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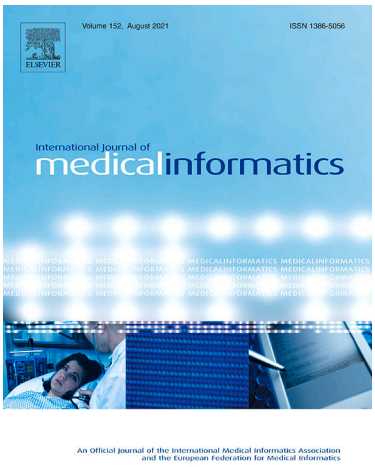

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Evaluating the interplay between emotional impact and usability of a technology-based socialization service in aged care: an Italian and Portuguese user study

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Keywords

Emotional impact, older adults, information and communication technology, socialization technology, aging well, user study, trust, health informatics.

Abstract

Background

As the global population ages, digital technological advancements offer solutions to promote active aging, but their effectiveness depends on usability and emotional impact, which could be influenced by demographic, organizational and geographical factors. An analysis of needs and emotional requirements revealed similar results in both countries. Based on these findings, a technology-based service to promote socialization was developed to address emotional needs such as feeling involved, staying safe, and being connected. For this service, participants integrated this technology into their routines for twelve months.

Objective

This study investigates the interplay between emotional evaluation and usability and trust scores for a technology-based service aimed at promoting socialization among older adults across two European pilot sites (Italy and Portugal).

Methods

This user study involved 77 older adults: 37 from Italy and 40 from Portugal. They were requested to interact with assistive technology that support the socialization (i.e. Sentab Technology). The analysis focused on the data collected after six months of system use and it is related to the evaluation of usability, trust, and emotional impact.

Results

Findings indicate significant differences in usability scores between sites ($p < 0.001$; Cohen's $d = 1.0$) and trust perception ($p = 0.01$; $r = 0.29$). Emotional impact evaluation of feeling "informed," "socially empowered," and "secure" also varied, with small to moderate effect sizes ($p < 0.05$). Additionally, an interplay was observed between usability and emotional impact in both pilots, while the correlation between trust and emotional impact showed different trends in the two sites.

Conclusion

Designing technological solutions must account for emotional requirements, as they correlate with usability. Geographical and demographic contexts also influence the relationship between trust, usability, and emotional evaluation in aged care technologies.

Introduction

In Europe, the proportion of older adults (OAs) aged 65 and older is steadily increasing, and it has been shown that between 2013 and 2023 the median age has increased by 2.3 years [1]. This significant demographic shift could be associated with social isolation, worsening of physical health and cognitive status. Additionally, another challenge that this shift entails is the need for formal and informal caregivers (FC and IC respectively) to support the OAs [2], [3].

In this context, digital technological devices offer some solutions to the problem by reducing social isolation [4] and supporting the monitoring of chronic diseases [5] alleviating the burden on caregivers [6]. However, there is a gap between the accessibility of digital technologies and their usage in daily life. Indeed, the acceptance and adoption of a technology does not solely depend on lack of affordability or socioeconomic status, but encompasses demographic factors, previous technological experience, lack of confidence, stress and anxiety, and distrust [5], [7]. Although many frameworks and approaches have been developed to deal with various kinds of functional and non-functional user requirements there is also the necessity to consider what the user is feeling while

interacting with technology defined as “emotional requirements” [8]. These requirements can be considered as latent factors that can positively influence user experience and thus contribute to effective long-term use of the digital technology.

Emotional requirements have shown promise in various domains by tailoring design elements to address users’ emotional needs. For example, in the context of age-friendly residential housing, emotional requirements were evaluated and mapped to interior design features using engineering principles [9]. The paper shows significant differences in emotional responses across various interface forms, demonstrating that each form had a distinct emotional tendency. The resulting model provides guidelines for the future design of residential indoor interface forms to match the emotional needs of older people [9]. In a medical health setting, emotional requirements were elicited and the opinion of the stakeholders were incorporated in the development of a clinical prediction tool for depression [10]. Findings revealed that incorporating stakeholders’ psychological factors enabled the identification of deeper and more nuanced requirements that extended beyond technical specifications. This approach underscores the value of considering human-centred factors to complement traditional technological requirements. Finally, meeting the emotional requirements identified during the design of mobile applications can impact the usage of the application, leading to greater trust and enjoyment [11].

A recent review [12] summarized the techniques to elicit emotional requirements during the design process. However, translating emotions to technical requirements is challenging due to the absence of a universally agreed-upon definition of emotional requirements [12][13]. Indeed, the most common way to elicit emotions is to use interviews or questionnaire and thus asking the participant to express their feeling using free text or a sentence [12]. This is because, although there are several models that provide a description of emotions (e.g., Ekman, Russel), the label/name that each person associate to an emotion is subjective as emotions are abstract concepts. Moreover, it is not possible to categorize emotional requirements based on a priori emotional category as they can have different meanings depending on the context or target group [13]. Nevertheless, it is possible to categorize emotional requirements by valence and arousal values. While these Pleasure-Arousal-Dominance models do not fully capture the complexity of the emotion, different words can still be spatially close when mapped for valence and arousal [13].

