How time, living conditions and stress related to technology influence user acceptance and usability of a socialization service for older adults and their formal and informal caregivers: a six-month pilot study

Jasmine Pani, Letizia Lorusso, Lara Toccafondi, Grazia D'Onofrio, Filomena Ciccone, Sergio Russo, Francesco Giuliani, Daniele Sancarlo, Novella Calamida, Gianna Vignani, Tarmo Phil, Erika Rovini, Filippo Cavallo, Laura Fiorini

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Abstract

Background: Considering the growing population of older adults, addressing the influence of loneliness among this demographic group has become imperative. Especially considering the link between social isolation and deterioration of mental and physical well-being. Technology has the potential of creating innovative solutions to increase socialization and potentially promote healthy aging.

Objective: This 6-month study examines the usability and acceptability of a technology-based socialization service and explores how stress and living conditions affect user perception of the older adult and his/her ecosystem, investigating cross-sectional and longitudinal differences among and across user groups.

Methods: Participants were recruited in Tuscany and Apulia (Italy) in a network of social cooperatives and a research hospital respectively. A total of 20 older adults (OA) were provided with the same technology installed on a tablet and on a smart TV. The technology has three functionalities: video-calling, games and sharing news. Additionally, 20 informal caregivers (IC) and 13 formal caregivers (FC) connected to the OA were included in the study. After the training in the use of the system (T0) and after 6 months of use (T6) questionnaires on usability, acceptability and technostress were filled in by OA, IC and FC. Non-parametric or parametric tests were conducted to investigate group differences at both time points and changes over time. Additional analyses on OA were done to assess whether differences on usability and acceptability were related to living conditions (ie, alone or with somebody). Furthermore, correlation analyses were performed between usability, acceptability and stress towards technology at T0 and T6.

Results: At both T0 and T6 OA had lower usability score than IC and FC and higher anxiety than the IC. Over time, there was a significant decrease in the OA's scores of attitudes towards technology (T0 median 4.2, IQR 0.5; T6 median 3.7, IQR 0.8; Cohen d=0.7), yet for IC and FC there was no change. At T0, those living alone had lower acceptability than those living with somebody, at T6 the difference disappeared. People or participants living with somebody had a decline in anxiety, attitudes towards technology, enjoyment and perceived usefulness. Stress towards technology affected usability and acceptability in the OA group entering the study (?=-0.85), but not after 6 months. In the IC group stress affected trust at T0 (?=-0.23), but not at T6.

Conclusions: Entering the study, OA judged the system to be less usable and more stressful than the caregivers. Indeed, technostress correlated with usability and acceptability. Yet, with repeated use technostress does not influence the perception of

technology. Overall, getting accustomed to technology decreased anxiety and stress towards technology.

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How time, living conditions and stress related to technology influence user acceptance and usability of a socialization service for older adults and their formal and informal caregivers: a six-month pilot study

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After the training in the use of the system (T0) and after 6 months of use (T6) questionnaires on usability, acceptability and technostress were filled in by OA, IC and FC. Non-parametric or parametric tests were conducted to investigate group differences at both time points and changes over time. Additional analyses on OA were done to assess whether differences on usability and

acceptability were related to living conditions (ie, alone or with somebody). Furthermore, correlation analyses were performed between usability, acceptability and stress towards technology at T0 and T6.
Results: At both T0 and T6 OA had lower usability score than IC and FC and higher anxiety than the IC. Over time, there was a significant decrease in the OA's attitudes towards technology score depicting a negative attitude over time (T0 median 4.2, IQR 0.5; T6 median 3.7, IQR 0.8; Cohen *d*=0.7), yet for IC and FC there was no change. At T0, those living alone had lower acceptability than those living with somebody, at T6 the difference disappeared. People or participants living with somebody had a decline in anxiety, attitudes towards technology, enjoyment and perceived usefulness. Stress towards technology affected usability and acceptability in the OA group entering the study (ρ=-0.85), but not after 6 months. In the IC group stress affected trust at T0 (ρ=-0.23), but not at T6.
Conclusions: Entering the study, OA judged the system to be less usable and more stressful than the caregivers. Indeed, technostress correlated with usability and acceptability. Yet, with repeated use technostress does not influence the perception of technology. Overall, getting accustomed to technology decreased anxiety and stress towards technology.
Keywords: Active aging, longitudinal study, technostress, technology usability and acceptance, scaling up

Introduction

Technological advances in healthcare research have extended the longevity of the population. However, solely increasing the lifespan does not assure healthy aging or prevent age-related diseases. One of the main complaints of older adults (OA) is feeling lonely and socially isolated, which in turn are linked to decreased mental and physical health [1,2]. In Italy, 31.5% of people aged 65 years and older have limited autonomy due to health problems [3]. In 2019 it was estimated that 11.3% of OA suffered from depression, with the presence of comorbidity, ie, of other chronic conditions. Currently, about 65% of OA with limited autonomy are helped by relatives, paid services or others [3].
In this context, technological devices may play a pivotal role in supporting daily life activities and promoting independent living. Technological devices are products that can be used to assist by increasing, maintaining or improving functional capabilities of people with disabilities or difficulties [4]. These can range from communication devices to wheelchairs or visual/hearing aids. In the context of aging, over the last years several research projects have been trying to develop technological devices to promote independent living and active aging [5,6]. Additionally, OA are experiencing new internet-driven personal devices such as smartphones and computers in their daily lives, boosted also by the effects of Covid-19 pandemic [7]. In that regard, formal caregivers (FC) and informal caregivers (IC) can play a crucial role in fostering the adoption of these technologies by OA [8].

Conversely to stereotypes, many OA show positive attitude and expectations toward technological devices [9,10]. For instance, several studies have highlighted an association between social interaction through internet use and the quality of life of the OA [11]. Internet communication provides an inexpensive tool to stay connected with friends, family, and society. However, currently, the older population for the most part is not digitally experienced and decreased cognitive and physical abilities could be a barrier to learning or using technology [12,13]. Furthermore, personal susceptibility to stress could influence performance by increasing cognitive load [14].

The settings and environments in which technological devices, products and services may be used are numerous and extend from the OA home, to nursing homes and hospitals. In an independent living situation, technologies can monitor OA by constantly monitoring their living environment, physical activity/exercise, medicine uptake, blood pressure and heart rate, but also supporting caregivers in their daily tasks [15-17]. In a survey conducted during the COVID-19 pandemic, more than half of the OA reported that they used technology to connect with others and that they adopted new technologies since the start of the pandemic. The study also indicated that one of the main factors that supported the willingness to learn was related to keeping in touch with family and specifically grandchildren [18]. The same study also highlighted that OA living in rural areas experience greater technological barriers to technology usage. Moreover, since social isolation and loneliness are associated with higher mortality risk [19], it is important to investigate ways to increase socialization and promote social connectedness, and technology could help in this matter. Indeed, although living alone has been suggested to be a risk factor for poor health, studies showed that is the social connectedness, measured with social network size, rather than the condition of living alone, that was associated with adverse health outcomes [20-22]. Furthermore results from a systematic review and meta-analysis showed that technological interventions to support OA in long-term care have one of the largest effect sizes in reducing social isolation and loneliness [23]. Regarding technology-supported interventions to improve well-being and socialization, from a recent systematic review [24] it is evident that the available studies have a short time span and less than half employ tailored solutions. The short time span between baseline and follow-up found in previous studies does not allow investigating in depth the effects of different technological devices in OA. Furthermore, as noted by an embedded case study [25] and reviews [26,27], adoption and acceptance are influenced by social influence, by family, friends, and caregivers. It is therefore important to explore the whole ecosystem that revolves around the OA to understand the reasons behind low usage of a device or user acceptance. Additionally, proposing a multi-stakeholder perspective to investigate the OA and his/her caregivers would provide an advantage and further support towards research.

In this context, this paper presents a service designed to increase socialization in the OA through a technological device. The study is part of the Pharaon project (www.pharaon.eu), which is a European large-scale pilot under the “Digitising European Industry”. The project aims to promote active aging using already available and mature platforms and technologies that are available in the project. The Pharaon project employs the action research method which entails four cyclical actions: reflect, plan, act, observe, and then reflect again to continue through the cycle. Specifically, after deployment and data collection, reflection meetings were organized to assess how the deployment was proceeding and to better plan next actions.
For this particular socialization service, the same technology was installed on two different user interfaces (UIs) a smart-TV or a tablet. This technology allowed video-calling between the OA (n=20) and their IC (n=20) and FC (n=13), and the possibility of sharing news/pictures and playing games. The service was implemented for 6 months in the home of the OA. The three cohorts were compared between each other and over time in terms of usability and acceptability in a cross-sectional and longitudinal design. Furthermore, we explored whether stress or living alone/with somebody affected user perception of the OA. Specifically, we aimed to answer the following research questions (RQ):

- RQ1: Are there any differences in acceptability and usability inter-group and between cohorts

(ie, OA, IC, FC) over time? For the OA is it related to different devices?

- RQ2: Can living conditions represent a discriminant factor for acceptance and usability of technology in OA?
- RQ3: Will stress related to technology usage affect the usability and acceptability of OA?

Methods

System service description

The type of technologies was selected on the feedback received from the OA and their caregivers during the needs analysis phase of the project. In the Italian pilot, the needs analysis led to the identification and deployment of two services: monitoring and socialization [28]. In this paper we focus only on the socialization service.

The socialization service is based on Sentab Technology (Sentab OÜ, Tallin, Estonia). The system is developed around a user interface working on the Web, Android, iOS, and Android TV. From a technical perspective, Sentab backend solution is based on Enterprise Java on Jetty, open-source RabbitMQ, and Redis dockers. Information is stored in a MySQL database on Ubuntu servers. The Content Delivery Network is built on Amazon CloudFront and S3.

