Hôsea: A Touch Table for Cognitive and Motor Rehabilitation for the Elderly - A Preliminary Study

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Abstract: As the population ages, it is becoming increasingly important to offer technological solutions for cognitive-motor rehabilitation. In this context, we have designed Hôsea, a new touch table offering an attractive, accessible and stimulating interface for the elderly. The table integrates various motor and cognitive exercises. The study presented in this article examines the ease of use of the table, as well as the motivation and effort perceived by elderly people. To achieve this, we engaged with 43 elderly individuals in good health, presenting them with a 15-minute session involving three games accessible on the table. At the end of the session, participants were administered standardized scales, evaluating the usability of the table via the F-SUS, the degree of perceived effort with the NASA-TLX, and their motivation with the SIMS. The results suggest that the Hôsea touch table offers a user-friendly and motivating environment. These results motivate further work on a personalized rehabilitation program.

1 INTRODUCTION

Digital technologies for seniors require special attention. Among the specificities of elderly users, we find diminished muscular conditions and cognitive decline (Awan, 2021). Therefore, gerontechnology must take into account the evolution of motor skills, visual and hearing disorders, but also cognitive decline (Liao, 2018). The intensity of age-related losses varies among individuals, affecting distinct cognitive functions and manifesting themselves at different stages, thereby influencing various aspects of daily life activities. In this case, innovative technologies can be used to stimulate motor and cognitive skills (Lee, 2021). Older people may encounter several difficulties with everyday digital interfaces for reasons related to learning barriers and accessibility issues (Iancu, 2020; Awan, 2021). A main reason is that interfaces generally require robust motor skills and specific cognitive abilities such as working memory, short-term memory, and selective attention (Iancu, 2020; Liao, 2018). The lack of digital accessibility for older people has more to do with non-inclusive design than a lack of capacity (Iancu, 2020; Lee, 2021). The complexity of design, its richness and its standards not transmitted to a population less aware of new technologies makes design a major element of digital accessibility (Tajudeen, 2022). The same observation applies in the context of video games, where the specificity of the environment in terms of game design and game dynamics must also be taken into account for accessibility (Ijsselsteijn, 2007).

Faced with this, a global approach is recommended to develop interfaces for older people with simpler interactions and better retention of information alongside adequate support. This study evaluates the usability, perceived workload and motivation for using a new touch table called Hôsea and its software dedicated to seniors by offering exercises that stimulate cognition and physical effort. To do so, the following section discusses related work on touch tables for the elderly. Section 3 details the conducted experiment, while Section 4 outlines the experiment's results. Section 5 presents a discussion and analysis of the results. The paper ends by a conclusion and provides some tracks for future work.

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2 RELATED WORK

2.1 Touch Table Interface

A touch table refers to a horizontal 2D platform for digital content and tactile interactions, with two main types distinguished by technological differences (Dillenbourg, 2011). Projection tables use a flat surface with an integrated frame mechanism (Figure 1-a) or a rear projection (Figure 1-b). The main issues with this approach include user shadow interference and low projected image resolution (Geller, 2006). However, projection systems allow the use of physical object and the ability to display the screen on any flat surface (Dillenbourg, 2011). Among examples of table by projection, the DiamondTouch table from Mitsubishi is well-known (Chen, 2012) as well as the SMART table by SMART Tech (Dillenbourg, 2011). The second touch table system incorporates a large touchscreen (Figure 1-c) either within or on top of a dial such as Microsoft's PixelSense (Kubicki, 2015). The screens use several different technologies to capture user's interactions, generally based on electrical projected capacitive multitouch. However, there are other methods such as infrared LEDs and photodiodes (Loenen, 2007). Interactive tables take advantage of natural direct touch and not using proxies such as mouse or joystick controllers to interact (Annett, 2012). Thus, it requires low cognitive demand from users (Shen, 2006) and enables integration for populations with intellectual and/or motor disabilities (Annett, 2012; Chen, 2012). In addition, touch tables bring new additional interactions (Öring, 2019) which stimulates the creation of new contents, with a strong emphasis on audio and visual feedback (Mahmud, 2008; Dillenbourg, 2011). Some studies have explored the use of touch tables for the elderly. The HERMES project introduced a touch table designed for cognitive training by employing an approach limiting the appearance of errors to facilitate learning, called errorless (Buiza, 2009). Additionally, the Eldergames project focused on cognitive stimulation through games aimed at improving selective attention, concentration and control (Gamberini, 2009). In terms of mental rehabilitation, the SOCIABLE and E-Core programs also offer activities to support and rehabilitate cognitive skills (Jung, 2013; Danassi, 2014). Other studies have also been carried out, notably during the interactive table golden age, around 2010s (Annett, 2009; Mahmud, 2008). However, the literature on touch tables remains very limited and, as Bruun et al. mentioned, focuses mainly on software development and interaction techniques and less on usability studies and user performance (Bruun, 2016). This is also true for touch tables for the elderly, despite new developments in current research (Cerezo, 2020; Hyry, 2017).

