

# Digital Television as a Usable Platform for Enhancement of Learning Possibilities for the Elderly

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## Abstract

The use of television (TV) for learning purposes has been a topic of interest for several decades. Although digital TV represents a highly up-and-coming platform for education, there is a plethora of issues from various areas. The primary goal of this article is to present details associated with the investigation of how elderly as a distinctive group of users perceive the usability of t-learning applications while communicating by diverse types of interaction tools and t-learning applications. These applications are focused on cognitive training, physical education, and game-like application dealing with building of family trees. A total of 119 subjects attended in the experiment. All participants participated in a group of appointments that involved 24 sessions for almost 3 months. The activity during these individual sessions demanded from 20 to 30 min of time, accumulating to between 8 and 12 hr in total. There were three hypotheses tested, focused on usability, and influence of age and gender. Evaluation of usability uncovers that t-learning applications have a higher chance of acceptance by the elderly when the content deals with mentally oriented tasks rather than physical exercise. In this way, it is proved that t-learning does not represent a suitable platform for stimulation of the elderly to undertake physical exercise.

## Keywords

elderly education, t-learning, technology development, cognitive games, usability

## Introduction

Digital television (TV) and related technologies introduce significant novelties areas such as business (Barač, Ratković-Živanović, Despotović-Zrakić, Labus, & Bogdanović, 2017), health care (Rivas Costa, Fernández Iglesias, Anido Rifón, Gómez Carballa, & Valladares Rodríguez, 2017), education (Reyes Gamboa, Soto Duran, & Jimenez Builes, 2015), or media sector (Cornia, 2016). Digital TV deals with end-user interactivity based on computer applications transmitted to end users together with the audio-visual stream. In this way, viewers can take advantage of selecting the most preferred content, or accessing services such as an interactive advertisement, personal photographs or movies stored in clouds, additional movie information, or weather forecasts. Interactive digital TV is considered as the convergence of both computer and TV technologies by taking advantage of three main traits associated with computer-based technologies (Bousbia, Miladi, Kooli, Chouki, & Boumaiza, 2017; Lytras, Lougos, Chozos, & Pouloudi, 2002), personalization, digitalization, and interactivity. Digital TV represents a promising educational platform because it utilizes both a large user penetration and interactivity (Bates, 2003). Hence, interactive digital TV supports the development of the t-learning concept in education and training. The extent of

influence of media upon learning has been a subject of debate by educational theorists for several decades. For instance, the research conducted by Salomon (1984) confirms that the media selection does not significantly differentiate the pace of knowledge acquisition and depth of understanding. Nevertheless, the intensity of learning substantially depends on the learner's volitional mindfulness (Bellotti, Mikulecká, Napoletano, & Rohrová, 2006). The idea of distance learning through TV is intensively investigated especially as a form with potential to complement PC-based e-learning and traditional educational programs broadcasted by analog TV (Bellotti et al., 2008). Garito (2001) claims that digital TV can be fruitfully applied as a solution finding answers to life-long educational needs and can be an important tool for ability to develop a new skills and knowledge. Several authors agree and state that the development of digital TV may have far-reaching implications in education (Pazos-Arias et al.,

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**Table 1.** Baseline Participant Characteristics.

	First group (n = 59)	Second group (n = 60)	p value
Age in years ( <i>M</i> ± <i>SD</i> [Range])	68.3 ± 5.8 (60-87)	67.75 ± 5.8 (61-85)	.582
Female (%)	62.7	63.3	.548 <sup>a</sup>
University level education (%)	32.2	56.7	.006 <sup>a</sup>
Lifelong learning in years	17.88 ± 7.67 (11-43)	19.57 ± 7.09 (11-43)	.087
Challenging mental activities in hours	47 ± 60 (0-240)	42 ± 50 (0-263)	.636
Self-reported physical activities (hours per 1 month)	150 ± 80 (13-388)	166 ± 110 (14-486)	.414

<sup>a</sup>The significance is for chi-square statistic.