In the project, two UIs were used: an Android application installed on a tablet (Apulia) and on the TV (Tuscany) and an Android application for the caregivers installed on their mobile phone. This final choice was selected on the feedback received from pilot managers as outcome of the needs assessment. It is worth underlying that the service was the same for both technologies; only the devices changed.

The OA could interact with the tablet using the touch screen, whereas for the TV a separate remote control was provided and Sentab was accessed using the arrows and an “ok” button (Figure 1). Despite the two different technologies for OA (ie, tablet or TV), the Sentab technology allows the following functionalities:

i) a video-calling function, where OA and their caregivers could video-call through the UIs;
ii) a stimulation game function, where OA can access some cognitive games (eg, sudoku, picture memory) and monitor their improvements by checking the cognitive index calculated by Sentab;
iii) a stay-informed function, where OA and IC can access news and information shared by the clinicians of the hospital regarding practices for maintaining a healthy and active lifestyle.

An overview of the socialization service can be found here: https://youtu.be/5-u5YHvVbT8?feature=shared. By connecting to their UIs, caregivers could communicate with their relative (or “assigned” OA), share photos or news.

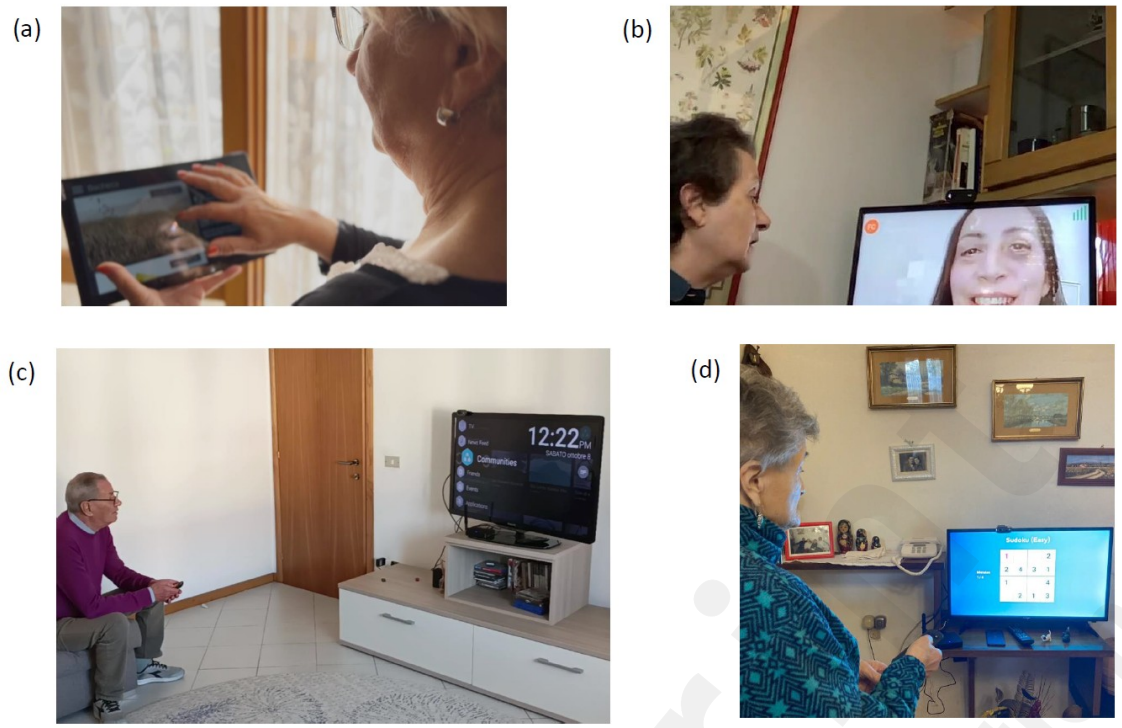

Figure 1. Photographs illustrating participants enrolled in the study. All the participants agreed and consented to have their picture taken and be used in publications. a) Older adult checking the “stay informed” function on the tablet. b) Older adult video-calling the FC on a smart TV. c) Older adult using the smart TV. d) Older adult participant using the TV game app.

Experimental protocol

The experimental protocol is composed of the following phases: installation and training, testing of technology, reflection meeting. An overview of these phases is presented in Figure 2.

As mentioned in the System service description, Tuscany and Apulia tested different devices. In Tuscany the smart TV was installed in the OA’s home and then facilitators trained them in the use of technology. On the other hand, in the Apulian pilot, facilitators trained the IC together with the OA and subsequently the tablet was given to the OA to be taken home for them to use freely. The participant could ask questions and clarifications. At the end of the training, facilitators delivered to the participants the user manual along with their contact details.

As soon as the participants felt confident with the technology, the facilitators administered the questionnaires, providing baseline data (T0). Then, participants were requested to freely use the technology and the service functionalities in their daily life. After 6 months of use (T6), they were requested to fill-in the same questionnaires administered at T0. The description of the questionnaires is reported in the Questionnaires section.

To better understand the end-users, we employed an action research approach that suggests organizing reflection meetings to critically reflect on the “results of action” [29] and to underline the lessons learned in terms of aspects that worked or not worked well in the pilot. The reflection meeting was scheduled after the first six months of use, and it involved meeting facilitators, facilitators and FCs to collect feedback. The meeting facilitators were in charge of presenting the results, foster the discussion and taking notes during the meeting.

The meeting was divided in three parts: presentation of the results of the first 6-months of use, discussion with the facilitators and FCs, and online survey. After the initial presentation, the

quantitative results were discussed to understand whether the facilitators and FCs expected or were surprised by these results, and potentially could explain them in a qualitative way. The discussion touched upon: i) the things that worked well or not worked properly; ii) the limitations of the technology; iii) findings of the study, including acceptance of the technology. After the plenary discussion, before closing the meeting, participants were asked to complete an online survey to give feedback on the main factors related to the technology readiness and its acceptability; additionally, participants were asked to outline the added values of the services for each participants' categories. The results of this meeting and survey were then aggregated to critically discuss the results of the questionnaires and to plan and suggest corrective actions for future tests.

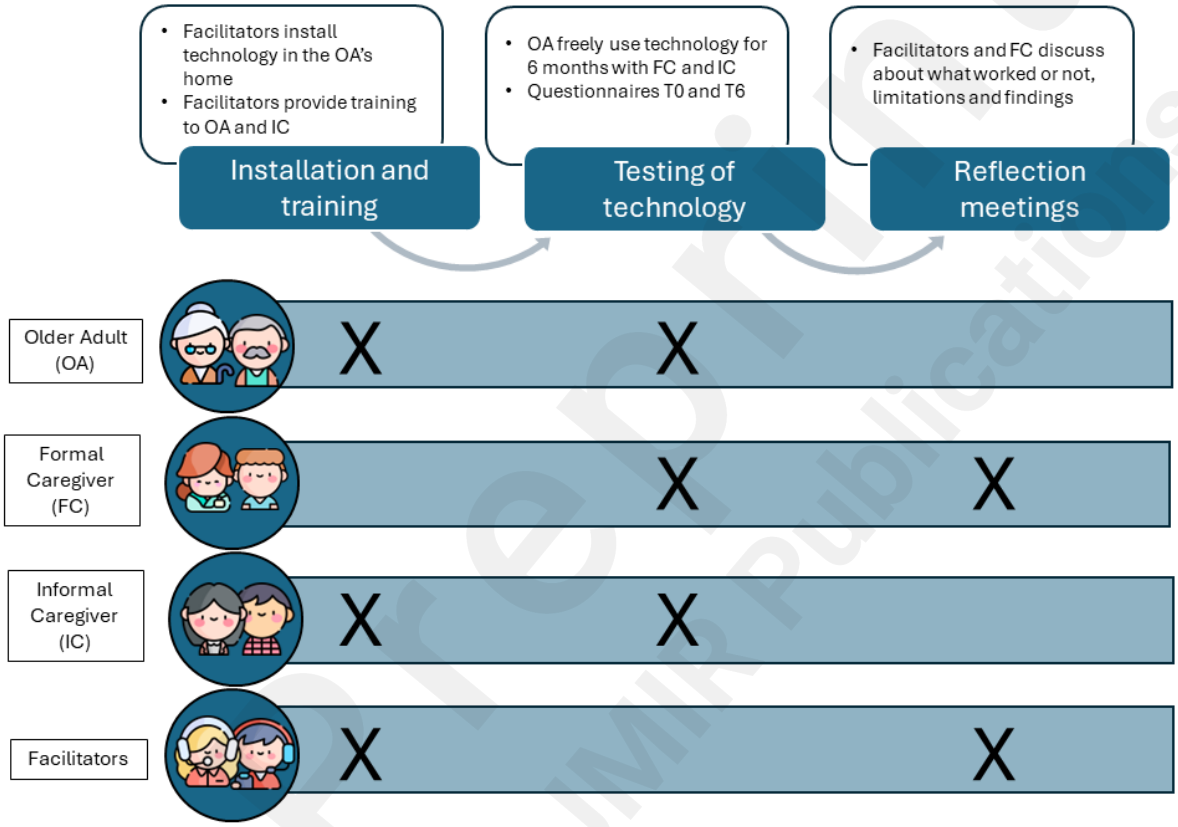

Figure 2. Graphical description of the experimental protocol of the three consecutive phases. The "X" represent whether the cohort participated or not in the phase. Icons downloaded from flaticon.com

Participants

Older adults, formal and informal caregivers

In order to achieve to paper's RQs, three cohorts of participants were recruited: OA, their IC and the FC who are the professionals in charge of their monitoring. A total of 105 people were recruited to be part of the study: 40 OA, 40 IC and 25 FC. The OA were recruited and were randomized 1:1 into a control and intervention group. The IC and FC were divided into a control and intervention group according to their OA randomization.

