

Report of M21 Final Master Project

# Wave

An active intervention  
for neck pain prevention

Xiaoyu Shen s148966

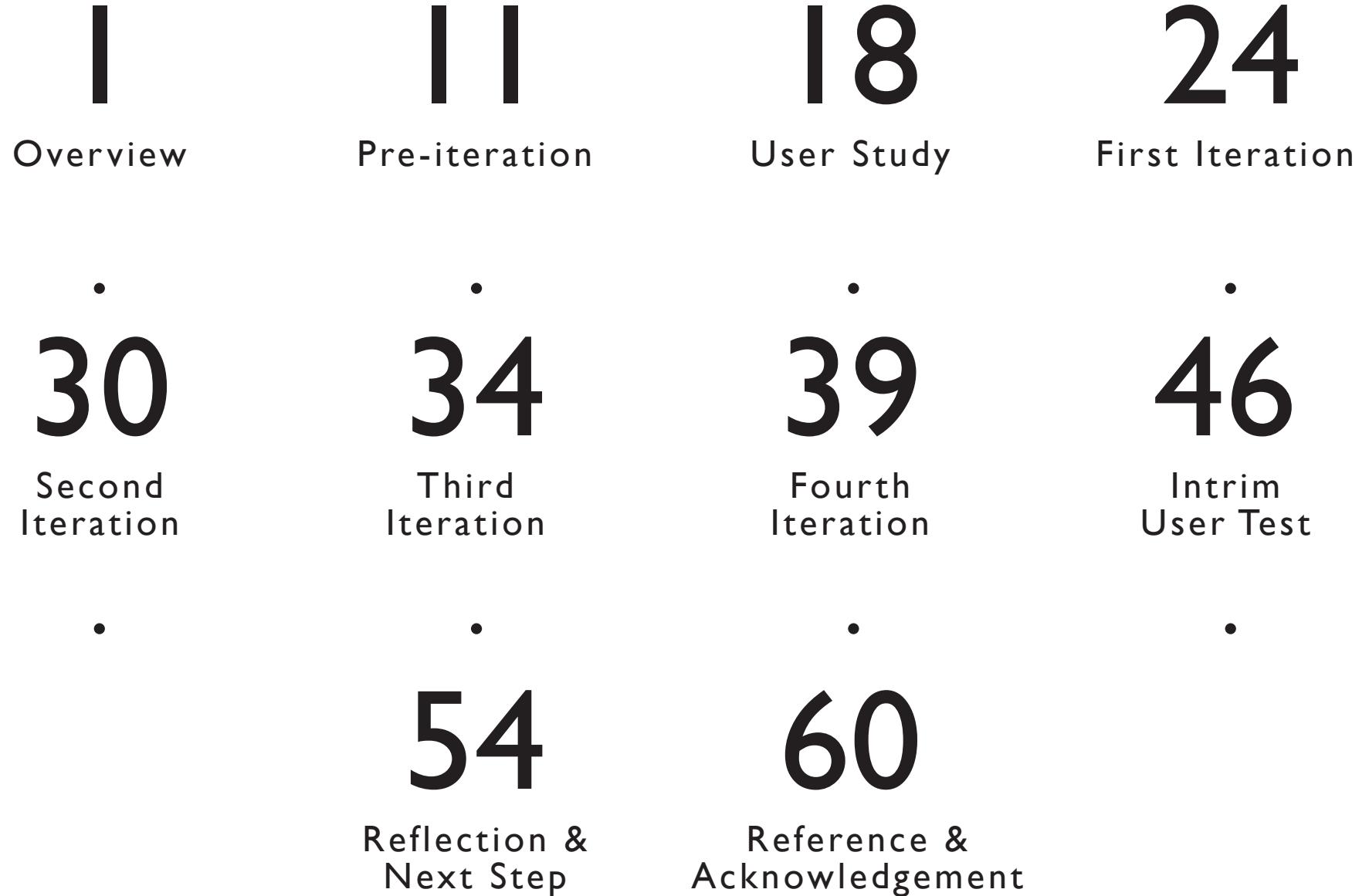
Coach: prof.dr. P. Markopoulos

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## ***People with neck pain want to improve their neck health***

Neck pain is a very common problem among office workers because of prolonged sedentary behaviors. However, there are not many products on the market aiming to help them out. This project is targeted at designing a healthcare product to assist sedentary people with neck pain prevention during working. For such a product, the challenge is to fit into people's daily activities seamlessly and increase users' adherence to support long-term intervention program. Therefore, the main focus is to explore a pleasant and intuitive persuasion process, which motivates behavior change with less effort and better user experience.



## O V E R V I E W

The background and objectives of this project

## VISION

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### **Technology-motivated patient empowerment**

In the information era, we are more empowered to shape our own healthcare today than ever before. Technologies are creating new opportunities for people to participate actively in healthcare. Nowadays, healthcare is changed from something that is done 'to' us, to something that is done 'with' us. Healthcare is no longer equal to receiving treatment for illness only, daily prevention and recovery after treatments also become great parts of it. As a designer, my ambition is to design daily healthcare products to improve people's well-being. For a long time, people may have the stereotype of healthcare: cold, strict, etc. What I want to do is to reverse this impression with a warm, humanized, enjoyable experience. In my imagination, people should not be regarded as patients, but users or players; they will not be forced to do things, but be persuaded into behavior change as an motivated user, which is actually my vision of designing for a better user experience.

### **Provide better user experience in healthcare**

People are always the starting point and the destination of design. As a designer, I would like to put people in the heart of services and deliver health and social care services by designing interactive products. It is fascinating to see how interactive technology can engage people and create a good user experience. Persuasive technology interests me a lot, since it focuses on motivating people to achieve their goals in a natural and acceptable way. While considering an enjoyable user experience, gamification comes out to be an attractive subject in this domain. When entertainment is not the main purpose, playful interactions could be a way to engage and motivate people for educational, awareness raising, training or other serious purposes. To make a difference, designers should keep up with the cutting-edge technologies and new culture & society change, break down the conventional stereotype and find new possibilities, and finally let people enjoy every moment in their life with pleasurable experiences.

## FROM VISION TO PROJECT

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Last semester was my starting point in designing for persuasion and behavior change in a specific healthcare context: autism. During my previous project, I explored my own insight-driven methods and user-centered approach in the design process, and I found it is interesting to bridge the theoretical therapy and real user experience in a natural and attractive way. My intention of FMP is to design interactive products in healthcare domain and explore how persuasion technology can help improving people's well-being. Therefore, the final master project is a good opportunity to dive deeper into my vision and keep developing capabilities in designing interactive products.

For my final master project, the direction I chose is to help office workers with neck pain prevention. With the help of my coach, I found a client, Prof. dr. A. Timmermans of the University of Hasselt, who is currently performing research towards patients with neck pain. Given my expectation of the final project, this direction fits my intention well. Neck pain is a typical work-related symptom caused by prolonged sedentary behaviors and insufficient movements. To prevent it, cultivating active and balanced working habits is crucial. As I mentioned before, behavior change is not an easy process. How to motivate people in an acceptable and natural way and let them experience personalized care as well as the emotion of satisfaction and delight will become the main topics of this project.

## PROJECT BACKGROUND

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### Prevalence of work-related neck pain

Modern desk-based office workers are typically exposed to prolonged sedentary behavior associated with computer use. It is well-known that there is a relation between the worldwide adoption of computers and the increasing population with neck and shoulder pain.<sup>[1]</sup> Incidence rates for neck and shoulder discomfort are found to be between 10% and 60% in individuals who have extensive computer use.<sup>[2]</sup> In the US, neck problem has become the leading cause of job-related disability, and huge clinical cost.<sup>[16]</sup>

### Risk factors

In the context of office, overtime poor posture, lack of adjustable features, inappropriate layout of computer workstation and duration of computer use are all well-known risk factors in cervical disorders associated with computer use.<sup>[8]</sup> However, sitting for lengthy periods in fixed postures could also result in muscle strains, especially in neck region.<sup>[4]</sup>

Computer allows users to accomplish their tasks with little or no regular large movements. The absence of movements has recently been recognized as a health risk.<sup>[3]</sup> Continuous and intermittent static muscular work is among the risk factors for work related musculoskeletal disorders.<sup>[9]</sup> The balance between muscle fatigue and recovery will reduce chance of bad symptoms.

### Possible Solution and Treatments

In order to keep this balance, exercise turns out to be a good choice. According to latest research, a regular stretching exercise program can decrease neck pain and improve neck function, owing to its effect in decreasing muscle stiffness and improving flexibility.<sup>[6]</sup> And its effect could be detected as early as four weeks with a sufficient frequency of exercise.

In another study performed by Irmak et al.<sup>[7]</sup>, a software program was used in a randomized control trial to remind office workers to perform 10-week exercise, including strengthening, stretching, and posture exercise. Its results support that exercise reminder software programs may help to reduce pain among office workers.

