

# Neckio: Design and Evaluation of A Smart System for Improving Neck Health in Work Environment

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## ABSTRACT

UPDATED—June 10, 2016. Neck pain is a very common health problem among intensive computer users. Prolonged sedentary behavior leads to unconscious neck stiffness, or even neck pain. Research shows that regular rest breaks and stretching exercises can effectively sustain neck flexibility. This paper presents the design, development and evaluation of Neckio a system intended to prevent neck pain by encouraging regular exercise during work hours. The system was conceived based on an extensive user survey (N=130) and an iterative design process with formative testing involving small numbers of users. Neckio comprises a software program and a wireless angulation device on headphone, which together provide an interactive exercise experience and motivate healthy work habits. A short-term evaluation was conducted in the working place with students of the department (N=10) System user experience and users' intrinsic motivation were evaluated positively.

## ACM Classification Keywords

Design.

## Author Keywords

Smart system; neck health; therapeutic exercise; work environment.

## INTRODUCTION

Neck pain is a common complaint in industrialized countries, and constitutes a major medical and socioeconomic problem. Neck pain is one of three most commonly reported complaints of the musculoskeletal system. Population based studies [20, 3, 8, 10, 17] suggest a lifetime prevalence of 67-70% and a point prevalence of between 10-12%.

Work related neck disorders are common problems in office workers, especially among those who are intensive computer users [7, 14, 21]. According to L Smith et al [23] there is a worrying association between neck pain and high hours of computing. Computers allow users to accomplish their tasks

with little or no regular large movements. The absence of movements has recently been recognized as a health risk [5]. Despite the low level of physical load, computer work requires staying in the same position for a long time and repetitive movements which may cause musculoskeletal problems [24].

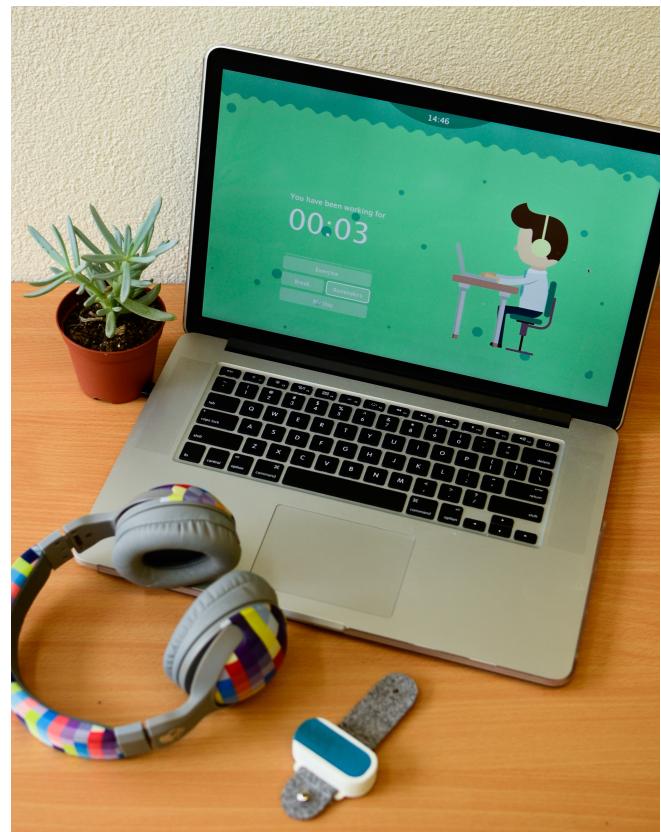
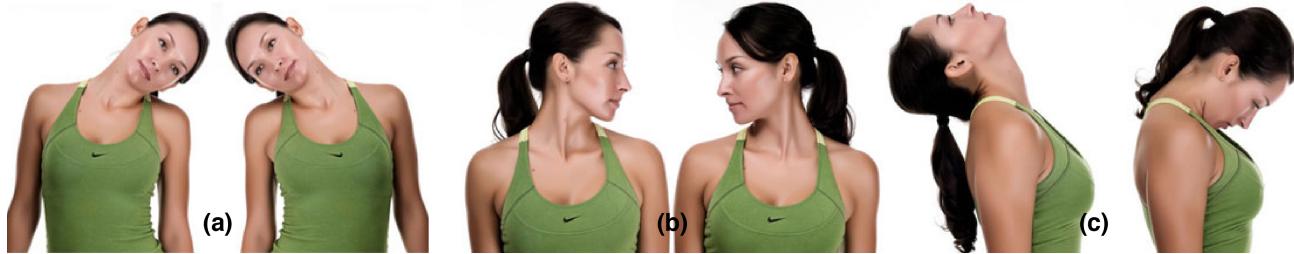


Figure 1. Project result, Neckio, a smart system comprises an desktop application and a headphone-attached tracking band.