Meeting emotional requirement is critical for a system’s success, yet these requirements are rarely studied in usability contexts, especially concerning socio-demographic differences [8]. Therefore, it is crucial to assess the emotional requirement during the design phase and to evaluate whether they were fulfilled (or not) in the long-term interaction with the digital technologies. In other words, to assess the emotional impact of a certain technological solutions on the OA’s life. Concurrently, it could be valuable to assess the factors that can alter the feelings caused by the interaction with technology, and that can influence technology perception.

Furthermore, the gap in research is even more prominent when considering the potential differences in usability across different geographical locations and demographic groups. Previous research has shown that usability depends on geography, however the tested groups were vastly different not only geographically, but had also sociodemographic disparities, further complicating the interpretation of results [14]. Less is known about differences in emotions and usability in geographically closer countries. Understanding these differences is essential for designing user-friendly, trustworthy and effective technology for diverse OAs group [5], [7].

Hence, this paper aims to explore the interplay between usability, trust, and emotional impact, and examine how these may influence each other after six months of technology-based service use in the aged care. To achieve this goal, a service based on assistive technology that promotes socialization (i.e. Sentab) among OAs was tested in two European countries: Portugal and Italy. By deploying the service in two countries, it will be possible to investigate the role of geographical areas in addition to the demographic factors. This service was defined starting from a needs analysis conducted on 473 participants across Europe to uncover the needs of all stakeholders [15] identifying three different goals (i.e. *do*, *be*, and *feel* goals) [16]. The results of the needs analysis showed that

the most prevalent functional needs (*do* goals) in Italy and Portugal were associated with health management and social interaction, while the emotional requirements (*feel* goals) included reassurance, information, empowerment, involvement, connection, confidence, and safety[1]. In the proposed study, participants were asked to freely use the service for twelve months. After six months, they provided feedback on emotional impact (see "Operational definition" for a comprehensive definition of emotional impact and emotional requirements), usability, and trust. This evaluation aimed to address the following research questions (RQs):

- RQ1: Is the usability score the same in both pilots? How do Italian and Portuguese older adult evaluate the trust associated with technology use?
- RQ2: Are the emotional requirements accomplished after six months of use? Namely, what is the emotional impact on the OA's life with respect to the emotional requirement?
- RQ3: What is the interplay between the trust, usability and the emotional impact in the two countries?

Operational definitions

Here below the concepts related to the emotional requirement sphere employed throughout the paper are defined.

- **Emotional requirement**: are actionable design criteria or specifications derived from users' emotional needs (i.e. feel goals), intended to guide the development of systems, products, or services that elicit desired emotional responses. Emotional needs can be captured as emotional requirements that represent how the end user should feel when using the system [8], [13]. Emotional requirements are latent factors that can positively influence user experience and thus contribute to effective long-term use of the digital technology.
- **Emotional impact**: the emotions experienced by the user while using the technology, indicating whether or not the intended emotional requirements have been met. In other words, it reflects the extent to which the technology influenced the OA's emotions and life.

Materials and methods

Scenario definition and technical description

The "Pilots for Healthy and Active Ageing" (Pharaon, GA 857188)[2] project aimed to develop integrated and customizable interoperable open platforms to foster healthy and active ageing (www.pharaon.eu). The project encompassed six large-scale pilots conducted across five European countries, namely Italy, Spain (Andalusia and Murcia), The Netherlands, Portugal, and Slovenia. In this framework, the focus of our investigation lies within the Italian and Portuguese pilots because of the implementation of a similar service. The Italian pilot comprises two distinct sites located in Apulia and Tuscany regions, whereas the Portuguese pilot is conducted in the Amadora municipality and in the district of Coimbra.

In both pilot sites, the technology employed to promote socialization was Sentab (Sentab OÜ, Tallin, Estonia). The system has a user interface compatible across various platforms, including Web, Android, iOS, and TV (through Sentab TV box). Technical information on the Sentab system can be found in [17]. In order to be used, Sentab needs an internet connection and an email account for users to log in to their personal profiles. To address privacy concerns, an anonymized code was initially created for each participant in the OA, IC, and FC groups. Subsequently, a Google Mail account based on this anonymized code was established for all participants. Each participant has a

[1] The complete results of the needs analysis are reported in Moses et al. [15]

[2] Programme: H2020-EU.3.1. - SOCIETAL CHALLENGES - Health, demographic change and well-being ; Topics: DT-TDS-01-2019 - Smart and healthy living at home

private profile, with anonymized email and password, but can freely interact with others on the platform, including sending friend requests, as is typical in social networks. Participants were instructed to enter only a name or nickname and were given the option to add a personal photo if desired. Data were securely stored at the pilot sites and was accessible only to authorised personnel, adhering to national regulations and the European Union's General Data Protection Regulation. Only pseudonymised and aggregated data were shared for analysis. The chosen platforms were tablet in Portugal, and both TV or tablet in Italy. The Sentab technology consists of three functionalities (the same in all platforms): video calling, cognitive stimulating games, sharing of news, events and information about an active and healthy lifestyle.

