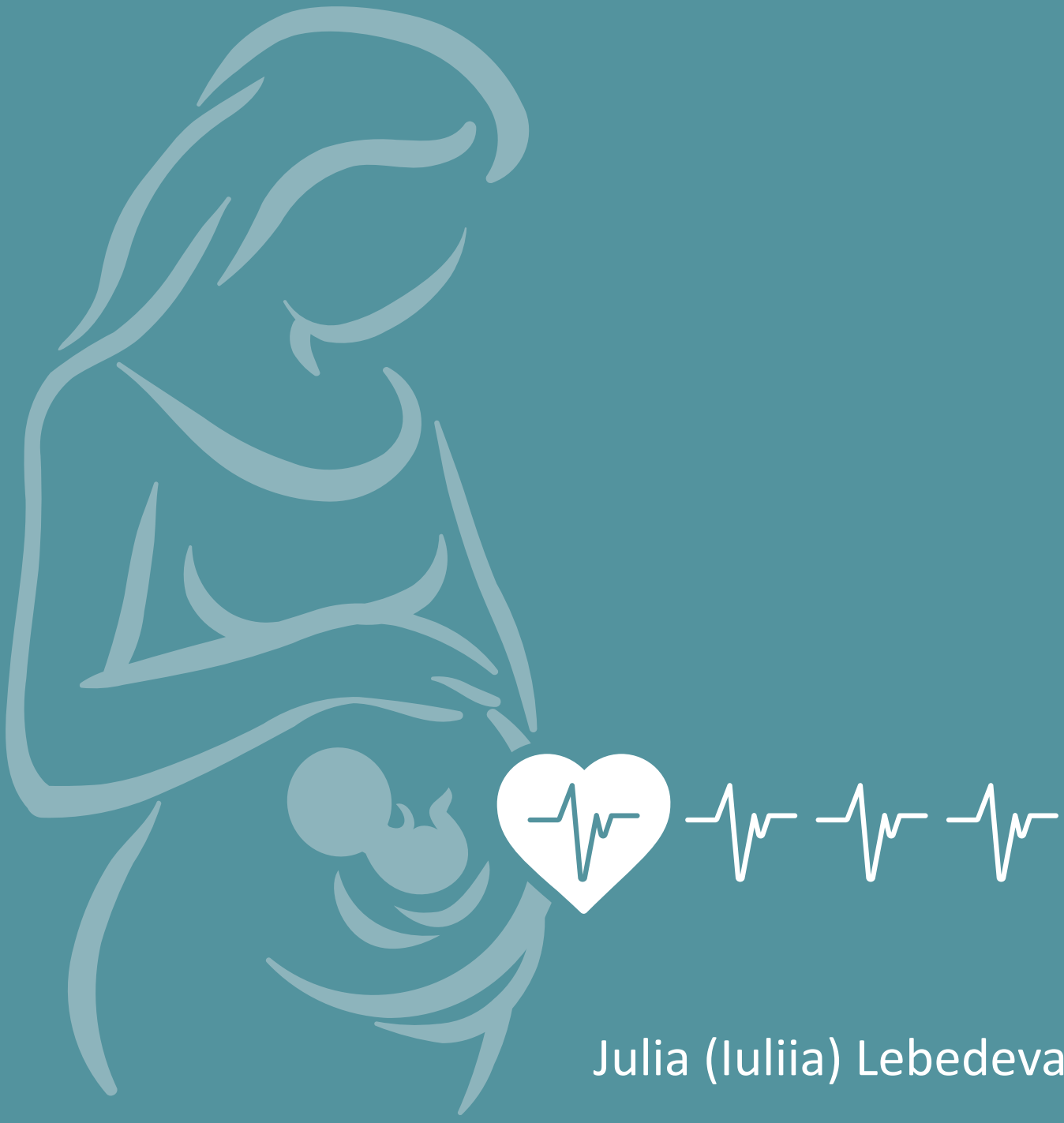
Product Concept Design

for Fetus Heartbeat Detection and Monitoring in Pregnancy Care



Julia (Iuliia) Lebedeva

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for Fetus Heartbeat Detection and Monitoring in Pregnancy Care

Julia (Iuliia) Lebedeva
Professional Doctorate in Engineering, User System Interaction
lebedeva.iuliia@gmail.com

Supervised by:

Dr. Jun Hu
Eindhoven University of Technology (Eindhoven, the Netherlands)
j.hu@tue.nl

Biyong Zhang
International SmartHealth Lab, BOBO Technology Ltd. (Hangzhou, China)
biyong.zhang@ish-lab.org

Cover design: Julia (Iuliia) Lebedeva and Katerina Malova
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Summary

A monitoring system based on the pressure sensor technology being developed by International SmartHealth Lab, BOBO Technology Ltd. (ISHL) shows broad possibilities of using this technology in development of smart wearables for heartrate monitoring. The project goal was to explore the possibility to use the pressure sensor technology in Pregnancy Care. The focus of this project was to come up with concepts of a product that can be used by pregnant women to monitor baby's heartbeat in home based context, and to explore different ways of representation and visualization of real data.

The first steps of the project was to explore previous studies and already existing solutions for 'at home' fetal heartbeat monitoring. As the second step, a thorough *User research* was conducted with pregnant women via interviews and an *Online survey* to explore their pregnancy routine, and, more importantly, to understand their emotions, thoughts and feelings during their pregnancy. The findings of these responses show that pregnant women really value being able to feel a 'connection' with a baby by knowing that the baby is doing well. In that case baby's heartbeat is actually the best 'sign of life' for the expectant moms and dads who wish to bond with their unborn baby, and also for the rest of the family members who is also interested 'how is it going with the baby?'