A recent study [25] shows that a regular stretching exercise program can decrease neck pain and improve neck function, owing to its effect in decreasing muscle stiffness and improving flexibility, which could be detected as early as four weeks with a sufficient frequency of exercise. Besides, the protective effect of rest breaks has been observed in several studies [9, 15, 19]. Breaks allow a reduction in computer exposure, and more especially enable muscle relaxation. To prevent neck pain from an early stage, it is necessary to motivate people to

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**Figure 2.** Neck stretches. (a)Lateral Bending; (b)Rotation; (c)Extension and Flexion.

build active and balanced working habits with regular breaks and exercises.

At present, products that also addressing neck pain prevention can be divided into two categories: posture tracking device and exercise coach apps. Posture tracking devices like Fineck [11] and the still experimental Cervic Wear [26] mainly focus on posture tracking, reminding users to stand straight and providing feedback on their posture related behavior. On the other hand, coach apps provide exercise guidance in a limited form of pictures, video or animation. However, without supervision, doing exercise heavily depends on users' own awareness and self-control which makes it a hard to sustain over the long term. This is a serious drawback because prevention requires by its nature long term behavior change. This project focuses on designing a daily healthcare product which helps intensive computer users to perform personally scheduled neck exercises in an interactive and motivating way.

The approach taken is to explore and evaluate interactive ways to increase users' adherence to regular exercises and persuade them to change sedentary behaviors that affect their neck health. Because we intend this product to be used during work hours in real life, it is important for this product to be minimally intrusive and fit well into the context of workplace. Within the project, a daily healthcare product Neckio is designed, developed and evaluated. (Figure 1) The purpose of Neckio is to remind users to take short rest breaks and perform a series of stretches for their neck. It is believed that an individual will possibly become more efficient and effective in their work and get less chance of developing job-related neck pain by using Neckio.

The remainder of this paper describes some background from the domain of physiotherapy, a user study that aimed to target potential user group before continuing with the design, implementation, and evaluation of Neckio. We conclude with discussions of evaluation results and future work.

## BACKGROUND

### Neck Stretching for the Work Place

Flexibility and stretching exercises can expand or preserve the range of motion and elasticity in the affected cervical (neck) joints, and thus relieve the stiffness that leads to pain. Several simple stretches have been shown to be effective relief [4]. The following bullet points summarized the instructions given to patients for the therapist program [18].

- Lateral Bending: Start by looking straight ahead. Slowly lean your head to the left. Then slowly pull your head towards the right shoulder with your right hand and repeat on the other side. Keep the position for 5 seconds on either side. Do ten repetitions.
- Rotation: Start by looking straight ahead. Slowly turn your head to the left. Hold for 5 seconds, then return to starting position. Then, slowly turn you head to the other side. Hold for 10 seconds. Return to starting position. Do 10 repetitions.
- Extension: Without arching your back, slowly move your head backward so you are looking upward. Hold for 5 seconds. Return to starting position. Do ten repetitions.
- Flexion: Without arching your back, slowly move your chin to chin to the chest. Hold for 5 seconds. Return to starting position. Do ten repetitions.

### Range of Motion of Cervical Spine

Neckio is intended to guide users to do such exercises. To do so correctly, and given that there cannot be a therapist present at all times, it is important to instruct users correctly regarding the range of motions. Table 1 shows the normal range of motion [22] of cervical spine of the neck stretches.

Movements	Normal ROM
Lateral Bending	20 to 45 degrees on both sides
Rotation	60 to 80 degrees to both sides.
Flexion	40 to 60 degrees
Extension	45 to 70 degrees

**Table 1.** Normal range of motion of cervical spine.

### PILOT USER STUDY

Neck exercise is physically effortless, but adherence to exercise is still challenging to many people. A pilot online survey with an expectation of 50 participants was conducted to get a better understanding of the user group and identify the factors that may hinder adherence to regular neck exercises. A survey was chosen because we wanted to quickly and easily obtain input from a large number and variety of users, to make sure we have a realistic image of who might be the user of such devices. People who are interested in neck pain topic were recruited on social media. Survey questions (<https://shenxy02.typeform.com/to/KN9pmn>) were defined on the basis of the Fogg Behavior Model (FBM) [12]

which 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. In order to identify whether people have the ability to perform neck exercises, questions were given from the perspective of time, physical effort, brain cycles, social deviance and non-routine, which are the subcomponents of ability [12].(Appendix 1)

### Result and analysis

In total, 130 adults participated in this online survey (55% male and 45% female) within five days, which is far more than expectation. The average duration they spend sitting in working days is 7.59 hours ( $SD=1.73$ ). According to a study, working with a computer during more than 6 hours per day was associated with WRULDs (work-related upper limb disorders) in all body regions [6]. However, 89% of participants go beyond this warning limit.

