Evaluating SpeakyAcutattile: A System Based on Spoken Language for Ambient Assisted Living

F. Fracasso, G. Cortellessa, A. Cesta, F. Giacomelli and N. Manes

Abstract The current work presents the SPEAKYACUTATTILE system, a computer based platform designed to enable its users to access a number of ICT services such as house management, health status monitoring or recreational services. It is deeply grounded on voice interaction and represents a Spoken Language System (SLS) meant to be a sort of intelligent assistant with which the users can vocally interact. The paper dwells on an experimental assessment of the system. Linear regression analysis have been carried out in order to assess the influence of system performance—in terms of dialogue efficiency metrics and dialogue quality metrics—on the perceived satisfaction of users. Results show that longer dialogues are preferred in order to positively influence the users satisfaction, suggesting the importance for people to have time for getting confident with new ICT solutions. Moreover, from the experimental analysis, it clearly emerges how system intervention should be reduced, suggesting how a good balance between user and system turns represents an important aspect for a fluid interaction. The same can be speculated for dialogues with no met requests that also tended to be associated with lower satisfaction scores. These last results support the importance for a vocal assistant to be effective in its purpose in order to be perceived as useful and satisfying.

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1 Introduction

Research in Ambient Assisted Living technology (AAL) is attracting more and more interest among ICT scientists. The present work is inserted within this context and aims to introduce SPEAKYACUTATTILE, an Italian project dedicated to support the daily life of vulnerable people, with specific regard to the elderly. SPEAKYACUTATTILE is a computer based platform designed to provide the users with a simple instrument for accessing a number of services such as house management, health status monitoring or recreational purpose. The system is grounded on voice interaction and represents a Spoken Language System (SLS) meant to be a sort of intelligent assistant with which the users can vocally interact. Spoken Language Systems by definition are systems that rely primarily or exclusively on audio for interaction, this includes speech and sound [1], and nowadays they are being used more often for a wide range of applications.

Since the eighties, different systems have been developed for several applications. In working environment, some administrative information systems have been developed (APHODEX—Acoustic-PHOnetic Decoding EXpert system, [2, 3]), such as office databases (SPICOS II—Siemens-Philips-IPO-Continuous Speech Understanding and Dialogue System [4]) or document retrieval systems (i.e. Hearsay-II [5]), and speech-to-speech real-time translation systems for the domain of conference registration (DmDialog [6]). Other applications covered different areas on travel planning (HWIM—Hear What I Mean, [5, 7]), specifically in trains travel information retrieving (Ernest [8]; VODIS II [9]), flight reservation and inquiries (SUNDIAL [10]) or air traffic inquiry systems (MINDS—Multi-Modal Interactive Dialog System [11]), and hotel reservations, like HAM-ANS—Hamburg Application-Oriented Natural Language System [12, 13], as well. More recently, ICT for Ambient Assisted Living paradigms is taking advantage of this interaction modality, since it appears to be a natural and valuable way in order to overcome difficulties due to, i.e., age-related impairment. In fact, despite some results from an automatic speech recognition (ASR) performance study where the ASR performance was lower for older persons and for female [14], experiments in an assistive environment using voice recognition pointed out that the speech interface is the easiest way for the user to interact with the computer based service system [15]. Application in assistive field has been covering several areas such as intelligent environments, in-car applications, personal assistants, smart homes, and interaction with robots and assistants for disabled and elderly people [16]. These solutions have to be able to understand and produce spoken language in various applied fields, pursuing the goal to make the interaction more and more effective by tailoring on specific users features. Since speech is claimed to be one the most natural modes of interaction, the numbers of speech-enabled applications are rapidly increasing and much effort has been put into considering the special requirements of assistive environments. Among others, some efforts have been carried out in order to study, implement, and evaluate the speech interface of a multimodal interactive guidance system based on the most common elderly-centered characteristics during interaction within assistive environments [17]. Moreover, studies on prosody, articulation and speech quality have been made in order to exploit this communication channel with the purpose of detecting accident-prone fatigue states from speech features [18]. The success of the SLS, and consequently their positive impact on AAL, depends on whether the user is able to accomplish the task successfully using the system and how the task is actually accomplished. For this reason, an extremely critical step in the development of a spoken language system is not only the designing of the interface and devising dialogue strategies but also evaluating how the system performs. Performance of the system includes some metrics such inappropriate utterance ratio, concept accuracy, number of turns, elapsed time and other such factors which make the whole process of comparing dialogue strategies across system and tasks difficult. A current challenge is represented by an increasing demand for standardized bench-marks to test and compare performance and usability of such of interaction modalities beyond metrics such speech recognition accuracy, adequate language modeling and appropriate semantic representation for efficient interaction with back-end knowledge sources [19]. In this direction, Walker and her colleagues put some efforts while developing a method for evaluating spoken dialogue systems [20]. These researchers developed PARADISE (PARAdigm for Dialogue System Evaluation), an evaluation framework that is useful to compare performances of different dialogues strategies, and system designed for different tasks as well, in order to evaluate the performance. PARADISE considers user satisfaction ratings as an indicator of usability. Usability is, in turns, calculated as a measure composed by two factors: task success and dialogue costs using a decision-theoretic framework with the main aim to maximize users satisfaction by maximizing task success and minimizing costs. This framework uses methods from decision theory to combine a discordant set of performance metrics. Subjective satisfaction is placed at the center of this model, and it is supposed to be influenced by objective features of the system, measurable through dialogue quality metrics and efficiency dialogue metrics.