## Neck Exercises



**Figure 1** Neck Extension and Flexion, Neck Rotation, and Neck Lateral Bending<sup>[17]</sup>

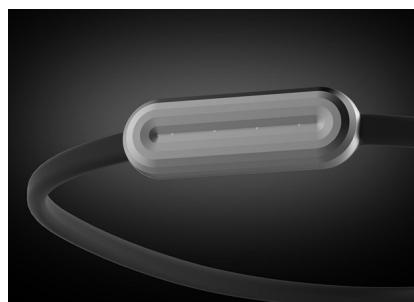
## EXISTING PRODUCTS

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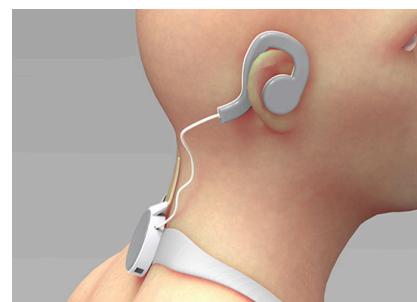
### 1. Tracking tool

By searching on Google, only one commercial product is found for neck's daily healthcare. Fineck<sup>[11]</sup> is a newly developed smart necklace for neck tracking. It is able to measure user's posture and everyday activities, store and visualize the data by connecting to smartphone application. (Figure 2)

CervicWear is a device that developed by M.M.Willems, a previous master student at TU/e. It provides an unobtrusive solution to improve neck posture as a peripheral reminder to provide visual feedback on the smartphone. It is promising in keeping people in good posture, but there is room for improvement for CervicWear's comfortability.<sup>[12]</sup> (Figure 3)



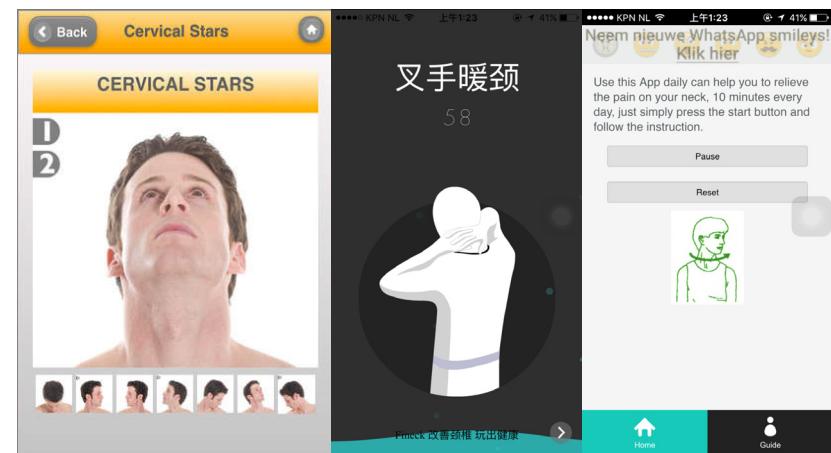
**Figure 2** Fineck



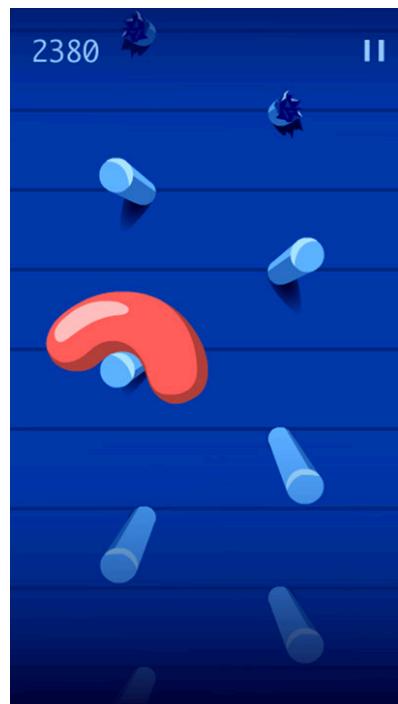
**Figure 3** CervicWear

### 2. Coach apps

In the domain of neck exercise, apps are the most common approach to get professional information. Several coach apps are found in the App Store. A few examples are Healthy Back, Relieve Neck Pain, Back & Neck Workouts and so on. These apps provide picture, audio or video coaching materials to lead people to do neck exercises. (Figure 4)



**Figure 4** Apps that provide image, animation, audio coaching material<sup>[14]</sup>



**Figure 5** Super Down<sup>[13]</sup>

### 3. Gamification

Besides the tracking function, Fineck also provides several interactive game apps to encourage neck movements: Super down, Jungle dew, Crushed meteorite, etc. However, I found the quick and short neck movements in the games don't support effective neck exercise, like stretching and strengthening.

### Design opportunity

The tracking products share the same focus of good posture maintenance. It is nice that the users can get real-time feedback of their neck health. However, they don't really encourage breaks or exercises during working time. Although Fineck is able to connect to several game apps to motivate movements, it doesn't take any long-term influence for building an active working/studying habit.

On the other hand, the apps related to neck health mostly provide professional exercises coaching. The guiding function is clear and useful, but it doesn't trigger users to follow it at right timing.

To make a further progress in the neck care product, I see the opportunity to combine the tracking function and coach software to provide users with a personal and interactive self-coaching experience. Inspired by the game apps, playful elements could also be a good way to engage and motivate users while exercising.

## GOAL FOR THIS PROJECT

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### Design space

In the sedentary working environment, office workers often fail in paying enough attention to their posture and neck stiffness while busy with computer. And these two factors will lead to neck pain, or even chronic cervical disorder in a long term. It is important to keep a good posture in the sedentary living. However, the tension in the muscles should be released by stretching exercise and active movements. To prevent the neck pain from an early stage, it is necessary to motivate people to build active and balanced working habits by regular breaks and exercises.

### Design focus

Sometimes, just knowing the right way to improve neck health is not enough, the hardest part is to follow the instructions and reshape the sedentary habits on your own. Without supervising, the efficacy of intervention heavily depends on users' own awareness of self-control. However, it is hard to operate in an office context, which requires a lot of attention on working. As a result, this design should act as a companion for users to keep an eye on their neck health and motivate them to change their

behaviors in a pleased and natural way to improve neck health.

This project proposes a daily healthcare product for sedentary workers to prevent them from neck pain from a physical perspective. The goal of this project is to explore and evaluate an interactive way to increase users' adherence to the intervention which helps them to keep track of their neck health and change unhealthy sedentary behaviors. Instead of doing medical research about neck pain, I will put more emphasis on the design part. Therefore, the focus of this project is to create an aesthetic and motivating experience to support behavior change and new habit formation in exercises. As a result, the evaluating points should also focus on user experience improvement, rather than validating whether it is more effective than the existing products.

### Challenges

Firstly, how to persuade people to adopt it in their daily life is the first challenge. The product should be easy to use and understand, and in the meanwhile, not too distracting and annoying. It requires the design with meaningful feedback and intuitive interactions. And as a product for daily use, it should

also fit into the context and become an essential part of people's routine.

Secondly, motivating people to do something new or different is always easier said than done. From awareness to behavior change, finding out why people often fail in taking care of their own neck health in this process should be the very first step. This project should build upon these weaknesses of the existing products. Persuasive technology will be adopted in this project to make the behavior change process more persuasive and convincing.

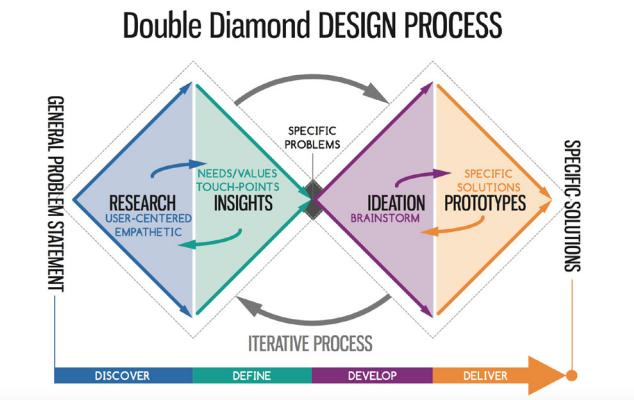
Thirdly, how to increase users' adherence is also something to be discussed. The intervention is expected to make a long-term influence on users, which means people will keep the good habits in sedentary working/studying environment after the help of intervention.

## Approach

### **Double diamond design process** <sup>[18]</sup>

The Double Diamond design process is adopted to better empathize with users' needs and lead to better solutions that meet them. The design process is divided into four distinct phases: Discover, Define, Develop, and Deliver. As an iterative design process, every phase will build on the output of the previous ones.

By using this kind of pattern, the process can keep flexible to new ideas and reflective to past works.



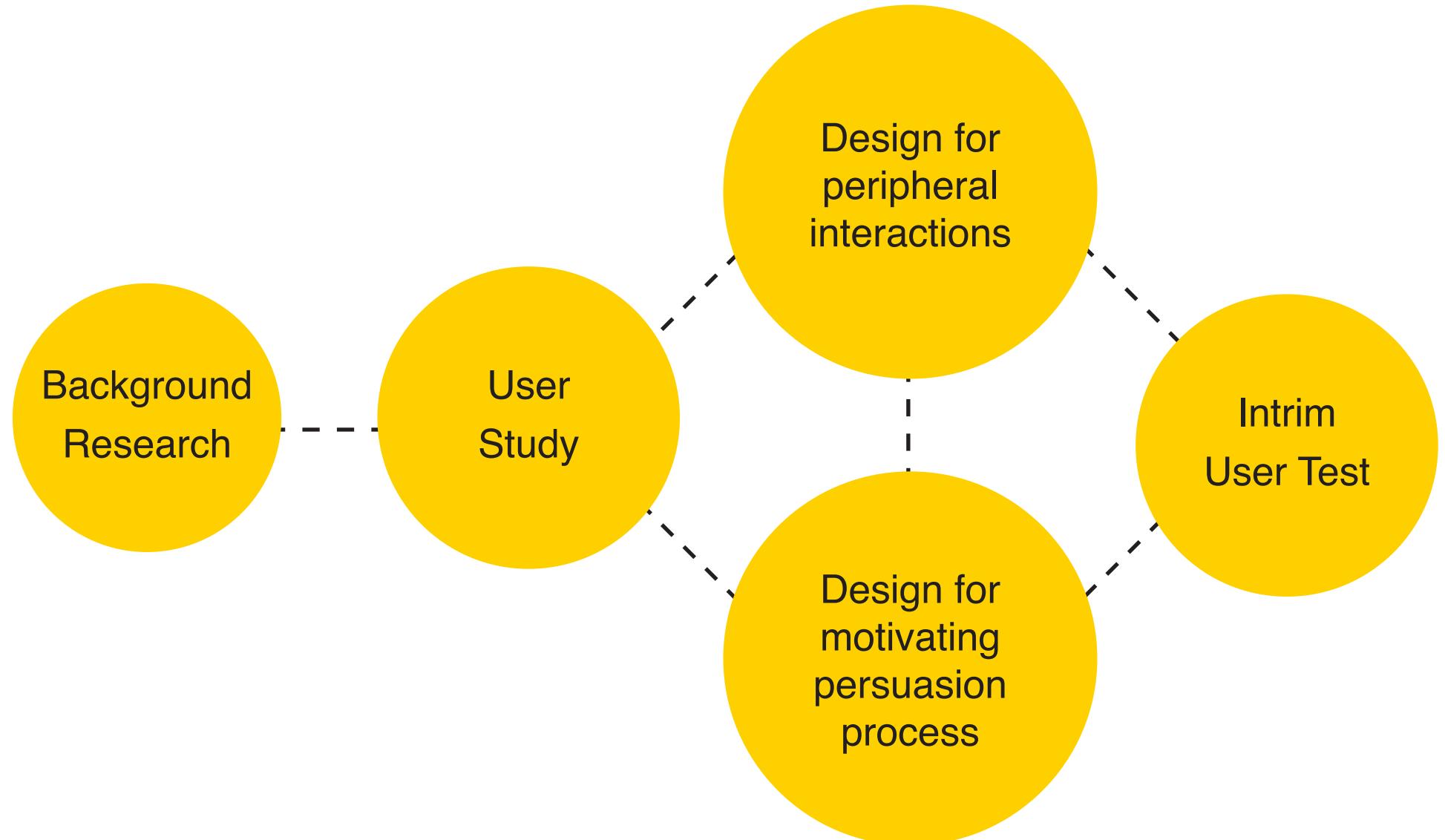
**Figure 6** Double Diamond Design Process <sup>[18]</sup>

### ***Scientific strategy exploration and User-centered design approach***

Scientific strategy exploration and user-centered design are the main approaches of this project. The first part focuses on obtaining insights through medical research, including literature research, experts meeting and so on. It is helpful to provide grounded reasons while making a design decisions from a rational perspective. The second approach is for pursuing good user experience. It requires a designer to step into the context, involve users in the design process, and gain empathy with them from both behavior and emotion layer.