As for the older adults, the inclusion criteria were to be aged ≥60 years, intact cognitive status (Mini-Mental State Examination >24) and a frailty score from well to moderately frail; exclusion criteria were presence of severe cognitive impairment and other conditions that cause memory impairment or

engagement difficulties. Participants in the control group were recruited with the same inclusion and exclusion criteria of the intervention group, this group did not interact with technology and was only required to fill in the sociodemographic questionnaire. In the present study we will focus on the user experience of technology use, and thus only on the intervention group (OA: n=20; IC: n=20; FC: n=13).

Participants were enrolled in two Italian Regions (Apulia and Tuscany) that composed the Pharaon Italian Pilot. The recruitment followed different strategies in the pilots, in Apulia the IC was first recruited, whereas in Tuscany the OA was the first to be recruited. For Apulia, the participants were recruited at the “Casa Sollievo della Sofferenza” research hospital (San Giovanni Rotondo, Foggia, Italy) in different clinical units and at the University of the Third Age, and in no case they were cognitively or medically compromised. The hospital’s ethical committee approved the research on June 14th, 2021, with protocol number 89/CE. For Tuscany, the participants were recruited among people that were already experiencing home services provided by the Umana Persone (s.r.l, Grosseto, Italy) network of social cooperatives. The research was approved by the Comitato Etico Clinico, Azienda USL Toscana Sud Est on the 22/07/2021 (Prot. 2021/000227) and by the Azienda USL Toscana Centro on the 18/10/2022 (Prot. 2022/22131_spe). Furthermore, the two pilot sites used the technology either on a tablet or a smart TV according to guidelines and feedback acquired in the needs analysis [28]. All participants read and signed the informed consent form before entering the study.

Facilitators

Following action research framework and to better discuss and reflect on the RQs we also involved the facilitators, who have different professional titles ranging from engineers and cooperative managers to health professionals, and whose main task was to ease the use of technology in all three cohorts and solve the problems that could arise during the experimentation. Additionally, facilitators installed the technology and delivered the training to the intervention group and administered the questionnaires.
A total of 20 participants joined the reflection meeting: 5 participants from the University of Florence who acted as meeting facilitators, 3 participants from the Apulian pilot site (Casa Sollievo della Sofferenza Research Hospital) and the remaining (12) participants from the Tuscan pilot site (Umana Persone network of social cooperatives). Only 8 facilitators (3 from the Apulian and 5 from the Tuscan pilot) agreed to fill in the final survey.

Questionnaires

To gather information about the participants’ characteristics, sex, age, education, and living conditions/environment were collected through a semi-structured interview at the beginning of the study. The Mini-Mental State Examination (MMSE) [30] was administered to assess the OA’s cognitive status.
The usability was measured with the system usability scale (SUS) [31] Italian version [32] composed of 10 items on a 5-point Likert scale where 1 stands for strongly disagree and 5 stands for strongly agree. Items 2,4,6,8,10 need to be reversed. The total SUS score is obtained by adding all the score contributions and multiplying the sum by 2.5. The SUS ranges from 0 to 100, scores lower than 68 are considered below average.
The acceptance was evaluated through the Almere model questionnaire (AMQ) [33] which is composed of 41 items on a 5-point agreement Likert scale. The AMQ is composed of 12 constructs created by combining specific items: anxiety (ANX), attitude toward technology (ATT), facilitating conditions, intention to use (ITU), perceived adaptiveness, perceived enjoyment (ENJ), perceived

ease of use, perceived sociability, perceived usefulness (PU), social influence, social presence, and trust (TRUST). We investigated 6 of these 12 constructs: ANX, ATT, ITU, ENJ, PU, and TRUST. Please note that ANX is reversed, therefore a higher ANX score translates to lower levels of anxiety.
To measure the quantity of perceived stress related to technology use (Technostress), the Perceived Stress Scale [34] Italian version [35] adapted as in [36] was administered. The test comprises 10 items with a 0-4 Likert scale with 0 meaning never and 4 very often. Items 4,5,7,8 have reverse scoring. The total score is calculated as the sum of the single item contributions. A total score from 0 to 13 is considered low stress, from 14 to 26 moderate stress, from 27 onwards high stress.
At T6 participants were also asked to estimate how frequently they used technology by asking how many times they used it per day and per month.

A schematic overview of when and to whom the questionnaires were administered is presented in Table 1.

Table 1. Overview of the questionnaires along with information on their administration at either T0 and/or T6, and the target (older adult, informal and formal caregivers).

Interview/questionnaires	Reference	T0	T6
Semi-structured interview:			
Age	-	OA, IC	-
Sex	-	OA, IC	
Education	-	OA, IC	
Digital skills	-	OA, IC	
Living conditions (alone/not alone)	-	OA	-
Living environment (urban/rural)	-	OA	-
Technology usage question	-	-	OA
Questionnaires:			
MMSE	[30]	OA	-
SUS	[31]	OA, IC, FC	OA, IC, FC
AMQ	[33]	OA, IC, FC	OA, IC, FC
Technostress	[36]	OA, IC, FC	OA, IC, FC

Statistical Analysis

We performed statistical analyses to evaluate longitudinal intra-group and cohort differences in usability and acceptability in the OA, IC, and FC. Moreover, we investigated the effect of the OA's living condition (ie, living alone or with somebody) and stress related to technology on usability and acceptability. Each analysis is described in detail in the following subparagraphs. For each questionnaire, we calculated the reliability with the Cronbach α metric. Given the low sample size, a value of .6 or higher was deemed acceptable [37,38]. Effect sizes of significant results were calculated with Cohen *d*. In the statistical tests performed, a P value <.05 was considered statistically significant. Statistical analyses and graphical illustrations were performed on RStudio [39] (version 4.2.3).

Differences in usability and acceptability

Data for SUS and AMQ was checked for normality using the Shapiro test. For changes over time in each cohort (intra-group), we checked for normality the distribution of the differences between T0 and T6. If the data was normally distributed, we performed a paired *t* test to examine differences over time, otherwise a paired Wilcoxon test was preferred. For OA, additional analyses were performed to

investigate differences between pilot sites.
Two-way mixed ANOVA was used to compare the scores for OA, IC, and FC at T0, T6 and changes over time (cohort differences). For OA and IC, the models were also repeated including age and sex in the model to account for demographic differences in the two cohorts. If there was a statistically significant effect, post-hoc pair-wise *t* test were Bonferroni corrected.

Effects of living condition on usability and acceptability in older adults

For OA, *t* test was performed to investigate the effects of living conditions (ie, alone or with somebody) at T0 and T6, and paired *t* test was employed to assess change over time between T0 and T6.

Effects of stress towards technology on usability and acceptability

For the OA, IC and FC groups, correlations were performed between technostress, SUS, and AMQ. Data for technostress, SUS and AMQ was checked for normality using the Shapiro test. If data was normally distributed the correlation was Pearson's, otherwise it was Kendall's.

Results

Participants characteristics

The demographic and cognitive characteristics as well as technostress at T0 and T6 for the OA and IC are presented in Table 2.

Table 2. Demographic and cognitive characteristics at T0, and stress towards technology at T0 and T6 in the older adult (OA) and informal caregiver (IC) group.

Characteristics	**OA** **n=20**	**IC** **n=20**
Age (years), mean (SD)	77.15 (7.07)	47.85 (13.10)
Sex, women, n (%)	14 (70%)	9 (45%)
Education, n (%)		
Primary education	13 (65%)	0 (0%)
Secondary education	5 (25%)	10 (50%)
Tertiary education	2 (10%)	10 (50%)
MMSE, median (IQR)	26.45 (6.55)	-
Technostress, median (IQR)		
T0	13 (11.50)	7.00 (9.25)
T6	10.50 (3.50)	5.50 (5.50)

Note. Cognitive testing was not conducted in the IC group (-). Median values and IQR are presented when the variables were not normally distributed.

Participants on average used the technology four times a week. Overall, 85% (17/20) of the OA lived in an urban area, 60% (12/20) of the OA lived with somebody, of which 42% (5/12) lived with their IC. The OA's associated FC consisted of 69% (9/13) women. The FC had various professions ranging from psychologists and nurses to care workers. No other demographic information was collected for FC.

Differences in usability

Intra-group and pilot site differences in usability

The Cronbach α for the SUS in all groups was higher than .6 both at T0 and at T6.
In the OA group, the distribution of the difference over time in the whole sample was not significantly different from a normal distribution, and normality was assumed. The mean SUS increased slightly over time; however, this increase was not significant (Figure 3).
Both the Apulian and Tuscan pilot difference over time was distributed normally, still, there was no significant change over time. The mean of the Tuscan pilot increased, and the standard deviation decreased, whereas in the Apulian pilot mean SUS score decreased from T0 to T6 (Apulia T0: 70.8, T6: 66.5; Tuscany T0: 45.0, T6: 49.8).
In the IC group, the distribution of the differences over time in the whole sample was not significantly different from a normal distribution, whereas it was normally distributed for the FC group. The SUS did not change over time in both groups (Figure 3).