The present work aims to introduce the SPEAKYACUTATTILE assistive platform and the validation of the first prototype. With this purpose, section two is devoted the presentation of technical features of the platform, while section three describes the experimentation carried out with users. The last section is devoted to outline some conclusions and future development on the SPEAKYACUTATTILE system.

2 The SpeakyAcutattile Platform

SPEAKYACUTATTILE has been conceived as an intelligent assistant centered on the use of vocal interaction in order to use a set of digital services. The underline idea moves from the goal to make an interface enabling access to digital contents to all kind of people, despite their specificities. The overall platform is showed in Fig. 1. The new enabling platform consists of hardware and software components. It enables the construction and use of new digital content and services as well as allowing new modes of access to existing ones. The platform provides access from both in-house/office and on the move. It is composed of several hardware and software modules based on a client/server architecture. The client side is based of a PC Box running an avatar with speech recognition technology and is accessible by voice through a special and innovative multifunction wireless device (Speaky Acutattile), which is the heart of the new platform. It acts as a spoken interface through a remote controller with incorporated microphone, connected to the computer through an USB. This device is provided with a push-to-talk button and allows the users to give vocal commands to the PC-box in a walkie-talkie manner The PC Box is also connected to an advanced sensors system for home automation, which allows people to manage and control their house. The SPEAKYACUTATTILE platform includes also a system for monitoring person posture. The system is supposed to monitor the user at home, and by detecting the posture it may indicate a critical situation in which the person loses consciousness or falls. Finally, the system includes biometric sensors for measuring vital parameters for Telemedicine and Telecare. In the server side architecture there is a full contact center for both caregivers and technical support operators monitoring all the connected PC Boxes. It is a call center with a first level voice portal automated system and a second level with the human operator. The service center also serves as a center for data processing, Content Management System (CMS).

As depicted in Fig. 2, from the client side a number of modules are integrated in order to provide different services to the users. More in detail the following applications are accessible from the main menu of the GUI.

- *Domotics* that allows the person a complete control of the house through vocal commands (appliances, utilities, communications, security, privacy, etc.) in orchestration with environmental sensors and actuators;
- *E-learning* that is a support to educational teaching;
- *Face Recognition*, that allows the authentication to the services in order to preserve security and privacy of the person;
- *Postural monitoring*, that combined with environmental sensors is able to detect falls or critical situations;
- *Agenda*, through which the person can fix appointments and set reminders;
- *Multimedia Library*, that allow the access through speech channel to the library in order to listen to music, and see videos or photos;

