenario utilizes a platform, installed on a TV or tablet

(Sentab, Estonia), which gives the OA the possibility to video call and share contents with the caregiver, family and friends [13].

A. Participants

Participants were recruited in Apulia at the Casa Sollievo della Sofferenza Research Hospital and in Tuscany among the network of Umana Persone Social Enterprise. A total of 64 OA was included in this study, 30 for the monitoring and 34 for the socialization scenario. The Pharaon project involves the OA and his/her caregivers. As suggested by the AR method, we asked formal caregivers (N=25) to give their own opinion regarding the services, whereas feedback from informal caregivers was not included. The study was approved by local ethical committees: in Tuscany the Azienda USL Toscana Sud-Est approved the study on the 22/07/2021 (Prot. 2021/000227) and the Area Vasta Centro on the 18/10/2022 (Prot. 22131_spe) whereas in Apulia it was approved on the 14/06/2021 (Prot. 1669/01 DG). All participants gave their written informed consent.

B. Experimental setup

At the beginning of the study (T0), the technologies were installed in the OA's homes, and after training on technology use, participants were requested to freely use the services for 12 months (T12) with an intermediate follow-up after 6 months of use (T6). The study is ongoing, and the presented results are the preliminary work from T0 to T6. Data were acquired as detailed in the *Evaluation tools* section.

This is a preprint of an article that has not yet undergone peer review. For the final, peer-reviewed version, please refer to: doi: 10.1109/EMBC53108.2024.10782413.

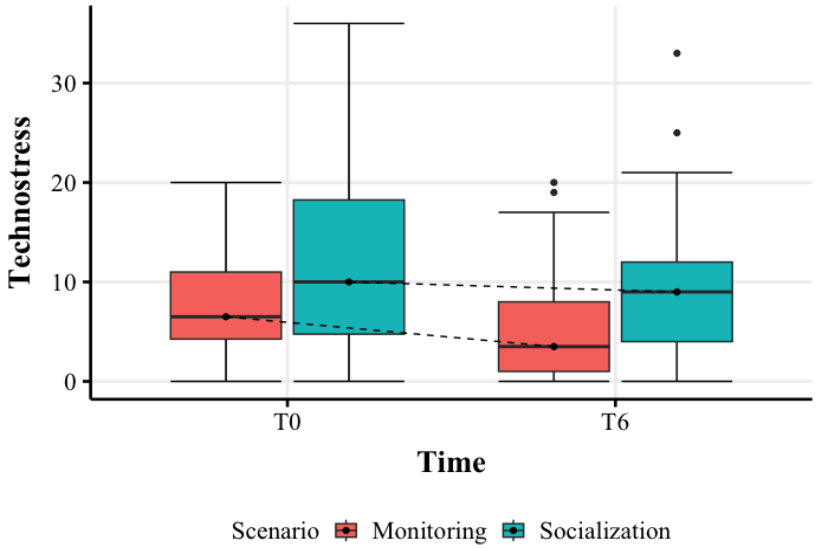

Fig. 1. Density plot of the emotional requirements for the monitoring (pink) and socialization (light blue) scenarios. The vertical line represents the median answer for each group.

As suggested by the AR approach, more information regarding how the Italian pilot was proceeding was gathered with a reflection meeting organized to critically reflect on the "results of action" after the first year of study deployment (September 2023) with formal caregivers from both pilot sites.

C. *Evaluation tools*

Data regarding OA's age, sex, educational level and digital skills were acquired at T0. Age was measured in years, sex was dichotomized as women and men, the international standard classification of education was

TABLE I. DEMOGRAPHIC CHARACTERISTICS OF OLDER ADULTS' PARTICIPANTS IN THE SOCIALIZATION AND MONITORING SCENARIOS

	Monitoring (N=30)	***Socialization (N=34)***
Age [median (IQR)]	70 (10.25)	74 (11.75)
Sex [women/men]	12/18	24/10
Education [n (%)]		
Low education (⩽9 years)	17 (56.7%)	19 (55.8%)
Medium education (⩽15years)	9 (30.0%)	12 (50.0%)
High education (>15years)	4 (13.3%)	3 (8.8%)
Digital skills [n (%)]		
None	10 (33.3%)	7 (20.6%)
Some experience	17 (56.7%)	22 (64.7%)
Advanced/Proficient	3 (10.0%)	5 (14.7%)

recoded into low (up to lower secondary education), medium (secondary education) and high (tertiary and university), whereas digital skills were graded as "none", "some experience" and "advanced/proficient". For the emotional requirements, the questionnaire was composed of 7 questions and was delivered to OA at T6. The answer options were on a 5-point Likert scale going from strongly disagree (1) to strongly agree (5). Two questions were scenario-specific and were not addressed in this article, as the focus was on the five shared emotional requirements, specifically:

- **Less stressed:** Have you felt less stressed by technology use?
- **Stay informed:** Do you feel like you have more information regarding your health?
- **Being involved:** Do you feel more involved in the interaction with technology?
- **Being empowered/more conscious about me:** Do you feel more conscious in using technology?
- **Stay secured:** Do you feel safer in using the technology?

