FLOW Pillow: Exploring Sitting Experience towards Active Ageing

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Abstract
In this paper, we present an exploratory study of the prototype of FLOW, a portable exercise platform that aims at aiding sedentary behavior among elderly people by offering them a more active sitting experience in their daily routines. We designed FLOW based on three iterations, revolving technology implementation, interaction design, and user experience design. With our prototype, we conducted a pilot study with elderly people (n=5) in a care center in the Netherlands. We evaluated user experiences and interactions with the FLOW pillow through observation, interview, and questionnaire techniques from Flow Theory. By analyzing the obtained data from the pilot study, we discussed the opportunities of FLOW in motivating active sitting behaviors for elderly and implications for future works.

Author Keywords
Active Ageing; Gerotechnology; User Experience; Interactive Music; Sitting Exercise.

ACM Classification Keywords
H.5.2. Information interfaces and presentation (e.g., HCI): User Interfaces – User-Centered Design.

Figure 1: FLOW pillow enables the elderly to interact with the music by shifting sitting postures.

Introduction

In HCI, motivational design for regular physical activity has been widely examined among children, teenagers, young and middle-aged adults. Regarding the older population, however, very limited work has addressed relevant challenges efficiently. There are too many factors that could influence exercise adherence for elderly, such as poor health condition, environment constraints, lack of physician advices and knowledge, and exercise experience in childhood [9]. As identified by Schutzer et al. [9], the deterioration of health plays a major role among the barriers to prevent seniors from doing exercise. Adversely, inadequate physical activity negatively affects their health and in turn leads to more sedentary lifestyles. Evidence has suggested that providing moderate physical exercises in repeated session are beneficial in aiding sedentary behaviors. For example, the frequent changes of sitting postures from one to another can help to decrease the health risk from excessive sedentary time [7], which is applicable for elderly people with deficient mobility.

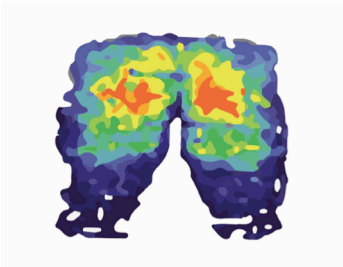
In this paper, we approach this opportunity through a formative study of the novel design of FLOW. Our prototype aims at providing active sitting experiences for elderly people to prevent sedentary lifestyles. Explicitly, FLOW is a portable smart exercise pillow, which learns sitting behaviors from users and in return uses interactive music to stimulate users to shift the sitting postures with different dynamics in different scenario (see Figure 1). We carried out a pilot study (n=5) to examine user experiences and interaction design, which resulted in new design implications for future works.

Prototype Design

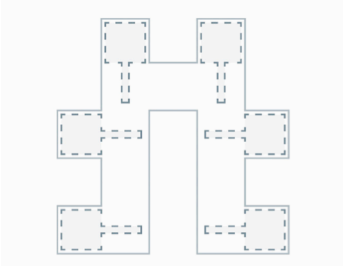
Current work of wearable technologies [11] and smart chairs [8] are promising to measure sitting behaviors and to provide motivational feedback. These types of applications, however, still have limitations in our context, such as inconvenient to move [8], undemanding interactions [11], and inadequate user experience to support behavior change. To address these issues, we explored design opportunities through three iterations, consisting technology design, interaction design, and user experience design.

1st iteration: technology design

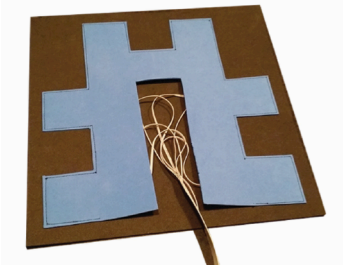
Similar to the project of Darma [12] and Pretty Pelvis [6], we designed a portable system, a sensor-based pad that can be placed on every normal seat, to track and archive sitting behaviors (see Figure 2).



(a) The reference for the sensor position, from [14].



(b) The design of the sensor pad



(c) The implementation of the sensor pad

Figure 3: The overview of the sensor pad in our prototype.