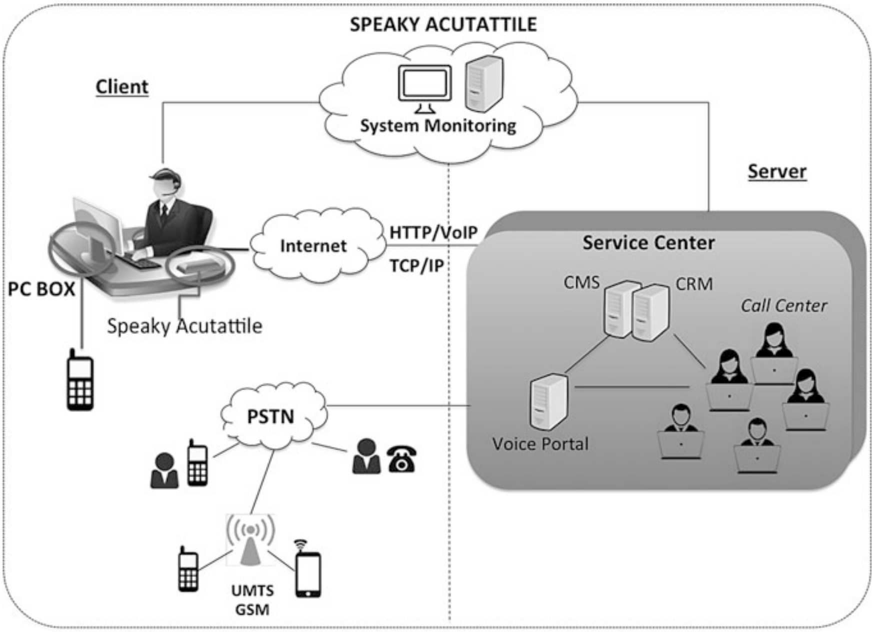

Fig. 1 The overall SPEAKYACUTATTILE platform

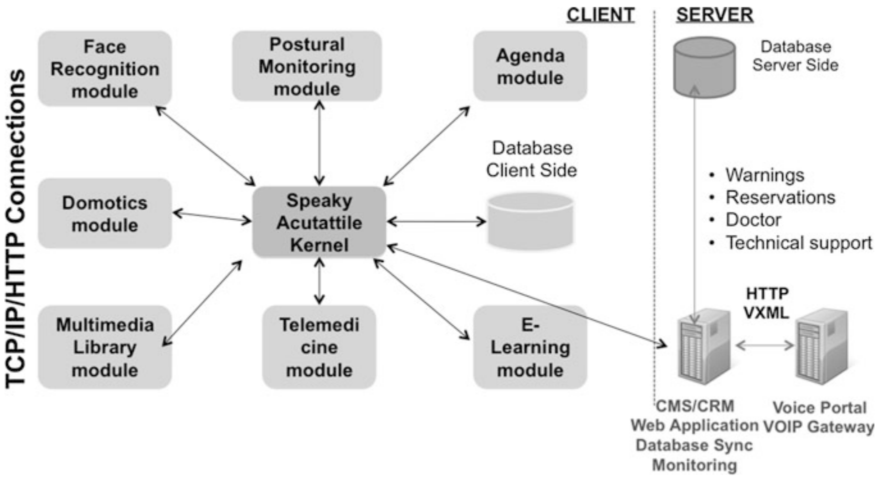

Fig. 2 The general architecture of the SpeakyAcutattile system

- *Target search*. Through the Acutattile device (see later) it is possible to explore the desktop of the PC. Thanks to it the user is provided with a feedback when an object (i.e. an icon) is reached. Both an audio feedback (a description of the object) and a tactile one (vibration) are provided to the user;
- *Telemedicine*, through which the user is allowed to make some physiological measurements (i.e. blood pressure, oximetry) and send them to the service center.

At server side, information is stored in a database and a Service Center allows a remote monitoring of some parameters detected by SPEAKYACUTATTILE. Specifically, information from Postural monitoring, Telemedicine and Agenda can be checked by a caregiver.

Finally, others components of the system deserve to be mentioned, just to provide a complete overall framework, despite they have not been subjected to evaluation. A particular mechatronic device (Acutattile), a sort of proactive mouse, that represents a further means to communicate with the platform. It acts both in a passive way—like an usual mouse do—and proactive way—by accompanying the users to perform certain movement within some modules (i.e. E-Learning module). Additionally, a network of environmental sensors and actuators are connected to SPEAKYACUTATTILE in order to allow the control of the environment, and an innovative system for postural monitoring for fall detection is part of the system as well. Finally, there are some biometric sensors useful for health status monitoring, in order to provide telemedicine and tele-assistance services. As introduced at the end of the previous section, the present work aims to present the results of experiments carried out in order to assess the speech interface. For this reason, the rest of the article will focus only on those modules, which require speech interaction.

3 Method

3.1 Participants

Thirty-five persons (19 women and 16 men), mean age 46.22 years old (SD = 18.93), took part in the experiment aimed to assess the SPEAKYACUTATTILE platform. Participants were asked to provide information regarding their attitude toward technology. As the reader can see in Fig. 3, the majority of them reported to have a pretty good idea regarding technology and its usefulness in everyday life. Moreover the majority of them reported good capability on computer usage, even if only 13 persons of the sample stated to have experienced speech dialogue system (i.e. Siri, Cortana) in their life.