Cohort differences in usability

Two-way mixed Anova with group (OA, IC, and FC), time and group*time interaction showed an effect of group on SUS, but not of time or group*time interaction. Post-hoc pair-wise *t* test showed a significant difference between OA and IC at T0 (OA: mean 57.9, SD 18.9; IC: mean 72.4, SD 16.5; *P*=.003; Cohen *d*=0.8) and T6 (OA: mean 58.2, SD 11.7; IC: mean 73.8, SD 10.9; *P*=.001; Cohen *d*=1.4), and between OA and FC both at T0 (FC: mean 68.8, SD 16.2; *P*=.04; Cohen *d*=0.6) and T6 (FC: mean 70.8, SD 14.6; *P*=.02; Cohen *d*=0.9) (Figure 3). The difference between OA and IC was not statistically significant when considering age and sex in the model. At both time points the OA had significantly lower SUS than the IC and FC. The difference between OA and FC was not statistically significant after post-hoc Bonferroni correction.

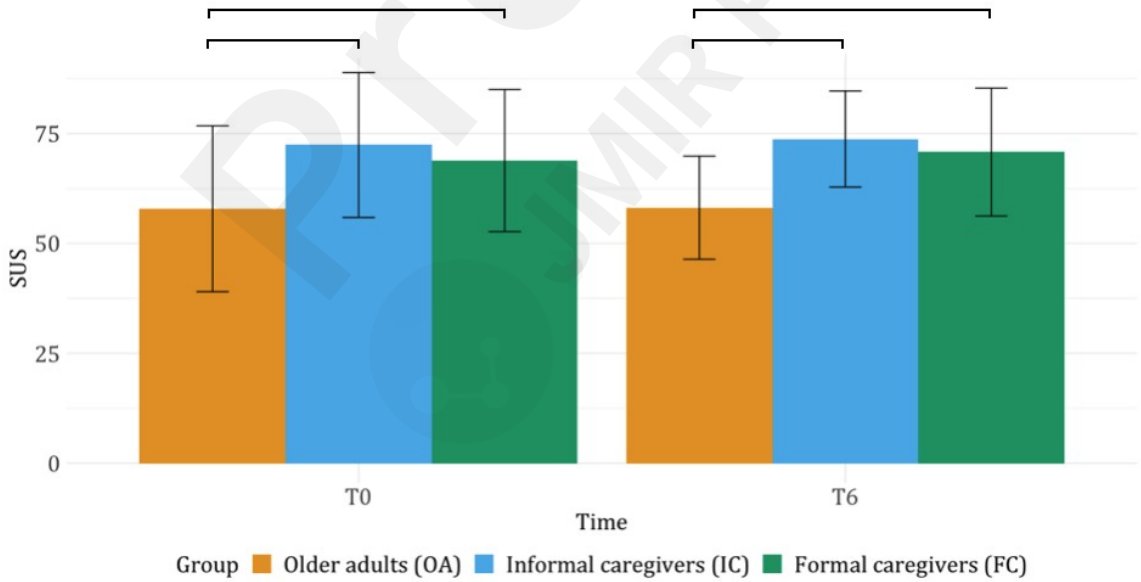

Figure 3. System usability scale (SUS) score in older adults (OA), informal caregivers (IC) and formal caregivers (FC) at T0 and T6. The error bars represent the standard deviation for each group. The bracket highlights statistical difference between groups. Note that the difference between OA and FC at T0 and T6 is not significant after post-hoc Bonferroni correction.

Differences in acceptability

Intra-group and pilot site differences in acceptability

For the OA and IC groups, Cronbach α for each construct of the AMQ was higher or equal to .7 at T0 and at T6. In the FC group, at T0 Cronbach α was higher than .6 for all constructs except PU that was .2. At T6 the reliability was higher than .7 for all AMQ constructs.
In the OA group, for ITU and TRUST the distribution of the difference over time was not different from a normal distribution. The distributions of the difference over time in the other constructs (ie, ANX, ATT, ENJ, TRUST) were not normal.
ATT significantly decreased (*P*=.01; Cohen *d*=0.7), whereas the other constructs did not significantly increase or decrease over time (Figure 4). In the Apulian pilot there was a significant decrease in ANX over time (T0: 4.9 and T6: 4.3; *P*=.03; Cohen *d*=1.0), but no other significant changes in constructs were found. No changes in AMQ constructs over time were found in the Tuscan pilot (see Supplementary Table 1 for mean and median values).
In the IC group, the distribution of the differences was different from a normal distribution for ANX, but the distribution of the differences for other constructs could be assumed to be normal. In the FC group, the distribution of the differences in all constructs was not different from a normal distribution. There was no significant change over time in any construct in either IC or FC groups (Figure 4).

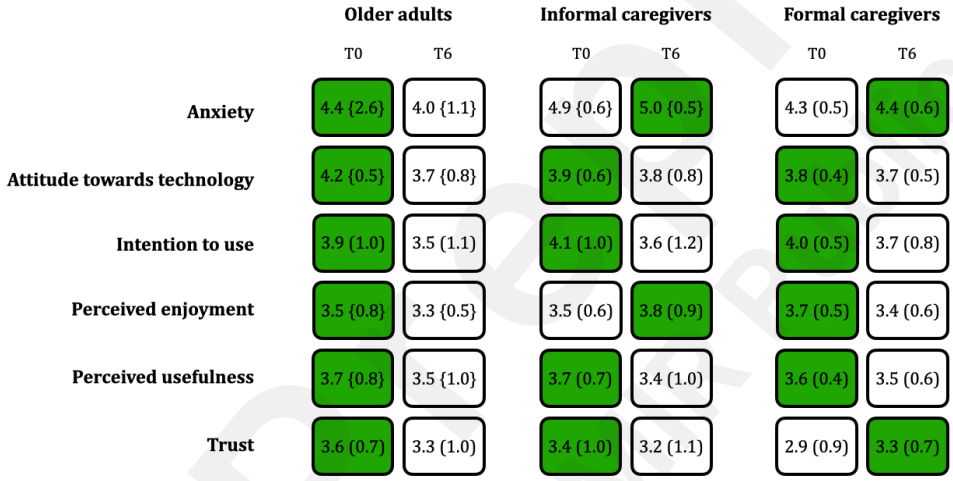

Figure 4. Mean values and standard deviations in parentheses for all acceptability constructs in the older adults, informal caregivers, and formal caregivers at T0 and T6. Green background highlights the higher value for each row, either at T0 or at T6. Note that values are mean (SD) or median {IQR} according to the normality of the differences over time.

Cohort differences in acceptability

Two-way mixed Anova with group (OA, IC, and FC), time and group*time interaction showed an effect of group on ANX, and time for ATT and ITU. No other group, time or group*time interactions were found.
For ANX, post-hoc pair-wise *t* test showed a significant difference between OA and IC both at T0 (*P*=.005, Cohen *d*=0.7) and T6 (*P*=.002, Cohen *d*=1.2), with OA having higher anxiety than the IC. This difference disappears when accounting for age and sex in the model. For ATT, there was a significant effect of time only in the OA as discussed in the Intra-group differences in acceptability (Figure 4). There was no effect of time on ITU for any group. The significances remained after post-hoc Bonferroni correction.

Effects of living condition on usability and acceptability in older adults

For usability, at T0 and T6, there was no difference between those living alone and those living with somebody. There was no significant change over time in SUS in either living conditions.
For acceptability, at T0 those living alone had significantly lower AMQ constructs than those living with somebody (ANX *P*=.02, Cohen *d*=1.1; ATT *P*=.04, Cohen *d*=0.9; ITU *P*=.01, Cohen *d*=1.3; ENJ *P*=.03, Cohen *d*=1.0; PU *P*=.01, Cohen *d*=1.4; TRUST *P*=.01, Cohen *d*=1.3). After 6 months, the difference disappeared (see Supplementary Table 2 for mean and median values).
In OA living alone there was no change in AMQ constructs over time, whereas in those living with somebody ANX, ATT, ENJ, and PU declined over time (ANX *P*=.03, Cohen *d*=0.7; ATT *P*=.02, Cohen *d*=0.8; ENJ *P*=.03, Cohen *d*=0.7; PU *P*=.04, Cohen *d*=0.6) (see Supplementary Table 2 for mean and median values).

Effects of stress towards technology on usability and acceptability

Older adults

At T0 the ANX and ITU constructs of AMQ, and at T6 Technostress, ITU and PU were not normally distributed and thus correlations with these constructs were Kendall's. We found out that technostress was highly negatively correlated with SUS and TRUST and moderately negatively correlated with ANX and ENJ (Figure 5A). After 6 months, Technostress was not associated with SUS nor AMQ (Figure 5A).

Informal caregivers

In the IC group, at T0 Technostress, ANX, ITU, PU and TRUST and at T6 ANX, ITU and PU were not normally distributed. At T0 Technostress was significantly negatively correlated with TRUST, yet Technostress was not associated with SUS or other acceptability constructs (Figure 5B). After 6 months the significant correlation between Technostress and TRUST was no longer present (Figure 5B).

Formal caregivers

ENJ and PU at T0 and Technostress, SUS, ANX and TRUST at T6 were not normally distributed. At T0 there was a significant moderate negative correlation between Technostress and ATT and between Technostress and PU (Figure 5C). At T6 Technostress was moderately negatively correlated with SUS and with ITU, there were no other significant correlations between Technostress and AMQ constructs (Figure 5C).

