SENSORISCH

HFNL Scriptieprijs

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The healthcare system faces many challenges due to societal developments, such as aging population and increase of people with chronic diseases (WHO, 2011). Due to administrative tasks and lack of human resources, nurses face a higher workload (CBS, 2019), which can lead to adverse consequences. Research showed that technological innovations, such as m-health and e-health, can increase work efficiency and reduce the costs of care (EC, 2014; van der Horst, van Erp, & de Jong, 2011).

Research Question

At the Maasstad Ziekenhuis (MZ) (a hospital in Rotterdam), almost half a million patients receive treatment per year. In its Department of Surgery both mobile obese patients and cancer patients are hospitalized. In order to assess their condition, nurses manually monitor their vital signs three times a day. These vital signs are heart rate, blood pressure, blood oxygen level, respiration rate, and body temperature. Due to the current error-prone method, lack of an alarm system and high workload, it is possible that patients' health deterioration is not detected in time which can lead to unplanned admissions to the ICU. Digitizing the current time-consuming method can have several positive effects, including:

(1) detecting small changes in health condition and im-mediately intervening at an early stage;
(2) saving time that can be utilized for patient guidance and contact;
(3) decreasing the workload of nurses and preventing burnouts. Digitizing can be realized with wearables for patients. These wearables with integrated bio-sensors can monitor various vital signs, depending on the type of wearable.

For this project, the Basic Design Cycle model (Roozenburg & Eekels, 1995) was used in combination with the Participatory Design methodology (Dorst, 2006). The project's main objective was to design a wearable device that has the following characteristics:

(1) it should be complete in its ability to measure the before mentioned vital signs;
(2) it should be user-friendly for nurses, meaning that the amount of performed actions is minimal;
(3) it should be comfortable to wear for patients.

Methods

Based on interviews, market and literature research, six different concepts for an wearable device were created and evaluated with the Harris Profile and Weighted Objected in order to make the concept selection easier (Daalhuizen, Boeijen, Zijlstra, & van der Schoor, 2014). These six concepts were discussed with patients, nurses, experts and the client. Eventually, the Earable V2, an ear-worn device, was selected for further development. It would provide more reliable measurements of patients' vital signs and higher level of user-friendliness for nurses compared to the other five concepts. In order to ensure proper contact between the wearable and the external ear, the curvature behind the external ear is essential. However, there was lack of data available regarding the design of the curvature behind the ear. It was not possible to directly scan the curvature with the handheld 3D scanner Artec Space Spider (3D scanner of metrological accuracy, Artec 3D, Luxembourg). This made us decide to create the hand-made ear models using polymorph (Figure 1). Polymorph is a material that can be formed and reformed multiple times when heated. After making ten models

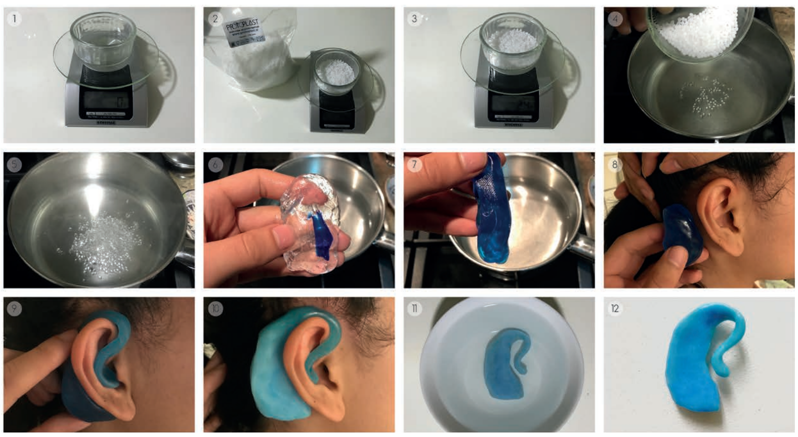

Figure 1. The process of making hand-made polymorph ear models.

Figure 2. Scanning of the handmade polymorph ear models using Artec Space Spider.

Figure 3. Potential user wearing and testing the comfort level of the 3D-printed average model.

from polymorph, Artec Space Spider was used to scan all models (Figure 2).The 3D data were processed with the software program R3DS Wrap (Russian 3D Scanner, Russia), which used the scans of all models for creating an average model in 3D. In order to test the comfort level with potential users, the average model was 3D-printed in Polylactide (PLA) with the Ultimaker 2 (single extrusion 3D printer, Ultimaker, the Netherlands). The recruited participants for the user-test - healthy acquaintances or fellow students - were asked to wear the 3D printed ear-worn device as long as possible, while they were doing their daily activities. Ten participants (age range: 24 to 54 years old) performed the test.

Results
The model was worn, on average, for five hours (Figure 3). Two participants slept with the model, which did not cause any discomfort or pain. The participants scored the model on average with a 3 (1=not comfortable at all, 5= very comfortable). Only three participants felt discomfort after a few hours; in their experience the model became 'heavier'. The other seven participants did not experience any discomfort while sitting. However, they did experience some annoyance or discomfort when they started walking, which caused the model to slightly move.

Conclusion
Although the participants experienced some discomfort during the user-test, the 3D model has potential for further exploration and development. Some participants lacked experience with ear-worn wearables, which could explain their discomfort. Nevertheless, more testing and iterations are necessary to increase the level of wearer comfort. For instance, more ear models must be included to increase the accuracy of the curvature. It is also recommended to create more than one size of the wearable. Other factors to ensure high level of comfort, include: material, form and flexibility of the model.

Personal impression
I was surprised that there was very little data and literature available about the curvature of the external ear, especially in this modern era where many of us use ear-worn wearables, such as sport earphones and Bluetooth headsets. During the discussions with experts, it was concluded that this area is difficult to scan with 3D scanners, especially when the external ear is close to the head. Therefore, a new method had to be created to discover the curvature of the external ear, i.e. hand-made polymorph modelling. This approach shows that we should be creative in our approach and that we sometimes need an extra step to achieve our goals. Moreover, I believe it is important for us as designers and researchers to keep the human-centred design approach in mind in order to suit the needs of end users. Overall, I can say that I am satisfied with my results and the quality of my work. Hopefully, this project will inspire others to create a more sustainable and healthier future for us all.

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