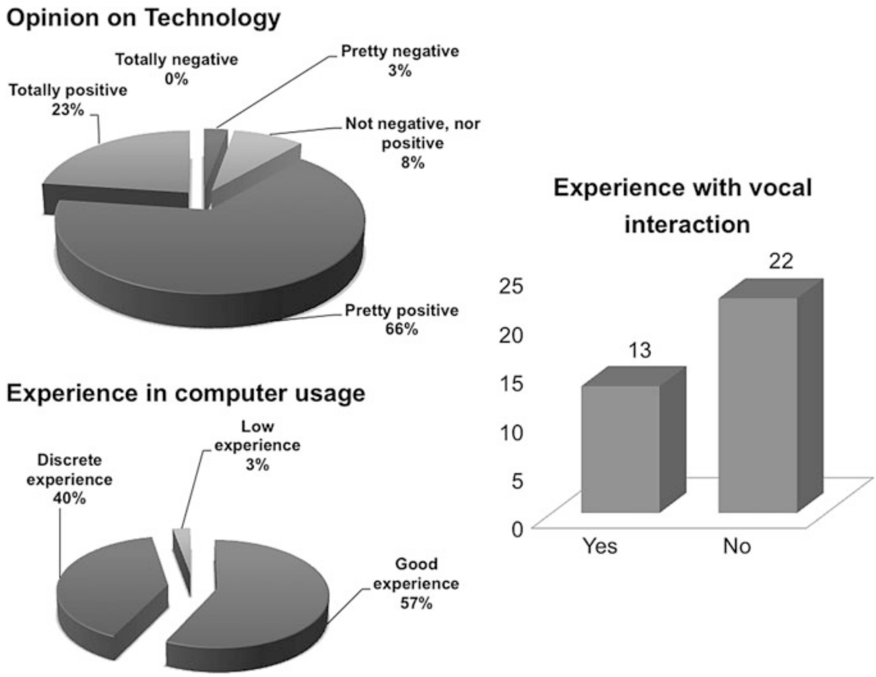

Fig. 3 Descriptive statistics on users experience and opinion with technology

3.2 Materials and Metrics

Subjects have been asked to fill in an ad hoc questionnaire for each module of the platform and a final questionnaire (SASSI [21]) regarding the whole interaction with the system. Moreover, some performance metrics (e.g., length of the interaction, frequency of system's errors) have been gathered from the log file of the system after each interaction. The following subsections are devoted to better describe the instruments used during the evaluation sessions.

3.2.1 Ad Hoc Questionnaire on Task Satisfaction

We built an ad hoc questionnaire based on the one proposed by [19] in order to gather feedback on user satisfaction for each single module. The questionnaire has been developed in order to investigate the following areas:

- *TTS Performance*—It has been easy to understand the system during the interaction.
- *Task Ease*—During this interaction it has been easy to find the information I was looking for.

Table 1 Cronbach's Alpha for each questionnaire

Questionnaires	Cronbach's Alpha
Face recognition	0.77
Telemedicine	0.72
Domotic	0.74
Multimedia library	0.79
Agenda	0.81

- *Interaction Pace* – I think that the pace of interaction with the system was appropriate.
- *User Expertise*—During this interaction I knew what to do and what to say at each point.
- *System Response*—It often happened that the system was slow to reply to me.
- *Expected Behavior*—The system worked the way I expected it to.
- *Future Use*—I would use this system for (different according to the specific module) in the future.

In order to assess the reliability of this ad hoc instrument, the Cronbach's Alpha has been computed for all the versions of the questionnaires developed for each module of the platform. Table 1 shows the obtained values, suggesting good reliability property for each questionnaire on single module satisfaction.

3.2.2 Subjective Assessment of Speech System Interfaces (SASSI)

Subjective Assessment of Speech System Interfaces (SASSI) consists of 34 statements about the tested system, which are to be rated with level of agreement on a 5-point Likert scale. This self-report instrument has been developed by Hone and Graham [21] with the purpose to build an instrument devoted to the assessment of satisfaction on speech dialogue system. It measures six factors of users perception of speech systems:

- *System response accuracy* (e.g. "the system is reliable", "the system makes few errors");
- *Likeability* (e.g. "the system is useful", "I felt in control of the interaction with the system");
- *Cognitive demand* (e.g."I felt tense using the system", "a high level of concentration is required when using the system");
- *Annoyance* (e.g. "the interaction with the system is irritating", "the system is flexible");
- *Habitability* (e.g. "I always knew what to say to the system", "the interaction with the system felt natural");
- *Speed* (e.g. "the interaction with the system is fast", "there were not too many steps needed to perform a task");

3.2.3 Performance Metrics

Among the metrics within the PARADISE framework we took into account those which better fitted with the SPEAKYACUTATTILE platform:

- Dialogue Efficiency Metrics
  - elapsed time, system turns, user turns, total turns
- Dialogue Quality Metrics
  - errors, noinput, reprompt, help (raw)
  - errors%, noinput%, reprompt%, help% (normalized).

The **dialogue efficiency** metrics were calculated from the dialogue recordings and system logs. The length of the recording was used to calculate the elapsed time in seconds (ET) from the beginning to the end of the interaction, indeed it has been calculated for the whole interaction. Measures for the number of **System Turns**, and the number of **User Turns**, were calculated on the basis of the system logging everything the platform said and everything it heard from the user. The total amount of Turns (**Total Turns**) has been computed as well. The **dialogue quality** measures were derived from the recordings and the system logs. Some of them were automatically logged by the system like the number of times the users had to repeat a command to the system (**reprompt**), whenever it was due to an error of recognition by the system or to a timeout. The **errors** of speech recognition by the system were also computed and the times the users pushed the button just to make the system stop talking (**noinput**). User behaviors that the system perceived as a possible situation affecting the dialogue quality were also logged: these included the number of times the system played one of its specific help messages because it believed that the user had asked for *Help* (**helps**). Finally, as in [19], we normalized the dialogue quality metrics by dividing the raw counts by the total number of utterances in the dialogue and this resulted in **errors%**, **noinput%**, **reprompt%**, **help%** metrics.

This solution has been chosen because all the efficiency metrics seems unlikely to generalize [22].