DESIGN PROCESS

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## **P R E - I T E R A T I O N**

The idea of pre-iteration is to integrate all the information collected in the previous sessions and form basic concepts.

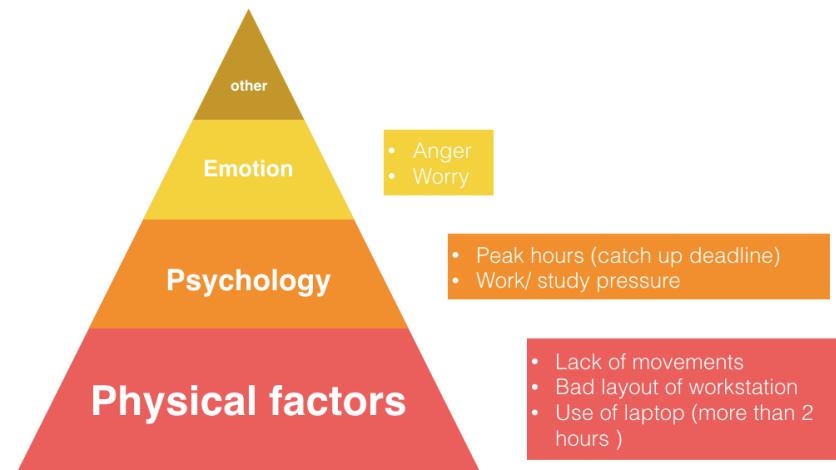
## EXPERT MEETING

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After the first round of literature research, a meeting was scheduled with a physiotherapist at Student Sport Center Eindhoven. He is a health care professional working with someone after injury, accident or surgery, and also working to prevent injury for instance with sporting clubs or in the workplace. He is experienced in dealing with neck pain without a red flag (obvious damage or injury). And his patients fit into my user group quite well, as they are the students and employees from TU Eindhoven. The purpose of this meeting is to gain a better understanding of users and the project context and select possible solutions for neck pain prevention.

First of all, Frits confirmed my initial idea about encouraging movements during working. On the contrary of dynamic loads caused by sudden movements or excessive force, the static loads is the main cause of neck pain in the office context, which is mostly resulted from bad sitting posture. It is hard to keep good posture all the time, as your tired sight will induce you to get closer to the screen, or change into a weird posture to relax tight muscles on back or neck. To avoid over-loading your neck muscle, frequent breaks and stretching exercise were suggested as the most effective solution, as the dynamic state is the very opposite of static state.

Second, work-related neck pain can be cured by leading a healthy lifestyle. As shown in figure 7, various causes of neck pain exist, such as physical factors, psychology, emotion state, etc. In fact, neck pain can be caused by one single factor or sometimes mixed factors. Therefore, besides physical correction, the intervention should also remind people of leading a healthy lifestyle, staying in good moods and coping with stress appropriately. For example, release stress actively by doing sports, have good time management to avoid working on peak hours, etc.



**Figure 7** Leading risks of neck pain

Third, the reason why traditional reminders always fail was discussed. As mentioned before, stress can lead to neck pain during the peak hours. It always happens when a deadline is approaching. Alarms of taking breaks were often discarded or disused, because people are too stressful to being reminded successfully in their peak hours. From this point, this design project should explore a soft reminder or relaxing tool to increase the success rate in reminding.

Overall, this expert meeting gave me a clearer view of the project context. This project will focus on active intervention, which prevent the neck pain by encouraging regular neck exercises and breaks. In addition, multiple treatment tips can be provided for psychology health and emotion management. And it is also important to explore a relaxing tool or soft reminder to increase the success rate of reminding.

## CO-CREATION

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**A**ccording to my design focus, this project is about motivating people to exercise regularly during work time. In order to generate more ideas, I invited three master students from the Industrial design department to have a 2-hour co-creation together. One thing to mention is that, the main idea of this session is to find out new design opportunities and possible strategy around the topic of designing for motivating office workers to do neck exercises during work time. Therefore, instead of pursuing the concepts generated only, I mainly focused on their thinking methods and the essential points of this design task.

### **This session was divided into 4 parts:**

1. **Background introduction:** Before the creative session, a brief introduction was given to clarify the context, user group and related medical information about neck pain.
2. **Warm-up questions:** To help the participants get into the context, several questions about their own experience about neck pain and expectations towards such self-coaching product were discussed.
3. **Concepts generation:** Every participant worked independently to

generate at least 5 ideas, which were described with sketch and simple text on the paper.

4. **Sharing & discussion:** In the end, every participant shared their ideas and feedback is given to each other.



**Figure 8** Co-creation session

In the end, we came up with 20 concepts in total. Although there were some overlaps, this brainstorm was proved to be very inspiring in the following perspectives:

### **1. Information presented in periphery**

Because of the office context, ideas were generated to design for a less distracting experience. One of the methods is peripheral information exhibiting. For example, background light of the monitor can indicate the neck situation through color feedback.

### **2. Intuitive interactions**

Ideal interactions in this context were regarded as natural and intuitive, or even automatic. In this way, people don't need too much thinking to do the exercises. There are some examples of concepts focusing on this point: moving animation that is projected on the wall to attract people look at and move with it, pats on shoulder to trigger people to look around intuitively, a slightly moving monitor which induce people to move along with it.

### **3. Music-guided exercises**

Music can help people to remember the exercise movements by its tempo and melody. An example was given that the morning exercises in Chinese schools are done with background music, after several years we can still recall the body movements when the same music starts to play. It was very inspiring in designing for exercise learning and the long-term persuasion process.

### **4. Wearable tracking devices and face tracking technology**

In order to make it a customized coaching experience, tracking the personal data is one of the inevitable parts. Ideas about wearable tracking device includes scarf, collar of cloth, necklace and so on. They are mainly focus on the combination of daily essentials and fitting into people's daily routine. On the other hand, web camera is put forward to explore a new way of detecting without hardware device.

## CONCEPT DEVELOPMENT

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Based on the insights from last brainstorm session, I came up with a basic concept.

### Headphone for neck tracking

One of the starting points is fitting into people's daily routines. By observing the people working in open office and library, I found they share the same behavior of wearing earphones to isolate themselves. And that's the risky time for neck pain development. As a result, the first concept is a headphone that is able to track the neck movements and sitting posture. Several further ideas like music-motivated neck movements, audio exercise coaching were imaged based on this tracking tool.

To make it experienceable, a simple prototype was made with MPU 6050, a detecting sensor to track the tilt angle and accelerated speed. It was placed on the top of the headphone, so that it can track the movements of neck and head. At this period, a Processing sketch<sup>[15]</sup> was used as a visual feedback.

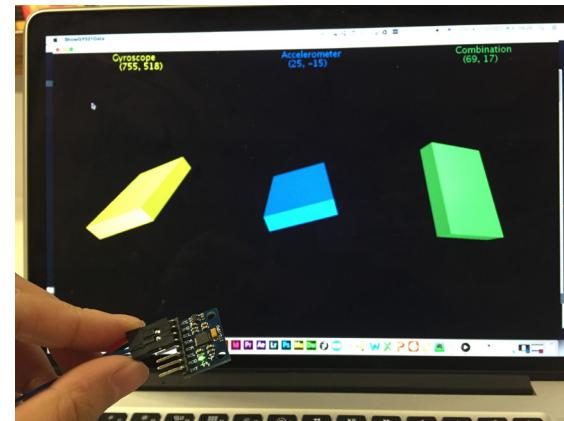


Figure 9 Exploration with MPU6050

## FEEDBACK & REFLECTION

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### **Feedback from coach meeting**

1. The general office workers who want to prevent neck pain during working were chosen as the current user group at first. I was recommended to focus on **designing for meaningful feedback and intuitive interactions**, as it is also applicable to daily rehabilitation training for people with cervical disorders, in case the user group will be redefined in the future.
2. It is important to get inputs from the user group at the early stage of the design process. **A user study** would be helpful to gain a better understanding of the context and users. Questions like why people always fail neck pain prevention on their own and what they expect from a product should be answered in following research.
3. The product was expected on **making a long-term effect on the users' working habits**. This iteration put more emphasis on motivating people to exercise, which is a short-term behavior change. Persuasive technology was recommended for designing a persuasive experience in long run.

### **Reflection**

After literature research and expert meeting, I found it easy to get lost in the overwhelming information. It is important to keep it in mind that the focus of my project is designing for an aesthetic and motivating experience to support behavior change in long run. In other word, it is impossible and unnecessary to keep track of everything. Instead, choosing an appropriate strategy as the main intervention and making it a pleasant ongoing experience will be more clear and practical.

My user group is defined as office workers at this stage. But it is a vague group, because other occupations also bear a risk from sedentary working style, such as college students or call center operators. The user group should be defined with more behavior details according to the user study, for instance the time spending on sedentary working, working environment, etc.

The co-creation is a good start for my project to open my mind and find out the design direction for the following sessions. One thing that contributes a lot is to focus on ones' thinking methods, and find out the factor they feel essential to reach the final goal, instead of the concepts generated only.