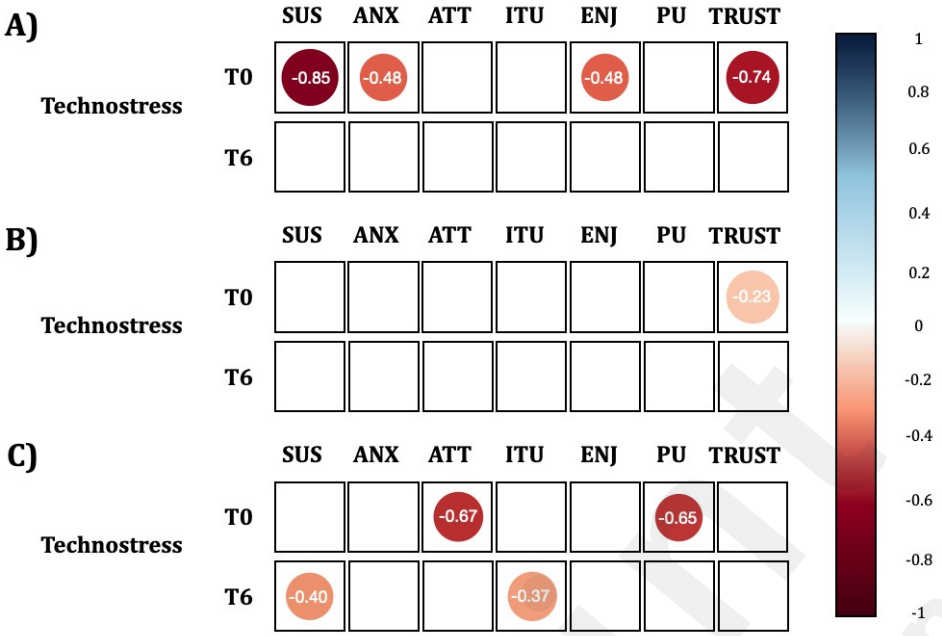

Figure 5. Correlations between stress towards technology (Technostress) and user experience (SUS and AMQ constructs) in A) older adults B) informal caregivers and C) formal caregivers, at T0 and at T6. Only statistically significant results are presented.

Results of the reflection meeting with facilitators

The reflection meeting lasted 2 hours and began with the presentation of the results, followed by a discussion. The discussion focused on the personal experiences and perceptions facilitators and FC had, and then touched upon things that worked properly or not, technical limitations and findings. The collected feedback was transcribed and combined with the responses collected by means of questionnaire that dealt similar topics. These arguments were aggregated and then summarized into concepts that could limit the use of technology. The identified barriers are summarized here below and were used to discuss the quantitative results:

- **Digital Skills** - All facilitators highlighted that in Italy the educational level and the digital skills of OA are low, an aspect confirmed by other studies [40]. These contextual factors could represent a barrier at the entrance of the study. Particularly, facilitators noticed differences in the ATT between the OA aged 65 to 70 years old and 70+ OA. Also, they stated that young OA were more skilled and "ready" to accept the technology compared to the other group. Indeed, younger OA are more likely to have a smartphone and use apps for text messaging (eg, WhatsApp).
- **Recruitment** – The facilitator, during the meeting, underlined some difficulties they had in recruiting the OA and IC. As mentioned in the Methods section, the two pilots used two different strategies for recruiting people, in Apulia facilitators first recruited the IC by asking if they would like to participate in the study with her/his older relatives. Conversely, in Tuscany the OA were the first to be recruited. Facilitators also noticed that OA were more likely to agree to be part of the study when they were part of domiciliary services (Tuscany pilot) or if they already have a relationship of trust with them. During the meeting the facilitator exchanged ideas and strategies to optimize the recruitment in the pilots.
- **Technology reliability and ease of use** – Technology reliability is affecting the user experience; indeed, facilitators indicated when there were some issues with the technology such as "internet connection issues" or "other bugs", then there was a negative influence on

the experience, whereas easiness of use was one of the key factors that positively influenced the overall user experience. During the meeting, the Tuscan facilitators reported some difficulties for OA in accessing the service because the user is requested to switch the “input” source on the TV before using the Sentab technology, and the remote needed to be pointed directly at the Sentab box instead of the TV. This procedure was considered confusing and complex. It was also noticed that after training, although the OA was able to make the input-switch and was able to use the technology, they tended not to use it independently. This feedback reflects the usability data; indeed, the OA’s usability is lower in the Tuscan pilot than in the Apulian one. However, OA who were more motivated in using the technology used it without problems, this was the case of a 90-year-old enrolled in Tuscany that loved the sudoku game. On the contrary, the Apulian facilitators did not experience any barriers related to technology use (ie, tablets). Indeed, they confirmed that it was the right technology for the OA population enrolled in the study. Specifically, OA in Apulia appreciated the size of the digital keyboard letters they were using.

- **Training** – Facilitators observed and reported that OA had some prejudice and mistrust of new technologies; therefore, we believe that the initial contact and explanation of the project must be effective. Facilitators noticed that OA often forgot the instructions for the technology, therefore a more effective training should be composed of multiple training sessions. Indeed, facilitators decided to call back the OA after the initial training during the first weeks of testing to refresh the instructions.
- **Cognitive and living condition profile** – Facilitators underlined that the cognitive profile may impact technology acceptance. Additionally, the OA’s cognitive profile may also impact the understanding of the questionnaire, indeed the facilitators noticed that sometimes the OA did not fully understand the questions. Facilitators also noticed some differences in technology perceptions linked to their living conditions, namely that the OA living alone were overall more enthusiastic and perceived the technology as more useful than those living with somebody, qualitatively confirming the research hypothesis.
- **Engagement** – Facilitators underlined that the engagement and the use of the technology were related to finding the intrinsic motivation and the added value the technology may have on the OA’s life. Additionally, another suggestion from the facilitator was to foster interaction with other people using the same technology. As a matter of fact, OA appreciated the presence of the operator and if and when they were unable to play a game, they called the facilitators. In Apulia, the facilitators re-explained the game to one OA, and she really enjoyed the technology. Therefore, if the OA are appropriately stimulated, they consequently use the technology. For instance, in case of the “stay-informed” functionality, the periodical publication of news acted as a "stimulus", so the OA were more likely to read it. Additionally, facilitators were concerned that technology could be used by the OA not for the socialization service per se, but more as means to foster the relationship with the caregiver. Indeed, in projects such as Pharaon, when the participant is recruited, he/she experiences more physical presence and connection with the operator compared to the usual home assistance service. Therefore, conceivably, the OA tends to use the technology only with the operator and not independently, because they do not know how to use it without assistance and/or do not have a real reason to use it.

Discussion

This paper aims to investigate the role of time in using technologies, living conditions and technostress in OA and their caregivers that were employing a technological device aimed at increasing OA’s socialization.

Principal Results and comparison with the state of the art

The first research question aimed to investigate the role of time in technology perception intra-group and between cohorts of participants (RQ1). As for the acceptance evaluated intra-group, except for ATT, the differences reported in Figure 4 are just trends being that they are not statistically significant. It is worth mentioning that the OA values for ITU (T0=3.88, T6=3.53) and ATT (T0=4.20, T6=3.65) were comparable to the intention of use and attitude measured in a related work (ITU = 3.34, ATT = 3.73) [41]. Moreover, values for ENJ, TRUST and PU were similar to those of an older Chinese sample, demonstrating that the values we uncovered are aligned with the literature [42], even though in a population geographically different. Please note that the Authors evaluated ITU and ATT with different models, but these constructs had comparable items. Additionally, in this study we observed a decrease of ATT for all the three cohort of participants over time. This result is aligned with the feedback collected during the reflection meeting, indeed the facilitators emphasized how the engagement is strongly interconnected with the personal intrinsic motivation that leads to long-term use of the technology. It was also noted that, contacting the OA through the technology in terms of video-calling or news sharing by the FC or IC helped in maintaining the participant engaged. The higher value of ATT at T0 may be due to the OA's initial high expectation. Nevertheless, despite the decrease in the ATT, the participants declared to have used the system on average four times a week.

It is also worth noting that we observed a higher TRUST value for the FC after use compared to the other two cohorts. Higher trust is important because trust is strictly linked with the use of technology. These results are aligned to the feedback collected during the reflection session that underlined a mistrust of some participants in technology use at the beginning of the study, during the training session.

The usability was rated differently between OA and their caregivers, which on average rated the system higher through SUS. These results are aligned with a recent survey [10] that underlined a different attitude and expectation toward technology according to the age group. Indeed, the statistical difference between the OA and IC group disappeared when including age and sex as controlling variables. Other than age and sex, there could be also other factors that contribute to this result such as the OA’s digital competence. Furthermore, as written in the “Results of the reflection meeting with facilitators” session under “Technology reliability and ease of use”, it emerged that in Tuscany the system was perceived as more difficult to use by OA, and they needed the caregivers' support to use it. Nevertheless, despite the lower values, the usability for the OA increased over time even though not significantly. This suggests that OA overcame their initial technical barrier and learned how to use the system, and this was independent of their living situation. Facilitators also underlined those technical problems which occurred during the trial or problems the OA experienced in the use of the technology negatively impacted technology acceptance, as remarked by Peek et al. [27].

As for the Apulian pilot, there was a decrease in ANX, which translates in an unexpectedly higher anxiety perception (see Supplementary Table 1 for mean and median values). On the other hand, in the Tuscan pilot there was no significant decrease or increase in acceptability. Yet, it is also worth noting that the recruitment of the OA in the Tuscan cohort was performed among domiciliary care services and thus with OA with higher fragility and lower MMSE index compared to the OA in the Apulian pilot site, which can somehow influence the perception of the technology. This remark was also highlighted in the reflection meeting. The difference in user experience between pilots could be related to the different types of technology (TV and tablet) selected at the beginning of the study, or to the slightly different profile of the two cohorts of OA involved in the two pilot sites.

Research Question 2 aimed to investigate the role of living condition in the acceptance perception, we found that those living alone had significantly lower AMQ constructs compared to those living with somebody. However, this difference disappears at T6. It should also be pointed out that those living with somebody had decreased ANX, ATT, and PU over time indicating that the anxiety towards the system increased, and the usefulness and attitude towards technology lowered, suggesting that having somebody helping in using the system may remove the perceived usefulness of using the technology. This finding could suggest that the living condition may play the role of a barrier at the beginning of the study: people that are living alone may be more skeptical at the beginning of the study, whereas on the contrary, people who are living with somebody may have higher expectations yet the reality-check of 6 months of use led to disappointment which lowered the acceptability of the system.