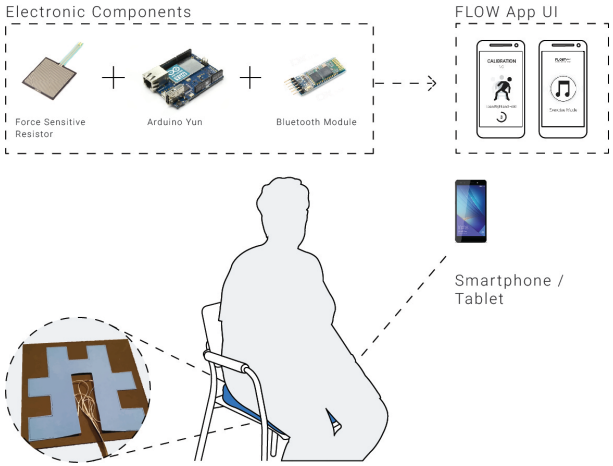


Figure 2: Interaction map of the hardware components.

We developed a fabric pad that could be embedded into the pillow. Six square-type force resistor sensors (FRS) were placed in the particular positions of the pad for maximum sensor range and detection. We selected the square-type FRS, as it has a larger area than the circular ones and can give a more accurate reading. Based on sedentary pressure map [13] (see figure 3 (a)), the current sensor configuration is designed for efficient area coverage and detection of posture when the user is seated.

The sensors are connected to an Arduino Yun, a small ATmega 328 micro-controller prototyping board with an internal flash memory (32 KB). Moreover, a Bluetooth module is connected as well. The Arduino gets the pressure input on each sensor and analyzes via a learning algorithm to suggest the possible postures. The necessary relevant data is then sent periodically (once every second) over Bluetooth to the smartphone and/or computer.

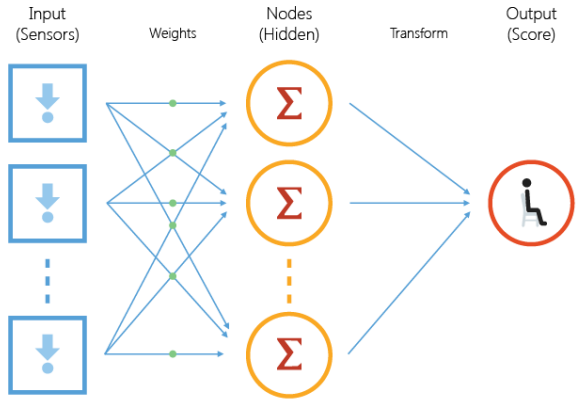


Figure 4: The Artificial Neuron Network used in FLOW.

Based on the hardware constructs, we applied a specialized Artificial Neuron Network (ANN), which is often used for machine learning and data mining, to determine the user's posture (see Figure 4). The basic mechanisms of how ANN works in FLOW are described as following: Firstly the sensory data is collected from the FLOW pillow and weights are given. An algorithm translates this data and gives a probability in which posture the user is currently sitting. The learning algorithms can be taught multiple different postures and can calibrate the user's movement range along this way. As such, the system can analyze the user's progress in movement and customize the exercises accordingly. Moreover, with the Wi-Fi connection the progress can be monitored over a distance by e.g. a physician.

2nd iteration: interaction design

Before designing the interaction in FLOW, we firstly visited a care center to better understand the context. We found that there was some equipment for different exercises. Therefore, we planed to incorporate those

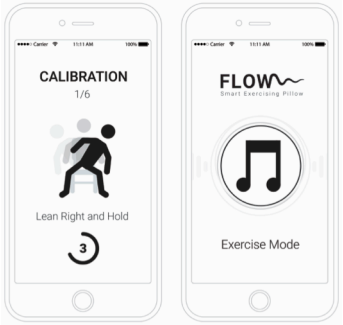


Figure 5: Examples of UI in the App for FLOW pillow. Left: posture calibration for first time use; Right: music activated in the exercise mode.