## USER STUDY

*Persuasive Technology*

The goal of this phase is to have a better understanding of the user group and context by means of online survey.

## FOGG BEHAVIOR MODEL

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Fogg Behavior Model (FBM) is a model for understanding human behavior, and it is especially useful in analysis and design of persuasive technologies. The FBM asserts that for a person to perform a target behavior, he or she must **(1) be sufficient motivated, (2) have the ability to perform the behavior, and (3) be triggered to perform the behavior.**<sup>[19]</sup> When a behavior doesn't occur, at least one of three elements is missing.

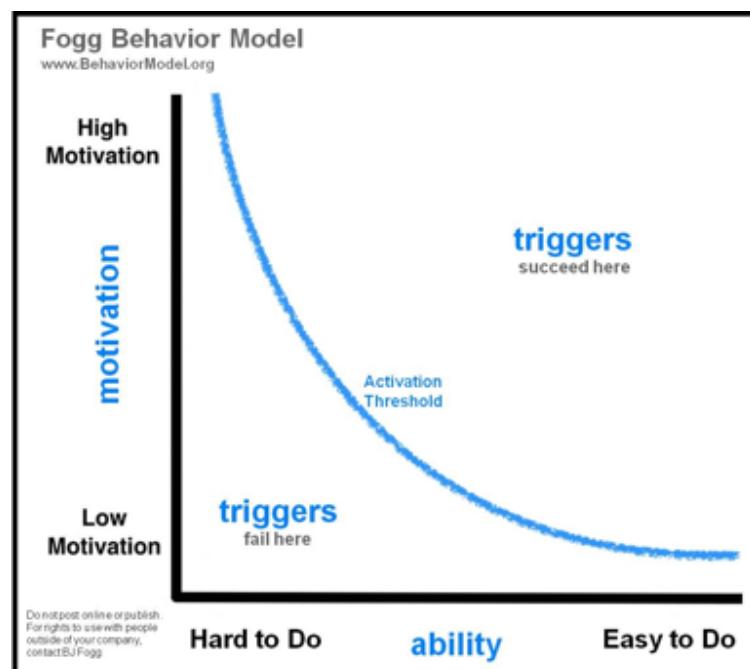


Figure 10 Fogg Behavior Model<sup>[19]</sup>

A behavior designer should seek to understand where the target audience lies on the graph (in terms of motivation/ ability). In my project, it refers to the motivation level of people to prevent neck pain by doing regular exercises and the capability to do the exercise. The subcomponents of motivation and ability<sup>[19]</sup> can be used to analyze the current situation.

**Elements of Motivation:** pleasure/ pain, hope/ fear, social acceptance/ rejection

**Elements of Simplicity (ability):** time, money, physical effort, brain cycles, social deviance and non-routine

A trigger is something that tells people to perform a behavior. It works only when a person has high motivation and ability (above the activation threshold) to perform the target behavior. The traditional triggers in neck pain prevention context are usually reminders like alarming sound and pop-up window.

Not all triggers function in the same way. Three types of triggers are facilitator (to make behavior easier), spark (to motivate behavior) and signal (to indicate or remind). A properly designed trigger can help increase the populations that go above the activation threshold.

## ONLINE SURVEY

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**T**he goal of this online survey is to get a better understanding of users, and furthermore identify what stops users from doing regular exercises during working time. I tried to keep it open in the participant selection, so that user group can be further defined according to the results.

The survey was mainly divided into two parts:

1. Neck pain experience and current sedentary habits.

Purposes	Related questions
Basic personal information	Age Gender
Context	Working environment
Sedentary habits	Working hours Stuffs used in working
Neck pain	Neck pain history

2. Opinions towards active intervention.

A brief introduction about active intervention was given before the questions. Information like whether participants knew or tried

this intervention before was collected. Then, in order to identify whether people have the ability to perform the target behavior, questions were given from the perspective of time, physical effort, brain cycles, social deviance and non-routine, which are the subcomponents of ability <sup>[19]</sup>. Money was left out because it is not a concern at current stage.

Link to the online questionnaire:

<https://shenxy02.typeform.com/to/KN9pmn>

### Results and analysis

#### Working duration, environment and habits

In total, 130 adults participated in this online survey (55% male and 45% female). The average hours they spend sitting in working days is 7.59. According to a study, working with a computer during more than 6h per day was associated with WRULDs (work-related upper limb disorders) in all body regions. <sup>[20]</sup> However, 89% of participants have gone beyond this warning limit. For working environment, 75% of participants work in an open space(e.g. open-plan offices, library, etc.), and 25% of them work in a private one(e.g. private offices).

## Map the user group on FBM graph

### *High motivation*

Survey participants are highly motivated by the hope of reducing neck pain. 84% of participants have had different levels of neck pain in past 12 months (47% early; 11% mid; 26% severe). 92% of participants knew that exercise can reduce neck pain, and 67% of them have tried it before.

### *Low ability*

However, most of them (53%) can not insist for a long period (mostly less than 1 week). The non-routine seems to be the biggest problem. Reducing memory burden and social deviance should also be taken into consideration of intervention design.

Based on these results, pre-intervention situation and expected post-intervention situation of target group can be mapped onto the Fogg Behavior Model.

### *Triggers: Facilitator*

According to the result of online survey, the target users are found with high motivation, but low ability. The trigger needed is mostly a facilitator. It means the trigger is not only a signal of acting, but also a facilitator to make the behavior easier. Based on the ability factors analysis, the trigger should help people form exercise routine, and reduce memory burden and social deviance.

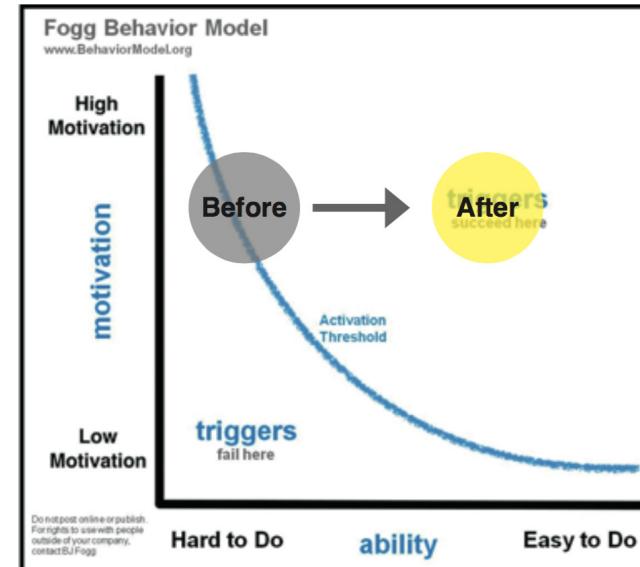


Figure 11 Map the user group on Fogg Behavior Model

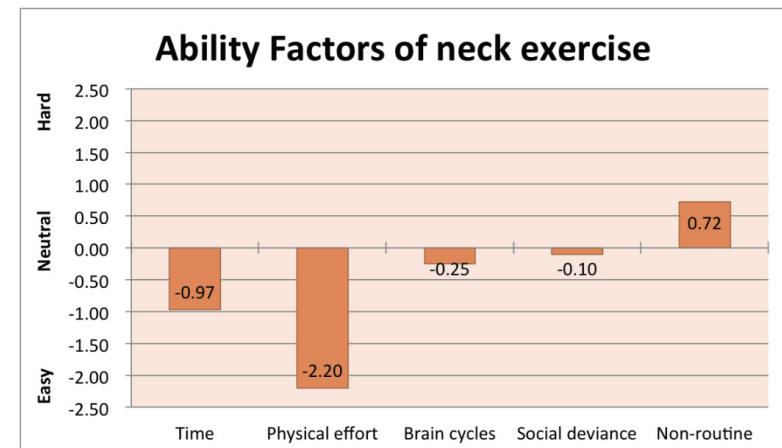


Figure 12 Ability Factors of neck exercise

## DESIGN DIRECTION

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### **User group redefinition**

After the survey, the user group was redefined as people who spend more than 6 hours per day in sedentary working and are willing to improve their neck health by daily healthcare. This user group includes people who have neck pain history or bear the risk to suffer from it. But people who have neck pain caused by physical injury or damage are not included here.

As for the context, I will focus more on the open-plan space, which has higher requirements on decreasing distraction and social deviance than private office. In this case, the product can easily fit into both two kinds of office environment.

### **Design directions**

According to the result of online survey, a daily healthcare product for neck pain prevention should have three basic functions, which are listed in order of importance:

#### *Reminder*

Non-routine is the greatest difficulty in performing active intervention at present. To overcome it, people should be reminded properly at right timing. According to the insights from expert meeting, the reminder should also be soft and relaxing, otherwise, people will be too stressful to be triggered successfully.

#### *Decrease social deviance*

Now, people stay neutral in whether doing exercises will cause social deviance. Further test needs to be done with a prototype in real context. But to support people from the social perspective, it would be helpful to take social support group into consideration, in which people can do the active intervention together with friends and family and support each other.

#### *Instructions of exercises*

To reduce memory load of exercises, the intervention should also act like a exercise coach to give instructions.

## REFLECTION

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In this phase, the greatest learning experience is applying theory to practical user study. This is an important method in design research, as it can provide practical frameworks or grounded evidence for design. One thing I found very important in designing a survey is to translate the theory into questions for a specific context. This time, I had all the questions with a concrete purpose from the theory framework. It makes the questionnaire very clear and directive.

By using the method of online survey, I found it a quick and convenient way to reach a lot of people compared to the traditional paper questionnaires. And the analysis tool provided by the survey website is easy to use. On the other hand, the online survey also has its limits in recruiting the target participants and does not

make it possible to ask follow-up questions. In my opinion, online survey is suitable in collecting quantified information. When it refers to a topic that is likely to have extended questions, such as personal feelings or experiences, it is better to have an interview which support an open conversation.

Now it is time to go back to further development of concept based on the findings from the user study. As stated in the pre-iteration, this intervention is expected to be a long-term intervention. However, it is easy to get lost if I desire to reach all goals at once. So the following design process should be decided into at least two parts: one for exercises trigger in short term and one for habits formation in long run.