2008). Aarreniemi-Jokipielto, Tuominen, Kalli, and Riikonen (2005) claim that participants in their course on Local Demands for Global Enterprising felt that digital TV is a quite appropriate platform for educational purposes and that they would like to be involved in further exploration of digital TV possibilities. Dos Santos, do Vale, and Meloni (2006) depict how t-learning can be applied in a society with high digital divide. Reasons are simple, TV is a familiar, easy-to-use, and reliable consumer device with a large penetration level in particular households.

However, there is a plethora of issues from areas such as pedagogical framework development, digital signal processing, and multimedia production, which need to be addressed. Specific research needs to be conducted in the area of user-TV interaction. Various studies focused on video as an instructional tool (Stoddard, 2012) or good practice in design of remote control features was reported in the past (Lessiter, Freeman, Miotto, & Ferrari, 2008). Therefore, following studies of Santana and Anido (2016) and Orso, Spagnoli, Gamberini, Ibañez, and Fabregat (2016), this article investigates how end users evaluate the usability of the t-learning application. Altogether, three hypotheses are tested. Moreover, demographic issues tied to aging population and low level of learning activities conducted by older adults have become universally disturbing worldwide. Considerable effort is invested at both national and supranational level with the aim to improve the current state. There are various reasons for this development, where help to prevent the cognitive decline related to aging can serve as an example. As there is a lack of attention to seniors as a specific target group in literature (Shatil, Mikulecká, Bellotti, & Bureš, 2014), the study concentrates on the elderly as the primary target group. The article is organized as follows. The next section presents a general introduction to the t-learning concept. The "Method" section describes the experiment, with its participants, methods, and measures used. The "Results" section details the results. The "Discussion" section focuses on the discussion and finally, the main conclusions in "Conclusion" section.

## Method

This section describes the conducted experiment. First, the basic characteristics of the experiment participants are

defined, and then the technology used is introduced. Finally, the details related to the usability test are presented.

## Participants and Intervention

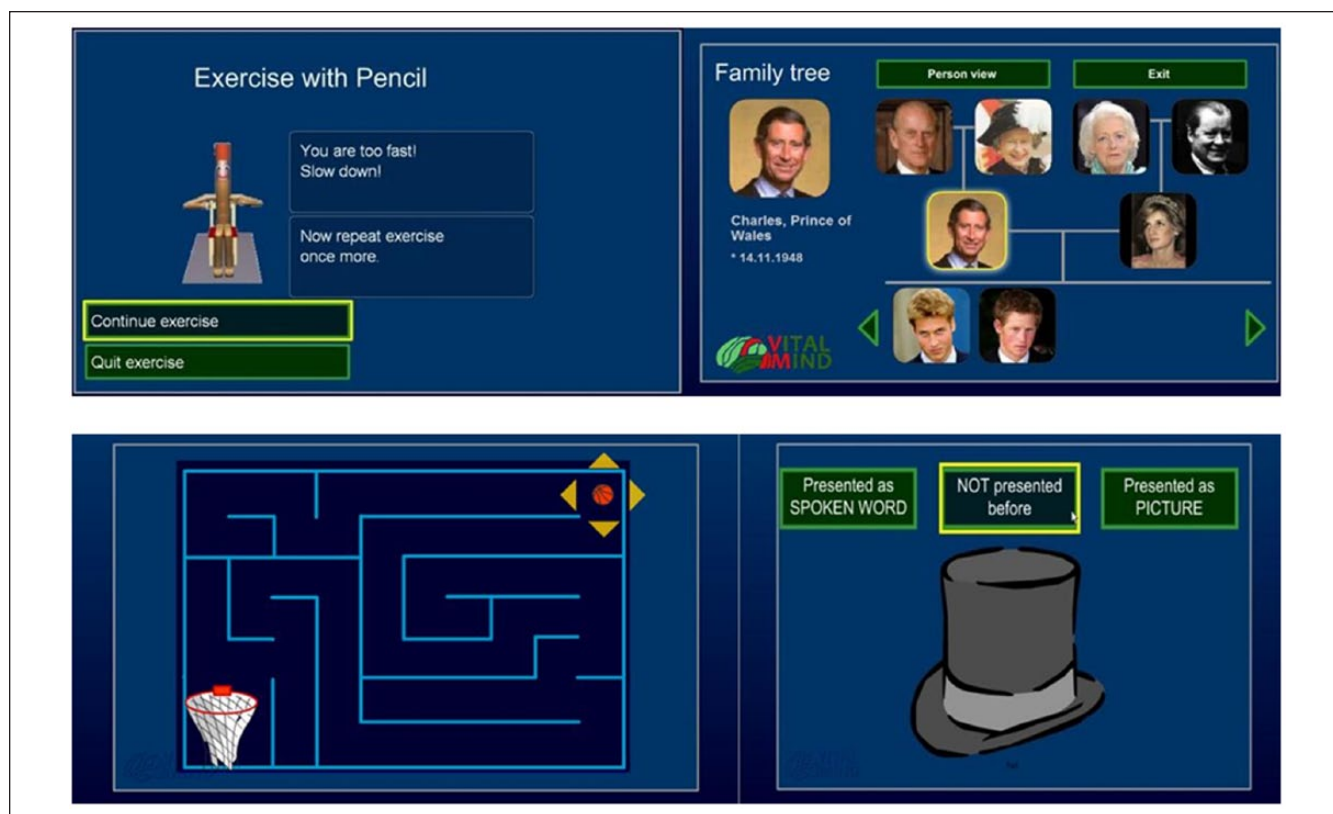
A total of 140 subjects were engaged through advertisements in local newspapers and a recruitment procedure at the University of Third Age (i.e., informal university for those who want to educate themselves at the university facilities even after retirement). Course attendees were approached directly during their regular sessions at the university. A total of 119 subjects participated in this experiment, and their valid data were processed. All participants signed the informed consent forms expressing their voluntary attendance and awareness of the study purpose. The experiment started with random split of volunteers into two groups. This enabled to test several applications in parallel and decrease the number of tests per one participant. Table 1 exhibits the equivalence of baseline personal characteristics in both groups, except for education.