3.3 Experimental Procedure

Participants came to the lab and were asked to compile a consent form, and subsequently they were instructed about the experimental protocol. They were supposed to perform some specific tasks for each module of the platform, since the experimental session focused on specific modules, namely the Face Recognition, the Media Library, the Telemedicine Guide, the Domotics module and finally the Agenda one (see Fig. 4 for additional insight on the experimental setup, and Table 2 for further information on instructions provided to the participants).

Fig. 4 The SPEAKYACUTATTILE devices. On the *left*, the remote controller connected to the pc via USB is displayed, while on the *right* it is possible to see the Speaky Avatar

Table 2 General instructions provided to the participants for each task

Task	Instruction
Face recognition	This is the first task you are asked to perform. Since you need to be registered within the system before you start using it, you have to create your account through the face recognition module. Indeed, please, create your account and register to the system
Multimedia library	Please, enter the media library module and ask the system to listen to an artist. Then, chose a particular song and adjust the volume as you prefer. Finally, check the photographs and look at the video called “countryside”
Telemedicine guide	Please, enter the tele-medicine module. You are supposed to measure your blood pressure. Follow the instruction, take the measurement, and send the data to the service center
Domotic	Please, enter the domotic module. Switch on the light, open the window, raise the shutter and turn on the air conditioner. Now, Switch off the light, close the window, lower the shutter and turn off the air conditioner
Agenda	Enter the Agenda module and check if there are any appointments for today. Now, set up a medical examination for next week

Except for the task face recognition which always was the very first one, the order of the other tasks was randomized among participants

Right after having performed each single task they have been asked to compile the ad hoc questionnaire on usability and satisfaction referring to the single task just performed. At the end of the whole experimental session, participants have been asked to fill in the SASSI questionnaire.

3.4 Statistical Analysis

The objective of the experimentation was to investigate how perceived satisfaction could be affected by performance metrics gathered by the system. For this purpose the following linear stepwise regressions have been performed. In order to investigate the satisfaction experienced by the users while interacting with the single modules, a linear regression has been carried out per each module, where the dependent variable was represented by the results from the ad hoc questionnaire on satisfaction, and the dialogue efficiency metrics and quality metrics, regarding the single task, have been inserted into the model as independent variables. In order to investigate the overall perceived satisfaction, a further linear regression have been performed with SASSI as dependent variable and the overall efficiency and quality metrics as independent variables. In a subsequent step the introduction of each dimension of SASSI as dependent variable has been considered in order to define whether the gathered metrics affected specific aspects of perceived satisfaction. Moreover, a final regression analysis has been carried out with the main aim to investigate the weight of each module on the overall perceived satisfaction. For this purpose, the SASSI score has been inserted into the model as dependent variable, while the scores on the ad hoc questionnaires per each task where inserted as independent variables.

4 Results and Discussion

In Fig. 5 the results from questionnaires on satisfaction assessment are presented. Specifically, on the left the feedback on the overall experience is depicted, both for the overall SASSI score and for each dimension of the questionnaire. On a rating scale from 1 to 5, it can be evinced how the overall experience has been judged pretty satisfactory (M = 3.42, SD = 0.23). More in detail, participants reported good degree of *Likeability* (M = 4.03, SD = 0.69), with discrete feelings of *Annoyance* (M = 2.44, SD = 0.93) and they judge the system effortless (*Cognitive Demand*: M = 4.06, SD = 0.57). Moreover, they found no particular problems with

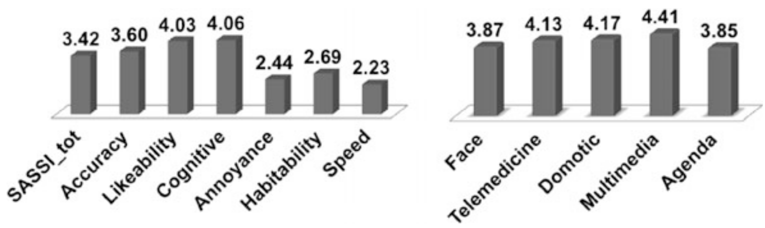

Fig. 5 Mean scores from satisfaction questionnaires. From SASSI (on the *left*) and from each module (on the *right*)

the system reactivity to their commands (*Speed*: M = 2.23, SD = 0.73), and the system behavior seemed to sufficiently match user's conceptual model on it (*Habitability*: M = 2.69, SD = 0.78).

With regard the usability and satisfaction feelings according to each module (graph on the right in Fig. 5), participants reported definitely positive judgments for every module with slight differences among them. The Multimedia Library seems to be the most appreciated module (M = 4.41, SD = 0.69), followed by the one for vocal control of the house (Domotics, M = 4.17, SD = 0.79), and the Telemedicine Guide (M = 4.13, SD = 0.79). Finally, the two modules with the lowest score were the ones devoted to the authentication to the services of SpeakyAcutattile (Face Recognition, M = 3.87, SD = 0.8), and the Agenda (M = 3.85, SD = 0.91).

In Table 3 there are the mean scores obtained by computing the performance metrics from log files and from video recordings. The table displays dialogue efficiency and dialogue quality metrics for interaction of each task according to single modules, and for the whole interaction.