## FIRST ITERATION

*Design for peripheral interactions*

From the perspective of time line, this iteration will focus on short-term motivation. Designing for an unobtrusive experience will be the main topic of this iteration.

## GOAL

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Working is an activity requiring ones full attention. In this context, a daily healthcare product should have the potential to reside in the periphery of the attention and shift to center of attention while needed. According to the project process of CervicWear from M.M.Willems, such kind of healthcare product was more appreciated to provide an unobtrusive experience. <sup>[12]</sup> Research towards peripheral interactions was performed to derive guidelines on designing and evaluating peripheral interactions.

# PERIPHERAL INTERACTIONS

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## Theories for peripheral interactions

With the upcoming pervasive computer technologies, people are at risk of being overburdened with information from various digital displays around. Weiser envisions the interaction with computers of the future vanishing into the background, so that users are enabled to monitor information without specifically paying attention to it, while at the same time facilitating them to focus on it if desired. This is what is meant with the term Calm Technology.<sup>[21]</sup>

In response to this theory, the term Peripheral Displays<sup>[22]</sup> was proposed to describe computing applications that allow a person to be aware of information while he is dealing with some other primary tasks or activities. Potential activities can reside in the periphery of attention, where they generally require minimal attention and cognitive effort, and are not part of a user's primary activity. The value of design for the periphery primarily lies in the idea that peripheral interactions can support computing technology to fluently embed in and become a meaningful part of people's everyday routines.<sup>[23]</sup>

## Design guidelines for peripheral interactions

Peripheral display Toolkit (PTK)<sup>[22]</sup> is a design theory that provides structured support for managing user attention in the development of peripheral displays. According to its framework, three issues should be taken into consideration in peripheral display design:

***Abstraction of raw input:*** Extracting features or reduce the fidelity of information to convey sufficient information while remaining subdued enough to allow a user to concentrate on a main activity.

***Rules for assigning notification levels to input:*** Notification levels refer to differences in information importance. Five notification levels are defined as ignore, change blind, make aware, interrupt, and demand action.

***Transitions for updating a display when input arrives:*** Transitions are a mechanism for creating effects on a display that attracts an appropriate amount of attention from the user.

## CONCEPT DEVELOPMENT

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**B**ased on the previous concept of smart headphone, the iteration made further development on feedback and interactions design. Headphone has its essential connection with audio. In general, audio is frequently used for alerts, alarms and reminder that are meant to attract the attention of the user. However, in this context, the reminder is expected to stay in the periphery.

The key feature of the developed concept is feedback in form of unbalanced audio effect. Unbalance means the volume of the left and right sound track is not equal. And when exercises are needed to release the tense of muscle, an unbalanced audio effect will be added to the audio to induce neck movements. In this case, unbalanced audio effect is also expected to be a neck movement motivator. Users can interact with the unbalanced audio, which induce users to do exercises right now. Audio is like flowing water in the headphone. While being reminded by an unbalanced audio effect, user can tilt their neck to make the audio “water” balance again. (Figure 13)

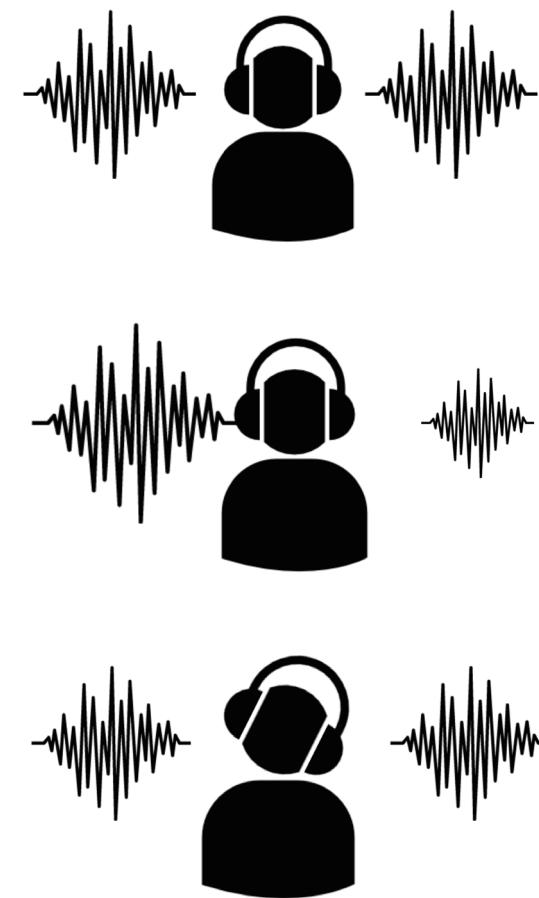


Figure 13 Audio effects feedback

## P I L O T   T E S T

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A pilot study was conducted to test whether unbalanced audio is potential to be designed as feedbacks of peripheral interactions.

### Procedure

Two participants attended this test without knowing the test purpose. They were asked to work with headphone, and listen to soft music with one sound wave (unbalanced audio effect) for 7 minutes. Then I had an interview with each participant and ask questions towards their experience.

### Result of test

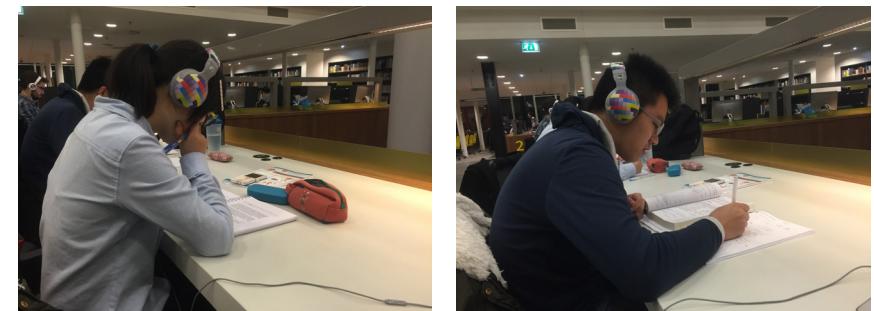
Both participants recognized the unbalanced audio effects.

The unbalanced audio effect were described as quite obvious, but not disturbing.

No neck movements were observed during the unbalanced effect in the test.

### Conclusion

Unbalanced audio effect is proved to be a potential feedback form of a peripheral display. According to the pilot user test, the audio effects can be recognized easily, and people won't feel being disturbed. Previously, the unbalanced audio effect was expected to motivate neck movements. But as mentioned by one participant, he didn't react to it because he didn't know what the sound effect means at the beginning. However, he found this audio effect is potential to encourage neck exercises if he knows before hand what it represents for.



**Figure 14** Pilot test

## F E E D B A C K S

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### **Feedbacks from coach meeting**

1. To find the value of the audio effect feedback, it will be more persuasive to compare it with other traditional feedback of healthcare reminders.
2. Different audio effects have potentials to represent different instructions. I was suggested to look into different audio effects and 3D stereo technology to design intuitive sound patterns for guiding exercises.

### **Feedback from client**

1. Reminders without detecting are already very common on the market; however, it is annoying to use them. It is important to detect the neck movements and give customized feedbacks.

## **S E C O N D   I T E R A T I O N**

An experienceable program for multiple audio effects control

## G O A L

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According to the feedbacks from coach meeting, the audio effects reminding will be further developed in this iteration to meet the request of multiple instructions.

## CONCEPT DEVELOPMENT

### Audio effects feedback

Exercise reminding: unbalanced audio effect

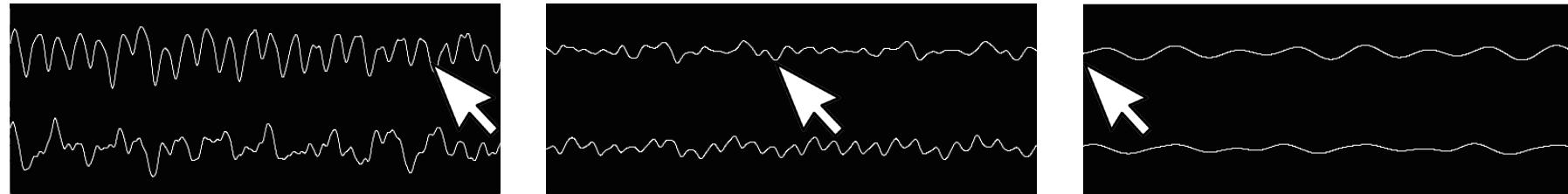
Bad posture: low pass filter

Take a break: volume down

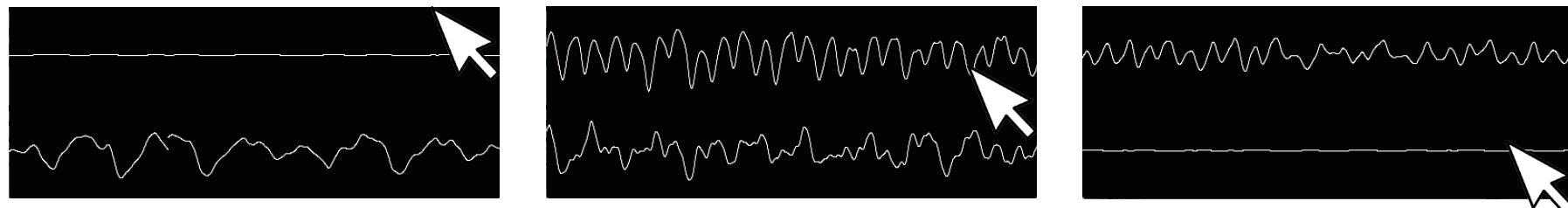
### Prototype

A program was built in Processing, which enables user to control the low pass filter and unbalanced audio effect by simply moving mouse. Two audio waveforms visualized the audio form left and right sound track. It is expected to provide a virtual experience of being reminded by audio effects.

Move the mouse from left to right: add low pass filter, which is the reminding of bad posture.



Move the mouse up to down to add unbalanced audio effect, which is the reminding of doing exercises.



**Figure 15** Screenshots of the audioeffect control program

## F E E D B A C K S

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### **Feedbacks from coach meeting**

1. How long should the exercises be? Whether moving too fast will cause injury? The reminder can also provide more underlying information like exercise speed and duration.