The technostress questionnaire, adapted from the perceived stress scale [14] to measure perceived stress related to technology [15], was administered at both T0 and T6. The questionnaire was composed of 10 items measured on a 4-point scale (0=Never; 1=Almost never; 2=Sometimes; 3=Fairly often; 4=Very often). Positive worded items (i.e. 4, 5, 7, and 8) have reverse scoring. The total score is calculated by summing the item contributions and ranges from 0 to 40, with higher scores indicating higher perceived stress.

To collect feedback during the reflection meeting, a questionnaire was circulated among the formal caregivers closely working with the OA. The questionnaire was adapted to the Pharaon project and was based on the sustainability assessment identified in the ACCRA project LIFE methodology (www.accra-project.org) [16]. For the purposes of this paper, we focused on four numerical or open-ended questions related to three domains of the sustainability focus group: technical aspects, user perception and outcomes.

- **Technical aspects:** How do you evaluate the service from a technical point of view? [0-100]
- **User perception:** Which are the most important factors connected to acceptability and technology use from the perspective of the older adult? [open-ended]
- **Outcomes:** How do you evaluate the results of the effect of the service? [0-100]
- **Outcomes:** What kind of outcomes are relevant for the OA? [open-ended].

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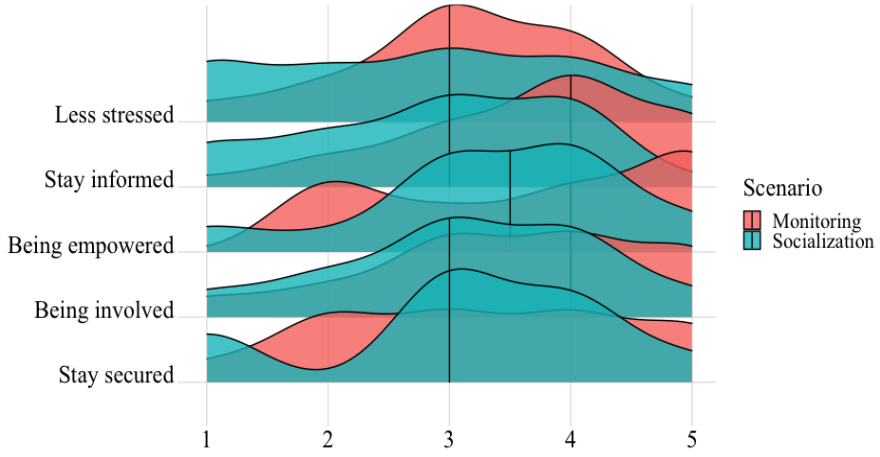

Fig. 2. Density plot of the emotional requirements for the monitoring (pink) and socialization (light blue) scenarios. The vertical line represents the median answer for each group.

D. *Data analysis*

All data analyses were conducted on RStudio (version 4.2.3) [17]. To check for demographic differences between the two scenarios, the continuous variable age was checked for normality using the Shapiro-Wilk normality test and group differences were checked using a t-test or a Mann-Whitney U test accordingly. Chi-squared/Fisher's exact test were used to check for group differences in sex, education and digital skills.

Regarding the emotional requirements and the numeric results from the reflection meeting, variables were compared between scenarios using the Mann-Whitney U test. As for the open-ended questions of the reflection meeting, a qualitative analysis of the most recurrent themes was presented.

To evaluate the change of Technostress over time, a delta variable was obtained as the difference between T0 and T6. The Shapiro-Wilk test for normality was used to check whether the deltas for each scenario were normally distributed and then a t-test or a Mann-Whitney U test were used to assess group differences.