All participants attended in a series of appointments during which they interacted with given t-learning applications. This involved 24 sessions for almost 3 months. The activity during these individual sessions demanded between 20 and 30 min, which represents approximately from 8 to 12 hr of workload. Although the first group interacted with applications without focus on cognitive training and had the occasion to attempt Nintendo sports, the second group worked merely with the cognitive application throughout the extended engagement period (see details below).

## Technology Deployed

Four technology sets were installed at the university labs. Each technology set deployed comprised both a standard Phillips TV device, and a set-top-box properly configured via with 4-GB USB port. Both the commonly used TV remote control, and a pointer device developed by Phillips Innovation Lab for the purposes of the study were used during the testing procedure. Further details can be found in Bureš, Mikulecká, Ponce, and Otčenášková (2013).

Three t-learning applications were tested in terms of their usability. The Figure 1 depicts content of the Cognitive



**Figure 1.** Screenshots from PE (moving pencil), FT (the Royal family of Great Britain), and CG (Seen or Heard Objects and a Maze). Note. PE = Physical Exercise; FT = Family Tree; CG = Cognitive Application.

Application (CG), Family Tree (FT), and Physical Exercise (PE). The PE application requires physical activity. An advantage of the PE application as compared with the instructional brochure or video is that all users can enjoy personalization of exercises and real-time feedback. The FT application uses family memories. The idea is that digital TV can provide users a very intuitive interface to database of their family memory multimedia (photographs or movies). The design of the CG application permits seniors to challenge and exercise the brain. The aim of the cognitive training application is “to prevent regression of well-preserved cognitive skills, as well as to enhance other cognitive capabilities through training” (Shatil et al., 2014). The time needed to respond to a simple stimulus where no decision is involved or reaction speed can serve as examples of abilities that were intended to be tested by developed set of games.