### **Feedback from client**

1. Insert an incentive to practice to exercise the neutral upright head position: make yourself as tall as possible with the chin gently tucked in.
2. Insert an instruction for stretches of muscles. It is also good to keep your head sideways for 2x 20 seconds to stretch the muscles at the side of your neck (Right and left).
3. Also detect the protracted head position (head translated forward), which is the most frequent aberrant head position that leads to pain.

## THIRD ITERATION

*Persuasive technology*

To support long-term intervention, this iteration will also focus on digital service design based on the findings from the previous user study.

## G O A L

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The user study shows that the target users have high motivation, but low ability. To move more target audience above the active threshold, the trigger needed is mostly a facilitator to make the behavior easier. Based on the ability factors analysis, an app was proposed to help people form exercise routine, reducing memory burden and social deviance.

## CONCEPT DEVELOPMENT

An app was proposed to support user from exercise routine, reducing memory burden and social deviance.

Figure 16 shows the relationships and the information streams among user, smart headphone, app and audio resource.

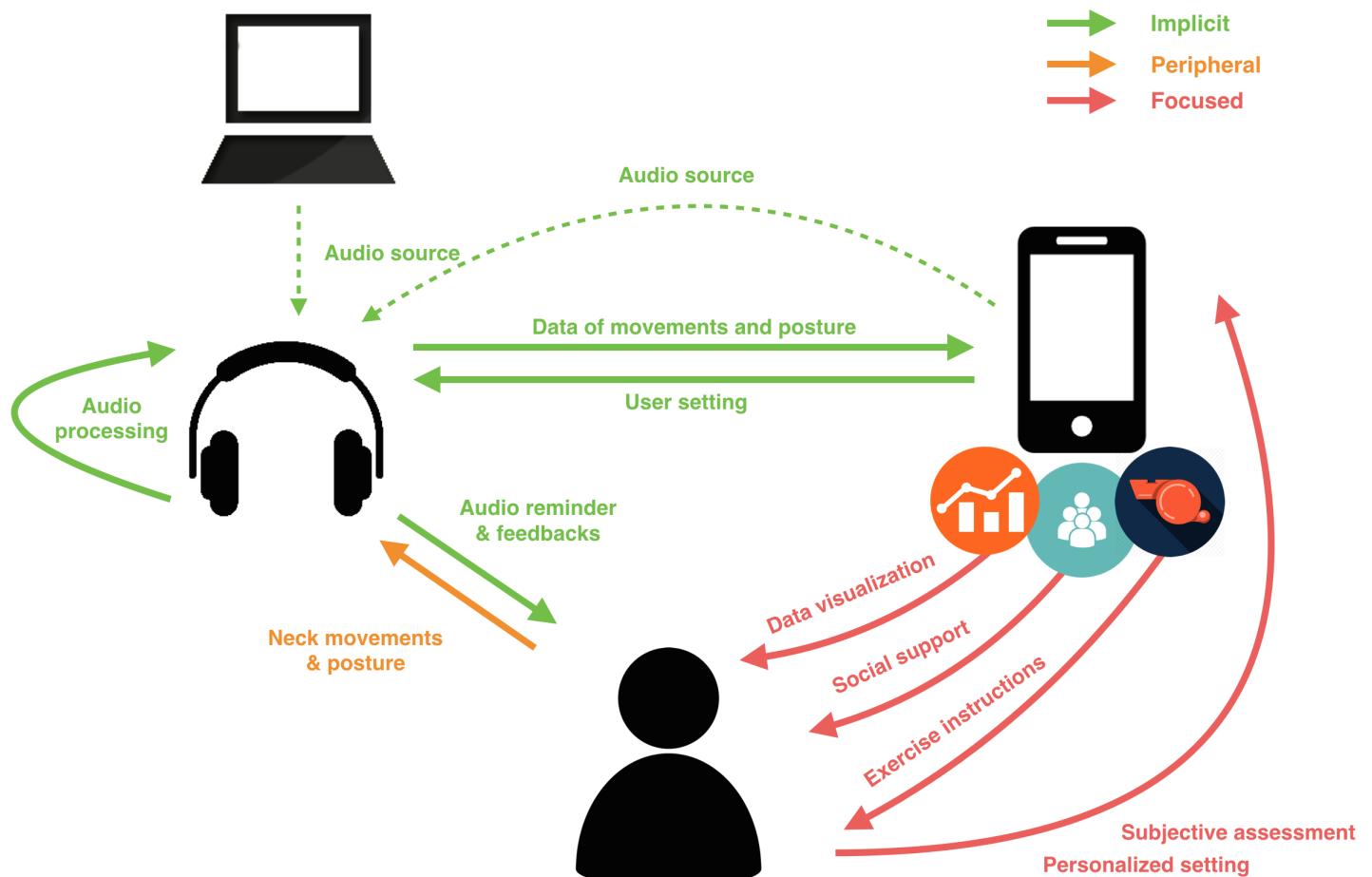
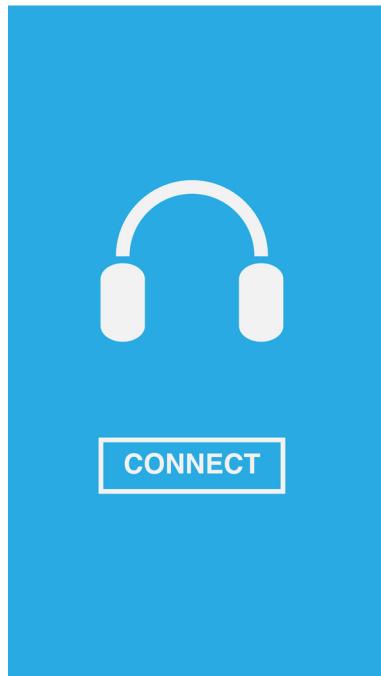


Figure 16 Information streams



### Detector and reminder

The smart headphone will be used to detect neck movements and sitting posture. Users will be reminded with different audio effects for exercising, correcting posture or taking a break.



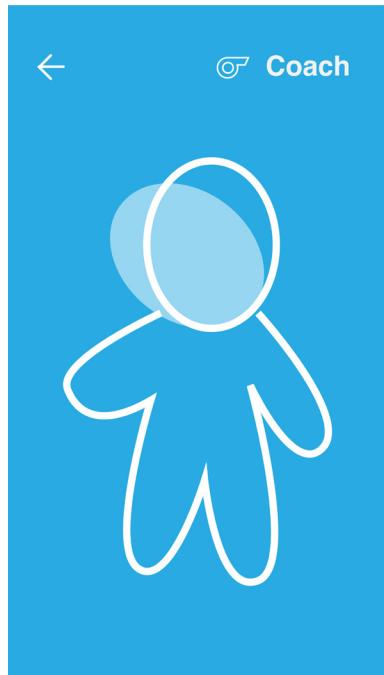
### Overview of current situation

The homepage provides an overview of the neck situation at that moment. The number in the center represents the amount of neck movements made by user.



### Data visualization

This function aims to provide overall neck health condition and visualize the progression user made.



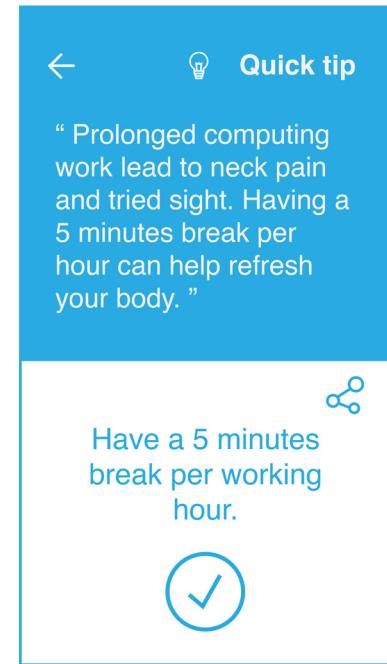
### Exercise coach

To decrease the memory load, a fresh user can choose to use the exercise coach and following the visual instructions, while a skilled user can do the exercise with the hints given by audio effects.



### Social support

A social support function is included to decrease the social deviance. Users can use the intervention with friends or families, and encourage each other by sending energy, which is also a way to add adherence to the product.



### Tips & suggestions

Professional suggestions will be provided to help users to gain a better understanding of neck pain and build a rounded healthier lifestyle. Besides, users are also encouraged to make a commitment to make a change.

## F E E D B A C K S

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### **Feedbacks from coach meeting**

1. People may not want to be reminded in some situation like having a video meeting on Skype. One suggestion is the headphone is smart to recognize what software is working and able to choose the right timing for reminding.
2. There is an opportunity to combine persuasive mechanism with playful components. A direction needs to be chosen among game, playful activity or a simple reminder. To find out whether gamification supports long-term intervention, I was suggested to talk to an expert in game design.

## FOURTH ITERATION

*Playful persuasion*

Development on playful strategies for a more fun and motivating user experience.

## DESIGN DIRECTION

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### Feedbacks from expert in game design domain

To choose a direction for further development, I contacted an expert in game design domain. After a brief introduction of my project, the question I proposed is whether gamification can support a long-term intervention program. And I am also curious about how to keep the feeling of freshness of a playful activity in a long time. Following are the suggestions from the expert:

#### *1. A long-term gamification intervention is not recommended.*

Freshness: In general, it is hard to keep a gamified experience interesting for very long time period. A long-term gamified intervention requires a long-term plan of drip-feeding new mechanics and a lot of money to support it.

Target group: Only people who are seriously interested in games would commit for longer time periods. There is not much overlap between gamers and chronic neck pain sufferers.

#### *2. Playful persuasion could be a good choice*

Attitude change: Design an intervention that changes their attitude.

Playful persuasion: Make the experience fun in such a way that

they like doing the needed exercise, and would still like it after removing the intervention.

### Design direction

The final direction I chose is a combination of a simple reminder as a trigger of exercises, and a playful persuasive solution to support long-term attitude change.