III. RESULTS

Participant's characteristics can be found in Table 1. The two scenarios were similar in age, digital skills and education, but differed in the proportion of women and men, with more women compared to men in the socialization scenario. The emotional requirements questionnaire was filled in by 30 OA in the monitoring scenario and 32 in the socialization scenario. The monitoring scenario rated significantly higher the "stay informed" requirement compared to the socialization scenario ($p=0.005$). While the other emotional requirements were not statistically different between scenarios, the monitoring scenario rated higher "being

empowered" and "being involved" compared to the socialization scenario (Fig. 1). The difference in the Technostress score was not significant over time between scenarios, yet as shown in Fig. 2, we can appreciate a trend of the monitoring scenario in decreasing the perceived level of stress towards technology more than the socialization scenario.

Regarding the questionnaire circulated after the reflection meeting, a total of 25 (9 from Apulia and 16 from Tuscany) formal caregivers volunteered to answer. Out of the 25 participants, 14 completed the monitoring scenario questionnaire, while the other 11 answered the socialization scenario questionnaire. In examining the numerical question of the sustainability questionnaire, from a technical standpoint [0-100], the Mann-Whitney U test showed that the monitoring scenario was perceived as technically more advanced and appreciated than the socialization scenario (median for socialization=65, median for monitoring=80; p=0.018). Similarly, the monitoring scenario was evaluated higher in terms of service efficacy [0-100] (median for socialization=50, median for monitoring=77.5; p=0.047). With respect to the sustainability question "which are the most important factors connected to acceptability and technology use from the perspective of the older adult" the most discussed recurring themes were that a technology should be easy to use (N=10/25) and useful (N=8/25), which are plausible technological requisites for OA interacting with technology. On the other hand, the formal caregivers for the question "what kind of outcomes are relevant for the older adult" noted that important outcomes are the independence in using technology and increased self-confidence (N=8/25), taking the reins of their own health (N=5/25), and feeling more secured as they are monitored by health professionals (N= 2/25).

IV. Discussion and Conclusion

This paper aims to tackle three main objectives. Regarding the evaluation of meeting the emotional requirements, the results indicate an overall positive outcome. The two scenarios were comparable to one another, except for the "stay informed" item (Fig. 1). The observed difference could be attributed to how OA found it easy to infer general information about their daily physical activity simply by glancing at the smartwatch. This peculiar function was not present in the socialization scenario. Additionally, these results suggest that, despite the different technical equipment and the final purposes of the scenario, the perception of OA is comparable and so not traced back to a specific scenario. In other words, the identified needs were answered independently with respect to the technology used (scenario). However, it is worth mentioning that the average evaluation of the monitoring scenario was higher than the socialization scenario. This trend was

aligned with feedback received from caregivers, who expressed a more positive assessment of the monitoring compared to the socialization scenario. Various factors, as highlighted by formal caregivers (such as technical reliability), and the outcomes of technostress, could contribute to this divergence in results.

The second objective was to assess the impact of technology use on perceived stress related to technology. The results obtained revealed a decrease in scores between those collected at T0 and those collected at T6 for the monitoring scenario, although not significant. Indeed, this finding aligns with the technical evaluation of the formal caregiver, which indicates a higher score for the monitoring scenario due to perceived easiness of use and reliability. These findings highlight the significance of the technical reliability of each scenario, which can be linked to perceived stress related to technology which may affect the usability and acceptability of a given technology. From a system developer's perspective, it is crucial to pre-test technical solutions before long deployment and propose reliable technologies usable by individuals with low digital skills without any technical assistance. For future studies, it is essential to control this variable to maximize the emotional perception of technology.

The third objective focused on depicting the formal caregiver perception on the implemented service. The results collected underline general positive feedback on the two services. Analyzing the responses from formal caregivers, it emerged that the factors – among others – associated with the experimental outcomes are increased self-esteem and ability to independently use the system. These results can be aligned with the decrease in the value of perceived stress towards technology, even if not statistically significant (Fig. 2). Another important aspect pointed out was related to the capability of OA of having better control of his/her own condition, which is indeed related to emotional goals of “stay informed”, “being empowered” and “being involved” (Fig. 1). This is an important remark on the correspondence between the needs and the scenario proposed, which it would be interesting to explore further, conceivably by checking whether sociodemographic factors could interfere and interact with this correspondence. Summarizing these observations as guidelines for future long-term implementation, it emerged that the most important factors that can influence the perception of the services, and related emotional requirement perception, can be linked to the technical reliability, the stress related to the technology, as well as the participants’ possibility to increase their own capability to use the system alone. These factors should be controlled during the experimentation to maximize service efficacy.

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