4.1 Overall Satisfaction

One of the main objectives of the present study was to investigate the influence of system performance on the overall satisfaction perceived by the users during the interaction with SPEAKYACUTATTILE. The model tested through the first linear regression analysis showed that the inserted factors explained 38% of the variance in the overall satisfaction (SASSI).

More specifically, looking at Table 4, it becomes clear how the rate of system turns can affect the overall satisfaction during the interaction with the platform. Indeed, a negative association emerged, suggesting how an acceptable interaction has to be characterized by a limited intervention by the agent. This is supported also by the significant negative association with the factor *noinput*. Since this metric accounts for those times when the user pushes the button in order to stop the platform talking, it can be evinced that an increased amount of *noinput* brings to lower perception of satisfaction and usability supposedly due to excessive redundancy of system speech. Moreover, it emerged that the length of the interaction has a positive correlation with the SASSI. Namely, the more the user interacts with the platform, the higher the experienced satisfaction is resulting by the interaction itself.

These results could be reasonably interpreted as the beginning of a sort of familiarizing process where the user get confident while interacting with SPEAKYACUTATTILE increasing his/her feelings of satisfaction and confidence through time. Despite the finding that longer dialogues were associated with higher user satisfaction disagrees with the results of many previous PARADISE-style evaluation studies (i.e. [23]), our results are in line with those of [24] who also find a positive influence of dialogue length. Users could possibly need more time in order to get confident with the system and this turns in more positive feelings expressed for longer interactions that allow the users to familiarize with it. More in detail, when taking into account the subscales of the SASSI questionnaire

Table 3 Mean values (standard deviation within brackets) of performance metrics

Performance metrics	Face recognition	Multimedia library	Domotics	Telemedicine guides	Agenda	Overall interaction
TIME (sec)	185.52 (127.41)	119.35 (72.1)	156.35 (74.45)	243.55 (149.91)	156.84 (107.11)	861.61 (294.52)
USER_TURNS	6.43 (3.93)	9.91 (2.75)	10.80 (2.08)	7.46 (4.21)	12.71 (5.87)	47.23 (9.51)
SYS_TURNS	8.49 (4.00)	8.57 (1.99)	10.63 (1.78)	8.20 (3.93)	12.26 (5.33)	48.14 (8.96)
TOT_TURNS	14.49 (7.54)	18.49 (4.33)	21.43 (3.49)	15.66 (7.80)	24.97 (11.08)	95.03 (16.95)
ERRORS	0.69 (1.32)	0.86 (1.19)	0.51 (0.82)	0.46 (0.70)	1.06 (1.35)	3.57 (2.73)
NOINPUT	0.37 (0.94)	0.66 (1)	0 (0)	1.23 (2)	0.26 (0.51)	2.51 (3.93)
REPROMPT	0.83 (1.15)	1.06 (1.45)	1.49 (1.29)	0.57 (1.20)	1.31 (1.41)	5.26 (3.02)
HELP	0.06 (0.24)	0.03 (0.17)	0 (0)	0.20 (0.53)	0.20 (0.41)	0.42 (0.82)
ERRORS%	–	–	–	–	–	0.04 (0.03)
NOINPUT%	–	–	–	–	–	0.03 (0.03)
REPROPMPT%	–	–	–	–	–	0.06 (0.03)
HELP%	–	–	–	–	–	0.001 (0.04)

Table 4 Linear regression results for SASSI and its subscales

Model	$AdjR^2$	Factors	t	p	Beta	VIF
SASSI	0.38	Time	2.50	0.018	0.40	1.45
		Sys_turns	−3.40	0.001	−0.53	1.36
		Errors%	1.56	0.128	0.22	1.09
		Noinput%	−2.88	0.007	−0.39	1.01
Accuracy	–	–	–	–	–	–
Likeability	0.40	Tot_turns	−1.69	0.101	−0.23	1.13
		Noinput	−3.91	0.000	−0.53	1.07
		Errors%	2.56	0.015	0.35	1.07
Cognitive demand	0.13	Reprompt	−2.59	0.012	−0.45	1.19
		Errors%	1.65	0.109	0.28	1.19
Annoyance	–	–	–	–	–	–
Habitability	–	–	–	–	–	–
Speed	0.22	Time	−1.97	0.05	−0.35	1.45
		Reprompt%	−2.40	0.022	−1.13	9.90

Significant with p-value < 0.05

(Table 4), not all the models resulted significant. Specifically, no significance emerged with regard to Accuracy, Annoyance and Habitability. Nevertheless some interesting results emerged for the other subscales. Likeability seems to be affected by *noinputs* in negative way. This could mean that redundancy in interaction, and consequently the needs to stop the system, risks to undermine the perceived pleasantness and usefulness of the system.