Finally, this paper aimed to investigate how the stress related to technology may affect the acceptance and the usability of a certain technology (RQ3). The results underlined a strong correlation between technostress and usability, anxiety, enjoyment, and trust in the OA at T0 (Figure 5A), but all the correlations disappeared at T6. The results obtained at T0 are aligned with our previous findings [36] where we highlighted a dependence between the perceived stress and related acceptance. However, these results may suggest that technostress could be a barrier only at the beginning of the study, but as soon as the OA becomes familiar with the technology, the dependence disappears. To mitigate the effects of stress at the beginning of the study proper training sessions should be organized. These sessions ought to be devoted to successfully teaching “how to use” the technology and to re-call the functionality of the system after the training session, adapting the training to the participant’s cognitive and educational level. As remarked by facilitators, oftentimes OA forget how to properly use the devices and tend not to use them unless the facilitators re-taught them how to use the technologies. Indeed, well-conceived training is a key feature of success and critical for technology acceptance.

In the caregivers, at T0, in the IC group higher perceived stress was a barrier to trust technology, and in the FC group stress affected attitude and usefulness of technology, possibly because of fear of substitution or the worry that the technology be extra work for them [39-41]. Nevertheless, the correlations were not significant at T6 (Figure 5B-C). This underlines how technology related stress for the proposed socialization service can be a barrier to technology acceptance and since caregivers can influence the OA’s perception of technology, it is crucial to include them in the study in a multistakeholder perspective to support and reassure their OA and promote a positive attitude towards technology.

Limitations

The main limitations of this work are the sample sizes and the duration of the test phase (6 months) as well as different recruitment carried out in the two different sites. As for the sample size we aim to increase the number of participants in the two pilots tracking their cognitive abilities thus evaluating the effect of this variable in the use of the technology. Further studies should also be planned to extend the duration of the testing phase, given that our preliminary results at 6 months seem to be not enough to get information regarding the impact of this service in real life. This is also of interest to policymakers who are coping with staff shortages and increasing health care expenses. Another encountered limitation was also the different recruitment process and the lack of randomization for the technologies. These factors can all contribute to different results between samples, researchers should think about standardizing the procedure as much as possible to reach generalizable results. Future studies should also investigate the factors that may influence the low use of the technology and come up with countermeasures to encourage the use of technology, which can also have an

impact on acceptability [27].

Conclusions

This paper investigates the role of time, living conditions and stress related to technology use on the usability and the acceptance of a socialization service. This manuscript presents the results collected after 6 months of use considering a multi-stakeholder perspective. In this study we uncovered that the OA has higher stress and anxiety towards technology than the caregivers. Nevertheless, getting accustomed to technology through 6 months of use removed this initial barrier. It is also important to consider the living situation of the OA as those living alone had lower acceptability than those living with somebody, which could suggest an increased resistance to change. However, counterintuitively, the OA living with somebody had a decrease in enjoyment, usefulness, and attitudes towards technology, possibly because living with somebody limits the need of the OA to socialize with others. The reflection meeting with the facilitators qualitatively highlighted demographic barriers in the use of technology that should be further evaluated quantitatively.

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Authors’ Contributions

JP and LF wrote the original draft. JP performed all formal analyses and graphical visualization. Investigation, resources, and data collection were conducted by LL, F Ciccone, LT, SR, FG, GV. LL and NC oversaw data curation and LL, DS, GD, F Ciccone and NC data collection. TP was responsible for the software. ER and LF provided supervision. ER together with F Cavallo were project administrators. LF and F Cavallo conceptualized the work and F Cavallo managed funding acquisition. All authors provided input to the draft, discussed the results, and reviewed the final manuscript.

Conflicts of Interest

None declared

Abbreviations

AMQ – Almere model questionnaire
ANX – anxiety
ATT – attitude towards technology
ENJ – enjoyment
FC – formal caregiver
IC – informal caregiver
ITU – intention to use
MMSE – mini mental state examination
OA – older adults

PU – perceived usefulness
RQ – research question
SUS – system usability scale
T0 – time point 0; beginning of the study
T6 – time point 6; after 6 months from baseline
UI – user interface
VAS – visual analogue scale

References

1. Cornwell EY, Waite LJ. Social disconnectedness, perceived isolation, and health among older adults. J Health Soc Behav 2009;50(1). doi: 10.1177/002214650905000103
2. Golden J, Conroy RM, Lawlor BA. Social support network structure in older people: Underlying dimensions and association with psychological and physical health. Psychol Health Med 2009;14(3). doi: 10.1080/13548500902730135
3. ISTAT. LE CONDIZIONI DI SALUTE DELLA POPOLAZIONE ANZIANA IN ITALIA. 2019.
4. Zallio M, Ohashi T. The Evolution of Assistive Technology: A Literature Review of Technology Developments and Applications. Human Factors in Accessibility and Assistive Technology 2022. doi: 10.54941/ahfe1001646
5. Calvaresi D, Cesarini D, Sernani P, Marinoni M, Dragoni AF, Sturm A. Exploring the ambient assisted living domain: a systematic review. J Ambient Intell Humaniz Comput Springer Verlag; 2017 Apr 1;8(2):239–257. doi: 10.1007/S12652-016-0374-3/METRICS
6. Ganesan B, Gowda T, Al-Jumaily A, Fong KNK, Meena SK, Tong RKY. Ambient assisted living technologies for older adults with cognitive and physical impairments: A review. Eur Rev Med Pharmacol Sci Verduci Editore s.r.l; 2019;23(23):10470–10481. PMID:31841201
7. Smith EM, Hernandez MLT, Ebuenyi ID, Syurina E V., Barbareschi G, Best KL, Danemayer J, Oldfrey B, Ibrahim N, Holloway C, Maclachlan M. Assistive Technology Use and Provision During COVID-19: Results From a Rapid Global Survey. Int J Health Policy Manag Int J Health Policy Manag; 2022 Jun 1;11(6):747–756. PMID:33201656
8. Øksnebjerg L, Woods B, Ruth K, Lauridsen A, Kristiansen S, Holst HD, Waldemar G. A tablet app supporting self-management for people with dementia: Explorative study of adoption and use patterns. JMIR Mhealth Uhealth 2020;8(1). doi: 10.2196/14694
9. Mitzner TL, Boron JB, Fausset CB, Adams AE, Charness N, Czaja SJ, Dijkstra K, Fisk AD, Rogers WA, Sharit J. Older Adults Talk Technology: Technology Usage and Attitudes. Comput Human Behav Comput Human Behav; 2010 Nov;26(6):1710–1721. PMID:20967133
10. Offerman J, Fristedt S, Schmidt SM, Lofqvist C, Iwarsson S. Attitudes related to technology for active and healthy aging in a national multigenerational survey. Nature Aging 2023 3:5 Nature Publishing Group; 2023 Apr 6;3(5):617–625. PMID:37118552
11. Aggarwal B, Xiong Q, Schroeder-Butterfill E. Impact of the use of the internet on quality of life in older adults: Review of literature. Prim Health Care Res Dev. 2020. doi: 10.1017/S1463423620000584
12. Yazdani-Darki M, Rahemi Z, Adib-Hajbaghery M, Izadi F. Older adults' barriers to use technology in daily life: A qualitative study. Nurs Midwifery Stud 2020;9(4). doi: 10.4103/nms.nms_91_19
13. Wildenbos GA, Peute L, Jaspers M. Aging barriers influencing mobile health usability for older adults: A literature based framework (MOLD-US). Int J Med Inform. 2018. PMID:29673606
14. Kim SY, Park H, Kim H, Kim J, Seo K. Technostress causes cognitive overload in high-stress