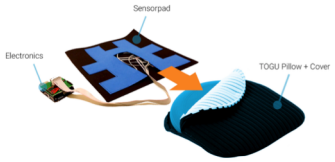


Figure 6: The components of FLOW pillow, from left to right: the sensor pad with Arduino, Dynair pillow, and the cover for the pillow.

exercises, such as lower back, hip, and balance exercises, using FLOW pillow. We conducted brainstorm and sketching sessions with industrial design students from Eindhoven University of Technology, and came up with the concept of utilizing interactive music to provide a more engaging and adherent exercise. We aimed to let the elderly influence the volume of the music by changing their postures and doing sitting exercises. Given that instrumental music could bring greater adherence in the exercise among elderly people [5], here we selected the instrumental music as the basis. To achieve this goal, the FLOW system is linked to a tablet or smartphone via Bluetooth. The User Interface (see Figure 5) allows a simple setup and calibration. The auditory feedback is given through the smartphone or tablet as well.

We confirmed the concept through an interview with elderly. From the interview, we also learned that, for some seniors, the moderate movement was still hard. Thus we decided to incorporate physical support with the interactive music to aid in the interaction. Eventually we employed the TOGU Dynair pillow [10] in the system. The pillow uses airflow to give the user support and more dynamic movement range. As is shown on Figure 6, we placed the sensor pad on top of the pillow, using the fabric cover to fix the position of the pad. Through a test we confirmed that the measurement still worked properly and the received data matched the position of the user.

3rd iteration: user experience design

As characterized by Forlizzi and Battarbee [2], there are three types of user experience in interaction for specific contexts. *Experience* happens constantly when user interacts with the system; *An Experience* happens in a time to influence behavioral and emotional change; *Co-Experience* happens in a social context to create or share with others. FLOW pillow accommodated the design considerations from these three perspectives to provide active sitting experience for seniors. For these purpose, based on the fact of their daily activities, we designed the user experience map (see Figure 7) in three modes: lifestyle experience, exercise experience, and co-exercise experience.

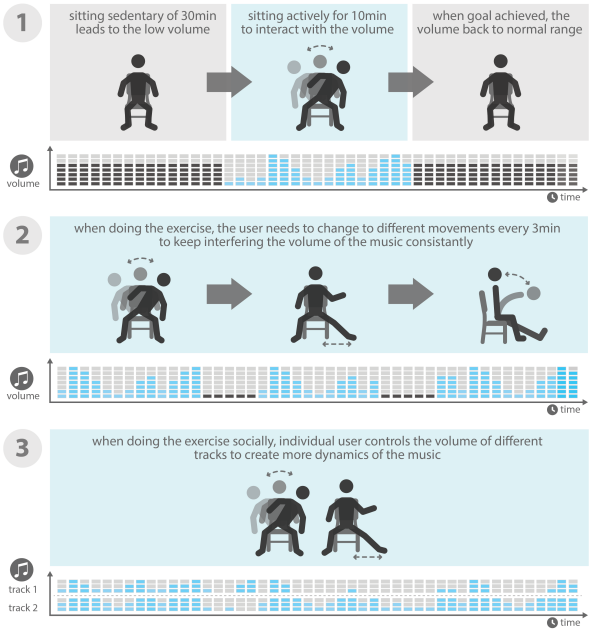


Figure 7: The user experience map of FLOW: (1) lifestyle mode, (2) exercise mode, (3) co-exercise mode.

Lifestyle Mode is based on daily routines and makes users to be more aware of sedentary behavior in a non-intrusive way. As is depicted in Figure 7(1), once the

Q1	What do you feel with FLOW?
Q2	How did you feel about doing exercises with the pillow?
Q3	How did you feel doing exercises with music?
Q4	What kind of music would you like to do exercises with FLOW?
Q5	Would you like to exercise with FLOW more often in the future?
Q6	What would you like to change to our design?

Table 1: Questions for interviews.

elderly sits on FLOW, after 30min sedentary time it reminds to sit more active by decreasing the volume of piano music in this study. The volume adjusts according to the extent of posture variations. After 5min, the volume returns to the initial settings.