#### *High motivation*

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 nature of exercises seems to be the biggest problem. Reducing memory burden and social deviance should also be taken into consideration of intervention design.

#### *Design direction: Facilitator*

According to the result of online survey, the target users are found with high motivation, but low ability. The trigger is expected as a facilitator to lower the barrier of performing the target behavior. Based on the ability factors analysis (Figure 3), the trigger should help people form exercise routine, and reduce memory burden and social deviance.

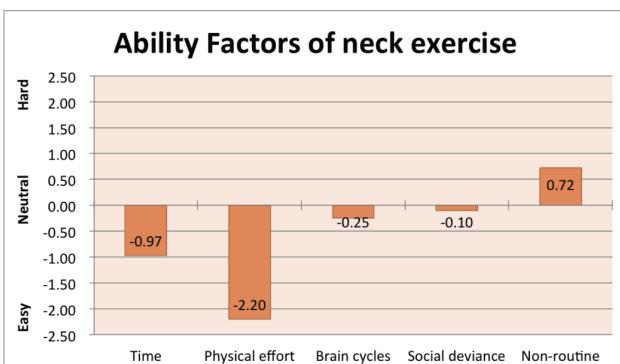


Figure 3. Ability Factors of doing regular neck exercise

## DESIGN PROCESS

### Design intentions

The purpose of this design is to motivate regular neck exercises and rest breaks in the context of workplace, which requires ease of use and minimal intrusiveness during work hours. Based on the interviews with the expert and the results from the online user study, the following requirements were identified:

- Reminding people with neck exercises and rest breaks regularly is supportive to raise awareness.
- Users were not as skilled as they think in doing neck exercises, besides interactive exercise experience, detailed exercise guidance should also be included.
- The system should provide meaningful feedback to the users about their performance on exercise and general activeness in work.
- The system should monitor users in a minimally intrusive way and fit into their daily working activities.
- Encourage users to schedule exercises on suitable time and make commitment to it.

The iterative design process of Neckio can be classified into two main phase:

### First design phase

The aim of the first iteration was to demonstrate that a wearable device can potentially support a motivating interactive exercise experience.

The webcam-based face tracking technology was considered in the early stage. However, some particular movements can not be detected, such as rotation, extension and flexion. Therefore, body monitoring is necessary for accurate tracking on head movements. Observing a common behavior amongst open space worker who wear headphones to isolate themselves from environmental noise, and given that these people are high risk individuals for developing neck pain, the first concept is a headphone with a sensor on the top, which is able to track neck movements and approximate sitting posture. Unlike Fineck [11] and Cervic Wear [26] which have sensors placed on the nape of neck, using headphone as tracking tool allows the wearer to move and exercise freely. The headphone itself can be used to remind or guide the user through audio.

In the first prototype, the sensor is a InvenSense MPU6050 sensor which contains a MEMS accelerometer and a MEMS gyro. And Arduino UNO was adopted as the micro-controller. The data is sent via USB cable to a laptop where the angulation of head movements is visualized in Processing with simplified graphics.

As Figure 4 shows, the length of two bars represent the tilt angle during Lateral bending (X-axis) and Flexion & extension (Y-axis). A circle moves on a circular pathway whose position indicates the rotation angle during neck rotation (Z-axis). In order to support self-assessment of neck flexibility, the color of the bars and circle changes when the user reaches standard



**Figure 4.** Exercise feedback exploration. Left: Real-time angulation data and the maximal angle reached are displayed on left side in degrees. The length of two bars represent the tilt angle during Lateral bending (X-axis) and Flexion & extension (Y-axis). A circle moves on a circular pathway whose position indicates the rotation angle during neck rotation (Z-axis). Right: The sensor is placed on the headphone and connected to Arduino by wire.

range of motions. Besides, the real-time angulation data together with the largest angle the user reached in one exercise were displayed on screen.

#### Reflection

The user interface makes a clear visualization of user's exercise performance. However, exercise guidance should be included as feedforward to display the standard movements, speed and range of the motion in the following development. In this case, even people who are new to these neck exercises can use it easily.

From the perspective of product design, the current USB cable connection makes the product less wearable and aesthetic. So it was decided to use wireless data transmission in further iterations to minimize product size. This iteration focused on technology issues and exercise interaction. Further exploration was found necessary regarding the motivation strategy to support long term intervention. How to persuade people schedule exercises and stick to it should also be discussed.