Participants

As part of the Pharaon project, various stakeholders—including OAs, ICs, volunteers, service providers, and FCs—tested the technology-based service over a 12-month period, with data collected at baseline, 6 months, and 12 months. This paper focuses on the data collected after 6 months from the OAs. Among the subject recruited in Pharaon Project, in this paper we consider 77 OAs that tested the service. Specifically, 37 from Italy (21 from Apulia and 16 from Tuscany) and 40 from Portugal (20 from Amadora and 20 from Coimbra). The inclusion criteria for the OAs in Italy was to be 60 years or older, whereas in Portugal was to be 65 years or older. Additionally, in both pilot sites OAs should not have pathologies/diseases/memory problems that could impede interacting with technology and be able to understand and sign the informed consent. In Portugal, an additional inclusion criteria was to be a beneficiary of the social support services provided by Santa Casa da Misericórdia da Amadora or Cáritas Coimbra. There was no specific criteria regarding digital literacy.

Participants provided written informed consent after being fully briefed on the study's objectives, procedures, and potential risks, including concerns related to privacy and technology. Participants were informed of their rights, including the ability to withdraw from the study at any time without consequence.

More information regarding training, technology installation and model of care is presented in Table 1, whereas demographic characteristics and comparison between pilot sites can be found in the results section under “Demographic characteristics”.

Fig. 1 Portuguese OAs during the training phase. All subjects gave explicit consent for photos to be taken and used.

Experimental setup

The technology was tested at the two pilot sites using the same methodology which is composed of four phases: 1) *Technology preparation and installation*: the pilots team created anonymous Gmail accounts, initialized Sentab and installed it in the participant's home. Where necessary, routers with sim cards were also installed to ensure a Wi-Fi network in each home. 2) *Participants training*: the team conducted training session with the OAs (**Fig. *1***); 3) *Pilot execution* (**Fig. 2**): the OAs (and the other stakeholders connected with them) were free to use Sentab functionalities following the *Model of care* proposed in the pilots; and 4) *Data collection* (see "Evaluation Tool" paragraph). Detailed information on phases 1 to 3 of the methodology in the two pilots is reported in Supplementary Material**Error! Reference source not found.**.

To reinforce data privacy outlined in the informed consent, the training sessions educated the OAs on how to enhance safe digital interactions (e.g., the option to use an anonymous account to log in, cybersecurity aspects such as not sharing personal data) and about the measures Sentab employs to ensure their safety (excluding publicity and sharing information with other entities). Caregivers also had access to the tablets and conducted regular digital activities with OAs, fostering the development and assimilation of new digital skills (**Fig. *1***). In both pilot sites technical assistance was provided if needed. In Portugal caregivers and social operators offered assistance during group sessions, addressing technical issues as they arose. In Italy each participant was given contact numbers for technical support and, when necessary, medical assistance.

Fig. 2 Italian OAs using the technology in their home. On the left, a man is playing Sudoku. On the right, Sentab is being used for a video call. All the subjects have given their explicit consent for the photos to be taken and used.

Evaluation Tools

This paper focuses only on the data collected after 6 months of use, so the following dimensions were considered: demographic information (i.e., age, sex, education, digital skills, living status, marital status and living environment), social isolation and health-related quality of life collected at baseline. Usability, Trust and Emotional requirement evaluation, each collected after 6 months using the tools described in **Table 1**. In particular, to measure usability and trust we employed two state of the art questionnaires which were previously used in similar context and could facilitate comparison with the related literature. It is important to monitor these parameters since they are strictly linked to the acceptance [18], particularly, negative correlations are found between trust, perceived usefulness and actual usage [19].

The emotional impact questionnaire was constructed based on the emotional requirement identified in the two countries [15], with the final purpose of measuring the emotional impact. It is composed of 7 questions with answer option ranging from strongly disagree (1) to strongly agree (5) [14] (**Table 2**).

Table 1 – Questionnaires – Questionnaires used in the pilots.