people: Eye tracking analysis in a virtual kiosk test. Inf Process Manag 2022;59(6). PMID:36119755
15. Al-Shaqi R, Mourshed M, Rezgui Y. Progress in ambient assisted systems for independent living by the elderly. Springerplus SpringerOpen; 2016 Dec 1;5(1):1–20. doi: 10.1186/S40064-016-2272-8/FIGURES/3
16. Cavallo F, Aquilano M, Bonaccorsi M, Limosani R, Manzi A, Carrozza MC, Dario P. Improving domiciliary robotic services by integrating the ASTRO robot in an AmI infrastructure. Springer Tracts in Advanced Robotics 2014. doi: 10.1007/978-3-319-02934-4_13
17. Fiorini L, Rovini E, Russo S, Toccafondi L, D'Onofrio G, Cornacchia Loizzo FG, Bonaccorsi M, Giuliani F, Vignani G, Sancarlo D, Greco A, Cavallo F. On the Use of Assistive Technology during the COVID-19 Outbreak: Results and Lessons Learned from Pilot Studies. Sensors 2022;22(17). PMID:36081090
18. Haase KR, Cosco T, Kervin L, Riadi I, O'Connell ME. Older adults' experiences with using technology for socialization during the COVID-19 pandemic: Cross-sectional survey study. JMIR Aging. 2021. PMID:33739929
19. Freedman A, Nicolle J. Social isolation and loneliness: The new geriatric giants Approach for primary care. Canadian Family Physician 2020;66(3). PMID:32165464
20. Tang D, Lin Z, Chen F. Moving beyond living arrangements: the role of family and friendship ties in promoting mental health for urban and rural older adults in China. Aging Ment Health 2020;24(9). PMID:30977378
21. Hamid TA, Din HM, Bagat MF, Ibrahim R. Do Living Arrangements and Social Network Influence the Mental Health Status of Older Adults in Malaysia? Front Public Health 2021;9. PMID:34026706
22. Sakurai R, Kawai H, Suzuki H, Kim H, Watanabe Y, Hirano H, Ihara K, Obuchi S, Fujiwara Y. Poor Social Network, Not Living Alone, Is Associated With Incidence of Adverse Health Outcomes in Older Adults. J Am Med Dir Assoc 2019;20(11). PMID:31000349
23. Hoang P, King JA, Moore S, Moore K, Reich K, Sidhu H, Tan CV, Whaley C, McMillan J. Interventions Associated with Reduced Loneliness and Social Isolation in Older Adults: A Systematic Review and Meta-analysis. JAMA Netw Open. 2022. doi: 10.1001/jamanetworkopen.2022.36676
24. Ibarra F, Baez M, Cernuzzi L, Casati F. A Systematic Review on Technology-Supported Interventions to Improve Old-Age Social Wellbeing: Loneliness, Social Isolation, and Connectedness. J Healthc Eng. 2020. PMID:32765823
25. Neves BB, Franz RL, Munteanu C, Baecker R. Adoption and feasibility of a communication app to enhance social connectedness amongst frail institutionalized oldest old: an embedded case study. Inf Commun Soc 2018;21(11). doi: 10.1080/1369118X.2017.1348534
26. Tsertsidis A, Kolkowska E, Hedström K. Factors influencing seniors' acceptance of technology for ageing in place in the post-implementation stage: A literature review. Int J Med Inform. 2019. PMID:31445274
27. Peek STM, Wouters EJM, van Hoof J, Luijkx KG, Boeije HR, Vrijhoef HJM. Factors influencing acceptance of technology for aging in place: A systematic review. Int J Med Inform. 2014. PMID:24529817
28. D'Onofrio G, Fiorini L, Toccafondi L, Rovini E, Russo S, Ciccone F, Giuliani F, Sancarlo D, Cavallo F. Pilots for healthy and active ageing (PHArA-ON) project: Definition of new technological solutions for older people in italian pilot sites based on elicited user needs. Sensors 2022;22(1). PMID:35009706
29. Reason P, Brandbury H. The SAGE Handbook of Action Research. Participative Inquiry and Practice. Second Edition. Sage Publications. 2008. ISBN:978-1-4129-2029-2
30. F. Folstein M, E. Folstein S, R. McHugh P. "Mini-mental state". A practical method for

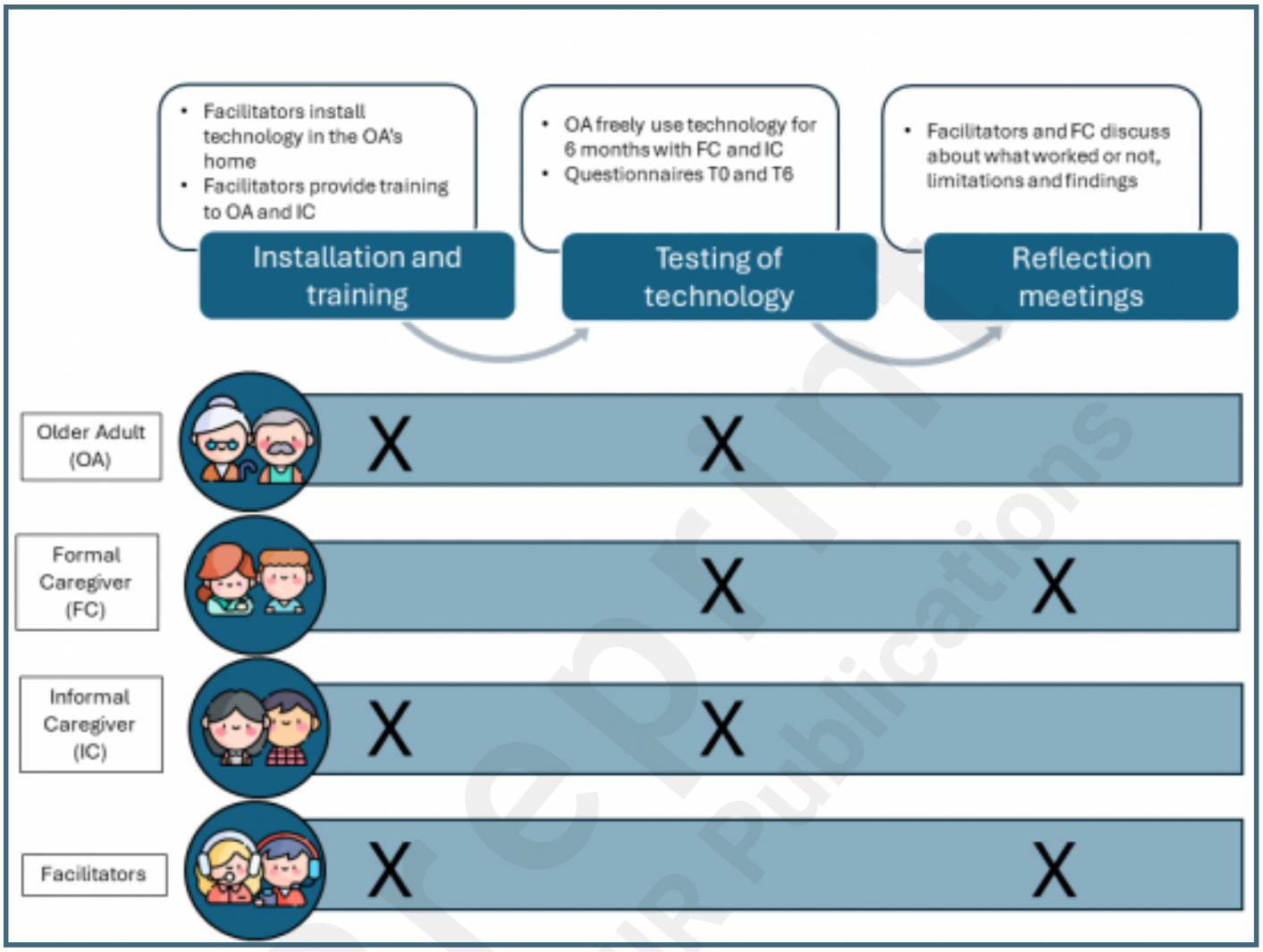
grading the cognitive state of patients for the clinician. J Psychiatr Res 1975;12(3).
31. Brooke J. SUS -A quick and dirty usability scale Usability and context. Usability evaluation in industry 1996;189(194).
32. Borsci S, Federici S, Lauriola M. On the dimensionality of the System Usability Scale: A test of alternative measurement models. Cogn Process 2009;10(3). PMID:19565283
33. Heerink M, Kröse B, Evers V, Wielinga B. Assessing acceptance of assistive social agent technology by older adults: The almere model. Int J Soc Robot 2010;2(4). doi: 10.1007/s12369-010-0068-5
34. Cohen S, Kamarck T, Mermelstein R. A global measure of perceived stress. J Health Soc Behav 1983;24(4):385–396. PMID:6668417
35. Mondo M, Sechi C, Cabras C. Psychometric evaluation of three versions of the Italian Perceived Stress Scale. Current Psychology 2021;40(4). doi: 10.1007/s12144-019-0132-8
36. Lorusso L, Mosmondor M, Grguric A, Toccafondi L, D'Onofrio G, Russo S, Lampe J, Pihl T, Mayer N, Vignani G, Lesterpt I, Vaamonde L, Giuliani F, Bonaccorsi M, La Viola C, Rovini E, Cavallo F, Fiorini L. Design and Evaluation of Personalized Services to Foster Active Aging: The Experience of Technology Pre-Validation in Italian Pilots. Sensors 2023;23(2). PMID:36679590
37. Taber KS. The Use of Cronbach's Alpha When Developing and Reporting Research Instruments in Science Education. Res Sci Educ 2018;48(6). doi: 10.1007/s11165-016-9602-2
38. Schrepp M. On the Usage of Cronbach's Alpha to Measure Reliability of UX Scales. Journal of User Experience 2020;15(4):247–258. Available from: https://uxpajournal.org/cronbachs-alpha-reliability-ux-scales/ [accessed Mar 18, 2023]
39. R Core Team. R: A language and Environment for statistical computing [Computer software]. Vienna, Austria. 2023. Available from: http://www.rstudio.com/. [accessed Nov 3, 2023]
40. Di Giacomo D, Ranieri J, D'Amico M, Guerra F, Passafiume D. Psychological barriers to digital living in older adults: Computer anxiety as predictive mechanism for technophobia. Behavioral Sciences 2019;9(9). doi: 10.3390/bs9090096
41. Jaschinski C, Allouch S Ben, Peters O, Cachucho R, Van Dijk JAGM. Acceptance of technologies for aging in place:a conceptual model. J Med Internet Res 2021;23(3). PMID:33787505
42. He Q, He Y, Liu Q, Ma C. Acceptance of social assistant robots for the older adults living in the community in China. Geriatr Nurs (Minneap) 2023;52. PMID:37392564
43. Sriram V, Jenkinson C, Peters M. Informal carers' experience of assistive technology use in dementia care at home: A systematic review. BMC Geriatr. 2019. PMID:31196003
44. Aaen J. Organizing for Emerging Welfare Technology: Launching a Drug-Dispensing Robot for Independent Living. Selected Papers of the IRIS 2019;(10).
45. Boyle LD, Husebo BS, Vislapuu M. Promotors and barriers to the implementation and adoption of assistive technology and telecare for people with dementia and their caregivers: a systematic review of the literature. BMC Health Serv Res 2022;22(1). PMID:36550456