### Usability Tests

Classes of usability measure are defined by ISO standards. According to Brooke (1996), these are “effectiveness (ability of users to complete tasks using the system, and the quality of the output of those tasks); efficiency (level of resources consumed in performing tasks); and satisfaction (users’ subjective reactions to using the system, p. 190).” Nevertheless,

other characteristics such as naturalness, aesthetics, or meaning can be evaluated (Drouet & Bernhaupt, 2016). The primary purpose of the study was to measure and evaluate the users’ point of view on usability of the t-learning applications. The following hypotheses were tested:

**Hypothesis 1 (H1):** The t-learning applications are usable for seniors.

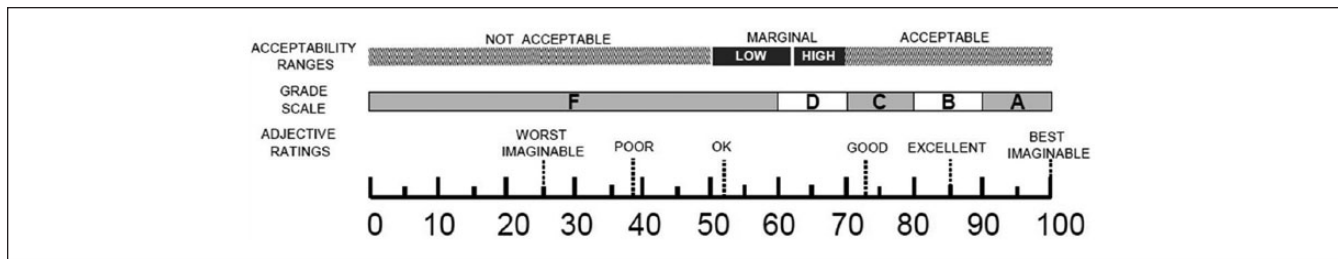
**Hypothesis 2 (H2):** The perception of usability is not effected by age.

**Hypothesis 3 (H3):** The perception of usability is not effected by gender.

System Usability Scale (SUS) was used to test the hypotheses. User evaluations were acquired at the University of Hradec Králové, Czech Republic, at the very end of the engagement period. The SUS questionnaire was composed of 10 statements presented by Bangor, Kortum, and Miller (2009) in their study. Nevertheless, this questionnaire was enriched by one statement and its own answer scale:

Eventually, I would evaluate the user-friendliness of this product as:

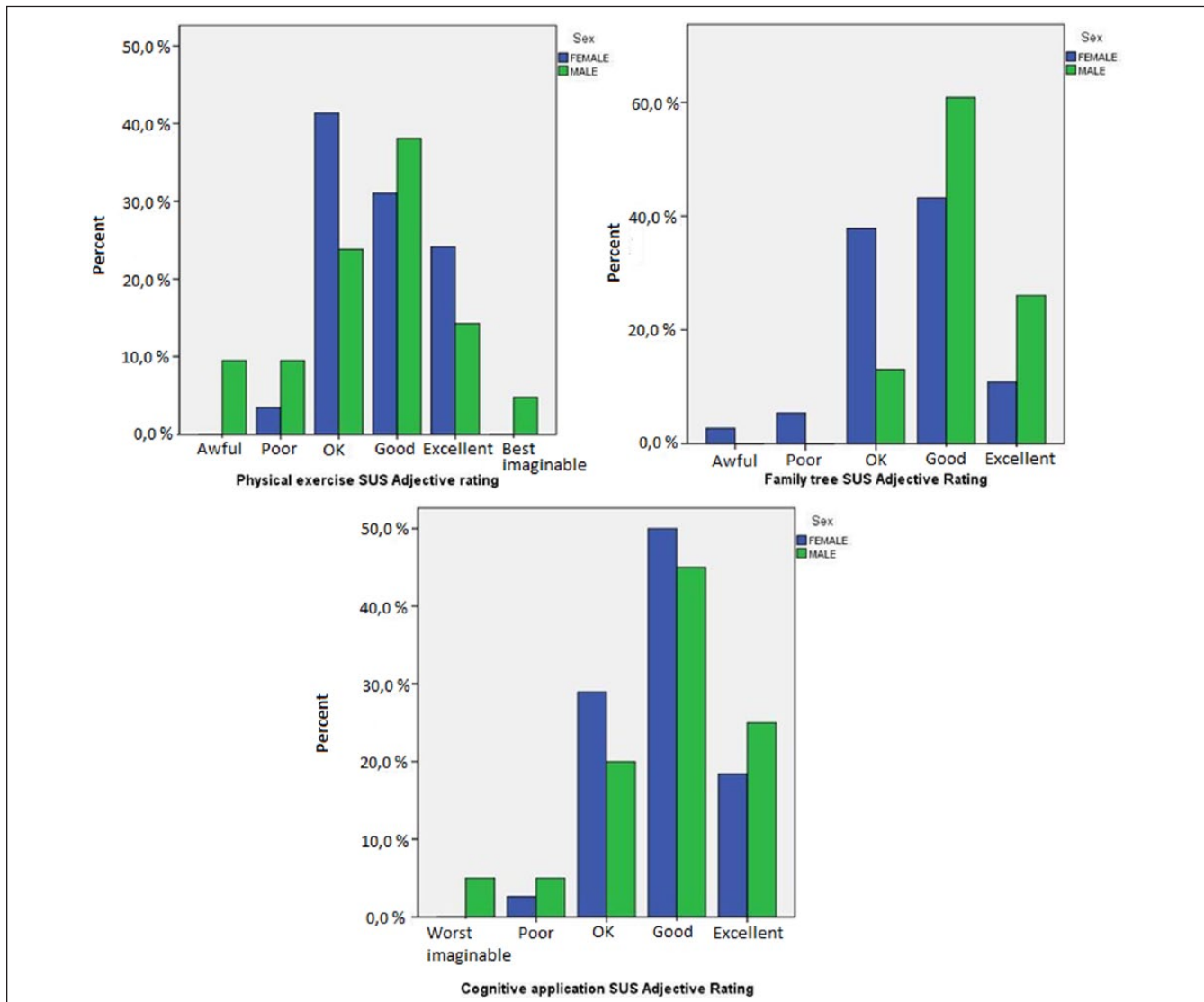
Worst imaginable / Awful / Poor / OK / Good / Excellent / Best imaginable.