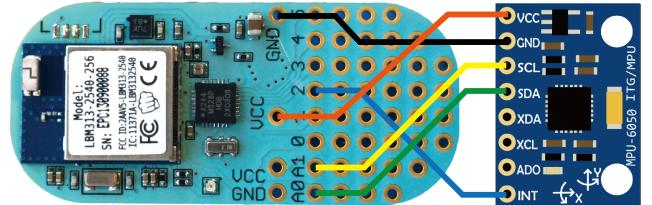
#### Second design phase

The aim of the final prototype is to create a system which can be used by computer users in daily working and motivate regular neck exercise and rest breaks in long term. It requires further improvement in user experience and product design. The final prototype Neckio comprises a software program and a wireless tracking device on headphone.

#### Hardware

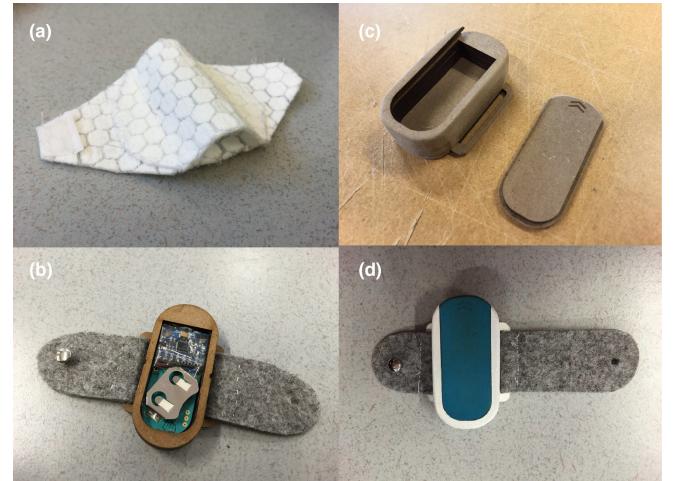
The final prototype is where the Arduino UNO board is substituted with Light Blue Bean board [2] (a small size development board), which is battery powered and uses Bluetooth Low Energy for data transformation. In this way, the tracking device becomes wireless, battery powered and minimized in size. Figure 5 shows the electronic schematic of the hardware.

The tracking device is designed as a headphone band, which is adjustable and can be easily placed on the top of headphone. The first prototype made with fabrics (Figure 6 (a))is



**Figure 5.** Technical schematic of hardware. Left: Light Blue Bean. Right: MPU6050.

easy-deformed and hard to stabilize the position of hardware. To solve this problem, a wooden case with two felt bands (Figure 6 (b)) was made to contain and fix the electronics on headphone. However, with the hard metal button on the top of head, the prototype was found uncomfortable to wear. Therefore, the bands in final design (Figure 6 (d)) were designed in different length, and the metal button was placed on the shorter band so it stays at the side of headphone to avoid contact with head. Figure 6 (c) shows the construction design of the case which can be opened by sliding the lid.



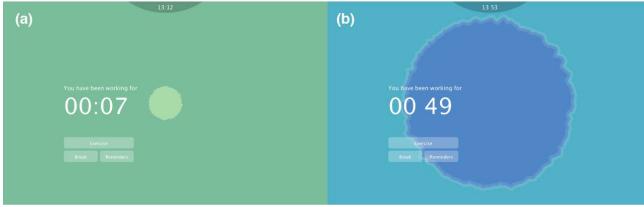
**Figure 6.** Iterative product design

#### Software

The Neckio application was developed in Processing, which is compatible with Light Blue Bean [2]. It runs in the background of computer and can be approached any time if wanted. Data from the tracking device is continuously sent to Neckio application via Bluetooth with frequency of 200 Hz. So far, the application is only available on mac computer because of compatibility issues. Generally, the Neckio application provides four functions: a) Exercise reminder. b) Interactive neck exercise. c) Work duration tracking. d) Posture tracking.

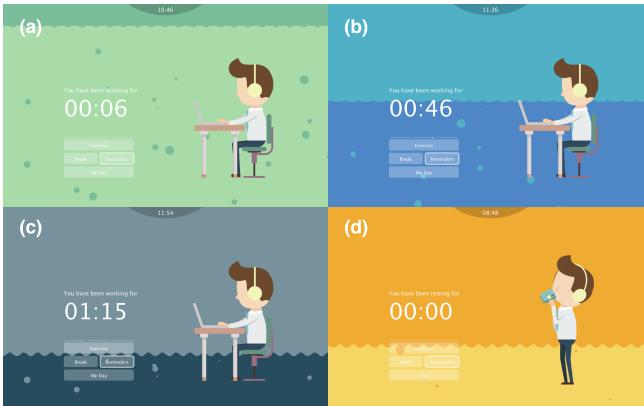
The home page displays user's current state (work / rest) and the duration of it, which aims to motivate at least one break in one-hour work. Two iterations of visual backgrounds were developed during the process. The first one is a noise circle

(Figure 7) which indicates the passing time by changing size and color.



**Figure 7.** First iteration of home page visual design: noise circle in the background of home page. The circle shrinks during working and expand during rest. The color changes every 30 minutes from green (a) to blue (b), and finally grey.