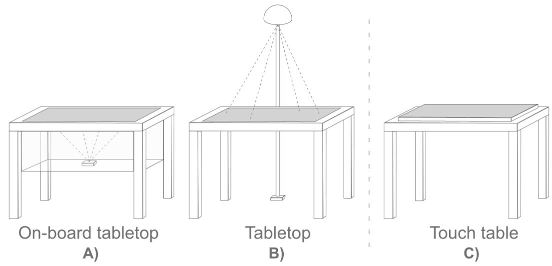

Figure 1: The three main types of tactile table.

2.2 Hôsea Touch Table

Developed by KARA Technology, Hôsea is a touch table initially conceived for occupational therapy. The touch table aims to enhance collaboration and interaction between patients and healthcare professionals. It allows solo or collaborative activities and is specifically designed to be a touch table accessible to people with reduced mobility. Unlike other touch tables, its height can be adjusted using bolts to accommodate wheelchair users or those who prefer to stand. The screen can be positioned flat (0° tilt) or tilted (up to 85°). The table offers better movement with four bidirectional wheels with brakes. The 43-inch screen of the Hôsea table allows bi-manual interaction with a maximum of ten contact points. A presentation of the table is provided in Figure 2. To meet the demand for accessible content, we collaborated with two teams of occupational therapists from two different centers to create a dedicated app integrated on the Hôsea table. The software was co-designed using regular feedback in the form of periodic requests from the two partner centers. The software is based on Laravel, a PHP framework and a MYSQL database. Patient data is encrypted and stored in a local database. The first version included 17 games related to nine work categories defined with occupational therapists: visual-spatial ability, causal effect, hand-eye coordination, musculoskeletal amplitude, memory, balance, strategy, precision and processing speed. Depending on the game, different session data are recorded (e.g., heatmap, score, time, number of trials). Customizing various aspects of the game to individual users is beneficial, but is not common in commercial games. We worked closely with the occupational therapists to customize each game, starting from open-source projects or developing from scratch, and considering factors like screen size, object speed, target score, and the number of trials based on their experience with commercial games. The settings are stored in a database to adjust difficulty and keep the same set-

Figure 2: 3D presentation of the Hôsea touch table.

tings for future sessions. The objective of this study was to evaluate the acceptability of the Hôsea table by elderly people in terms of usability, perceived effort and motivation to follow a cognitive training program on this interface. For this, we met 43 individuals aged 55 to 85, whom we asked to play three of the tasks implemented on the table: the *Simon Says*, the *flow free* and the *wordfind* games (See, Section 3, for more details). In this study, we did not use the game adjustment functionality to guarantee the same task characteristics for each participant. Different questions were asked at the end of each game and an overall evaluation of the interface was offered at the end of the session. We expected that the interface would be well received by the participants, with high scores on the F-SUS (usability scale, (Gronier, 2021)), the SIMS (motivation scale, (Guay, 2000)), and low scores on the NASA-TLX (scale evaluating the perceived load, (Hart, 1988; Maincent, 2001)).