**Figure 2.** SUS scores.

Source. Adapted from Bangor, Kortum, and Miller (2009).

Note. SUS = System Usability Scale.



**Figure 3.** Adjective rating of PE, FT, and CG applications.

Note. PE = Physical Exercise; FT = Family Tree; CG = Cognitive Application.

SUS scores and associated acceptability range for mean presented by Bangor et al. (2009) were followed. These ranges can be expressed in a form of grades depicted in Figure 2.

As positive users' impression represents quite significant aspect of TV-based environment, a questionnaire with 10 additional questions was created and used during the

evaluation process. This extension was grounded in the affectivity subscale comprised in the Software Usability Measurement Inventory—SUMI, developed by Kirakowski and Corbett (1993). The statistical analysis was performed with the help of the SPSS statistical software application. One-sample *t* test was conducted to compare the mean usability level with the required value. Differences between the age and gender groups were tested by the General Linear Model.

## Results

This section provides results of both the usability tests and statistical tests. Although the former reveal the evaluation of the developed t-learning applications by elderly, the latter offer specific answers to particular research hypotheses.

### Usability Tests

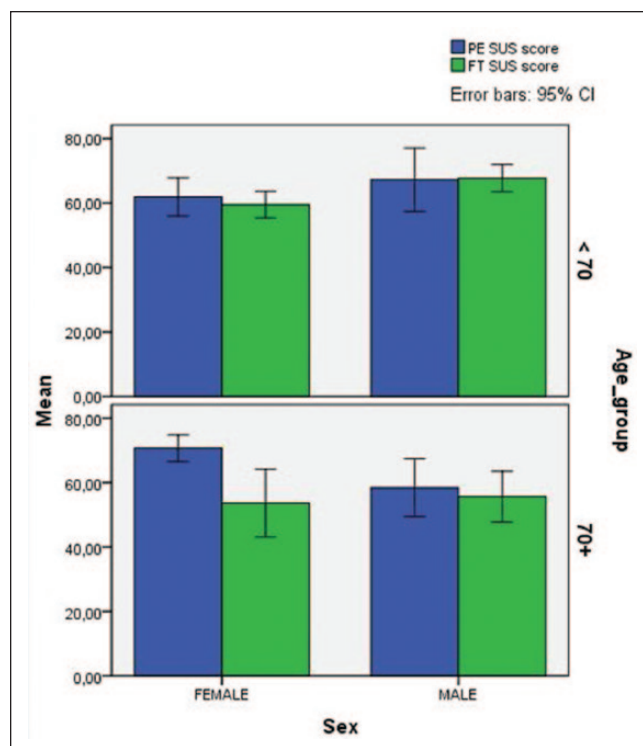
SUS adjective ratings associated with particular applications are presented in Figure 3 in a form of the bar charts. Results reveal that the PE application, the FT applications, and the CG application were considered at least as “good” by 47.5% (50 users), 67.8% (59 users), and 69% (58 users), respectively. If the “OK” response is set as the threshold for usability, then the aforementioned results will grow to 76%, 95%, and 95%, respectively. If SUS score in its standardized score is reckoned, other, more realistic, evaluation outcomes are acquired— $59 \pm 12$ ,  $63 \pm 14$ , and  $65.5 \pm 11.2$ , respectively. However, even this evaluation assigns to applications the “D grade” which makes them usable, although at the borderline (Bangor et al., 2009).