As the shape and movements of noise circle was found distracting and less intuitive to interpret, a new version inspired by tide is designed (Figure 8). User can switch states by clicking the button of "Work" or "Break". The water in the background drains away slowly while user keeps working. And the color of water changes from green (0-30 minutes) to blue (30-60 minutes), and then to grey (more than 60 minutes). Besides, an audio reminder with bubble sound will be activated when the duration of working is more than an hour. When switched to "Break", the water will become yellow and increase again. It spends 20 minutes at most to reach the starting level.



**Figure 8.** Overview of the home page in different states: work less than 30 minutes(a), work for 30-60 minutes (b), work for over 1 hour (c), rest (d).

In "Reminder" page (Figure 9), user can simply schedule neck exercises and set reminders by rotating the hand of the clocks and turning on the switch button. When the reminder goes off, soft meditation music plays smoothly to remind user for exercising.

Because the tracking device is not placed exactly horizontal at most of time, to give correct feedback, the device needs to be calibrated to set the angulation detected in a straight sitting posture to zero. Before the exercise starts, the starting posture is introduced and user is required to calibrate the device in this posture (Figure 10 (a)).



**Figure 9.** User interface of "Reminder" page to set reminders for exercise. Interaction: Rotate the hand of clocks to set reminder and press the switch button for turning on or off.

After calibration, the user will be guided to do three exercises (Figure 10 (b))which are mentioned in previous section: lateral bending, rotation and extension & flexion. The exercise guidance is given in both visual and audio way. Character animations are displayed on screen to show the exercise movements. Audio guidance, on the other hand, uses audio effects to indicate the direction, speed and moment to change direction in a more peripheral way.

The visual feedback of head movements is displayed in a similar way as the previous iteration: A circle moves on a circular scale bar to indicate the rotation angle on the certain axis, which depends on the specific exercise. To provide a clear visualization of exercise performance, normal range of motion is highlighted on the scale bar. While reaching the normal range, the moving circle will turn green to indicate the healthy condition.



**Figure 10.** User interface of device calibration (a) and exercise (b).

During working, the sitting posture is detected by the device. The percentages of time user spends on leaning left/right and looking down are calculated and shown in "Posture" page (Figure 11(a)), which aims to raise user's awareness of his own habitual sitting posture. "My Day" page (Figure 11(b))presents the overview of user's daily activities during work hours, which includes working, resting and exercising.

Figure 12 shows the interactions between user and Neckio system in daily activities.

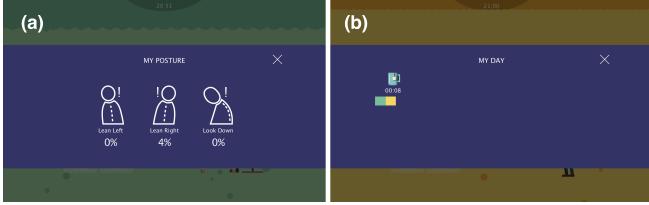


Figure 11. User interface of "Posture" page(a) and "My Day" page(b).



Figure 12. Storyboard of Neckio system. (a)work; (b)rest; (c)exercise: rotation; (d)exercise: extension and flexion.

## EVALUATION

A user test was set up to evaluate participants' subjective experience of using Neckio system. A total of 10 participants (18-30 years old) without obvious neck injury participated in the evaluation, mainly students in Eindhoven University of Technology. They all work more than 6 hours per day on computer work in open workplace such as library, open-plan office, etc. All participants were tested in their familiar workplace to testify whether Neckio fits into normal work environment.

### Procedure

In the test, the participants were asked to use Neckio for 2 hours in their daily work. Neckio application was installed and connected to Neckio band (tracking device) beforehand by researcher. Participants did their normal work on computer and perform three tasks to experience Neckio system as a whole:

- Use work duration tracking function by shifting states between "work" and "break" according to ones actual work pace.
- Set one exercise reminder
- Do neck exercise for one time

After that, a questionnaire based on User Experience Questionnaire (UEQ) [16] and Intrinsic Motivation Inventory (IMI) [1] was handed out to test whether the product fulfill the general expectations concerning user experience. In the end, questions about wearability of Neckio band, social deviance, exercise

experience and the value of Neckio system were discussed with participants in an interview.

## Results

The User Experience Questionnaire was used to collect quantitative data in 6 scales [16]: Attractiveness, Perspicuity, Efficiency, Dependability, Stimulation, Novelty. Table 2 and Figure 13 shows the average scores of each scale and confidence intervals from UEQ. Here all scales show an positive evaluation.<sup>1</sup> The overall design has been found especially strong in Attractiveness and Novelty.