Exercise Mode provides a dynamic experience when doing the sitting exercise with FLOW. As is shown in Figure 7(2), the elderly actively engages in doing exercises with the pillow. Salsa music is used to support interaction as this has a distinct rhythm. The user has to switch the movement every 3 min to keep the music working. For example, after marching for a while, the user can change to whatever other movement, such as stretching, to continue the flow of interaction and music.

Co-Exercise Mode offers co-experience for multiple users with a number of FLOW. It can be either co-located exercise in the care center or exercise in the home with friends remotely. As is illustrated in Figure 7(3), a generic composition with different instrumental music is used where each user could influence one instrument with the FLOW pillow. The music is influenced by the efforts from all the involved users. In this way, we aim to create a 'band' or team atmosphere for the elderly.

Pilot Evaluation

To verify how the dynamics of user experiences and interactions with FLOW are related to elderly people's exercise behavior, a pilot evaluation was conducted in Zuidzorg extra (a care center) in Veldhoven in the Netherlands. Due to the time limitations, currently we were only able to examine the Exercise Mode experience using FLOW pillow.

Participants

We recruited five participants (2 males and 3 females), ageing between 65 and 88. By inquiring the physician in the care center, we confirmed all the participants could join in the test. Before entering the experiment, all the participants were asked permission to use their information for academic purpose and signed the consent form.

Experiment design

We conducted the test with individual participant respectively. The experiment consisted out of three sections: introduction of the concept, exercising with the FLOW pillow, the questionnaire and a short post-interview. In total the experiment lasted around 30 minutes for each participant. To be noted, during the exercise, the participants moved on their own without any instructions on what kind of movement they should do. Moreover, there was no specific goal for them to achieve during the test.

Data collection

We observed and noted for the whole process of the exercising session. After each experiment, the interviews were conducted to compliment the observation of their exercise session. Questions asked are organized in Table 1. Moreover, every participant was given the Flow State Scale (FSS) [4], a 36-item five Likert scale questionnaire. FSS was originally developed by Jackson and Marsh [4] based on Flow Theory [1], which explains why people engage in certain activities intrinsically. To be noted, since one participant had cognitive difficulty in intense reading, we finally collected 4 feedbacks rather than 5. FSS provides 9 measures for us to understand the elderly's experiential characteristics of using FLOW pillow,

Figure 8: The results from the questionnaire of Flow State Scale.

including balance of challenge and skills, action-awareness merging, clear goals, explicit feedback, focus on task, feeling of control, loss of self-consciousness, indistinct sense of time, and autotelic experience.

Results

The data from the pilot evaluation is organized into two parts: 1) the general feedback on user experiences from the questionnaires and 2) the feedbacks from the observation and interview responses.

Questionnaires

The data from the questionnaire was analyzed and visualized using spreadsheet software. Due to the limited number of participants in this pilot study, we could not conduct very rigorous quantitative analysis. From the simple analysis, the mean scores for most categories were quite high (see Figure 8). This implies that FLOW pillow more or less provided an immersive user experience during the exercise. There was one exception that the sense of time scored relatively low (M=3.375). This might due to the reason that we did not assign the specific timeframe for them in the test.

Observations & interviews

During the test, we observed the exercise went well for most of the participants. One participant also pointed out the strength of our prototype in their daily life, as they could explore and see how much movement they could make during the day with FLOW pillow.

One of our main goals from this pilot study was to examine the system interaction from FLOW pillow. Therefore, we organize the obtained results on the interactive music and the physical support (Dynair pillow in this case) in the remainder. Our findings are presented into four categories, including usefulness of the music, lessons for the music, usefulness of the physical support, and lessons for the physical support.

USEFULNESS OF THE MUSIC

During the test, we observed that exercising with music worked well for most of the participants. Some participants were very active, attempting to use both hands and feet to interact with the music. There was one participant had difficulty to catch the beat and rhythm but did move vigorously during the exercise. In the interviews, their reactions on the music were positive as well. They thought doing the exercise without music was adequate. However, they still liked the concept of moving with the music.

