Midwives Experiences of Using HMD in Ultrasound Scan

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ABSTRACT
The head-mounted displays have been tested in various fields in medicine. According to some results, using a head-mounted display makes medical operations faster, more effective and accurate than using a conventional table display. In this study we wanted to find out midwives experiences of using a head-mounted display in an ultrasound scan. Our preliminary result shows that head-mounted display in ultrasound scan could work better than conventional method. We also noticed that midwives who got higher scores of diffusion of innovation scale have a tendency to like head-mounted displays more than those who got lower scores.

Author Keywords
Head-mounted displays, user experience, ultrasound scan, patient-midwife communication.

ACM Classification Keywords
H.5.2 Information systems: User Interfaces

INTRODUCTION
The possibilities of head-mounted displays in medicine have been widely studied [1-8] and the results have generally been positive [4]. This can be attributed to several factors, but one of the most important issues is the decreased need to shift attention between two or more displays during an anaesthesiological or other medical operation [5, 3].

In this study the purpose was to investigate the issue of attention shifting in an ultrasound scan task, where a midwife has to alternately gaze the patient and the display showing the scan results. We wanted to know how midwives with previous experience of conventional ultrasound scanning would experience using a HMD in ultrasound scan task.

In Finland ultrasound scan is done for mothers twice during the pregnancy. First screening is done in weeks 12+0 - 13+6 and the second in 19+0 – 20+0 weeks. The meaning of the screening is to control that fetus is developing properly and there are no abnormalities. There are approximately 60 000 births per year so, the total amount of fetal screenings is approximately 120 000 per year. This amount includes only the normal screenings.

Conducting an ultrasound scanning task can be straining because the midwife has to constantly gaze either to the display or to the patient. This can be straining for the neck and other upper body muscles and can be uncomfortable during a long working day. Using a HMD would reduce the need to turn the head, because the scanning result is all the time visible in the visual field of the midwife.

On the other hand, there are a number of possible problems related to the using a HMD in an ultrasound scanning task. Firstly, earlier studies related to head-mounted displays indicate that subjective visual strain symptoms are present during and after the HMD use [9, 11]. On the other hand, there are also studies suggesting that the symptoms are similar to using on ordinary display [10]. The question of eye strain and other adverse symptoms is significant, as it is important that the HMD would not reduce working comfort of midwives.

Second possible problem is related to the reduced social cues in the interaction, as the HMD covers part of the visual field. This might reduce the eye contact and make the expressions of the midwife more difficult to interpret.
The purpose of this study was to find out how the midwives experience the new way of doing the ultrasound scan using the HMD. The participants compared the new method to the old one and answered the questions concerning their feelings and opinions of the displays. We also asked patients’ opinion about the interaction, but these results are reported elsewhere. Several ergonomics issues were also considered: we wanted to know whether the working position would be better while using the HMD and whether the level eye strain and sickness symptoms was significantly higher with the HMD. Finally, we were interested in finding any relation of HMD use comfort and existing visual dysfunctions, like presbyopia.

METHODS
The participants did an abdominal ultrasound scan with see-through Sony Glasstron in experiment 1 and with Micro-Optical SV-6 PC viewer in experiment 2. The task of the participant was to do an abdominal ultrasound scan for 20 minutes. The participant had to find, mark, identify and measure different abdominal organs. The organs were uterus or prostate depending on patients’ sex, right and left kidney and bladder. They measured each organ linear and crosswise. They also measured the volume of the bladder. Each of the identified organs was documented by printout. The task lasted approximately 20 minutes. During the task the experimenter was observing the user behind her. The experiment starting times were randomly distributed in the morning (9 am – 11 am) so that the existing eye strain would not affect the results. The participants did not know the ultrasound machine used in the experiment beforehand but they were able to familiarize themselves with the machine before the experiment.

Participants
Twenty-four midwives participated the experiments. 13 participants took part of experiment 1 and 11 participants were in experiment 2. All participants had a normal or corrected-to normal vision.

The mean age of all the participants was 43.1 years with the minimum age of 33 years and maximum age of 52 years. In experiment 1 the mean age was 41.6 years and in experiment 2 the mean age was 44.8 years. All the participants were female. They were registered midwives and they had several years experience in ultrasound scan. 42.0 % worked in local hospital, 33.5 % in the university central hospital, 17.0 % in the central hospital, 4.0 % in health care centre and 4.0 % of them were coming back to working life so they did not have a working place yet.

Apparatus
We used two different kinds of head-mounted displays. In an experiment 1 we used a see-through Sony Glasstron head-mounted virtual display and in an experiment 2 the monocular Micro-Optical SV-6 PC viewer. The resolution of both of the displays was set to 640x480 pixels in both experimental conditions. The virtual image was an at a distance of 1.4 meters with both displays. We placed monocular display in front of the leading eye measured with target aiming method. We used Vivid 3 ultrasound machine where we connected displays one at a time.

![Figure 1. The HMD in use while doing Fetus Scan.](image1)

![Figure 2. Ultra Scan Picture of Uterus.](image2)

Procedure
In the main experiment the participant first filled in a background questionnaire that contained general questions regarding the health state of the participant. They described their head-mounted display and virtual reality experience, daily near work time, computer gaming frequency, motion sickness frequency, headache frequency and handedness. We also asked when was the last time they had eaten and taken any medicines that made them more susceptible to nausea (sedatives or tranquilizers, decongestants, anti-histamines, asthma medicine or alcohol). We also measured their technical innovation using Diffusion of Innovation Questionnaire [12]. Finally, the participants described their preconceptions and opinions about head-mounted displays. After filling in the background questionnaire the participants began to do the task. After the task we gave the participants a questionnaire in which they described their opinion about the head-mounted display as well as the level of sickness symptoms they experienced after the use of the head-mounted display.
RESULTS
In table 1 are described the frequencies of most common positive and negative opinions about head-mounted displays before and after the task. The opinion types have been coded from the free answers the participants provided in the questionnaire. The pre-task opinions indicate that the participants anticipated better ergonomics and display quality, but were worried about the sickness symptoms and lack of eye contact with the patient. However, one fourth of the participants did not have any clear expectations of using the HMD.

Table 1. Positive and negative opinions of HMD before and after the task.

<table>
<thead>
<tr>
<th>Positive pre-task</th>
<th>Negative pre-task</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ergonomics will be better</td>
<td>Adverse symptoms</td>
</tr>
<tr>
<td>Don’t know</td>
<td>Decreased contact patient</td>
</tr>
<tr>
<td>Better display quality</td>
<td>Lack of eye contact</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Positive post-task</th>
<th>Negative post-task</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ergonomics was good</td>
<td>Difficult to maintain contact to patient</td>
</tr>
<tr>
<td>Good image</td>
<td>Reduced visibility</td>
</tr>
<tr>
<td>Focus to patient</td>
<td>Too much weight</td>
</tr>
</tbody>
</table>

The post-task opinions show that one third of participants regarded the ergonomics of the HMD as good. In these answers the participants indicated that using the HMD allowed them to move more and helped them to find out better working position. Many participants also mentioned that the image quality of the HMD was better than in the default display of the ultrasound machine. Also the ability to focus to the patient was rated as positive aspects of the HMD. In these answers the participant described that they liked the opportunity to see the patient all the time.

Negative post-task opinions show that contact to patient and reduced visibility in general was experienced as problematic. In addition, the weight of the head-mounted display was felt as uncomfortable. Interestingly, the sickness symptoms that was often mentioned in the pre-task questionnaire was not regarded as problematic in the post-task questionnaire.

Table 2 shows the change in attitude that the participants reported after the task. Although there is no possibility of making statistical comparisons due to the small sample size, there are several trends visible in the table. Firstly, there are slightly more changes towards more negative opinion with Sony Glasstron display. This might occur because the Sony display covered the whole visual field and the contrast of the visual field seen through the display was reduced. This effect might be more pronounced with participants who have age related changes in the contrast sensitivity function. Furthermore, the participants may have felt that the display that covers the whole visual field has more disruptive effect to the social connection between the midwife and the patient.

We used a diffusion of innovations scale to measure the level of technology acceptance in the participants. 46 % of the participants belonged to the early majority group, 12.5 % were early adopters and 41.5% of them were late adopters. Participants who were not enthusiastic about new technology reported more difficulties than the other participants. This finding suggests that participants who did not have a lot of experience on computers or who have a neutral or negative attitude towards new technology might experience the situation involving new technology more stressful and thus pay more attention to the negative sides of the HMD use. On the other hand, participants who have a positive attitude towards new technology might be more enthusiastic about the new display type and consequently pay less attention to any difficulties with the HMD.

The relation of technology attitudes and experienced symptom levels indicates that the selection of participants might have a strong effect to the experimental findings. If the experiment participants work in a hospital which have a positive attitude to the new technology the resulting negative opinions and sickness levels might be lower than with other participants. However, the effect might be caused by short-term enthusiasm toward the new technology, so in the future studies it would be interesting to test whether the differences between persons with different technology attitudes are reduced with the long term use of the device.
One remarkable thing that was visible in the free answers was the fact that most of the participants were interested in trying to use the HMD in their own work with the ultrasound machine they usually used in their work. Many participants complained that they were not familiar with the machine that was used in this study and thus had to pay more attention to operating the machine compared to normal work situation. This might have affected the findings of the study to negative direction. In future studies it would be useful to test the use of the HMD in the midwives’ normal working environment and typical work tasks.

CONCLUSIONS
Use of a head-mounted display can be more precise than conventional desktop system. It also allows better accuracy and safety of clinical decisions based on images. However, psychological factors have a strong effect to the acceptance of the new technology. The use of head-mounted displays in medicine is in a preliminary stage and further research is needed to evaluate its long-term clinical impact on patients, nurses, doctors and hospital administrators. Its widespread use and the universal transfer of such technology remains limited until there is a better understanding of user experience issues related to this application. Our preliminary results indicate that midwives regard head-mounted displays as an acceptable accessory to ultrasound scanning task. However, a larger study will be needed to evaluate the possible trends in user performance over single sessions and over longer time periods. There may also be significant variability between users in performance accuracy and fatigue effects.

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REFERENCES