Domain	**Questionnaire**	**Description**
Social isolation	UCLA questionnaire [20] using the Italian [21] and Portuguese validated [22] versions.	Items are rated on a 1 (never) to 4 (often) scale.
Quality of Life	EQ-5D-3L [23].	Participants rated their health using the visual analogue scale (VAS) selecting a point on a

		vertical line that ranges from 0 (worst imaginable health) to 100 (best imaginable health).
Usability	System usability scale (SUS) [24] translated and validated in Italian [25] and Portuguese [26].	10 items ranging from 1 (strongly disagree) to 5 (strongly agree). The threshold score 68 determines average usability.
Trust	Items 40 ("I would trust the system if it gave me advice") and 41 ("I would follow the advice the system gives me") of the Almere model questionnaire [27].	Items are rated on a 1 (don't agree) to 5 (strongly agree) Likert scale.
General Feedback	During the administration of the questionnaires, if OAs remarked some facts or sentences, they were annotated and included in the results as qualitative feedback.	

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239 **Table 2 – Emotional Impact Questionnaire -** Questionnaire evaluating the accomplishment of the emotional
240 requirements (in brackets) thus measuring the emotional impact. The emotional requirements are outlined in
241 [15].

Emotional impact assessment (emotional requirement)	**Question**
Reassured (Less stressed)	Have you felt less stressed by technology use?
Informed (Stay informed)	Do you feel like you have more information regarding your health?
Empowered (Socially empowered)	Do you feel like you have increased opportunities for socialization?
Involved (Being involved)	Do you feel more involved in the interaction with technology?
Connected (In contact)	Do you feel like you have more contact with your family members/friends?
Confident (Being empowered/more conscious about me)	Do you feel more confident in using technology?

Safe (Stay secured)	Do you feel safer in using the technology?

Statistical analysis

Demographic information (age, sex, education, digital skills, marital and living status) and participant's subjective perception of social isolation and health-related quality of life (UCLA and VAS) were compared between pilot sites using the Mann-Whitney U test for ordinal or non-normally distributed variables, t-test for continuous normally distributed variables comparisons, or Chi-square test for nominal variables.

To assess differences in the usability of the system between pilot sites, the SUS was checked for normality, and t-test or Mann-Whitney U test were used accordingly. To further investigate the system's usability, we explored 5 selected items from the SUS questionnaire (see **Table 4**). Differences between pilot sites in trust and the fulfilment of seven emotional requirements were assessed using the Mann-Whitney U test. The most suitable effect size was calculated for statistically significant results: Cohen's d, Wilcox effect size 'r' ($z/\sqrt{N}$) or Cramer's V.

Finally, Kendall's correlations were performed separately in the two pilot sites to evaluate whether emotional impact, SUS and trust were correlated in each country. For all the aforementioned analyses, a p value lower than 0.05 was defined as statistically significant. Data analysis and visualization was conducted on RStudio (version 4.3.3) [28] [3].

Results

Demographic characteristics

A total of 37 OAs in the Italian and 40 in the Portuguese pilot were included in the present study. There were statistically significant differences between pilots in the age of participants, marital status, and digital skills (Table 4). The pilot site difference in age was partially expected given the different inclusion criteria in age (≥60 years in Italy and ≥65 in Portugal). The effect size shows that the distribution of age and marital status may differ somewhat between individuals in Italy and Portugal, but the strength of this difference is moderate. For digital skills, the effect size indicates a large difference between Italy and Portugal with respect to digital literacy.

The variables sex, living status, education, UCLA and EQ-5D-3L scores were not significantly different between pilot sites, suggesting a similar proportion or distribution in both pilot sites.

Table 3. Pilot site differences in demographic characteristics, health-related quality of life, and loneliness scores.

	Italy N=37	**Portugal N=40**	**p value [effect size]**
Sex, %Female	73	85	0.308

[3] Particularly, the following packages were used: "ggplot2" [33] , "rstatix" [34] and "corrplot" [35].

Age, median [IQR]	74.0 [68.0, 80.0]	82.0 [75.0, 85.0]	**0.006 [0.318]**
Marital status			**0.014 [0.364]**
%Divorced	0	10	
%Married	45.9	17.5	
%Single	5.4	12.5	
%Widowed	48.6	60.0	
Living status, %Not alone	60.0	50.0	0.525
Digital skills			**<0.01 [0.471]**
%None	18.9	62.5	
%Some	67.6	37.5	
%Experienced	13.5	0	
Education			0.065
%Primary school	48.6	70.0	
%Secondary school	43.2	25.0	
%Tertiary school	8.1	5.0	
UCLA (score ranging from 20 to 80), median [IQR]	35.0 [27.5, 47.3]	40.0 [34.0, 48.5]	0.114
EQ-5D-3L VAS (score ranging from 0 to 100), mean (SD)	68.2 (16.5)	70.3 (20.1)	0.630

Note. The bold p values highlight a significant difference between pilot sites.

Differences in usability

Overall, the SUS score for the system was below threshold (mean 56.61, SD 17.91). In the two pilot sites there was a large significant difference in usability ($p < 0.001$; Cohen's $d = 1.0$). The mean SUS score for the Italian pilot was slightly below threshold (mean 65.6, SD 16.8) and for the Portuguese pilot was 48.6 (SD 14.9) (**Fig. *3***. A). Regarding the analysis for the SUS items, significant differences were identified between the pilots. A medium effect was observed for ease of use, and a large effect for independent use and complexity. Overall, except for intention to use, the Italian pilot reported higher scores compared to the Portuguese pilot (Table 5). The intention to use and confidence items, however, did not show statistical differences between pilot sites, suggesting similar levels of intention and confidence in the system.