Scale(-3 3)	Mean	Std. Dev.	Confidence	Confidence interval
Attractiveness	2,08 ↑	0,708	0,439	1,644 2,522
Perspicuity	1,50 ↑	0,920	0,570	0,930 2,070
Efficiency	1,46 ↑	0,816	0,506	0,953 1,964
Dependability	1,53 ↑	0,768	0,476	1,049 2,001
Stimulation	1,70 ↑	0,715	0,443	1,257 2,143
Novelty	1,85 ↑	0,592	0,367	1,483 2,217

Table 2. Results of User Experience Questionnaire.

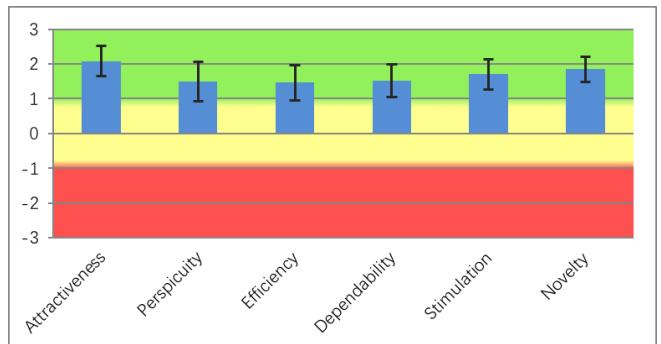


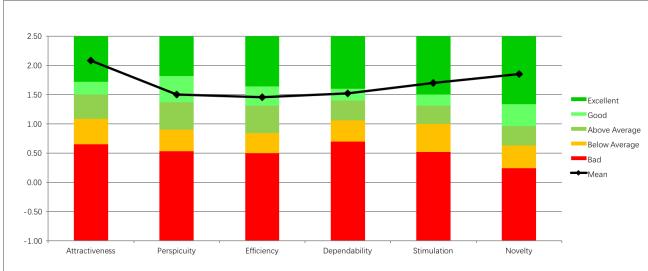
Figure 13. User experience measurement graph.

To get a better picture on the quality of a product it is thus necessary to compare the measures user experience of the product to results of other established products. UEQ [13] offers a benchmark, which contains the data of 163 product evaluations with the UEQ (with a total of 4818 participants in all evaluations). According to the Figure 14, Neckio was evaluated as quite positive. It performs excellent in Attractiveness,<sup>2</sup> Stimulation and Novelty, and good in the rest sub scales.<sup>2</sup>

Questions based on Intrinsic Motivation Inventory [1] assesses from 6 six sub-scale: effort/importance, interest/enjoyment,

<sup>1</sup>The standard interpretation [16] of the scale means is that values between -0,8 and 0,8 represent a neutral evaluation of the corresponding scale, values > 0,8 represent a positive evaluation and values < -0,8 represent a negative evaluation.

<sup>2</sup>The benchmark classifies a product into 5 categories (per scale)[13]: Excellent: In the range of the 10% best results. Good: 10% of the results in the benchmark data set are better and 75% of the results are worse. Above average: 25% of the results in the benchmark are better than the result for the evaluated product, 50% of the results are worse. Below average: 50% of the results in the benchmark are better than the result for the evaluated product, 25% of the results are worse. Bad: In the range of the 25% worst results.



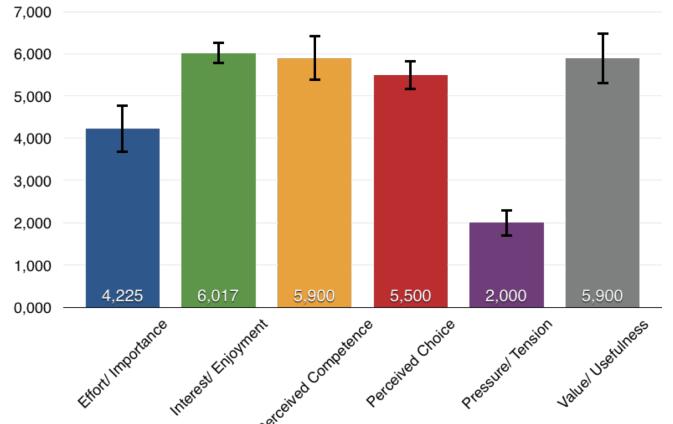
**Figure 14.** Neckio user experience measurement in benchmark chart.

perceived competence, perceived choice, pressure/tension and value/usefulness. The data from the questionnaire was averaged per sub-scale over all participants. The average values are shown in Table 3 and visualized in Figure 15 showing the 95% confidence interval. The interest/enjoyment sub-scale is considered the self-report measure of intrinsic motivation [1], which is scored high with low standard deviation in this test. Therefore it can be concluded that participants were strongly motivated to use Neckio. The value/usefulness scale also got high score, which can be interpreted as it is believed that Neckio system is useful and valuable to one's neck health. In this case, people internalize and become self-regulating with respect to using the system (e.g., Deci et al, 1994). The perceived choice and perceived competence concepts are theorized to be positive predictors of self-report and behavior measures of intrinsic motivation, and pressure/tension is theorized to be a negative predictor of intrinsic motivation [1]. As the Table 3 shows, Neckio system was considered as easy to be mastered (perceived competence) and it leaves space and freedom for users to choose what they want to do without compelling (perceived choice). Effort/importance is a separate variable to measure the perceived effort user spends on using the system. According to the result, participants found using the system is relatively effortless.