LESSONS FOR THE MUSIC

Although the music adjusted accordingly to the movements, we have learned that each participant's movement range was different. This differentiated the interaction, as some movements were too tiny to influence the music. Moreover, we found that they had distinct preferences on the music. Some felt the music pieces a bit too slow and others thought it was okay. One participant even commented that she wanted to determine her own pace. On the flip side, the participant who had hearing disorders did not move much during the exercises and mentioned he did not feel the music, even though he had a hearing aid during the test. This also caused the music not to change much.

USEFULNESS OF THE PHYSICAL SUPPORT

From the test, we observed it did take some time for participants to get used of the Dynair pillow. However,

most participants liked the air-based pillow as it helped them sitting more upright. Some participants felt comfortable when sitting on the pillow and the support on movements were helpful. Particularly, one participant highlighted the pillow was more flexible and lighter than the exercise pillow he used, as with that one more force was needed.

LESSONS FOR THE PHYSICAL SUPPORT

We also learned here is some space to improve the physical support from the pillow. One participant suggested giving more apparent feedback from the pillow if they did the correct movement. Moreover, one participant felt tiring when sitting constantly, as the pillow was too small.

Discussion

In general, our explorations revealed that FLOW pillow could support to leverage the health barrier [9] of doing exercise among elderly people, as our design offers an immersive experience to do low-intensity activity. Furthermore, music provided clear and demanding interactions and exercising with music was a positive user experience for most participants. This conformed that the music could be a great motivator [5] to stimulate the elderly to do exercise and to encourage them to adhere on the activity. To our surprise, we also found that the impact of physical support and tangible feedback, Dynair pillow [10] in our case, was significant to optimize the interaction and thus user experiences during the physical activity. Given the lightweight of the pillow, it also improved the mobility and flexibility of FLOW system. Regardless of the relatively small size ($40*40cm^2$), most participants gave positive feedback on using the pillow to support their exercise.

From the pilot study, on the other hand, we also obtained a few insights that could be further applied to improve the sitting experience provided by FLOW pillow. First, similar to the insights from prior studies [3], we found it is necessary to offer seniors the pathway to do exercise repeatedly in different sessions during the day. From the interview, we learned that most participants already did some exercises at home or at the care center. However, without explicit schedules and structures, they would get lazy and skip trainings. As mentioned earlier, we already considered the lifestyle mode to remind sedentary behaviors. Therefore, we will implement a 'music reminder' into the elderly's daily routine to provide repeated active sitting experiences.

Second, the study revealed that the unclear goal for the exercise could block the exercise for elderly people. Given the explorative nature of our current study, participants were free to move to explore and interact with the music. However, some participants were confused with this kind of uncertainty and were more aware of the time consumed. Therefore, the task of the exercise should be clarified. Accordingly, clearer instruction and feedback should be given to prompt the performance. For example, placing vibration motor in the pillow to provide instructions of the movement.

Third, an important lesson learned from this study was one size might not fit all, as the cognitive and physical conditions among elderly people are quite distinct. Therefore, enable personalizing the system, such as choose the music, adjust the movement range based on the physical condition, and set the workout time, would improve the usefulness and usability of FLOW.

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Fourth, there is a room to modify the current design of our prototype. In the test, the sensors we used did not work very properly, as the surface of the pillow was very flexible and dynamic, which is not entirely suitable for the more ridged sensors we used. This could be improved by using fabric pressure sensors. Moreover, as mentioned previously, we should make a larger pillow for elderly people. Lastly, since we observed that movements from participants were not very dynamic, we should lower the threshold for interfering the music to make the interaction more noticeable.

Conclusion & Future Work

This paper explained how we explored the design of FLOW pillow regarding technology, interaction, and user experience. We then gave details on the pilot study about the exercise experience and user-system interactions. A few preliminary insights was generated to improve our works and to enlighten our next step.

For future work, firstly we plan to update our prototype according to the earlier insights from the pilot study. We then plan to conduct a control study with three groups of participants to evaluate: 1) if the interactive music improves the exercise experience, 2) if the co-exercise experience has the intended effect to motivate active behavior. In the long run, we aim to conduct a long-term study to verify to what extent FLOW can be used to support active ageing.

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