Table 4. Central tendency values (median [IQR]) of the SUS items in the two pilots and statistical comparison.

SUS item	Question	Italy	Portugal	p value [effect size]
Item 1: Intention to use	I would like to use this system frequently	4 [1]	4 [1]	0.37
Item 3: Ease of use	I found the system easy to use	4 [1]	3 [1.25]	**0.008 [0.30]**
Item 4: Independent use	I think I would need help to use the system	1.5 [2]	5 [1.25]	**<0.001 [0.69]**
Item 9: Confidence	I am confident in using the system	4 [1]	3 [1]	0.28
Item 10: Complexity	I needed to learn a lot of processes before being able to use the system better	2 [1]	4 [2]	**<0.001 [0.56]**

Regarding usability, notable feedback was annotated in the Amadora, Apulia and Tuscany pilot sites. Participants in Amadora felt safe and more at ease using the devices in Daycare centres, expressing higher support regarding doubts or fears. On the other hand, OAs in Apulia expressed that they mainly used the system for playing games and checking news and information about active lifestyle rather than the video calling/socialization functionalities ("*I felt good using the system, the activity that I liked the most was playing games", "I found the news useful for taking care of our health*"). This because most of them lived with or near their ICs, and were already using other systems that effectively let them communicate with their relatives. On the other hand, in Tuscany there was a positive response for the cognitive stimulation games functionality.

Differences in trust

In the overall sample, trust in the system had a median value of 3.5 (IQR=1). The two pilots significantly moderately differ in trust in the system ($p=0.01$; $r=0.29$). The median value of the

Portuguese pilot was higher than the Italian pilot (4 vs 3) (**Fig. *3***. B). The qualitative feedback collected is aligned with the care model in place in the two pilot locations was different. While in Portugal the focus was to employ the system in a way that increased a sense of community, in Italy the focus was to increase the OA's technological independence. This could have led the linkage in Portugal of the trust in the system to trust in other peers, professionals, volunteers and service providers, which further increased the sense of belonging.

Differences in the emotional impact evaluation

Overall, the median scores were on the high end of the scale (Fig. 3. C). We found significant differences between pilots in the evaluation of the "informed" ($p = 0.036$), "empowered" ($p = 0.0003$), and "safe" emotional requirements ($p = 0.005$). For the "informed" construct, the effect size was small (0.243), whereas for "empowered" and "safe" it was moderate (0.416 and 0.317 respectively).

The pilot sites were not significantly different in the emotional impact "reassured" ($p=0.37$), "involved" ($p=0.051$), "connected" ($p=0.45$) and "confident" ($p=0.87$).