Scale	Mean	Std. Dev.	Confidence	Confidence interval	
Effort / Importance	4,23	0,93	0,58	3,65	4,80
Interest / Enjoyment	6,02	0,44	0,27	5,74	6,29
Perceived Competence	5,90	0,87	0,54	5,36	6,44
Perceived choice	5,50	0,58	0,36	5,14	5,86
Pressure / Tension	2,00	0,53	0,33	1,67	2,33
Value / Usefulness	5,90	0,99	0,61	5,29	6,51

**Table 3.** Results of Intrinsic Motivation Inventory.

A short interview was held to know participants' thoughts about wearability, social deviation, exercise experience and perceived value. All participants reported the wearability of Neckio band is good as they didn't feel the band placed on their headphone. Only two participants expressed their slight



**Figure 15.** Intrinsic motivation graph.

anxiety to do neck exercise in their workplace, whose workplaces are comparatively more crowded. On the other hand, it was also mentioned that it helps if people around know what they are doing. The Neckio exercise was described as relaxing and easy to learn. "Neckio is very useful to look into my work pace. While doing exercise, I did feel my neck is kind of stiff...The exercise is quite relaxing, and the audio effect is easy to follow." The visual feedback was found motivational carrying out the exercises in place. "Exercising with Neckio makes me more aware of my neck stretching range, I tried very hard to reach the green part." It was also suggested to add audio feedback, so that the exercise performance can be heard while not facing the screen. "I can't see the feedback while doing exercise like rotation. It may be better to have audio feedback too, so I can hear how I am doing without looking at the screen." In terms of Neckio's perceived value, Neckio is generally considered as motivational in regular breaks and exercise and helpful to improve neck health. And it may improve work efficiency through tracking work duration. "I think Neckio boosts my work efficiency, because I got better track of my working time." A floating window was suggested to display the basic information in a peripheral way during working. Further, it was suggested that gamification may make the exercises more engaging and fun.

### Discussion of user evaluation

The user experience of Neckio system was proved as sufficient in this evaluation. And people are found motivated intrinsically to use Neckio system. So far, there is not sufficient evidence to prove Neckio is efficient in behavior change, such as more rest breaks, regular neck exercise, etc. It is recommended to conduct user test in a longer period and compare users' behavior before and after using Neckio system. It is also interesting to see whether the exercise feedback could help people to do exercise more in place. The bending/ rotation angle in the exercise with and without Neckio could be recorded and compared.

## FUTURE WORK

### Feedback exploration

The current version only has visual feedback, which is only visible while facing the screen. As a remedy, audio feedback is potential to indicate the performance during exercise. How to make the audio clear and understandable with both audio guidance and feedback playing at the same time should be further studied.

### Peripheral information display

The Neckio application runs in the background most of the time. To help users keep track of Neckio in a minimally intrusive way, a floating window could be added as a peripheral display.

### Product design

At this moment, the hardware of Neckio is based on Light Blue Bean, which is not purpose specific hardware, so it takes more footprint than necessary and is not power efficient. In future development, a smaller and energy saving design can be achieved by integrating only relevant functionality, such as, Low Energy Bluetooth, sensors and chargeable battery pack. In this way, the electronics part could be made into a tiny clip or band, or embedded into headphone itself, which are both plausible for volume production.

### From desktop software to mobile application

"iPad Neck" has recently became a popular description of neck pain caused by prolonged tablets use. Neckio system is potential to help mobile device users to improve neck health. For example, tablet use requires a significant head and neck bending [27], which could be avoid with the posture tracking function of Neckio. Therefore, developing mobile a Neckio application could be an interesting direction for future design research.

## CONCLUSION

Within the project, a neck care system Neckio was designed, developed and evaluated, which has three main contributions. The first one is the designed motivational approach of encouraging regular rest breaks and neck exercises in workplace. It provides a new solution for the neck pain prevention which is a prevalent job-related health problem. The second contribution is to create a new interactive exercise experience. The feedback and guidance has been carefully designed in both visual and audio modalities to make people feel more in control and engaged during the exercise. The third contribution is the design of the headphone-attached Neckio band. The tracking device is comfortable to wear and the new placement of sensor doesn't limit the movements of neck, which is an improvement from conventional posture tracking devices. The user experience and users' intrinsic motivation of using Neckio system in daily working has been evaluated as positive in this study. Further research on behavior change over a long period time is necessary to conclude the effectiveness of its actual functions. Further work on product design and application development is needed. As the prevalence of neck pain raised by tablet use, mobile application development for Neckio is considered as a promising direction in the future.