3 EXPERIMENTAL STUDY

3.1 Participants

The group of participants was comprised of 43 volunteers (65.12% women), French-native or bilingual speakers between the ages of 55 and 85. The average age was 68.74 (*SD* = 7.10). The sample may appear heterogeneous, but this choice was motivated by the subsequent phases of development of the Hôsea software, including the development of an algorithm aimed at automatic personalization and adaptation of the exercises offered. The diversity of profiles encountered was motivated to allow higher sensitivity of the algorithm. The average education duration was 16.63 years (*SD* = 3.88) while the average professional life of the participants was 31.35 years (*SD* = 11.88), as shown in Table 1. The participants are all healthy volunteers who accepted to participate in the study following an online call, or through local communication. To meet ethical questions, each participant signed informed consent before the study and all data were anonymized.

Table 1: Demographic characteristics and psychological assessment. Standard deviations are presented between brackets.

Baseline characteristics	**Elderly** (*N* = 43)
Mean age	68.74 (7.10)
Sex (% women)	65.11
Laterality (% right)	95.34
Mean education level (years)	16.63 (3.88)
Mean years of work (years)	31.35 (11.88)
Psychological testing	
MMSE (/30)	26.51 (2.59)
mini-GDS (/4)	0.36 (0.76)

3.2 Procedure

The study was conducted in two stages: participants firstly used the table, as displayed in figure 3, before filling out questionnaires. Before the session, participants completed a health questionnaire that included self-assessment of fine motor skills and vision/hearing abilities. Participants were also administered the Mini Mental State Exam (MMSE) (Folstein, 1975) and the Mini Geriatric Depression Scale (Mini-GDS) (Clément, 1997), to ensure the absence of cognitive disorder or depressive state likely to affect results. Participants were also asked about their comfort level with digital tools. After the basic questionnaires, there was a 15-minute touch table test session, during which participants performed three Hôsea software tasks. Tasks were randomly shown for 5 minutes each, and were followed immediately by usability questions addressed orally by the experimenter. After each game, participants were also asked about several aspects: familiarity with a similar version of the game, adequacy of object size, questions about mental, physical, and performance load (from the NASA-TLX), and a general open-ended question allowing feedback on the game. Once the 15-minute gaming session was over, the participants completed with the experimenter standardized scales aimed at assessing the usability of the table with the F-SUS (Brooke, 1995; Gronier, 2021), subjective workload with the NASA-TLX (Hart, 1988; Maincent, 2001), as well as

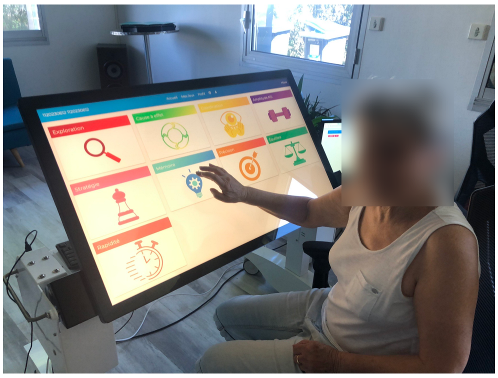

Figure 3: Supervised usability study with a coordinator.

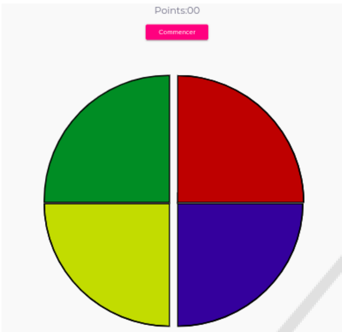

Figure 4: Adapted version of *Simon Says* game.

their motivation to use the table with the SIMS (Guay, 2000).

3.3 Tasks

3.3.1 Simon Says

One of the three tasks from the Hôsea software's used during the study was an adapted version of the *Simon Says* game. The task aims to reproduce color sequences using a point touch in the indicated areas. Success leading to the game introducing longer sequences (i.e., introducing a new color in the last sequence). The color sequence remains constant, with each color displayed one second apart, as shown in Figure 4. The game is configured to offer a single sound for each color.

When the participant fails to reproduce the sequence, the game ends. If a participant completed a game session before the five-minute limit, a new game with the same color sequence was restarted by the experimenter.