To explore the possible role of age in the perception of usability, the clustered bar charts with error bars are used. Figure 4 suggests that noncognitive applications are perceived as less usable by persons above 70 years of age and that female users in this category prefer a very simple interaction which was the case of the PE application. The affectivity appears to be perceived equally by male and female users as presented in Figure 5.

### Statistical Tests

One-Sample *t* test was applied to test the H1 hypothesis. It compared the mean SUS score achieved by each application with the selected value of 60 (borderline between the “D” and “F” grade). Table 2 shows the results.

Obtained results can be interpreted in the following way. Significant mean difference from the threshold value can be identified in case of the CG application ( $M = 65.53$ ,  $SD = 11.17$ ;  $p = .00$ ) and PE application ( $M = 63.40$ ,  $SD = 13.84$ ;  $p = .08$ ). Confidence intervals of both applications score differences have positive values. Hence, it can be stated that the scores are not below the threshold within the 90% confidence



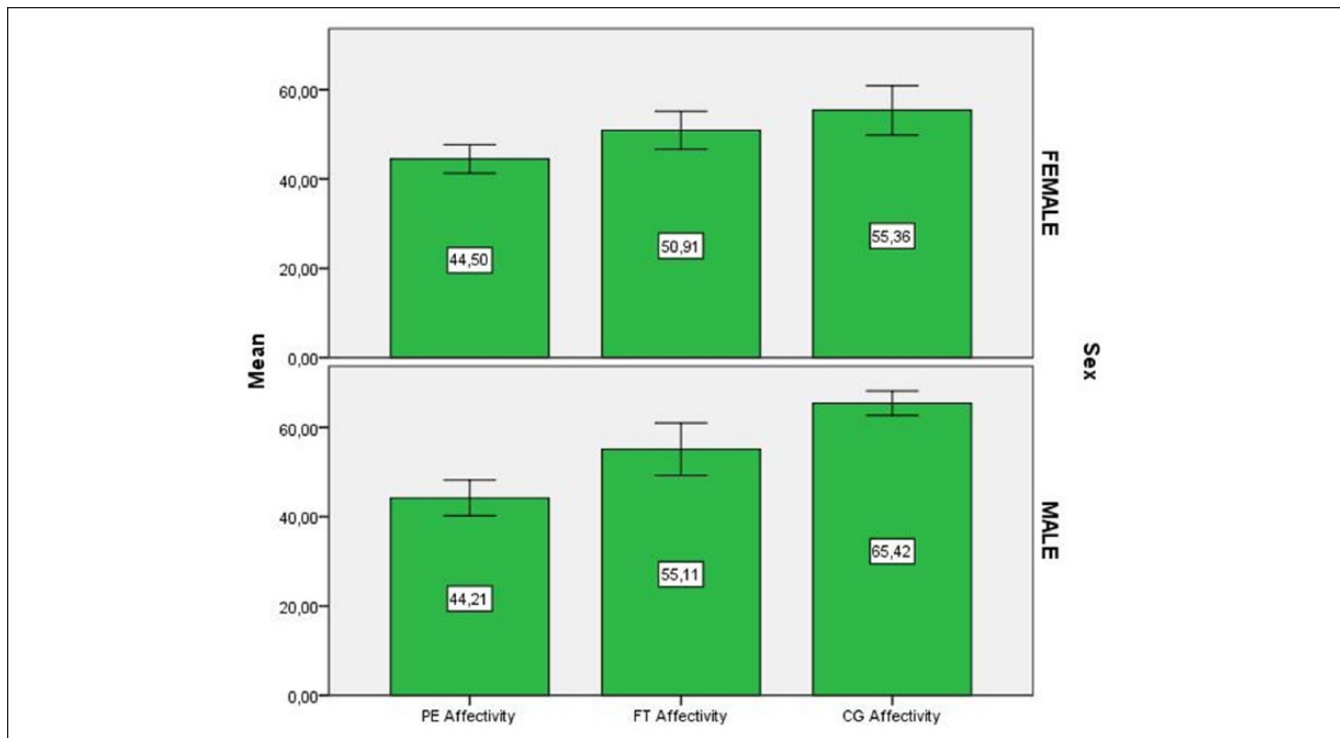
**Figure 4.** SUS score of PE and FT applications.