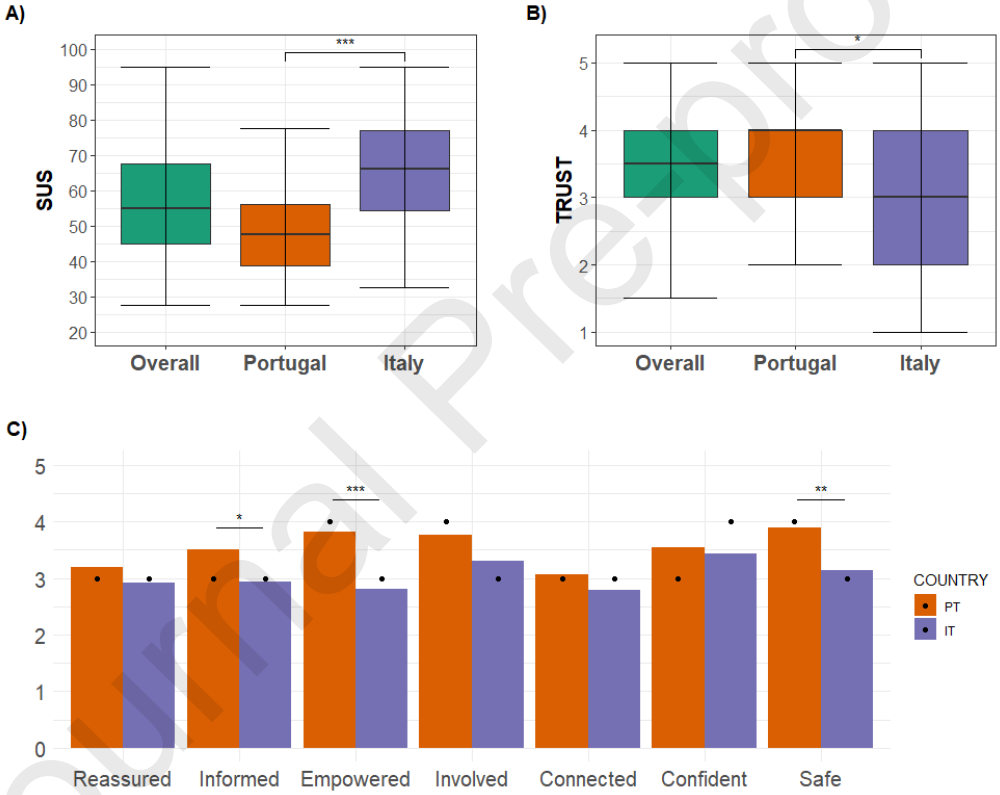

Fig. 3 Results of the statistical comparison between pilot sites. A) The SUS score for the overall system and the comparison by pilot sites. B) The trust score for the overall system and comparison by pilot sites. C) Bar plots of the emotional impact in the Portuguese (PT) and Italian (IT) pilot sites. In each pilot site, the bar represents the mean and the point the median value.

Correlations between usability, trust and emotional impact

The correlations between usability, trust and emotional impact were performed separately for each pilot site, with results depicted in Fig. 4. In Italy, the SUS score was significantly positively correlated with a higher score in "reassured", "socially empowered" and "confident", and strongly correlated with "involved" and "informed". Conversely, trust was moderately positively correlated with "informed" and "safe". In Portugal, the SUS was significantly positively correlated with "reassured", "informed", "socially empowered", "confident" and "safe". Trust was correlated with "socially empowered", "involved", and "confident", and strongly correlated with "safe".

No significant correlation was observed in either pilot sites between trust and “reassured”, nor between either SUS or trust and the emotional impact “connected”.

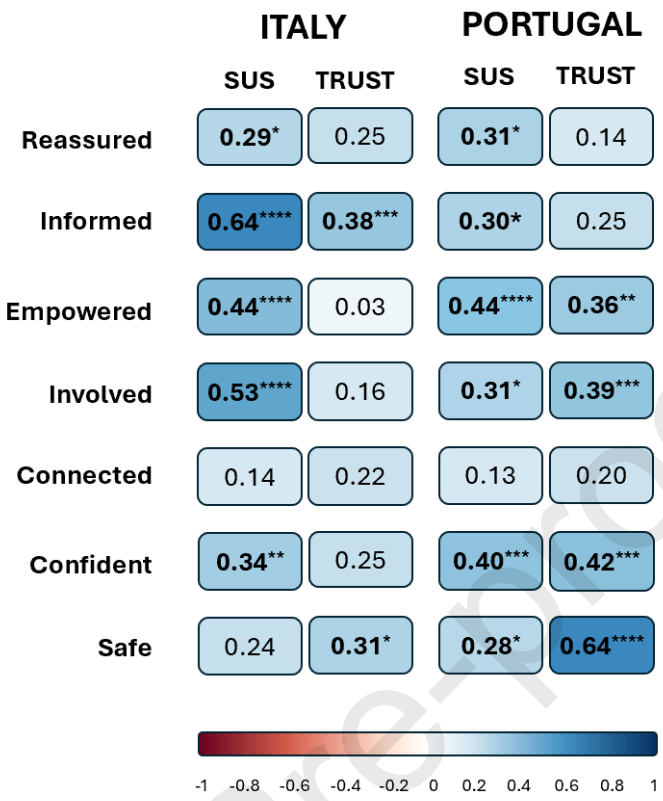

Fig. 4 Correlations between the emotional impact evaluation and usability and trust in the Italian and Portuguese pilot. Significant correlations are reported in bold, and significance is highlighted with an asterisk: *p>0.05, **p>0.01, ***p>0.005, ****p>0.001.

Discussion

The primary aim of this paper was to investigate the interplay between usability, trust and emotional impact (assessed through the emotional impact questionnaire) of a digital technology- based service to promote socialization among OAs and to investigate how the external factors such as personal characteristics, the model of care and geographic regions may influence these relationships.

The two pilots tested the same technologies but obtained different results that may be related to the adopted methodology (Table in Supplementary Material**Error! Reference source not found.**), but also to socio-demographic and geographical factors (**Table 3**).