3.3.2 Flow Free

The second game selected was an adapted version of the *Flow Free*, visible in Figure 5. The task is to connect pairs of dots of the same color by sliding a finger across them to fill the grid without crossing each other. The difficulty of the task gradually increases with the size of the grids and the number of pairs to connect. Thus, the first three grids (3:3 matrix) required the connection of 3 pairs; then 4 pairs in the next three ones (matrix 4:4), and this until 7 pairs (grid 7:7). After completing a grid, the participant moved on to the next one with the help of the experimenter.

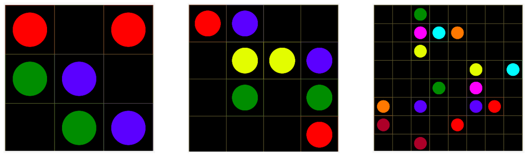

Figure 5: Three grids from the adapted *Flow Free* game.

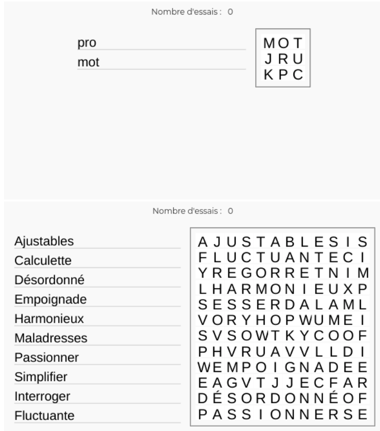

Figure 6: Two grids from the adapted *Wordfind* game.

3.3.3 Wordfind Dame

Lastly, we proposed a digital version of the *Wordfind* game, assuming it would be more recognizable to the intended age group (Figure 6). Similar to the *Flow Free*, the difficulty of the game increased as participants filled in the grids, underlining the words with their finger: each level had larger grids with more words. The word list on the left matched and highlighted words in the grid as they were found. All grids allowed words to be arranged horizontally or vertically and could have appeared in any direction (e.g., right to left).

3.4 Collected Data

Once the 15-minute gaming session was over, the participants completed, with the help of the experimenter, standardized scales presented in a fixed order. The first scale administered was the F-SUS (French

System Usability Scale) (Brooke, 1995; Gronier, 2021), consisting of 10 questions assessing interface usability using a 5-points Likert scale, with the value 1 refering to “Strongly disagree” and 5 to “Strongly agree”. The scale gives a usability score from 0 to 100, reflecting the user-friendliness of the system. Researchers generally consider an SUS score between 70 and 100 to be an acceptable range. Below this score, the interface is considered marginally acceptable for the target population (Bangor, 2008).

The second scale proposed was the NASA-TLX (Hart, 1988; Maincent, 2001), aimed at assessing subjective workload after a physical or cognitive activity on six dimensions evaluated by different subscales. These subscales require rating feelings from 1 to 20 for Mental demand, Physical demand, Time demand, Performance, Effort, and Frustration. The last measurement realized was the SIMS (Situational Intrinsic Motivation Scale) (Guay, 2000) to assess participants' motivation for the tasks. More specifically, the SIMS assesses whether a session was perceived as stimulating, interesting, and personally rewarding through four subscales, and involves answering questions using a Likert scale. While the SIMS is usually administered on a 7-points scale, we used a 8-points one (with 1 for “Strongly disagree” and 8 for “Strongly agree”). This prevents participants to refer to a cut-off value.

The first subscale, Intrinsic motivation, assesses autonomous motivation. The second one, Internal Regulation, assesses motivation driven by personal values, beliefs, or goals. External regulation measures motivation influenced by external rewards. Finally, the Amotivation subscale evaluates overall lack of motivation.

Four extra questions followed the survey, addressing post-session feelings. These included an open question about participants' post-study emotions and three questions about their experience with the table. Using a 10-points scale, where 1 meant ”really bad” and 10 ”very good”, participants were asked to rate the interface quality, touchscreen suitability for their condition, and their ability to use it independently.