Note. SUS = System Usability Scale; PE = Physical Exercise; FT = Family Tree.

interval, and CG and PE applications are perceived as usable by older adults.

To find out whether perception of usability is influenced by gender and age (H2 and H3), the General Linear Model was applied to the usability score of each application. Subjects were divided into two groups according to their age (Group 1: 60–69 years; Group 2: 70 years and above). The descriptive statistics are found in Table 3. Levene’s test results are not significant for all three applications indicating no violation of the assumption of homogeneity of variances. Inspection of the table of Tests of Between Subjects Effects indicates a nonsignificant interaction effect for FT ( $p = .338$ ), and a significant interaction effect for PE ( $p = .039$ ) and CG ( $p = .047$ ). Therefore, the main effect for independent variable only for FT was considered. The main effect for FT is significant ( $p = .007$ ). The direction of the effect was determined by examination of the mean scores provided in the Descriptive Statistics table and graphically, in the plot of mean scores.

The overall level of usability perception of the FT application is higher for younger subjects as age matters for the FT application. The situation is different for the CG and PE applications. Due to the significant interaction effect, interpretation of the results is not as evident as in the previous case. The significant main effect of age is noticed only in CG ( $p = .012$ ). After exploring the plot of mean scores, younger subjects perceive higher usability of the CG application.



**Figure 5.** Affectivity of applications.

**Table 2.** One-Sample *t*-Test Statistics.

Test value = 60									
	<i>n</i>	<i>M</i>	<i>SD</i>	<i>t</i>	<i>df</i>	Significance (two-tailed)	Mean difference	90% confidence interval of the difference	
								Lower	Upper
CG SUS score	57	65.53	11.17	3.736	56	.000	5.53	3.05	8.00
PE SUS score	53	63.40	13.84	1.786	52	.080	3.40	0.21	6.58
FT SUS score	58	59.35	11.91	-0.414	57	.681	-0.65	-3.26	1.97

Note. CG = Cognitive Application; SUS = System Usability Scale; PE = Physical Exercise; FT = Family Tree.

However, in this case, male users are the “driving force” as age is more important for this gender. The main effect of gender is not significant for any application. Nevertheless, it might be deduced from the marginal means plot that gender in the case of the PE application matters, although the influence is not statistically significant.

## Discussion

The achieved results further contribute and support conclusions presented by Aarreniemi-Jokipielto et al. (2005) or Dos Santos et al. (2006). As already stated, this study aims at assessment of the usability of three purpose-built t-learning applications. These were created for the elderly with zero experience with t-learning studies. Bureš et al. (2013) describe

t-learning only as a “part of supportive environment of the elderly” and provide preliminary testing of usability. In this sense, this study elaborates acquired results. This study also follows critiques and takes into consideration negative issues related to t-learning (Silva, Cavalcanti, & Gomes, 2015). Atwere and Bates (2003) as well as Aarreniemi-Jokipielto and Tuominen (2004) argue that “most of the t-learning developments have been conceived merely as a value-add to the offer of TV programs, with little concern of pedagogical issues.” Alongside with the technological issues, Bellotti et al. (2008) express the need for the interrelationship of two distinct areas to arise during the development of particular educational content. They depict this condition, in which learning with the help of digital TV connects the entertainment realm of TV programs as well as the educational nature of e-learning. The