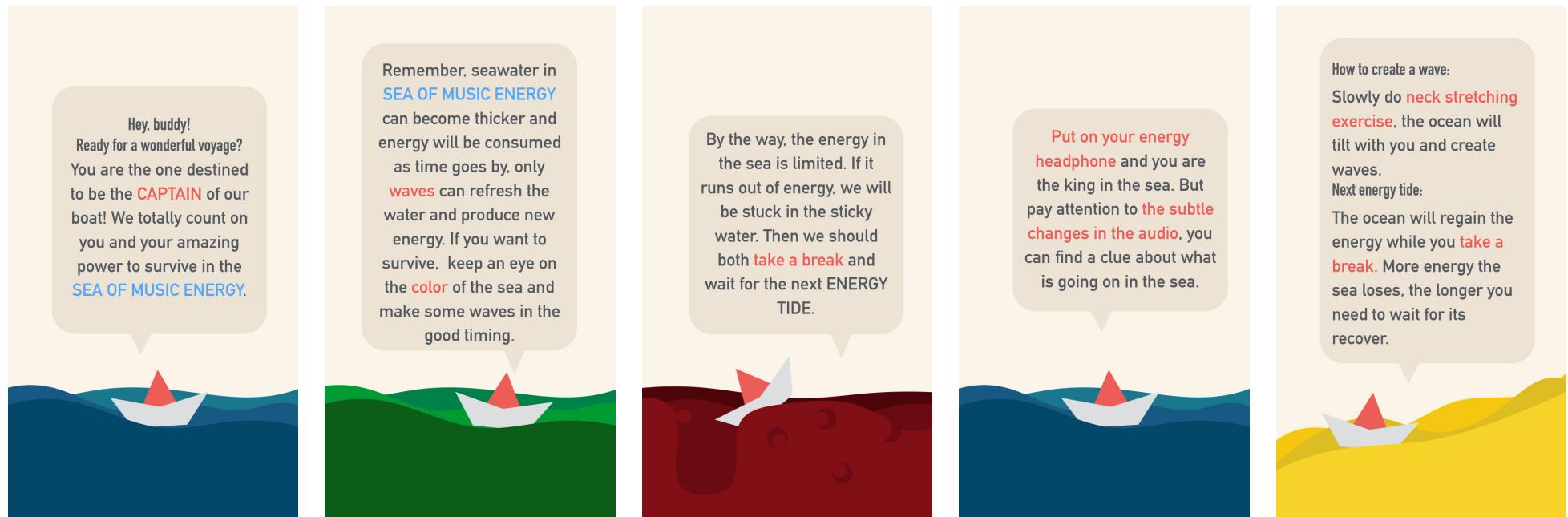
As a real-time detector in working context, the product should stay as less distracting as possible. Instead of designing a game, a simple reminder with instruction hints of exercises (facilitator) would be enough for this context.

On the other hand, the intervention is expected to make an long-term effect on users' working habits. Exploring more subtle playful mechanisms that not only bring a fun experience but also serve as triggers to motivate people to engage in longer intervention program. In this project, playful persuasion is expected to motivate people with playful user experience and change users' attitude about neck healthcare in long run.

## CONCEPT DEVELOPMENT

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This iteration focuses on applying playful strategies to the digital services. A background story is added to make the user experience more fun and motivated. In the progression of building healthy habits, users can act as a powerful captain in the game, and lead your sailors to survive and explore new world.



**Figure 17** Introduction of the playful strategy

## Homepage

To be consistent with the background story, the homepage was designed as an animation, in which a little boat is sailing in the ocean. To win the game, user needs to help the boat to finish a world tour.

Different heights of sea level and colors of seawater refer to different neck condition. For example, a large volume of blue water means the neck is in good condition, the boat can move faster in this situation. However, a little volume of water with red color is a warning of neck pain risk, boat will run aground and stop moving further. The volume of water decreases while working, together the color of water also changes.

Users can regain the good condition by following two ways:

Do neck exercises: make waves in the ocean, and the volume of water will increase immediately.

Take a break: the volume of water will slowly increase during the break.



**Figure 18** Homepage in four different situations



**Figure 19** Progression visualization

### Progression visualization

To win the game, user need to help the boat to sail around the world. The boat can sail faster while the water is sufficient, which means neck is in a better condition. In the compass map, user can check where he or she has arrived, and how far away from the next destination.



Figure 20 Screenshots of the app demo

## Demo

An experienceable app demo was built on invision, which can be accessed by the following link:

<https://invis.io/YR5BDXCME>

## F E E D B A C K S

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### **Feedbacks from coach meeting**

1. Like the homepage of Google, updating the UI according to festivals, anniversary or important events can be a good way to keep the freshness of the game.
2. "Whether the app with playful elements performs better in motivating behavior change in long term" can be an interesting research topic. If I want to go further in this direction, I can develop two versions of app (with and without playful elements) and compare how users were motivated in behavior change in assistance with these two apps.

## INTERIM USER TEST

## G O A L

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This user test aims to find whether the feedback form (audio effect) and playful strategy of the supporting app add value to this concept. The first part is to find whether audio effect feedback performs better in the working context, by comparing it with other traditional feedbacks of healthcare reminders. The second part focuses on evaluating whether the playful strategy motivates people to form healthier habit in sedentary working environment.

# TEST ON FEEDBACK FORM

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## Comparisons selection

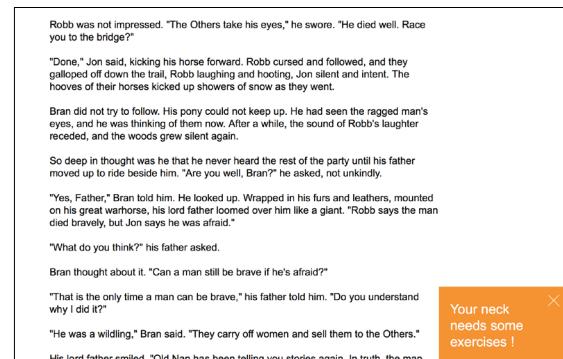
Pop-up window and alarming sound were selected as the comparisons against audio effect. Pop-up window is main feedback type of CtrlWORK, which is a software to remind people of taking breaks. This software is found widely known around the campus, as every TU/e PC has it preinstalled. Alarming sound is a traditional way to catch people's attention by audio, which makes it a perfect comparison to audio effect feedback.

## Procedure

Seven participants are recruited from the campus. The working durations of all the participants are all longer than 6 hours.

Three subtests on pop-up window, alarming sound and audio effect were conducted separately in random trial. In each test, participants learned and experienced being reminded by each kind of feedback while focusing on working. Reading was the primary activity and listening to music is a peripheral one, as this is a very common situation during working or studying. Participants were asked to listen to the same music piece in all three subtests so that the results of three subtests are comparable.

Pop-up window: While reading and listening to the music, two windows popped up one after another in lower right corner on the screen, with text of "your neck needs some exercises" or "you are in a bad posture".



**Figure 21** Pop-up Window

Alarming sound: Before the test, participants learned two kinds of alarming sound, which respectively reminds users of exercises or posture correction. Then while reading with music, the two alarming sound was added to the music they were listening.

Audio effect: Before the test, participants learned two kinds of audio effects, which respectively reminds users of exercises (unbalance) or posture correction (low frequency filter). Then while reading with music, the two audio effects were added to the music they were listening.

## Questionnaire

According to Peripheral display Toolkit [22], three issues should be taken into consideration in peripheral display design: Abstraction of raw input, appropriate notification level and transitions when input arrives. Basing on this framework, a questionnaire was set up with nine statements (Figure 21). All statements were rated on a 5-points Likert Scale with a range from 1 (strongly disagree) to 5 (strongly agree).

Purposes	Statements
Abstraction of raw input	It is easy to learn before hand to understand what the reminder means.
	The meaning of this reminder ("your neck need some exercises" or "you are in a bad posture") is intuitive or straightforward.
	I can distinguish the reminding instruction for exercise trigger easily from the one for posture correction.
Appropriate notification level	Potential reminding and being detected won't bother me during working.
	I am able to ignore the reminder and continue working if I can't do the exercise at that moment.
	This reminder distracted me from working and forced me to focus on it.
Transitions when input arrives	When I was reminded, I noticed it at once.
Motivation	I felt motivated by the reminder to exercise or sit straight.
Stress	Using the neck care product with this reminder makes me feel stressful and nervous.