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## Appendix 1

# Consent Form of User Evaluation

*The research on people's experience and intrinsic motivation of using Neckio system during work hours.*

I agree to participate in a study on people's experience and intrinsic motivation of Neckio, which is conducted by Xiaoyu Shen (TU/e Industrial Design, +31645357921).

I understand that the purpose of this study is to understand people's experience and intrinsic motivation of using Neckio system during work hours. I understand that I have been asked to participate in this research because I worked with computer in open work space.

I understand that my participation in this research will involve installing the Neckio app and Bean Loader on my own computer.

I understand that my participation means that I will be asked to use Neckio during work with the goal to find out how I experience the system. The study will take 2 hours, divided over introduction and installing (15 minutes), experience (90 minutes), questionnaire( 5 minutes ), interview(10 minutes)

I understand that, to be able to evaluate the study, audio will be recorded in the interviews and notes will be taken. All information will be collected only to support the analysis of the study and will be kept in confidential.

I am aware that I can contact Xiaoyu Shen if I have any concerns about the research. I also understand that I am free to withdraw my participation from this study at any time I wish, without consequences, and without giving a reason. I will not be penalized in any way for declining to take part in any stage of the research.

I agreed that Xiaoyu Shen have answered all my questions fully and clearly.

I understand that all the data that is collected during the study will only be available to the research and her supervisors. I agree that the research data gathered from this project may be published in a form that does not identify me in any way.

Signature (participant):

\_\_\_\_\_  
\_\_\_\_\_

Date:

\_\_\_\_\_/\_\_\_\_\_/\_\_\_\_\_

Signature (researcher):

\_\_\_\_\_  
\_\_\_\_\_

Date:

\_\_\_\_\_/\_\_\_\_\_/\_\_\_\_\_

## Appendix 2

# Questionnaire of User Evaluation

**Please assess the product now by ticking one circle per line.**

**For each of the following statements, please indicate how true it is for you, using the following scale:**

	Statements	Not true at all		Somewhat true		Very true	
1	After working with Neckio for awhile, I felt pretty competent.	1	2	3	4	5	6
2	I am satisfied with my performance at working with Neckio.	1	2	3	4	5	6
3	I believe I had some choices about using Neckio.	1	2	3	4	5	6
4	I believe using Neckio could be beneficial to my neck health.	1	2	3	4	5	6
5	I did neck exercises with Neckio system because I wanted to.	1	2	3	4	5	6
6	I did not feel nervous at all while using Neckio.	1	2	3	4	5	6
7	I didn't try very hard to do well at neck exercise with Neckio.	1	2	3	4	5	6
8	I enjoyed using Neckio very much.	1	2	3	4	5	6
9	I felt like it was not my own choice to work/rest or do exercises with Neckio.	1	2	3	4	5	6
10	I felt pressured while using Neckio during working.	1	2	3	4	5	6
11	I felt very tense while using Neckio.	1	2	3	4	5	6
12	I spend a lot of effort on using Neckio.	1	2	3	4	5	6
13	I think I am pretty good at using Neckio.	1	2	3	4	5	6
14	I think I did better at doing neck exercise with Neckio, compared to do it without the system.	1	2	3	4	5	6
15	I think that doing neck exercises with Neckio is useful for improving my neck health.	1	2	3	4	5	6

16	I think this is important to use Neckio because it can help me form better work habits.	1	2	3	4	5	6	7
17	I think using Neckio while working could help me to avoid neck stiffness.	1	2	3	4	5	6	7
18	I thought doing neck exercise with Neckio was a boring activity.	1	2	3	4	5	6	7
19	I thought working with Neckio was quite enjoyable.	1	2	3	4	5	6	7
20	I tried very hard on doing neck exercise with Neckio.	1	2	3	4	5	6	7
21	I was very relaxed in doing neck exercises with Neckio.	1	2	3	4	5	6	7
22	I would be willing to use Neckio again because it improves my neck health.	1	2	3	4	5	6	7
23	I would describe using Neckio as very interesting.	1	2	3	4	5	6	7
24	It is fun to do neck exercise with Neckio.	1	2	3	4	5	6	7
25	It was important to me to do well at neck exercises with Neckio.	1	2	3	4	5	6	7
26	Neckio did not hold my attention to watch my neck at all.	1	2	3	4	5	6	7
27	Using Neckio is something I couldn't do very well.	1	2	3	4	5	6	7
28	I did neck exercise with Neckio because I had no choice.	1	2	3	4	5	6	7