Both pilot sites evaluated the system lower than the benchmark value set to 68. The benchmark can be synthesized as not usable (SUS 0 – 50), marginal (SUS 50 – 70) and usable (SUS 70 – 100). The Italian pilot rated the system as more usable, with scores falling in the “marginal” category compared to the Portuguese pilot, which was rated just below “marginal” (**Fig. 3**. A). Analysing the SUS items, the results showed that the OA in Italy used the system autonomously (**Table 4**, Independent Use) and found it less complex (**Table 4**, Complexity). This may be related to the lower age and higher digital skills of the Italian OAs (**Table 3**). Younger OAs may find the technology easier to navigate due to greater exposure to similar tools. Similarly, digital skills influence how users interact with technology such as the possibility of effectively use the features of the system. In parallel, qualitative feedback from Amadora revealed that the users preferred to use the system in a multi-user/shared approach. Particularly, they felt safer and more at ease when they got to use the devices in the presence of the Daycare centres’ professionals and caregivers, who could in turn support them and assist them in case of any doubts. This result could be linked to the cultural differences in the two countries. According to the revised Minkov-Hofstede model, Portugal

compared to Italy leans more towards collectivism and flexibility, whereas Italy tends to be more individualistic emphasizing personal goals and individual achievements [29]. Despite the different usability scores, the OAs in the two countries expressed the same high confidence in using the system, as pointed out by the SUS item 9 (**Table 4**, Confidence) and **Fig. 3**. C, and similar intention to use (**Table 4**, Intention to use). This is a positive result because participants with low confidence have the tendency to be resistant towards the mobile health technologies [30]. It is possible that introducing the system (Sentab) during training phases had increased self-confidence, and intention to use a certain technology, as it was shown that OAs' intention to use assistive technologies increases when they get to know or experience technology before actually using it [31]. To be beneficial to the community, a technology must be understood in terms of its advantages and used with minimal difficulty. If the user does not know how to use it, does not understand its benefits or resonate with technology, they will not fully experience its advantages. In other words, understanding of how to use technology and its level of development is related to the experience (positive or negative) of its users.

The tested service received a medium score of 3.5 out of 5 in trust (**Fig. *3***.b), which indicate a general medium/positive evaluation. Numerous studies have highlighted the crucial role of trust in the acceptance and usage of emerging technologies [18], [19], so it is crucial to have a positive evaluation of this dimension to ensure the technology acceptance. It is also worth noticing that the trust score was significantly higher in the Portuguese pilot (**Fig. 3**. B). This may be explained by the two different operative conditions (i.e. Model of Care), indeed Portuguese people could use the system - if needed - with the social operators (for all or selected activities), whereas in Italy, the OAs did not have this option. Hence, the Portuguese OAs may have evaluated also the "human" support in addition to the technology, resulting in higher trust. That being said, OAs relied on and trusted the suggestions of social and healthcare professionals in using new equipment, digital product or technology. As confirmed by [31], the social influence of people closer to the OA, including caregivers, can affect the perception of a technology-based service.

Concerning the emotional impact, overall the Portuguese had higher scores than the Italian pilot (**Fig. 3**.C). Specifically, they achieved significantly higher scores for the evaluation of "informed", "empowered" and "safe" emotional impact. In the Portuguese pilot sites, there were activities promoted by sociocultural animators using Sentab posts which possibly could have created a higher sense of community, resulting into a higher "(socially) empowered" evaluation for Portugal. In a collectivist culture like Portugal [32], there is a strong emphasis on community, relationships, and shared experiences. This was evident in the participants' preference for using the technology in group settings within daycare centres. These shared environments fostered a sense of belonging and mutual support, which positively influenced the trust and emotional impact scores, particularly in dimensions such as feeling "empowered" and "safe". The presence of caregivers and social operators during these sessions further reinforced this sense of community and provided immediate support when participants faced challenges, reducing potential feelings of isolation or anxiety. This aligns with the observation that collectivist societies integrate individuals into cohesive groups that offer lifelong support in exchange for loyalty [29], [32]. On the other hand, although in Apulia posts on promoting healthy lifestyles were shared, the annotated qualitative feedback showed that the participants did not use the specific socialization functionalities because the ICs lived with or nearby participants and preferred to use other systems to call their relatives. As for the "safe" construct, in Portugal OAs during training were informed about cybersecurity issues, and this may have enhanced their sense of security in using the service. One of the cultural characteristics found in the literature is the high uncertainty avoidance found in Portugal, meaning that individuals prefer clear structures and are less comfortable with ambiguity. As noted by [32], members of high uncertainty avoidance cultures often feel threatened by ambiguous or unknown situations. This cultural trait was addressed through the comprehensive training sessions provided in the pilot. These sessions not only introduced participants to the technology but also emphasized safe digital practices, such as the use of anonymous accounts and avoiding the sharing of personal data. This systematic approach helped to mitigate concerns about privacy and technology use, aligning with the cultural preference for well-defined processes.

Regarding the interplay analysis, despite the noted differences between the two countries (i.e., age, digital skills, care model), usability was consistently correlated with five out of seven emotional impacts (**Fig. 4**), suggesting an invariant relationship. On the contrary, trust showed varying relationships with emotional impacts, except for the 'safe' construct (**Fig. 4**). In this context perceived safety was directly related to the trust in the organisations and their carers/professionals that participants felt while using the technology. In Italy, trust was more closely tied to feeling 'informed,' likely due to the service's focus on sharing information-based articles on correct lifestyle based on credible and/or controlled sources. In Portugal, the correlation between trust and emotional impacts "empowered", "involved", "confident" and "safe", could be related to the strong caregivers' intervention. These results also suggest that the different service models tested in the two pilots influenced these results: in Italy, the technology supported home assistance and reduced the need for caregivers' physical presence, while in Portugal, the care model emphasized promoting autonomy and empowerment. The result strengthens in value because the trust in the technology acquires a different meaning: the technology as means for a more meaningful connection, to become part of the community, and feel safer because of it.