4 RESULTS

4.1 Baseline Characteristics

We collected psychological health data using the MMSE and mini-GDS. Regarding the MMSE, the results indicated that 55.81% participants had a score suggesting the absence of cognitive disorder (27-30), 30.23% presented a mild score (24-26) presenting normal cognition with some points of vigilance, and 13.95% had a score between 18 and 23 with suspected mild cognitive impairment (Derouesne, 1999). In terms of psychiatric disorders, 23.25% of participants presented suggestive signs of depression (mini-GDS score $>$ 0) (Clément, 1997). Regarding digital habits, participants evaluated their skills at a mean level of 6.49 after reporting their response on a scale from 1 to 10, and primarily engaged in basic activities like communication, research, and information-seeking. In addition, 23.25% participants declared playing regularly video games. Concerning the frequency of use of digital tools, most people (86.05%) reported using a numerical device on a daily basis. Apart from that, 4.65% individuals mentioned weekly use, and 2.33% used them monthly. Finally, it seems worth mentioning that 11.63% have worked in information technologies during their careers.

The results in this section are computed from data from all participants for the sake of inclusiveness of Hôsea, and account for variations in physical, cognitive, and psychiatric abilities within the aging population intended for using the touch table.

4.2 Usability Study

According to F-SUS, the mean usability score was 91.33/100, suggesting a high acceptability of the table (Bangor, 2008). Based on the 10 SUS questions, 8 of them presented a standard deviation of less than 1.00, indicating homogeneous evaluations. The question with a higher standard deviation concerned support in use (*mean* = 1.98; *SD* = 1.42) suggesting the need of a supervisor. We also assessed the subjective workload of users after using the table. Figure 7 presents the average perceived demand of our participants based on the 6 NASA-TLX subscales. After scaling to 100 the results of each subscale independently, Mental demand on the touch table seems moderate, with a mean height of 64.77 (*SD* = 20.79). The mean levels of Physical (*M* = 22.44, *SD* = 18.69) and Temporal demands (*M*= 29.42,*SD* = 23.56) during the execution of activities were reported as low by participants. Moreover, the Effort required was moderate with a mean score of 52.44 (*SD* = 27.50). Participants also reported high auto-evaluated Performance on the proposed tasks with a mean score of 78.49 (*SD* = 12.84), but manifested a strong level of Frustration during the tabletop sessions, with a mean score of 86.51 (*SD* = 9.03). Finally, the mean scores obtained at the SIMS subscales are depicted in Figure 8. The mean score of 7.26 (*SD* = 1.19) on Intrinsic motivation suggests a relatively good motivation during the sessions. The score on Internal regulation was also high, with an average score of 6.85 (*SD* = 1.53).

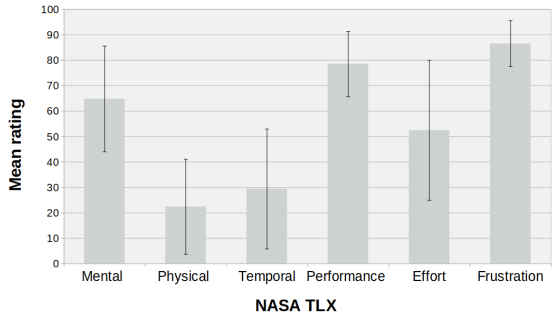

Figure 7: NASA-TLX observed for the six subscales.

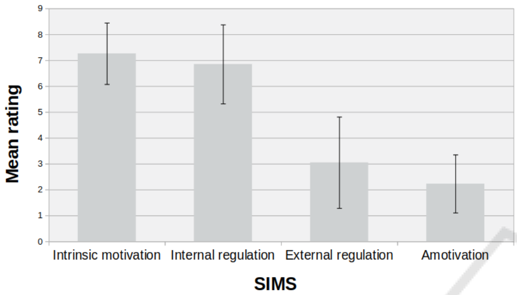

Figure 8: SIMS observed for the four subscales.

Consistently, the External regulation and the Amotivation mean scores were low, with 3.05 (SD = 1.76), and 2.23 (SD = 1.12), respectively. Other questions were asked to assess the quality of the table. On average, the interface was considered to be of high quality, with a mean score of 87.85/100 (SD = 7.74). Similarly, a mean score of 86.78/100 (SD = 14.22) was given for the ability to use the table independently. Finally, the participants found that the table was suitable for their use up to 87.73/100 (SD = 12.98).

4.3 Analysis by Sub-Groups

As the conditions for applying an ANOVA were not met, due to unbalanced groups and insufficient numbers in some of them (n = 24 in the group with higher MMSE scores [27-30]); n = 13 for moderate scores [24-26], and n = 6 for lower MMSE scores [18-23]), we conducted a Kruskal-Wallis test to determine the impact of cognitive efficiency (operationalized through our 3 MMSE groups) on usability testing results. The analysis revealed no statistically significant differences in overall F-SUS, NASA-TLX, and SIMS mean scores (all $ps > .05$). Moreover, we performed a Mann-Whitney test to examine whether the presence of a depression indicator (score > 0 from the mini-GDS) had an impact on usability testing results. The analysis indicated no statistically significant variation in overall usability scores (all $ps > .05$). Finally, we performed a Mann-Whitney test to assess whether perceived visual and auditory dysfunctions had an effect on system usability. These results indicated no significant variation in perceived usability related to visual and auditory abilities (all $ps > .05$).

5 DISCUSSION

Our study aimed to evaluate the usability of the Hôsea table for seniors. Results of the F-SUS (Brooke, 1995; Gronier, 2021) suggests that the interface is well received by a large panel of healthy seniors. Compared to similar studies, the SUS score is higher (Elboim-Gabyzon, 2021). The touch table and the design of the proposed games seem to have an impact on the acceptability of the interface. Results obtained with the NASA-TLX showed that using the touch table requires continuous mental effort due to the complexity of the proposed tasks. The divergence in terms of Mental demand may be linked to the heterogeneity of the study population and is consistent with similar results on other cognitive training on touch screens (Lu, 2017). There is also a minimal perceived Physical demand similar to results presented in studies on tablets, suggesting that the size of the table's touch screen is not a factor increasing physical demand (Castilla, 2020; Lu, 2017). Participants also reported low Temporal demand, suggesting that the pace of the tasks was adapted to their abilities. The Frustration subscale mean score was high, a result that can be attributed to the time constraints of the protocol, as expressed several times by participants in the feedback question following each game. On average, the NASA-TLX subscales showed little variation across participants. Further analyses examined the effects of MMSE and mini-GDS scores and reported no effect of theses variables on the different dimensions assessed by this scale. However, null results must always be considered with caution. In our case it is possible that its observations were caused by the low number of participants in some groups and the imbalance of numbers between the groups. On average, participants reported being motivated for reasons related to curiosity, enjoyment or skills acquired as highlighted by scores reported in the SIMS Intrinsic motivation and Internal regulation scales. Internal regulation was the subscale with a high score, suggesting pleasure and satisfaction in carrying out the exercises. Conversely, External motivation and Amotivation mean scores were low, suggesting that external factors did not influence as much motivation and that general motivation was preserved throughout the study. As reported by participants, the enjoyable and user-friendly large screen added extra motivation for the provided exercises. Moreover, our results suggest that there was no difference in the evaluation of usability, perceived demand and motivation as a function of cognitive level, depression and visual and auditory abilities. However, there are limitations to these results. First, the participants were independent individuals with good experience with digital tools. In addition, the seniors in the study are mostly active, which limits the conclusions for sedentary or retired profiles. In addition, the limited number of participants may not cover all senior cognitive profiles, reflecting the great diversity of their conditions and characteristics, as noted previously. We deliberately shortened the exposure time at the table and focused on participants who were experiencing the interface for the first time; a more in-depth study on more regular use could provide more information, particularly on long-term perseverance. Another limitation relies on the fact that the activities provided were not designed with a user-centric approach tailored explicitly for the elderly population.

6 CONCLUSIONS AND FUTURE WORK

Hôsea appears as a user-friendly interface, aligning with prior research on digital content integration on regular touchscreen (Ten Brinke, 2017; Groenewoud, 2017) offering an accessible and engaging fun environment requiring moderate physical and cognitive abilities among seniors. Future work will analyze the quantitative data recorded by the table and study their use in the context of machine learning to deduce needs for adapting exercises according to the user profile. We will study the use of Bayesian optimization models to define an ideal configuration for each exercise and respond to multi-objective optimization between rehabilitation effort and exercise accessibility.)

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