With respect to the perceived amount of effort needed to interact with the system and the feelings resulting from this effort (Cognitive Demand), a negative influence by reprompts emerged. This means that the efforts spent in repeating several time the same commands to the platform—with no receiving answer or receiving a wrong one—can result in too much cognitive load for the users. Speed is the last dimension investigated as dependent variable in a regression linear model, and it has been found to be affected by some performance metrics. Specifically, the model showed how the percentage of repeated commands (reprompt%) and the time required to complete the task (time) influenced negatively the perceived responsiveness of the system to the users commands.

A further step envisaged within the analysis design consisted in deeper investigation of which one of the single modules could better contribute to the overall perception of usability and satisfaction during the interaction (see Table 5). The results revealed that the satisfaction experienced during the interaction with the single modules contributed for 49% to the variance of the overall satisfaction. Two modules resulted to influence the overall experience in a significant manner, the interaction with the Telemedicine Guide and the Agenda. More specifically, the

Table 5 Linear regression analysis results for SASSI and single module satisfaction

Model	AdjR^2	Factors	t	p	Beta	VIF
SASSI	0.49	Face recognition	1.77	0.08	0.25	1.34
		Telemedicine	3.00	0.005	0.56	2.34
		Domotics	−1.50	0.144	−0.27	2.27
		Agenda	3.02	0.005	0.39	1.14

P-value < 0.05 significant

Table 6 Linear regression analysis results for single modules

Model	AdjR^2	Factors	t	p	Beta	VIF
Face recognition	0.19	Time	−1.56	0.12	−0.24	1.01
		Noinput	−2.52	0.01	−0.39	1.01
Domotics	0.13	Reprompt	−2.50	0.01	−0.39	1.00
Multimedia library	0.18	Noinput	−2.95	0.005	−0.45	1.00
Agenda	0.30	Errors	−3.12	0.003	−0.45	1.03
		Help	−1.92	0.06	−0.28	1.03

P-value < 0.05 significant

contribution of the satisfaction experienced while performing these specific tasks seemed to influence in an effective way the overall experience contributing to define it as satisfactory and defining the platform as usable and useful.

It is possible to speculate on these results by recurring to qualitative comments made by the users while participating at the experimental sessions. Indeed, they particularly appreciate the Telemedicine module because of its usefulness in monitoring the health status of the persons, and because of its property devoted to foster the relation with a caregiver in order to make him aware of possible warning on the person's health status. These results can be read under the lens of well-known models of technology acceptance (TAM [25], UTAUT [26]). In fact, according to these models, the perceived usefulness represents one among the determinants of technology acceptability.

4.2 Single Module Satisfaction

Finally we were interested in understanding whether any performance metrics could somehow affect the experienced satisfaction on single modules. Actually, the coefficient of determinations did not show valuable results on the proposed models (Table 6). Moreover, many metrics have been removed through the stepwise selection and the model, where the scores from Telemedicine satisfaction were inserted as dependent variable, did not result significant at all. This could be due to a methodological issue: probably a low amount of observations per each metrics within subjects could affect the results. This issue was conversely overcome when taking into account the whole interaction.

5 Conclusions

The present work described SPEAKYACUTATTILE, an innovative assistive computer-based platform devoted to support the daily life of people. Healthy people have assessed the prototype in order to test the technology readiness, and this represented a preliminary step before introducing the solution to frail people. In fact, this solution has been conceived as an enrichment for home environment in everybody daily life, and specifically for frail people. SPEAKYACUTATTILE is primarily meant to represent a means to break down those barriers which arise when frailty comes over. Results from the evaluation bring valuable contributes to better delineate which features could be ascribable to a satisfying Spoken Language System for Ambient Assisted Living. It emerged how longer dialogues are preferred in order to positively influence the users satisfaction, suggesting the importance to let people the time to get confident with new solutions. Moreover, it emerged how system intervention should be reduced, suggesting how a good balance between user and system turns represents a further critical aspect of those systems. The same can be speculated for dialogues with no met requests that also tended to be associated with lower satisfaction scores. These last results support the importance for a vocal assistant to be effective in its purpose in order to be perceived as useful and satisfying. Overall, this experience represented a step forward bringing additional insights on SLS as valuable solutions in everyday life of people, even not taking into account possible impairment. After all, the value of such speech-based solutions in people everyday life was suggested by the wide diffusion of instruments like vocal assistants on smart phones. This work will drive the industrialization process of the SPEAKYACUTATTILE assistive platform, which will be launched on the global market in 2019. The patented product SPEAKYACUTATTILE may be a highly innovative product worldwide. Nevertheless, this work represented a preliminary step, because still further investigations on SPEAKYACUTATTILE are required now by involving frail people. The goal for further investigations is to involve blind users in order to refine the platform according to specific needs and to assess its usability within the Universal Design framework. In fact, additional efforts are still necessary in order to validate speech interfaces as meaningful means in AAL paradigms.