**Table 3.** Gender × Age Groups Descriptive Statistics.

Sex	Age	Cognitive application			Family tree application			Physical exercise application		
		M	SD	n	M	SD	n	M	SD	n
Female	<70	66.10	11.46	25	59.52	10.44	26	61.90	14.78	25
	70+	64.17	9.96	12	53.61	15.11	9	70.63	5.63	8
	Total	65.47	10.89	37	58.00	11.86	35	64.02	13.61	33
Male	<70	69.50	11.15	15	67.73	6.84	11	67.22	14.39	9
	70+	54.00	4.18	5	55.63	12.89	12	58.41	14.02	11
	Total	65.63	11.94	20	61.41	11.94	23	62.38	14.52	20
Total	<70	67.38	11.32	40	61.96	10.16	37	63.31	14.65	34
	70+	61.18	9.77	17	54.76	13.55	21	63.55	12.65	19
	Total	65.53	11.17	57	59.35	11.91	58	63.40	13.84	53

connection of t-learning with edutainment is also supported by Damásio and Quico (2004) or Neto, Muniz, Burlamaqui, and De Souza (2015).

The first hypothesis that deals specifically with usability of t-learning application run on the interactive personalized TV is confirmed. The testing procedure identified two applications (CG and PE, namely) that are evaluated as usable. Nevertheless, the last remaining t-learning application (FT) has not reached the acceptable score of usability. Interpretation of this results might be based on the approach used for interaction and moving among objects on the screen, which can be considered as unusual. As stated by Bureš (2012), “this is a new type of interaction for the elderly.” Apparently, elder TV users consider ease of use as a significant criterion for evaluation. As for the second hypothesis, the experiment confirms that age represents a significant aspect in the perception of usability of t-learning applications. The results demonstrate that for the FT and CG applications, younger subjects perceive the applications as more usable than subjects aged above 70 years. For the PE application, the pattern is different, most probably caused by the different attitudes of male and female users. There is no significant age impact. Older females perceive better usability of the PE application than females aged below 70 years, contrary to males. The second hypothesis is rejected. However, ambiguity in evaluation represents a proper starting point for further research. As for the third hypothesis, it appears that gender also plays a role. Results indicate that there might be a different pattern of overall usability perception by gender. Males tend to use extreme levels in their judgments more often than females. However, the experiment was not set properly to achieve results, which could either confirm or refute this hypothesis (H3). Apparently, more experiments are needed to understand better the role of gender in usability perception. Thus, this opens a pathway to future research activities.

SUS evaluation results reveal that in case of t-learning applications, the elderly prefer the mentally engaging content, rather than the physically oriented one. It can be concluded that t-learning applications do not represent an appropriate instrument to activate the elderly and encourage

them to do PE. Other technologies can be used for this purpose (Maresova & Klimova, 2015). Therefore, the deployment of this technology in practice could be focused more on communication activities and functions, entertainment, or mediation of a cognitive exercise.

## Conclusion

Latest advancements in the digital TV domain enable the evolution of e-learning within t-learning, in which the TV device and broadcasting systems are used for education (Vilkonis, Bakanoviene, & Turskiene, 2013). This article focuses on the usability of t-learning applications while taking into consideration the mode of user interaction with a TV set. The elderly aged above 60 years represent the main target group of this study. The acquired results grounded in usability and statistical testing confirm that t-learning applications are usable. However, the age category to which the application is aimed merits further attention. Significant differences in the particular age categories are identified. Gender also needs to be considered; nevertheless, its role in the perception of t-learning applications requires further investigation. Moreover, the context and overall environment in which t-learning applications are in service represent a significant issue that needs to be considered.

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## Declaration of Conflicting Interests

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### Author Biographies

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