Supplementary Files

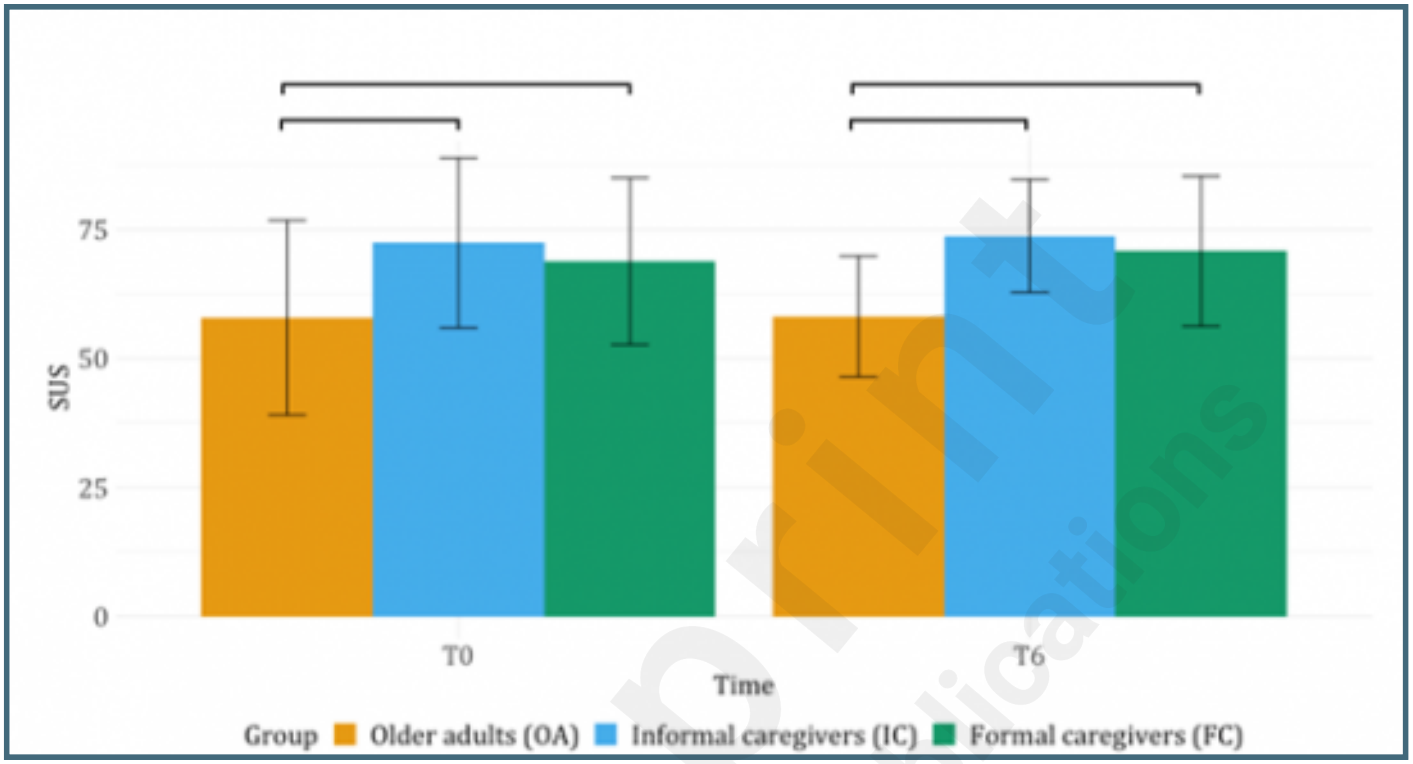
Figures

Photographs illustrating participants enrolled in the study. a) Older adult, informal and formal caregivers, during the “Installation & Training Phase”. b) Older adult participant using the game TV app. c) Older adult participant using the tablet.

Graphical description of the experimental protocol of the three consecutive phases. The “X” represent whether the cohort participated or not in the phase. Icons downloaded from flaticon.com.



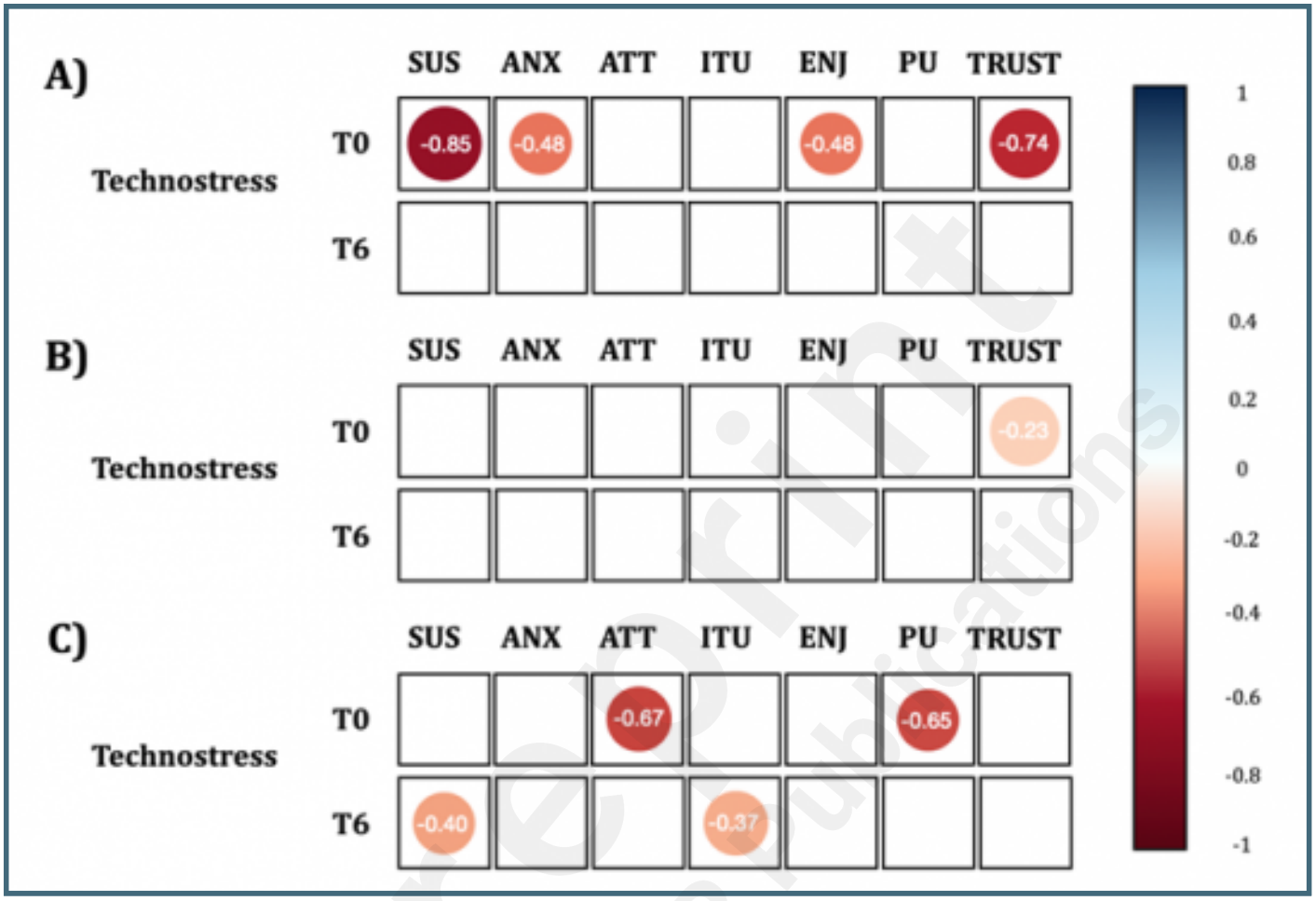
System usability scale (SUS) score in older adults (OA), informal caregivers (IC) and formal caregivers (FC) at T0 and T6. The error bars represent the standard deviation for each group. The bracket highlights statistical difference between groups. Note that the difference between OA and FC at T0 and T6 is not significant after post-hoc Bonferroni correction.



Mean values and standard deviations in parentheses for all acceptability constructs in the older adults, informal caregivers, and formal caregivers at T0 and T6. Green background highlights the higher value for each row, either at T0 or at T6. Note that values are mean (SD) or median {IQR} according to the normality of the differences over time.

	Older adults		Informal caregivers		Formal caregivers	
	T0	T6	T0	T6	T0	T6
Anxiety	4.4 {2.6}	4.0 {1.1}	4.9 {0.6}	5.0 {0.5}	4.3 (0.5)	4.4 (0.6)
Attitude towards technology	4.2 {0.5}	3.7 {0.8}	3.9 (0.6)	3.8 (0.8)	3.8 (0.4)	3.7 (0.5)
Intention to use	3.9 (1.0)	3.5 (1.1)	4.1 (1.0)	3.6 (1.2)	4.0 (0.5)	3.7 (0.8)
Perceived enjoyment	3.5 {0.8}	3.3 {0.5}	3.5 (0.6)	3.8 (0.9)	3.7 (0.5)	3.4 (0.6)
Perceived usefulness	3.7 {0.8}	3.5 {1.0}	3.7 (0.7)	3.4 (1.0)	3.6 (0.4)	3.5 (0.6)
Trust	3.6 (0.7)	3.3 (1.0)	3.4 (1.0)	3.2 (1.1)	2.9 (0.9)	3.3 (0.7)

Correlations between stress towards technology (Technostress) and user experience (SUS and AMQ constructs) in A) older adults B) informal caregivers and C) formal caregivers, at T0 and at T6. Only statistically significant results are presented.



Multimedia Appendixes

Supplementary Materials.
URL: http://asset.jmir.pub/assets/fb511c7f4991b8cea263a4dd2a7aaab6.pdf