**Figure 22** Overview of the questionnaire

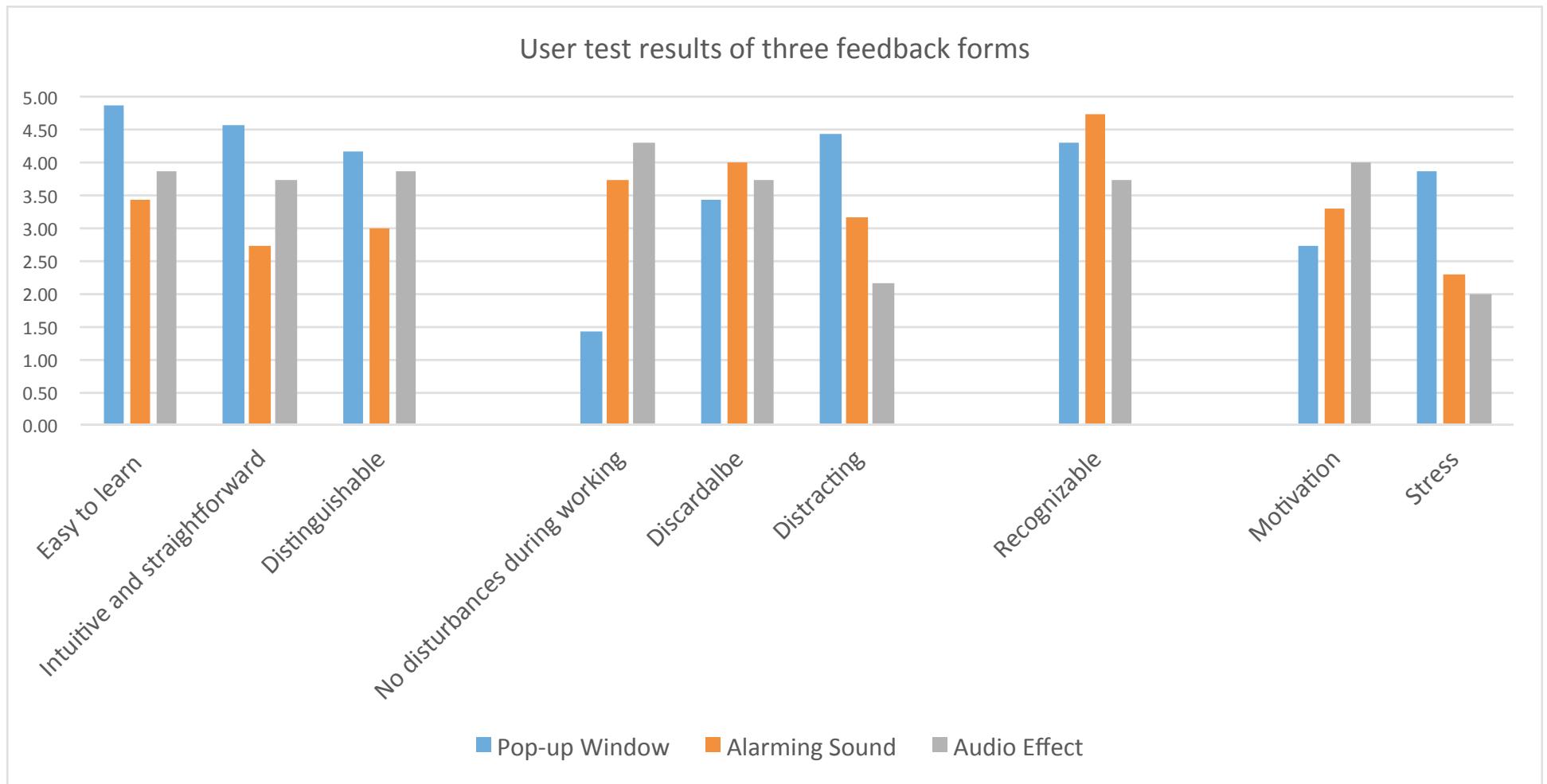


Figure 23 User test results of three feedback forms

## Results and analysis

Figure 22 showed the data gathered from the participants' questionnaire.

### *Abstraction of raw input*

Pop-up window performs best in input abstraction. Reading the text on the screen needs no learning effort and its meaning is straightforward. Compared to it, the two audio reminders turn out to be less efficient. But compared to alarming sound which also use audio as feedback, audio effect is found easier to learn and more straightforward. The different effects were also easier to be distinguished than alarming sound.

### *Appropriate notification level*

Potential reminding by audio effect is less disturbing during working. And participants feel less distracted while being reminded by audio effect. In the question about whether it is possible to be ignored, the alarming sound is a little more discardable than audio effect. It may resulted from the shorter audio piece of alarming sound.

### *Transitions when input arrives*

Pop-up window and alarming sound can be noticed in a shorter time than audio effect when the participants were reminded.

### *Motivation*

Audio effects perform better in motivating people to exercises and sit straight. More neck movements were observed with audio effect. As mentioned by one participant, it is intuitive to move towards the unbalanced sound while knowing it is a hint for exercises.

### *Stress*

Audio effect is proved to be the less stressful feedback of reminder.

### **Conclusion**

In general, audio effect is proved to be a promising feedback form for this project. Pop-up window is straightforward to convey information, however it is too stressful and distracting for a working context. Alarming sound, on the other hand, is easier to recognize, but it is less intuitive and more distracting than audio effect. Compared to these two forms of feedback, audio effect is a better one to balance a less distracting experience and intuitive information conveyance. Furthermore, its intuitiveness also found potential to motivate neck exercises.

## TEST ON PLAYFUL STRATEGY

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### Procedure

I gave an introduction of the app at first. Then the playful strategy and main functions were explained in detail with the experienceable app demo I built in the last iteration. The participants were also encouraged to interact with the demo on their own. A questionnaire was filled afterwards, which includes three statements on a 5-points Likert Scale (with a range from 1 (strongly disagree) to 5 (strongly agree)) and two open questions.

Statements on a 5-points Likert Scale:

- The interface of the app is easy to understand.
- The relationship between the audio effect feedback and this visual feedback in app is easy to understand.
- The playful strategy motivated me to do better in self-coaching neck care

Open questions:

- What functions in the prototype you find useful or unnecessary?
- When would you like to use this app?

### Result and analysis

The interfaces of the app are found quite easy to understand ( $M=4.4$ , range 3-5), as well as the connection between the audio feedback from the smart headphone and visual feedback in the app ( $M=4.1$ , range 3-5). And the playful strategy was predicted as a motivation for the self-coaching neck care ( $M=3.85$  range 3-4). The usefulness of functions varies from participants, a few of them thought 'friends' is not necessary, however some of them thought it is a good way to add adherence. Professional data was considered as useful, because it is more reliable than those translated in a playful way. As mentioned by all the participants, the app will not be used during working, it will only be checked in their spare time.



Figure 24 User test

## REFLECTION & NEXT STEP

Reflect on design process of this semester and my growth as both a designer and a student in this department.

## PROJECT OVERVIEW

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This project is about designing a healthcare product to help sedentary people with neck pain prevention in working.

Motivating neck exercises and good sitting posture are found to be an effective solution to prevent neck pain. Instead of synthesizing medical therapies into a product, the focus of this project is to explore a pleasant and intuitive persuasion process, which motivates users to change behavior about doing neck exercises with less effort and better user experience.

This semester is regarded as an exploration period, which mainly focuses on the following three points:

1. Gain an overall understanding of the project context and user group by collecting useful insights from design activities, such as

literature research, expert meetings, user study and so on.

2. Lead a structured design process driven by design theories, such as persuasive technology, peripheral interactions design and playful strategies.
3. Generate possible solutions and get feedbacks by testing the probes in context with users.

In general, the project went smoothly. The concept of smart headphone with audio effect reminding was iteratively developed as a main solution. Its possibilities to support a long term intervention in means of digital services, were also explored as extended functions.

## N E X T   S T E P S

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The aim of next semester is to build a hi-fi prototype based on my concept and test it in real context. Continued with my progression in this semester, I will mainly **focus on the smart earphone**, as it is the precondition and base of a longer intervention where the app plays its role. As a result, I will start with another round of evaluation about the audio effect motivated exercises with users. And new insights will be gathered through literature research and meetings with clients and experts for further concept development.

In the meanwhile, I will start to work on the **hi-fi prototype**, a earphone that tracks neck movements and gives feedback in form of audio effect. This session will start with talking to an expert in technology domain. How to distinguish the movements by using sensors will be discussed in the meeting.

In the final quartile, I will conduct several **user tests** to validate my final work for its usability and efficacy on behavior change in a real context, and work close to my user group and collect feedbacks from them.

At the end of the semester, I will present my idea with a nicely crafted functioning prototype backed up with theoretical frameworks and carefully carried out user tests.

## COMPETENCY DEVELOPMENT

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### In project

#### *Design process driven by theories*

As stated in previous sections, I led a structured design process driven by theories in this semester. Instead of generate random concepts, theories provide practical frameworks and grounded evidence to support design decision-making. In the meanwhile, I keep it open and flexible to generating more ideas. Now I feel more in control to adopt theory frameworks and customize them to practical design activities in various contexts. Compared to my last two projects, I found it is a big progression in this competency.

Related Competency: Design and research process

#### *Information processing*

As a designer, I keep challenging myself with different design tasks. In this semester, I chose to work on a project in healthcare domain. At first, it's easy to get lost in the huge amount of medical information and forget about the design value I can produce. My way to solve this problem is to actively involve experts to filter useful insights from various inputs, and it also helped me to gain a better understanding of users and context from different

perspectives.

Related Competency: Self-directed and continuous learning; Communication

#### *Focus on design for the experience*

It is important to keep it in mind that the focus of my project is to design for an aesthetic and motivating experience to support behavior change in long run. In other word, it is impossible and unnecessary to keep track of everything. Instead, choosing an appropriate strategy as the main intervention and focusing on make it a pleasant ongoing experience is more directing and practical.

Related Competency: Ideas and concepts

#### *Development on integrating technology*

Technology is not my strength. During my study in TU/e, I keep working on this competency. In this semester, I followed Creative Programing, which is a bachelor course where I learned coding with Processing. Then I applied my learning to prototype building

in my project and built a program in which audio effect could be manually controlled by mouse moving. This program was used in the final user test to create an experience of being reminded by audio effects.

Related Competency: Integrating Technology

#### *Users are the starting point and the destination of design*

In user tests, I found it important to make the user experience in test as similar as the ideal one. Because the prototype is not fully working at this moment, I can only evaluate my concept without detecting neck movements on users. However, my concept is featured triggering at the right timing, for example, the moment they are lack of exercises or they are in bad posture. In the following tests, I will take timing issue into consideration while designing for a user test. And the fully functioning prototype is also required to gather users feedback from a real context.

Related Competency: User focus and perspectives

#### **In Extra curricular activities**

##### *Volunteer work at DDW*

I worked as a volunteer in Dutch Design week this year. It is a valuable experience for me to communicate with people who share the same enthusiasm but different vision towards design, which is very inspiring compared to visiting the exhibitions only.

##### *Exploration on co-creation methodology*

In December, I organized a co-creation at Hasselt University with other three students. I benefit a lot from the experience of methodologies application in creative session. Three methods were adopted in this co-creation: role-play, dirty prototyping and body storming. Different methods were found to emphasize different design perspectives. I am now more skilled at organizing creative sessions based on multiple methodologies.



**Figure 25** Volunteer work at DDW



**Figure 26** Co-creation at Hasselt University

## DEVELOPMENT AS AN INDUSTRIAL DESIGNER

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### **A good design is 'invisible'**

Throughout this semester, I went further in development of design vision. Previously, I defined good design as products that is easy to use and deliver care and happiness to users. Now I think it should be more than that. To provide a good user experience, the product should be 'invisible', which means the product stays with users as a thoughtful companion in an appropriate notification level. It is smart enough to avoid annoying, distracting or embarrassing users, but works seamlessly to be interacted at right timing.

### **Less is more.**

I always appreciate the spirit of craftsman to put all heart on one important detail until it is perfect and leave other unnecessary things behind. Now, I am also encouraged by this spirit to focus on the essential details in design. I learned to focus on the most essential part for my design, which is designing for a motivating and intuitive persuasion experience. There are many decision making moments in the process of design for a product in healthcare domain, like function or therapy strategy recruit. Instead of being confused and hesitated, now I choose to discard it if it can't add to value to the design focus.

**R E F E R E N C E S &  
A C K N O W L E D G E M E N T**

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