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References

1. Kamm C, Walker M (1997) Design and evaluation of spoken dialogue systems. In: IEEE workshop on automatic speech recognition and understanding, pp 14–17
2. Carbonell N, Pierrel J (1988) Recent advances in speech understanding and dialog systems. NATO ASI series F: computer and systems sciences, vol 46. Task-oriented dialogue processing in human-computer voice communication, p 491–495. Springer
3. Haton J (1988) Recent advances in speech understanding and dialog systems. NATO ASI series F: computer and systems sciences, vol 46. Knowledge-based approaches in acoustic-phonetic decoding, pp 51–70. Springer
4. Niedermair GT, Streit M, Tropf H (1990) Linguistic processing related to speech understanding in SPICOS II. Speech Commun 9:565–585
5. Ermon LD, Lesser VR (1990) The hearsay-ii speech understanding system: a tutorial. In: Waibel A, Lee K-F (eds) Readings in speech recognition. Morgan Kaufmann Publishers Inc., San Francisco, CA, USA, pp 235–245
6. Kitano H (1990) Dmdialog: a speech-to-speech dialogue translation system. Mach Transl 5 (4):301–338
7. Wood W (1990) Language processing for speech understanding. In: Waibel A, Lee K-F (eds) Readings in speech recognition. Morgan Kaufmann Publishers Inc., San Francisco, CA, USA, pp 519–533
8. Sagerer G, Kummert F (1988) Knowledge based systems for speech understanding. Springer, p 421–458
9. Young S, Russell N, Thornton J (1991) The use of syntax and multiple alternatives in the vodis voice operated database inquiry system. Comput Speech Lang 5(1):65–80
10. McGlashan S, Fraser N, Gilbert N, Bilange E, Heisterkamp P, Youd N (1992) Dialogue management for telephone information systems. In: Proceedings of the third conference on applied natural language processing, p 245–246. Association for Computational Linguistics
11. Young S, Hauptmann AG, Ward WH, Smith ET, Werner P (1989) High level knowledge sources in usable speech recognition systems. Commun ACM 32(2):183–194
12. Hoeppner W, Morik K, Marburger H (1986) Talking it over: the natural language dialog system ham-ans. In: Bolc L, Jarke M (eds) Cooperative interfaces to information systems. Springer, New York, NY, USA, pp 189–258
13. Mctear M (1987) The articulate computer. Blackwell Publishers Inc, Cambridge, MA, USA
14. Goetze S, Moritz N, Appell J-E, Meis M, Bartsch C, Bitzer J (2010) Acoustic user interfaces for ambient-assisted living technologies. Inform Health Soc Care 35(3–4):125–143
15. Becker E, Le Z, Park K, Lin Y, Makedon F (2009) Event-based experiments in an assistive environment using wireless sensor networks and voice recognition. In: Proceedings of the 2nd international conference on PErvasive technologies related to assistive environments, p 17. ACM
16. López-Cózar R, Callejas Z, Griol D, Quesada JF (2014) Review of spoken dialogue systems. Loquens 1(2):e012
17. Jian C, Schafmeister F, Rachuy C, Sasse N, Shi H, Schmidt H, von Steinbüchel N (2012) Evaluating a spoken language interface of a multimodal interactive guidance system for elderly persons. In: HEALTHINF 2012—proceedings of the international conference on health informatics, Vilamoura, Algarve, Portugal, 1–4 Feb 2012, pp 87–96
18. Krajewski J, Wieland R, Batliner A (2008) An acoustic framework for detecting fatigue in speech based human-computer-interaction. In: Proceedings of the 11th international conference on computers helping people with special needs, pp 54–61. Springer
19. Walker M, Kamm C, Litman D (2000) Towards developing general models of usability with paradise. Nat Lang Eng 6(3&4):363–377
20. Walker MA, Litman DJ, Kamm CA, Abella A (1997) Paradise: a framework for evaluating spoken dialogue agents. In: Proceedings of the eighth conference on European chapter of the

association for computational linguistics, p 271–280. Association for Computational Linguistics
21. Hone KS, Graham R (2000) Towards a tool for the subjective assessment of speech system interfaces (sassi). Nat Lang Eng 6(3&4):287–303
22. Litman DJ, Walker MA, Kearns MS (1999) Automatic detection of poor speech recognition at the dialogue level. In: Proceedings of the 37th annual meeting of the association for computational linguistics on computational linguistics, pp 309–316. Association for Computational Linguistics
23. Litman DJ, Pan S (2002) Designing and evaluating an adaptive spoken dialogue system. User Model User-Adap Inter 12(2–3):111–137
24. Foster ME, Giuliani M, Knoll A (2009) Comparing objective and subjective measures of usability in a human-robot dialogue system. In: Proceedings of the joint conference of the 47th annual meeting of the ACL and the 4th international joint conference on natural language processing of the AFNLP, vol 2. pp 879–887. Association for Computational Linguistics
25. Davis F (1989) Perceived usefulness, perceived ease of use, and user acceptance of information technology. Manage Inf Syst Q 319–340
26. Venkatesh V, Morris M, Davis G, Davis F (2003) User acceptance of information technology: toward a unified view. Manage Inf Syst Q 425–478