Based on the findings from this study, several practical implications for technology designers in aged care settings can be identified. This paper found a discrepancy between high trust in Portugal and high usability in Italy, which suggests the need to devise a service not only based on the technology, but also consider the appropriate "model of care" which can be influenced by socio-demographic, digital skills and geographic area of the target population. Additionally, it is also important to consider that it is difficult for study participants to disentangle the "human" component from "technology" evaluation. Training should also be provided to account for low digital skills of participants. Prior research highlighted the relationship between usability, acceptance, and usage of technology; however, our findings suggest that usability is also closely linked to emotional factors. Despite variations in pilot usability scores, consistent – and congruent - correlations in the two pilots underline the importance of addressing emotional aspects early in the development process. Additionally, trust is linked to the "secure" component, confirming existing acceptability models. Enhancing trust through system design improvements is crucial for ensuring secure and effective adoption.

Limitations

As for the limitation, this paper involved a limited sample size of participants that were recruited in the network of the pilots involved in the Pharaon project, which is a convenient sample. Further studies should be conducted to enrol a larger number of participants including diverse age groups with different digital skills and other geographical areas, or by stratifying participants based on their digital competences thus to ensure results generalizability among broader European OA populations. To collect feedback on the emotional impact, a custom questionnaire was used. Nevertheless, future research could apply the same methodology, by evaluating the emotional requirement and assessing their emotional impact after technology use. The focus of this paper was to evaluate the Pharaon system and not to directly compare the cultural aspects. Nevertheless, in the future it could be beneficial to include specific questionnaires to consider cultural factors that could influence the usability and acceptability of a technology. Additionally, it could be valuable to collect data related to the socio-economic status to verify if this factor may influence technology perception. Finally, data in this paper refer to 6 months of use, and it would be interesting to assess whether these results are confirmed after 12 months to investigate the longitudinal validity.

Conclusion

This study highlights the interplay between usability, trust, and emotional requirements, showing how socio-demographic and cultural factors influence perceptions. The findings suggest that – in future research - testing technology cannot be separated from the existing care model, which must address both user needs and emotional expectations to promote digital and health literacy. The extended testing period (6 months) was crucial in revealing dynamics that shorter studies might miss, providing insights into how the results can be applied in each pilot site. A summary of paper findings is reported in Table 5. In Portugal, the results will be exploited by integrating digital literacy activities into the

daily routines of health and social centres, facilitated by caregivers. The tablets from the pilot study will remain in these centres for use by OAs, helping to bridge the digital divide. In Apulia, the focus will be on enhancing the 'informed' emotional impact by offering a paid service that provides clinically validated news and lifestyle advice. In Tuscany, the cognitive game functionality will be expanded into a standalone paid service. These efforts aim to continuously improve an integrated, user-centred care model that meets the needs and preferences of OAs.

Summary Table

Table 5. Summary Table

What was already known on the topic	**What this study added to our knowledge**
• Majority of the research on assistive technology mainly focus on mapping the functional requirements. • Less is studied about the relationship between the usability, trust and the emotional requirement.	• Usability, trust and emotional requirements are interconnected. • Although the two pilots yielded different usability scores, it remains crucial to map both the functional and the emotional requirements and assess whether they have been fulfilled. • Trust and usability are strictly connected with the "model of care".

Ethical statement

The study was approved by ethical committees. Specifically, in Amadora the study was approved on the 16/02/2022 (Comissão de Ética para a Saúde of the Santa Casa da Misericórdia da Amadora; 001/CES/2022), in Coimbra on the 11/07/2022 (Comissão de Ética Universidade da Beira Interior; CE-UBI-Pj-2022-043-IDn/a), in Tuscany on the 22/07/2021 (Azienda USL Toscana Sud-Est; Prot. 2021/000227) and on the 18/10/2022 (Area Vasta Centro; Prot. 22131_spe), and in Apulia it was approved on the 14/06/2021 (Ethical committee of Casa Sollievo della Sofferenza; Prot. 1669/01 DG).

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Highlights

- The two pilots started from the same needs analysis which led to the identification of technology-based services that can promote socialization among OAs.
- Despite the same premises, pilot sites ended up having different experiences and outcomes: geographical, cultural, demographic and social context play a role on the usability, trust and emotional impact of technology.
- The technology testing could not be divided from the care model in place, which can enable the promotion of digital and health literacy.

Declaration of interests

☒ The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

☐ The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: