

## Tilburg University

### Switch2Move

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# Switch2Move: Designing a Tangible Interface with People Living with Dementia for Initiating and Engaging in Music-Supported Exercises at Home

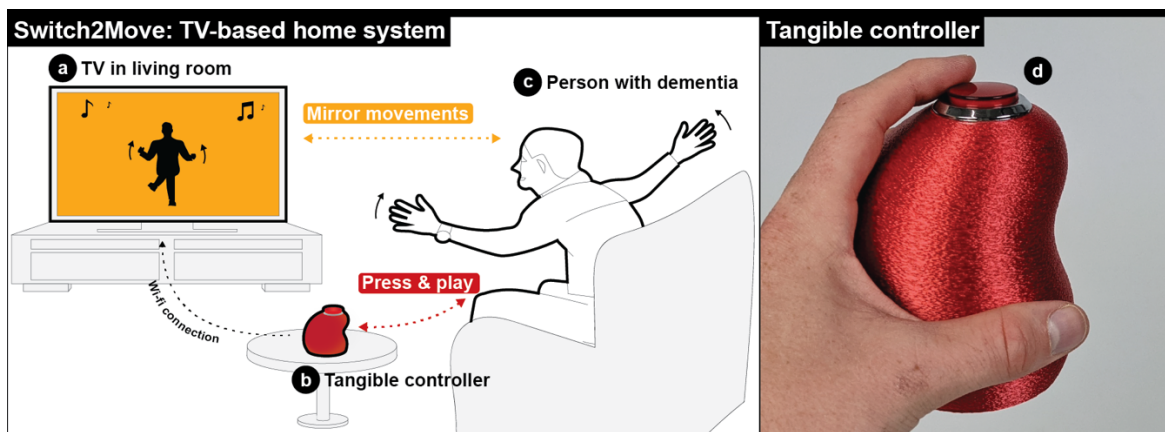
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**Figure 1:** The Switch2Move home system stimulates initiative and engagement in music-supported video exercises (a) through an attractive interface (b) that cues physical activity at home for people with dementia (c) via an accessible tangible controller (d).

## ABSTRACT

Dance exercises offer recreational and social activities that engage people with dementia in physical exercise to increase fitness and cognitive functioning. However, there is limited research on how technology supports people with dementia to initiate and engage in music-supported dance exercises at home. We present Switch2Move: a TV-based home system with a tangible interface to trigger music-supported exercises at home for people with dementia. Four people with dementia and their informal caregivers

explored a mockup to reveal design improvements for stimulating initiative and engagement. Next, we evaluated a high-fidelity prototype in the homes of three other couples during a one-week pilot study. The Switch2Move home system stimulated initiative by providing ongoing access in the home setting and supported engagement through daily enjoyment, calmness, and relief. We present opportunities for technology to increase self-efficacy, offer rich experiences, and fit the physical and social home environment of people with dementia.



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## CCS CONCEPTS

• **Human-centered computing** → Human computer interaction (HCI); Empirical studies in HCI.

## KEYWORDS

Dance, Dementia, Design, Home, Informal caregiver, Physical activity

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**1 INTRODUCTION**

There are more than 55 million people with dementia worldwide, and this number is predicted to increase due to demographic aging [95]. Dementia is a term describing characteristic symptoms, e.g., memory loss, language difficulties, or impaired problem-solving caused by neurodegenerative diseases such as Alzheimer's [2]. People with dementia require support in day-to-day activities due to the progressive loss of cognitive functioning [22]. Nevertheless, people with dementia and their informal caregivers strive to maintain normality and prefer to continue living in their homes [58]. However, high caregiving loads for informal caregivers and lack of self-reliance prevent people with dementia from living independently at home [85]. Therefore, there is a general incentive to develop products and services to support people with dementia to age in place [14] and reduce admissions to over-burdened care institutions [32, 95].

People with dementia benefit from physical exercise that positively influences cognitive and physical functioning [13, 39, 63, 83]. Furthermore, music provides numerous behavioral, cognitive, and emotional benefits for people with dementia [82], such as supporting reminiscence [72, 81], stimulating social interaction [33, 91], and fostering engagement from people with dementia [53]. Therefore, there is an increasing interest in combining the benefits of music and exercise to support the physical and cognitive functioning of people with dementia [80, 83]. For example, a musical exergame can provide pleasurable interactions for people with dementia and their caregivers, such as moving, dancing, and singing together [91]. Similarly, social robots dance to music to evoke active movement [12, 36, 79]. While most dance and music interventions take place in care settings [63, 65], home-based exercise is widely applicable and safe to preserve and improve the fitness of older adults [17], especially during periods of restricted activity, such as a pandemic [13, 35].

Recent HCI research highlighted the opportunity to design for the home context of people with dementia to support their quality of life and to live longer at home [11, 45, 88, 90]. Building on this work, we identify a potential for technology to bring physical exercise and music into the home environment of people with dementia and their informal caregivers. Increasing the autonomy and confidence of people with dementia in initiating physical exercise at home contributes to independency and reduces the care load for informal caregivers. However, more insight is needed into how technology can initiate and facilitate such interventions at home and promote self-efficacy, personal dignity, and relief for people with dementia. This paper explores the role of technology in supporting people with dementia to independently initiate and engage in music-based physical exercise at home.

We situate our research in a dance program that offers reoccurring implicit-movement classes for people with dementia and

their informal caregivers at a community center. Dancing provides cognitive, physical, and social benefits for people with dementia and their informal caregivers as they move to music during an enjoyable activity [34, 40, 65]. We identify an opportunity to bring the benefits of dance to the home situation through accessible technology. Therefore, we have designed the Switch2Move home system with a tangible interface to play music-supported video exercises for people with dementia and their informal caregivers (see Figure 1). First, we explain the conceptualization of the home system and initial design requirements based on informal interviews and observations at the dance class and exploring various design concepts with experts. Next, we involved four couples consisting of a person with dementia and an informal caregiver in workshop sessions to explore what aesthetics, interaction, and functionality stimulate autonomy in using the device. The outcome of these sessions revealed four design improvements that we integrated into the subsequent iteration of the Switch2Move home system. Finally, a high-fidelity prototype was evaluated in the homes of three different couples living with dementia for one week. This pilot study revealed how technology that offers home-based dance exercises requires ongoing access in the home setting for stimulating initiative and offering enjoyment, calmness, and relief to support engagement. Based on our results, we formulate opportunities for technology to increase self-efficacy, offer rich engaging experiences, and fit the social and physical environment at home.

**2 BACKGROUND****2.1 Music, Movement, and Dance in Dementia**

Current approaches to dementia care focus on mental well-being and healthy living, in addition to addressing the pathological features of dementia [95]. This focus resulted in the need for non-pharmacological interventions to support the cognitive and physical functioning of people with dementia [70]. Physical exercise positively influences the everyday functioning of people with dementia, such as reducing the decline in performing activities of daily living [63]. In addition, music evokes spontaneous body movement in people with dementia as embodied forms of musical expression [61]. Therefore, music is commonly used to engage people with dementia in physical exercise [80].

Dance interventions combine the benefits of physical exercise and music in a recreational and social activity [65], resulting in increased physical movement and decreased depression, loneliness, and negative emotions [40]. Music-supported movement therapy taps into the remaining abilities of people with dementia by evoking organically occurring rhythmic movements, such as tapping feet and clapping or waving hands [34]. For example, people with impaired cognitive and physical abilities can mirror movement patterns to connect non-verbally to the facilitator in the dance intervention [52]. While home-based exercises support and improve physical health and fitness [13, 17], movement or dance therapy is mainly facilitated by trained professionals in care settings [65].

Previous research explored the role of technology in stimulating engagement and initiative in people with dementia during music sessions [28, 46, 55, 67]. For example, tactile props engage people with dementia in collective movement during music activities through embodied expressions and social interactions [67].

Accessible musical interfaces encourage social collaboration and group movement [28, 46] or stimulate self-expression for people with dementia through bodily movement [55]. Motivated by previous research on home-based technology for people with dementia [11, 45, 91], we identify a potential to bring the combined effects of music, dance, and movement into the homes of people with dementia.

## 2.2 Technology for Physical Activity in Dementia

Technology provides novel opportunities to increase the efficiency and effectiveness of physical therapy for people with dementia [51, 79, 83]. For example, autonomous robots provide guidance and companionship during physical activities, in response to the lack of trained care professionals [36]. Humanoid robots instruct dance exercises and encourage people with dementia to mimic arm and upper body movements [79]. Similarly, on-screen avatars provide understandable instructions for people with dementia to perform physical movements [20, 26]. Therefore, video exercises accompanied by music are a feasible, cost-effective alternative to a real-life instructor for engaging people with dementia in physical activity [83].

In addition, Gerling et al. [30] proposed a shift in supporting physical activity in the later stages of life with technology, from prescribing and monitoring physical exercise to addressing the subjective experiences of older adults in exercising and providing enjoyment. Similarly, research on exergames and dementia demonstrated that gamification principles contribute to overcoming a lack of motivation or perseverance in cognitive and physical exercises [51, 62, 76, 92]. This research has consistently highlighted the value of social interactions with professional and informal caregivers as a primary benefactor while performing physical activity [51, 62, 92]. Technology that provides a shared activity for couples at home relieves part of the care tasks of the informal caregivers and so empowers the person with dementia [45, 88, 92]. However, the successful deployment of technology in the home environment also relies on the time investment and efforts of the informal caregivers [88, 90, 98]. For example, informal caregivers are tasked with setting up technology for the user with dementia [98] and stimulating sustainable use over time [88, 90].

## 2.3 Tangible Interaction in Dementia

There has been an emerging interest in co-design and participatory approaches to actively involve people with dementia in research and design [9, 45, 74, 94]. However, difficulties with problem-solving, abstract thinking and verbal communication typically characterize dementia [2] and are skills needed in most participatory design methods [38]. Progressively, research explored other modalities of expression for people with dementia beyond the verbal, such as gestures, bodily movement, play, and creativity [59, 94]. For example, engagement with craft materials, objects, or props supports embodied expressions of ideas, values, and emotions by people with communication difficulties [18, 60] and results in an enjoyable, social, and reciprocal activity [54].

Similarly, research involving people with dementia in design processes demonstrated how tangible artifacts stimulate engagement and active feedback [45, 66, 68, 69, 75]. Working prototypes or mockups communicate abstract design concepts that are in general difficult to comprehend by people with dementia [66, 68, 75]. While engaging with tangible exemplars, people with dementia suggest improvements or alterations, contribute their thoughts or opinions, and influence decision-making in the design process [45, 69]. Consequently, researchers have argued to look beyond general screen-based solutions and exploit the multisensory richness of tangible interactions in technology design for people with dementia [49]. People with dementia interact intuitively with tangible artifacts that offer familiar affordances related to past experiences [5]. For example, opening a drawer to discover personal media [47, 93], placing physical tokens to purposefully select audio content [42, 86], or feeling recognizable textures on a handrail to support wayfinding [64]. Furthermore, previous research reported how the presence of a physical device drives its use by caregivers and people with dementia during everyday routines [45, 88].

## 3 STUDY OUTLINE

We adopted a research through design approach [96] to evaluate how technology supports the initiation and engagement in physical exercises at home. Our approach consisted of three sequential steps:

- **Exploration and Ideation.** First, we conducted informal observations and interviews at a dance program. Next, multiple design proposals were discussed with professional and academic experts. Based on these insights, we proposed Switch2Move: a TV-based home system with a tangible controller for music-supported video exercises at home for people with dementia.
- **Workshop Sessions with Mockup.** Four couples evaluated and adapted a mockup during the workshop sessions at home to explore the concept and identify design improvements.
- **Pilot Study with Prototype.** Lastly, we developed a high-fidelity prototype of the Switch2Move home system and created new video exercises that were deployed for a week in the homes of three couples.

### 3.1 Ethics

The university Ethics Review Board approved this research. All participants gave informed consent individually to participate. Before the study, the main researcher visited each couple at their homes to explain the research aim, activity, participant rights, and data processing, while participants could ask questions directly. These informal meetings established a safe and informal connection and communication [4, 21]. The home environment offered the familiarity and comfort of the personal living space during the study [15]. The informal caregiver was present during all research activities to support the person with dementia [21]. This safe and social atmosphere allowed for sharing thoughts and experiences while the interests of the person with dementia are safeguarded by a familiar caregiver [21, 69]. The participants were reminded regularly that they could withdraw from the research at any moment, yet this did not occur. All collected data were pseudonymized and securely stored following GDPR requirements.



**Figure 2: People with dementia perform implicit-movement exercises during the dance class program.**

## 4 EXPLORATION AND IDEATION

### 4.1 Exploring the Potential for Dance-Based Exercises at Home

This study is situated in the ‘Switch2Move’ dance program for people with early to moderate stages of dementia and their informal caregivers, organized in local community centers in the Netherlands [99]. This dance program draws upon implicit motor learning strategies by providing minimal rules or verbal instructions, relying on skills unconsciously retrieved from implicit memory [57]. The class is led by a trained professional who aims to train and preserve muscles and flexible joints while enhancing emotional well-being through implicit social movements to music [99]. The dance class starts with a body scan meditation by introducing simple hand and foot movements to allow the participants to become mindful and in tune with the self [73]. Next, the participants perform simple movements with their arms and legs, doing one movement at a time and building trust and familiarity with the environment. Gradually, the movements become uninterrupted to cultivate the concentration and engagement of the participants. The facilitator then introduces movements such as stretching and using force simultaneously, releasing tension on the body’s connective tissues, such as ligaments, joints, and bones [78]. These movements address the upper and lower body, using small and big motor skills to move naturally (see Figure 2).

The conceptualization of the Switch2Move home system started by attending the implicit movement classes and engaging with the participants of the dance program. The informal interviews and observations at the dance classes revealed a general interest among participants in performing similar exercises at home. We found how participants aim to execute and enjoy the dance exercises at home since the movements are relatively simple and easily performed while sitting on a couch or chair. Performing these movements at home would prolong the physical and cognitive benefits of the class for participants, as indicated by literature [13, 17]. However, the participants indicated that the lack of a professional trainer, low motivation, and high care load of the informal caregiver are potential barriers to executing exercises at home. Furthermore, participants expressed concerns about difficulties using technology at home, such as smartphones and tablets, especially for people with dementia.

### 4.2 From Ideation to Design Concept

The informal observations and interviews at the dance class inspired the ideation of multiple design propositions by the main researcher (see Figure 3) to offer implicit-movement exercises supported by music at home through accessible technology. The first design proposal was a portable beamer to project instructional video exercises in the living room of people with dementia. The second proposal was a humanoid robot that provides dance instructions. The third proposal was an ambient art piece visualizing movements through LED pixels. The last proposal involved matching digital wristbands that provide LED and vibrotactile feedback during the exercises. These design propositions were discussed and reiterated during multiple online discussion sessions involving domain experts in physiotherapy, design for dementia, music therapy and the organizers of the dance class program. These discussions revealed three initial design requirements: 1) make use of existing infrastructure and technologies, 2) be accessible and easy to use with limited barriers, and 3) support the self-efficacy and dignity of people with dementia.

As outcome, we conceptualized the Switch2Move home system with a tangible controller to initiate music-supported exercise videos. We grounded this concept in literature on the effectiveness and feasibility of screen-based interventions [19, 91, 92] and instructional videos [83] for people with dementia. Videos that depict a dancer performing movements can be followed and mirrored by the person with dementia and their informal caregiver. We intended for the home system to allow people with dementia to initiate exercise videos on their TV. The TV is a standard technology and a feasible option for video-based interventions in the home environment [19, 26, 92]. However, people with dementia, with the assistance of their family, often need to customize standard technologies to their abilities, such as covering buttons on a TV remote control [31]. Therefore, we envisioned an accessible and tangible controller with a single button connected to the TV, replacing the traditional remote control, which is reported as difficult to use for people with dementia [19]. A single-button interface offers a push-and-play principle, as pressing the button immediately plays an exercise video on the TV without struggles such as selecting the right source channel. Such an interface allows avoiding reported struggles of people with dementia to navigate menus in software applications [24].

## 5 WORKSHOP SESSIONS WITH MOCKUP

The workshops aimed to explore the concept and feasibility of the Switch2Move home system. Four couples, each with a person with dementia and their informal caregiver (see Table 1), explored a mockup and adapted the tangible controller to their preferences and opinions.

### 5.1 Mockup of Switch2Move Home System

**5.1.1 Tangible Controller and Participants’ TV.** The mockup of the controller consisted of a white cardboard box and a bright yellow push button mounted on top (see Figure 4, left). Pressing the button started the video and pressing it again would stop it. We used the participants’ TV to display the exercise videos. The mockup was operated through a ‘Wizard of Oz’ approach [56], as the main researcher played the exercise video on the TV when the participant



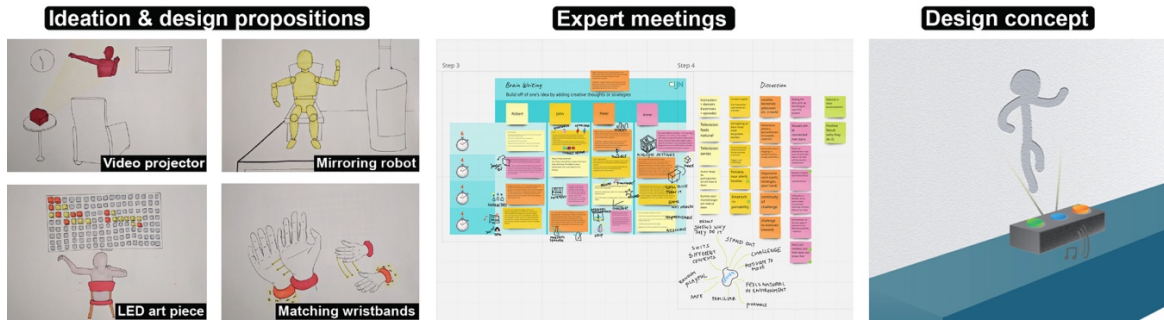


Figure 3: The informal observations and interviews inspired the ideation of four design proposals: 1) a video projector, 2) a mirroring robot, 3) an LED art piece, and 4) matching wristbands, discussed in expert meetings and resulted in the Switch2Move home system.

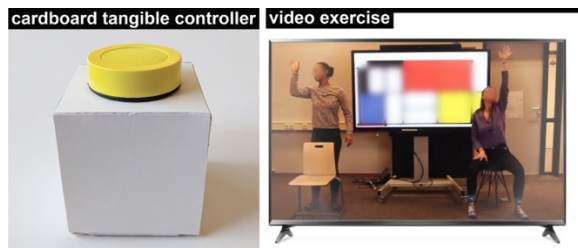


Figure 4: The tangible cardboard controller (left) was used to play the exercise video displayed on the participants' TV (right).

pressed the button. The researcher's laptop was connected to the participants' TV via HDMI.

5.1.2 *Videos.* We recorded initial exercise videos with two dancers performing and instructing the dance exercises (see Figure 4, right). Two physiotherapy graduation students who attended the dance class regularly provided similar instructions on performing the implicit movements, accompanied by music with an art piece in the background. The duration of these videos was three minutes.

## 5.2 Workshop as Home Visit

5.2.1 *Participants.* We recruited four couples (see Table 1) consisting of one person diagnosed with early-stage dementia above 65 years of age and their informal caregiver, the partner in all cases. We recruited couples that participated in the dance class program for 12 weeks to help translate the benefits of the program to their home environment.

5.2.2 *Procedure.* The researcher set up the Wizard of Oz testing in the living room of the participants in the seating area. The mockup of the Switch2Move home system was introduced to the participants, who sat on their couches in front of the television. The researcher invited the participants with dementia to freely explore the cardboard mockup and try to initiate an exercise video on their TV. Next, the researcher asked questions about their understanding of the functionality of the mockup while listening and responding to the experiences and thoughts of the participants with dementia.

Table 1: Four couples living with dementia at home were recruited to participate in the workshops (pseudonymized).

Participant with dementia (m/f)	Stage of dementia	Informal caregiver (m/f)
Andrew (m)	Early stage	Albert (m)
Bruce (m)	Early stage	Beverly (f)
Carl (m)	Early stage	Cynthia (f)
Daniel (m)	Early stage	Diane (f)

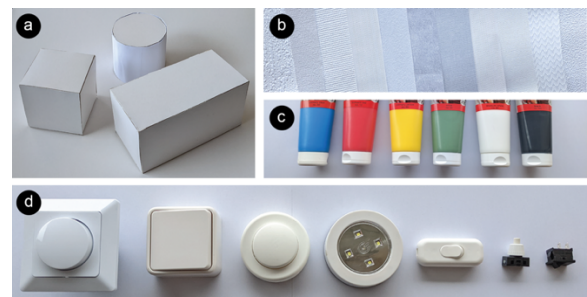


Figure 5: Four couples explored different materialities for the tangible controller by using: cardboard shapes (a), such as a cube, a beam, and a cylinder; textures on wallpaper samples ranging from coarse to smooth (b); paint (c); and various input controls (d).

The researcher specifically asked the participants with dementia to explain their interactions out loud. The exploration of the mockup lasted approximately ten minutes.

After a short break, the couples created their mockup of the tangible controller based on their personal preferences and opinions. The participants sat at the living room table, and the researcher brought craft materials and input controls that could be assembled (see Figure 5) to support the participants with dementia in creatively voicing their thoughts and opinions [75]. The researcher asked the participants to reflect on their choices throughout the workshop session, which lasted approximately 40 minutes.

In four consecutive steps, the participants explored different:



**Figure 6:** The participants initiated the videos and watched their TV while holding the mockup.

- **Shapes:** such as cubes, beams, and cylinders;
- **Textures:** by sticking pieces of wallpaper with different textures on the cardboard shape;
- **Colors:** by painting the cardboard shape;
- **Controls:** by trying various controls on how they would preferably operate the tangible controller.

At the end of the home visit, the researcher conducted a five-minute open-ended interview with the informal caregivers with questions on: 1) the ease of use of the mockup, 2) their thoughts on the adaptations of the tangible controller, and 3) any additional remarks and general thoughts.

**5.2.3 Data Collection and Analysis.** The following data were collected: 1) audio of conversations during the workshops; 2) observational field notes on the interaction with the mockup; 3) audio of the five-minute interviews with the informal caregivers. All audio recordings were transcribed verbatim, and the observations were incorporated into the transcripts. The main researcher conducted a thematic analysis through an inductive approach [10] by describing the data with initial codes (e.g., ‘shape’ or ‘size’). The first and second authors refined the codes into an initial set of themes (e.g., ‘holding and touching’). The final set of themes was formed through iteration and discussion with all co-authors (e.g., ‘material and tangible attraction’) to reflect the research objective of the workshops, namely the usability and accessibility of the Switch2Move home system. All authors have previous research and personal experience with dementia.

### 5.3 Findings Workshop Sessions

The analysis of the workshop outcomes resulted in four themes: 1) engagement with the dance exercises; 2) simplicity and intuition in interaction; 3) material and tangible attraction; and 4) visibility in the environment.

**5.3.1 Engagement with the Dance Exercises.** All participants with dementia linked the tangible controller to the videos as we observed them watching the TV intently with the mockup in their hands (see Figure 6). For example, *Daniel* explained aloud how he perceived the Switch2Move home system after pressing the button and pointing to the TV: “That’s in this box [the mockup in his hands]. I activate the TV with this thing.” However, we observed how *Andrew*, *Bruce*, and *Carl* only sometimes recognized the video as an exercise from the dance

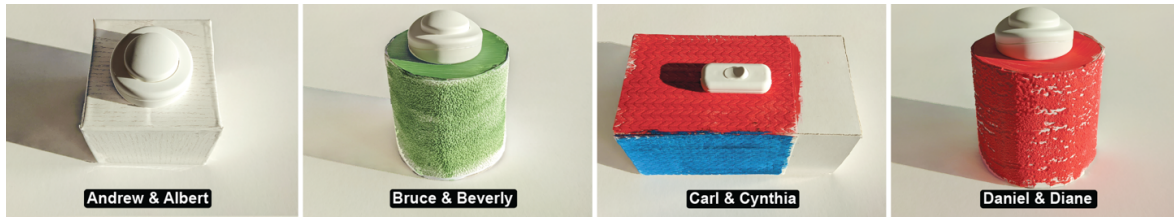


**Figure 7:** The participants pasted different textures (left) and mounted various input controls on the cardboard mockup (right).

class. For example, *Carl* pointed at the TV but only commented on the painting in the background: “Then the TV turns on. A red area, there [the Mondrian painting].”

**5.3.2 Simplicity and Intuition in Interaction.** The observations of *Bruce*’s, *Carl*’s, and *Daniel*’s interactions with the mockup revealed how the button was easy to use, as explained by *Bruce*: “It is very easy, user-friendly. You only have one button [...] I can do this [presses button and video stops] Look, very simple”. *Andrew* and *Daniel* immediately recognized a push button: “It is what you see [on TV], and then you have to know where to press so that you can get that woman [the dancer] behind the chair in no time.” (*Andrew*) We observed how *Bruce*, after some time understood how to start and stop the video exercises: “Now it’s off, and now I’m putting it back on [clicks again].” Yet, *Bruce* and *Carl* recognized different interactions with the button as they both were turning the button sideways, as *Bruce* remarked: “I think you should turn this [yellow button].” Similarly, *Andrew* thought he controlled the content of the video by pushing on different sides of the button: “If you [press] left, right, front, back [on the button]. It could be that she [the dancer] moves left or right.” Nevertheless, *Andrew*, *Bruce*, and *Daniel* all preferred the round button (see Figure 7, right), as *Andrew* explained: “It is damn practical for some things!”

**5.3.3 Material and Tangible Attraction.** The participants valued aesthetically pleasing materials and tangible qualities in the design of the controller. *Bruce* and *Daniel* preferred a cylinder as the shape for their controller, as *Daniel* clarified it was more comfortable to hold in his hands: “I find it [the cylinder] more attractive for doing something with it, and it’s better to hold. The others [shapes] have angles and stuff.” Similarly, *Bruce* was drawn to the cardboard cylinder and unenthusiastic about the “hard” rectangular shapes. *Andrew* and *Carl* chose a rectangle shape as *Andrew* stated: “I would instinctively grab this one [the cube]. I don’t like it, but it is notable.” Three participants, *Bruce*, *Carl*, and *Daniel*, preferred a coarse texture for the tangible controller as it offered more grip and confidence in holding (see Figure 7, left), as illustrated by *Daniel*: “gritty. . . I like this pattern, and I also like it in terms of grip. I don’t like that [other] very smooth stuff.” Three informal caregivers, *Albert*, *Beverly*, and *Cynthia*, had remarks on the size of the controller and indicated it should be easy to hold and operate: “Something smaller is more manageable, less noticeable but still prominent enough” (*Cynthia*).



**Figure 8:** The four couples created their interpretation of the tangible controller, which revealed insights into the tangible, material, and visual qualities needed for developing an attractive and inviting interface.

**5.3.4 Visibility in the Environment.** Using colors was popular with the participants with dementia (see Figure 8). *Bruce* opted for a slightly calmer color (olive green), while *Carl* and *Daniel* chose bright red as *Daniel* clarified: “I like it [the controller] more colorful, and it should be a little cheerful.” *Andrew*, *Carl*, and *Cynthia* reflected on the button’s color as *Andrew* indicated he would like it to have a “flaming color” so it stands out and is visible in their interior. *Carl* also preferred a bright button, while *Cynthia* remarked: “the button has to be a different color so it stands out.” All informal caregivers also clearly expressed how the controller: “needs to fit with the room [...] that green is beautiful because it fits well in the living room.” (*Beverly*).

## 5.4 Formulating Design Improvements

Based on the four themes reported in the previous section, we summarize four design improvements for the next iteration of the Switch2Move home system:

- [I1] **Clear and Understandable Dance Movements:** The participants mostly understood using the tangible controller to initiate a video on the TV, but the video content could have been more clearly recognized as an exercise. The two dancers were doing unsynchronized movements, and a cluttered background made it difficult to identify the movements. The video exercises need to be clear and understandable so the movements can be easily identified.
- [I2] **Afford to Push-and-Play:** The push-and-play interface of the mockup was perceived to be intuitive, although two participants misinterpreted the button for a rotary knob. The button should be separated from the casing and inviting to press with the fingertips to communicate the push-and-play principle.
- [I3] **Material Attractiveness:** The participants expressed that the material and tangible properties needed to be pleasant and inviting to hold, as they also preferred smaller shapes, emphasizing the need for a comfortable grip.
- [I4] **Offer External Memory Cues:** The participants proposed bright colors for the tangible controller to improve its visibility in the living room and emphasize its presence. Using bright colors can have a stimulating effect and thus increase the use of the Switch2Move home system, yet the design should also aesthetically fit with the living room.

## 6 PILOT STUDY WITH PROTOTYPE

We deployed a high-fidelity prototype at the homes of three couples for one week to generate initial insights on the usability and feasibility of the Switch2Move home system.

### 6.1 High-Fidelity Prototype of the Switch2Move Home System

Based on the design improvements identified during the workshops, we developed a high-fidelity prototype and recorded a series of professional video exercises suitable for the in-context deployment in the participants’ homes.

**6.1.1 Exercise Videos.** Each exercise video started with an introduction clip depicting the tangible controller to visualize the link between the controller and the exercise video. We recorded and edited twelve exercise videos, offering three difficulty levels with four background themes each (see Figure 9). Each video exercise lasted eight minutes and 30 seconds. All videos presented a professional dancer, background footage, and music to focus on the dance exercises, as formulated in the design improvements [I1]:

- **Dancer:** A trained professional from the involved dance class program performed the implicit-movement exercises in the video. The video exercises provide three difficulty levels in how the dancer demonstrates the movements: *seated*, *standing*, and *blended*, a combination of seated and standing.
- **Background footage:** The movements are performed over four themes of background footage: *color art*, *London*, *sea*, and *forest*, to make the dancer stand out from the background while providing a calm atmosphere.
- **Music:** The videos were accompanied by a meditative background song to provide a pleasurable yet soothing atmosphere to perform the exercises.

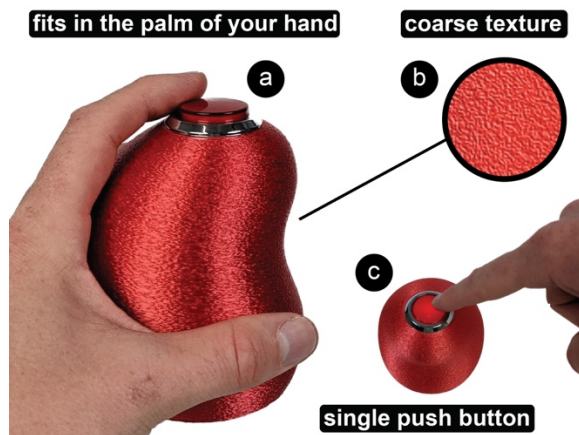
**6.1.2 Tangible Controller.** We developed a tangible controller (see Figure 10), which was durable and robust for independent use in an everyday household. Based on the design improvements identified during the workshops, we improved the:

- **Push button:** We equipped the controller with a more distinct push button [I2].
- **Shape:** The controller was designed as a curved shape that fits the palm of the user’s hand and is comfortable to hold [I3]. When holding it, the index finger naturally rests on the button [I2]. The portable size (80 x 80 x 100 mm) and low weight (160 grams) ensured it was easy to pick up or put aside when performing the dance exercises.





**Figure 9:** The videos depict a professional dancer performing dance exercises accompanied by music in three difficulty levels, *seated, standing, and blended*, with four themes of background footage: *color art, London, sea, and forest*.



**Figure 10:** The tangible controller is easy to hold (a) with a coarse texture that provides grip (b) and a single push button with LED and haptic feedback to initiate the exercise videos (c).

- **Material:** The controller was made from high-quality plastic to provide a robust, sturdy object to withstand rough handling or being dropped on the floor. The casing is finished with a bright silk-red colored plastic material to be inviting [14], which is also pleasant to hold with a slightly coarse texture to offer grip, safety, and security [13].
- **Interaction:** We integrated three functions: 1) pressing the button to start the video; 2) pressing the button briefly to pause and pressing it again to continue the video; and 3) pressing and holding the button for three seconds to stop the video completely [12]. When pressing the button to play again, a new video was selected, with the most-watched videos presented first.
- **Feedback:** We integrated haptic and light feedback in the tangible controller [12 & 13]. When the video is paused, the controller lights up and vibrates. When a video is stopped, the controller lights up and decreases the intensity of light and vibration to indicate it is shutting down. The monitor will display text that *'the video is stopped.'*

**6.1.3 External Monitor and Media System.** For this pilot study, we provided an external monitor with a direct connection to the tangible controller to avoid technical difficulties when connecting

the controller to the TV. However, it is intended for future iterations as a system that can be seamlessly connected to the TV already in the living room. The Switch2Move home system contained an external 27-inch monitor, a media player device on the backside of the monitor, a speaker, and a Content-Management-System (CMS) on an online server containing the videos (see Figure 11). The CMS was only accessible to the researcher to manage the video content, and the participants would not interact directly with the media player. When a participant pressed the button on the controller, the media player instantly played a video from the CMS on the monitor. Therefore, turning on the monitor, changing the channel, or selecting the correct input source were unnecessary. The system was placed in the living room and ready to use throughout the pilot study. An external speaker was attached to the screen's backside to provide high-quality sound, and the participants could adjust the volume with a rotary knob.

## 6.2 One-Week Deployment at Home

During a one-week pilot study, we investigated the role of technology in facilitating the video exercises at home for people with dementia based on the participants' real-life experiences using the Switch2Move home system.

**6.2.1 Participants.** In contrast to the workshops, we recruited couples for the pilot study (see Table 2) without previous experience with the dance class program. By doing so, we aimed to avoid potential biases or influences caused by past experiences or opinions of attending the dance class program while evaluating the Switch2Move home system. An external care organization recruited participants with dementia and informal caregivers who were generally interested in music and exercising at home. The small sample size offered time and resources to adopt a personal and relational approach [37] by establishing a close connection and trust between the researcher and participants [4]. In this study, we recruited participants experienced with dance and physical exercise to uncover opportunities and challenges like early adopters [97]. During the pilot study, we aimed to balance the needs of the person with dementia and the informal caregivers, e.g., by triangulation between different data sources [21]. While the informal caregiver might hamper the person with dementia in voicing their thoughts, it remains relevant to involve care dyads in research to understand the more general lived experiences of dementia [71]. For example, informal caregivers can



Figure 11: During the pilot study, the Switch2Move home system consisted of a tangible controller (a) connected to a 27-inch external monitor (b); a media player attached to the backside of the monitor (c), and a speaker with a volume control knob (d).

Table 2: Three couples living with dementia at home were recruited for the pilot study (pseudonymized).

Participant with dementia (m/f)	Age	Stage of dementia	Informal caregiver (m/f)
Edward (m)	76	Early-stage Alzheimer	Elaine (f)
Frederick (m)	82	Early-stage Alzheimer	Frances (f)
George (m)	71	Mid-stage Alzheimer	Gloria (f)

offer insight into their daily lives, habits, and routines [45], supporting the adoption of technology during household routines [88], ultimately benefiting people with dementia.

**Edward** struggles to remain physically active. He used to have a busy life, building and renovating houses but now visits a physio-therapist twice a week. According to his wife **Elaine**, he was an excellent dancer in his time. **Elaine** still exercises daily at home to stay flexible and indicates she is always on the move as an informal caregiver. She also likes dancing but struggles to remain active due to an injury.

**Frederick** has difficulty speaking due to aphasia. **Frederick** has been able to exercise every morning with **Frances** for 30 years and still leads a very active life. For example, he works in his sister’s garden and fulfills the role of assistant in the daycare he regularly visits. **Frances** describes her life as “active and interested in sports.” **Frances** loves to dance like **Frederick** and plays music almost daily at home to relax.

**George** is an extrovert with a great love for theatre and jazz, having been a jazz band drummer for many years. **George** is still quite active and walks 10 km once every two weeks. **Gloria** joins **George** on walks together and sometimes on bike rides. **George** and **Gloria** danced on special occasions but were not avid dancers.

6.2.2 Procedure. During a first home visit, the researcher deployed the Switch2Move home system in the living room of the participants, conducted a test run, and demonstrated an exercise video. The participants were given a manual with clear illustrations and were free to use the Switch2Move home system when, how, and

Table 3: The interviews with the couples were guided by a topic list.

Main topics
1) the role of dance and music in their current lives
2) the experience of the Switch2Move home system
3) how and when they used the system
4) how the activity affected their daily life
5) who initiated the activity
6) the movements in the video
7) the design of the controller, monitor, and video layout
8) envisioned use in their daily lives and potential improvements

whenever they wanted. We instructed the participants to describe their daily experiences in a diary containing the following open-ended questions: 1) ‘How did you experience using Switch2Move?’ 2) ‘Could you describe how you used Switch2Move today?’ and 3) ‘How did dance and moving to music affect you?’ On the second day, we checked with the participants by telephone if the system worked and solved any technical issues. After one week, we conducted semi-structured interviews with each couple guided by a topic list and the diary entries (see Table 3).

6.2.3 Data Collection and Analysis. We collected diary entries and audio recordings of the interviews. The diary entries were used as input to steer the interviews and supported the participants’ memory about the use and experiences of the Switch2Move home system. The audio recordings of the interviews were transcribed verbatim. A deductive or theoretical thematic analysis was conducted over the transcripts [10], by classifying statements in line with the research question regarding how the prototype supported the 1) initiation and 2) engagement in the dance exercises. The main researcher created the initial set of codes clustered in themes by the first and second authors. Next, all authors were involved in clustering the codes into subthemes to provide insight into how technology can support and initiate dance exercises.



**Figure 12:** A participant demonstrates how he used the Switch2Move home system during the pilot study.

### 6.3 Findings Pilot Study

In this section, we report the insights from the one-week pilot study on the role of the Switch2Move home system in initiating dance exercises and fostering engagement.

**6.3.1 Initiating Dance Exercises.** The Switch2Move home system supported the participants in initiating the video exercises through ongoing access in their environment and by fitting into the home setting, also showing potential barriers in use.

**Ongoing Access in Immediate Surroundings.** All couples indicated that the tangible controller was easy-to-use for initiating the videos. *George* and *Frederick* used the tangible controller successfully by themselves. For example, *Frances* mentioned: “You [*Frederick*] pressed the button, sometimes you also said: ‘We have to do exercises.’” Similarly, *Edward* stated, “It’s very user-friendly; you can turn it off and on.” However, *Elaine* pointed out that she mostly operated the tangible controller and explained: “I had the incentive to do it. It holds nicely, and the control is so obvious.” While the controller is portable, *Frances* explained that they stored it in sight (see Figure 12) and: “barely moved it. We just pressed that button every time.” *Elaine & Edward* pointed out that the presence of the tangible controller in the living room and the push-and-play principle supported them in initiating the exercise videos: “Because it was in the room, you grab it very quickly. You don’t have to go upstairs or to another room, but you can do it here. [...] I think it’s important that you have it at hand. [...] We would say spontaneously, ‘Oh yes, let’s use the nice device for a while!’” Similarly, *Elaine* further explained the attraction coming from the single-button interface: “A friend of ours who visited last week was also drawn to press the button. Then when the program started, he liked it!”

**Fitting the Home Setting.** The informal caregivers found it essential that the aesthetics of the tangible controller matched their living room for accepting it in their homes. *Elaine* and *Frances* were pleased with the red color: “We do have some red in our living room, don’t we! But if it had been this color [points to a bright blue phone case], I would have hated it” (*Frances*). However, *Gloria* pointed out that the red color is too bright and opted to choose from different colors as she would prefer: “Green. Like everything else in our living room.” The presence of the tangible controller in the living room

was experienced to not be disturbing, like an ornament or household object. For example, *Frederick*, *Frances*, *Edward*, and *Elaine* appreciated the aesthetic design: “Yes, it’s just there, not disturbing. I think it’s a nice thing.” However, the additional external monitor of the prototype was indicated to be intrusive in the living room since *Edward*, *Elaine*, and *Frances* expressed the inconvenience of having a second TV in their living room. All couples indicated that they would prefer to use their TV, as explained by *Frances*: “It’s quite something to have a second screen in the living room. I imagine that you can install it on our television. That would be nice.”

**Potential Barriers in Use.** *Frances* indicated that she and *Frederick* would use the Switch2Move home system daily. However, *Edward & Elaine* revealed that they would not expect to use Switch2Move daily for more extended periods. *Elaine* expressed her frustration that she always must encourage her partner to participate in such interventions: “I think I will have to encourage you [*Edward*] to do it all the time. [...] I find that annoying because I already have so much to stimulate.” *Gloria* reflected that for doing the video exercises over a more extended period, variation in content is needed: “Variation! Variation, also in music. I also dropped out when hearing the song. If you do not care about that [music], you will never build a habit with it.”

**6.3.2 Engagement through Enjoyment, Relief and Matching Abilities.** The Switch2Move home system offered dance exercises as an enjoyable activity and provided calmness and relief, but should be adapted to the diverse and dynamic abilities of the person with dementia.

**Enjoyment as Motivation for Exercise.** The Switch2Move home system brought a pleasurable activity in the living room for *Frederick* and *Frances*, but also for *Edward* and *Elaine*, who expressed that they enjoyed and used the system daily. The participants clarified that pleasure and enjoyment was their primary motivation for initiating the video exercises, as summarized by *Frances*: “He (*Frederick*) was so happy with it [...] I think pleasure, music, and dancing are essential to people. And I am 100% sure that – yes, I am emotional – it is in our case too. We do everything to make it fun, don’t we?” In contrast with these two couples, *George & Gloria* expressed they did not enjoy the Switch2Move home system and stopped using it after three days, as *George* explained: “I just don’t like it [the exercise video].” *George’s* wife *Gloria* further clarified that he did not like the dancer’s appearance as a potential cause for his disinterest in the exercise videos: “Hey, but *George*, you didn’t like that man on the screen very much,” as *George* confirmed another dancer: “would have been nicer huh!” *Edward* perceived the music in the exercise videos as enjoyable and calming: “It was nice to hear that music, and it’s very calming.” In contrast, *George* and *Gloria* did not enjoy the music as *Gloria* suggested: “The music is okay at the start, but I also give up at one point [...] nature sounds with classical musical instruments could work very well here.”

**Providing Calmness and Relief.** *Edward* also appreciated the background footage: “I think it’s gorgeous, with water underneath,” as *Elaine* added: “The sea but also the forest with the light through it [the trees], stunning images.” *Frances* also described how the background footage of nature and colors was calming: “I found the sea very soothing.” However, the background footage also gave rise



to distractions observed during the interview when *George* activated a video and stated: “It’s nice, but it’s... I’m unsure whether you should act like this or like that...” *Gloria* replied: “You must think very carefully about what you want to focus on, and I think you want to focus on the dancer. The rest [background and music] is just secondary.” Mainly the London-themed videos contained too many visual distractions, even for informal caregivers. In contrast, the participants expressed that nature themes felt more soothing, as *Gloria* explains: “London is very distracting. All kinds of triggers. But nature works better! Because the movements are also more in line with that, and that [nature] is safer.” Informal caregivers *Frances* and *Elaine* indicated that the video exercises were perceived as relaxing and enjoyable by their partner, but also relieved themselves, as illustrated by *Frances*: “After the exercises, *Frederick* was happy every time! [...] I’ll say, for my life situation, this gives relaxation.” Similarly, *Elaine* told her partner *Edward*: “Wonderful exercises [...] You’re already quite a restless person. For you, it’s very good to do this.”

**Exercises Matching Abilities and Context.** *Elaine* and *Frances* expressed that their partners with dementia, *Edward* and *Frederick*, could perform the exercises well during the pilot study. For example, *Frances* explained that *Frederick* performed similar movements from the exercises without using the system: “He (*Frederick*) walked through the house in the middle of the day humming and moving his hands as in the exercises.” Also, during the interview, *Frederick* remembered and performed a part of the exercises as he got up from his chair and imitated the movements: “Then the foot moves like this, and the other foot goes up. And then I sit down again; he [the dancer] does that too!” *Frances* also commented on her own experiences regarding the beneficial effect of the exercises: “I like the exercises. You feel it in your body because I have experience with such exercises. I have been doing yoga since ‘74 [...] You feel that it [the video exercise] warms up the body.” However, all informal caregivers perceived during the pilot study that some exercises were too difficult to perform for their partners with dementia. *Elaine* explained that *Edward* did not complete all exercises as he: “is not that flexible, so it’s hard to follow.” Furthermore, *Gloria* indicated that the exercises were quite intense: “If you do the exercises as he [the dancer] performs them, it is very intense! Because you use your whole body.” As a result, *Gloria* explained that it was just too tricky for *George* to mimic the movements: “*George* just sits there a bit, imitating the exercises in his way.” Furthermore, *Elaine*, *Frances*, and *Gloria* all indicated how they observed that the pace of the exercises was too fast for their husbands with dementia, as *Frances* remarked how: “*Frederick* can follow it for a while. Me too. But it goes too fast sometimes.” *Frederick* later confirmed: “And then he [the dancer] does that with his hands. He is always busy. And, well, I occasionally forget one movement. But most movements I can perform.” Similarly, *Edward* suggested that he would like to be able to adjust the pace of the exercise video himself: “It [the system] should be more adjustable [...] faster and slower.”

## 7 DISCUSSION

This paper explored the role of technology in supporting people with dementia to initiate and engage in music-supported video exercises at home. The workshop sessions highlighted the value of visual and tangible design qualities to stimulate independent

and active participation. Furthermore, our pilot study suggested that the participants easily initiated dance exercises at home and, by doing so, experienced visible pride and self-efficacy. Based on our findings, we suggest opportunities for technology to increase self-efficacy, offer rich, engaging experiences, and fit with the home environment of people with dementia aging in place.

### 7.1 Increasing Self-Efficacy

We contribute to existing literature on interventions for physical activity in dementia [6, 40, 51, 62, 76, 80, 91] by highlighting the potential of technology to promote dance exercises at home and overcome barriers to engaging in physical activity [80]. With the single push button, we provided an intuitive interface that draws upon a familiar interaction [5]. Furthermore, the visual and tactile qualities of the tangible controller, in combination with the ease of use of the push button, triggered active initiative from people with dementia to use the device at home. These insights contribute to literature proposing that intuitive and simple interaction design stimulates the independency and active engagement of people with dementia at home [45, 88].

This paper further highlights the potential of technology to support dancing as a recreational activity suitable for self-supporting physical fitness and adherence to exercising [6]. Although the informal caregivers sometimes initiated the exercises, our findings suggest that the ongoing access to the tangible controller motivated active engagement from the person with dementia. As such, the Switch2Move home system relieves informal caregivers [16] as it supports a recreational activity and increases the self-reliance of the person with dementia. Therefore, our findings further add to views on technology for couples aging in place with dementia to improve and maintain fitness at home [13, 17] and regulate emotional well-being independently [48].

Our findings also revealed that the pace of the dance movements needed to be adaptable to the mobility and response time of the person with dementia. For example, the video exercises were less appreciated by the participant with mid-stage dementia (i.e., *George*) compared to participants with early-stage dementia. Therefore, we recommend offering different difficulty levels and additional hardware for registering movement performances. These insights feed into the increasing work on how people with dementia appropriate existing technologies to support their unique situations and dynamic needs [1, 25, 98]. For example, the informal caregivers expected variation in video content and music could stimulate use over time, as ongoing curation of media content supports a continued curiosity and interest [43, 87]. With the Switch2Move home system, we propose a first opportunity for **technology combining music and movement to enhance self-management and adherence to physical exercise for people with dementia aging in place.**

### 7.2 Fitting the Physical and Social Environment

The Switch2Move home system reflects the trend of in-home health technologies that avoid clinical representation but adapt to the domestic and socio-cultural context of family life [50]. As a result, the system was embraced by most informal caregivers as a homely product. The participants with dementia also clearly preferred a



noticeable and visible design within the home setting. Therefore, the visibility of the tangible controller in the living room offered an external memory cue [89] which was vital in stimulating daily exercising, as ongoing access to exercise content is essential for people with dementia to integrate physical activity as part of everyday routines [92].

We designed a tangible controller as a mediator between existing technology, namely the exercise videos shown on the TV, and the abilities of the person with dementia. Whereas introducing new assistive technologies at home is challenging [8, 31], the Switch2Move home system incorporates a TV which is widely available in households [19, 26, 92]. Furthermore, a video-based platform offers an effective cost-friendly alternative to expensive rehabilitation equipment [83]. The participants embraced the Switch2Move system in their homes but strongly preferred it to be fitted to their already owned TV. These findings align with how assistive technologies embedded within available everyday products (e.g., TV) reduce the associated stigma or feelings of embarrassment [7]. Therefore, technology should include aesthetic design features to facilitate a careful balance between being noticed and fitting the home interior, as assistive technologies that do not fit become unwanted and abandoned over time [31].

Similar to previous studies on technology for people with dementia [11, 45, 88, 90], our findings demonstrate that the involvement of the person with dementia and their partner supports a pleasurable and rewarding shared experience. Therefore, this paper demonstrates the potential of dance exercises to provide enjoyment, social activity and physical activity to support couples affected by dementia. We suggest a second opportunity for technology as **'homely' devices for people with dementia aging in place that naturally fit into the physical home environment and are embedded in existing social relationships.**

### 7.3 Engagement through Enriching Experiences

The exercise videos offer rich experiences through dance, music, and scenic background footage, which was experienced as soothing and relaxing by the participants and the informal caregivers. Numerous studies have highlighted the value of nature-based media in relieving stress to people with dementia [29, 42, 77, 84]. We suggest that soothing imagery of nature contributes to the relaxation and comfort of people with dementia and caregivers during dance exercises. Correspondingly, the participants with dementia and the informal caregivers had difficulty following the *London*-themed exercise videos with the busy background. These findings further support studies on multimodal technologies in dementia, raising caution about overstimulation and that technology should adapt to the changing sensory perceptions of people with dementia [23, 42, 87].

By offering rich experiences, the Switch2Move home system follows current developments in assistive technologies to transcend purely medical approaches by focusing on everyday living contexts [7, 50], addressing the dynamic and personal contexts [54, 59], and supporting social and meaningful activities [3, 30]. In addition to stimulating physical exercise, the system offered pleasurable moments of social contact and sensory engagement to enrich everyday life through aesthetic and authentic experiences that reinforce a

sense of normalcy [44]. These findings also tie in with research on enhancing the home experience for the general population by creating the desired atmosphere, strengthening social connections, and maintaining personal health within a household setting [27]. As such, an enhanced home experience supports people with dementia and their informal caregivers to actively initiate and participate in activities of daily life [41]. We highlight a third opportunity for **technology to engage people with dementia in everyday social activities that enrich their home experiences to age in place well.**

## 8 CONCLUSION

This paper presents the Switch2Move home system as an exemplar of how technology can support music-based exercises for couples living with dementia at home. Our findings provide insight into how technologies that provide dance activities are a feasible and cost-effective strategy to support the self-management of physical exercise for couples with dementia aging in place. Furthermore, such technologies should naturally fit the existing home environments and offer engaging, enriching experiences to stimulate initiative and adherence to daily exercising. In future research, we will conduct an evaluation study with the Switch2Move home system with a larger and broader participant sample to investigate the long-term benefits of engaging in home-based exercise facilitated through technology. We aim to encourage future research to investigate the adoption of technology in home environments for stimulating initiative in people with dementia through aesthetic and enriching experiences that foster new socially meaningful habits.

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