The initial purpose of the design project was to meet a design challenge with the question: How the product should look like that based on baby's heartbeat will give the feelings of the emotional bonding between an unborn baby and a mom (and preferably the rest of a family)?

A concept named *'Smart' maternity pillows* was created based on some of the existing maternity pillows of different shapes. This was a concept of a product (i.e., INPUT), which by using the pressure sensor embedded inside can 'read' baby's heartbeat when pregnant women use it while resting and relaxing at home. The first pilot tests with the sensor and with the prototypes of the pillows with couple of pregnant women showed that it seems possible to specifically extract fetal heartbeat from raw data collected by the sensor. This positive results gave a good sign to continue with the idea of using the pressure sensor technology in Pregnancy Care. Several concepts, such as *'Smart' bracelet, 'Creature' on a phone (Visualization on a mobile phone)* and *'Live' toy*, were created as potential options for developing a second product (i.e., OUTPUT) that could visualize and represent the baby's heartbeat real data. First prototypes of the mentioned concepts were built with using fake data at the early stages of the *Concepts development*.

To gain comprehensive understanding if potential users would actually like the ideas, *Online User tests* were conducted with international pregnant women and also women who had just delivered their baby. In the tests all concepts were shown in form of a video and the users were asked to give their feedback about the ideas. The results show that the main idea of making existing maternity pillows 'smart' by embedding the pressure sensor inside for baby's heartbeat monitoring looks quite attractive for our potential users. The ideas of the *'Creature' on a phone (Visualization on a mobile phone)* and *'Smart' bracelet* seem more promising for representation and visualization of the real data.

To continue this project, first of all, long-term technical tests need to be conducted with larger number of pregnant women in different stages of pregnancy with the *'Smart' maternity pillows* prototypes in purpose to get plenty of raw data for future analysis. This analysis should include several important questions, such as:

- In which ways could the prototype give a higher quality signal?
- How does the stage of pregnancy influence the quality of a signal?
- How does the material of the prototype have effect on the quality of a signal?
- How the material of the prototype should be adapted accordingly to get a better signal?
- What is the best position of the sensor inside the pillow?
- Which specific condition for using the pillow have effect on context of using the pillow?
- What should be done to make technically possible to get live data and represent it at the same time?

Only by knowing clear answers to these questions can we be sure whether the idea of the presented 'smart' maternity product is worth further development. If this is the case, then the second part of the product for visualization and representation can be implemented easily based on the concepts presented in this project, which were already preliminary tested with potential users. After all the overall concept in forms of hi-fi prototypes can be tested in the aspects of usability and implementation before starting the actual development for the market.

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Introduction

This section gives an introduction of the project background and the project goals.

Project background

International SmartHealth Lab, BOBO Technology Ltd. (ISHL) located in Hangzhou, China, cooperates with Eindhoven University of Technology, the Netherlands, on a number of projects in the area of smart healthcare solutions for patient care in hospitals. One of these projects involves the development of 'smart' wearables for heartrate monitoring.

Basically ISHL uses BCG technology (pressure sensors - Piezoelectric PVDF films) to extract human heart rates, respiration rates, body movements, and HRV (Heart Rate Variability), among other types of medical data. This data, especially HRV, can be used in the fields of sports and sports science, corporate health, cardiology, ergonomics, diabetes care and relaxation training therapy.

In 2016 a touchless monitoring system was designed by ISHL for use with patients in hospitals and elderly who live in nursing homes.

Figure 1 (left) shows the Piezoelectric PVDF films that ISHL uses for the development of special belts shown in Figure 1 (right). Each belt has a special 'bridge' structure in order to get a better signal. When the belt is located in a bed under a mattress in a hospital, medical data can be extracted from patients in a non-obtrusive way, for example while they are sleeping.

Figure 1.
Left: Pressure sensor – Piezoelectric PVDF films
Right: Belt containing the PVDF Piezoelectric films

In the beginning of 2017, ISHL intended to explore more application fields for using the pressure sensors. The choice was between two directions to pursue: Baby Care or Pregnancy Care. In order to go further with the exploration of these directions, new ideas were needed of new 'smart' products for heartrate monitoring of infants or fetuses in home based context.

Both design and development possibilities looked quite promising, but at the same time they had different design challenges. A 'smart' product in Baby Care could be designed based on an already existing system developed by ISHL for adults. The design challenge in that case would be that only some new ideas in terms of forms and shapes of the product would be

applicable for infants. However, developing a 'smart' product in Pregnancy Care presented a major design challenge due to higher level of difficulty in specifically extracting a fetal heartbeat using an algorithm.

After considering both directions, we decided to try to follow the second direction. However, to start with this direction, ISHL needed to find strong evidence that it would be technically possible to specifically extract a fetal heartbeat from raw data gathered by the pressure sensor from pregnant women, and that the data will be extracted quite accurate. Without strong arguments to support this design development it was a risk to start with any concepts of the product.

The first tests performed by ISHL at the beginning with couple of pregnant women with the pressure sensor yielded positive results that allowed the confident choice to pursue design of a 'smart' product in Pregnancy Care.

We decided to start our investigation with the same size of the pressure sensors (80 cm long) that ISHL uses for their development (Figure 1, left). This choice limited our flexibility in developing testing prototypes, but we agreed to shorten the sensor if future ideas prove to be attractive and promising options.

Project goals

At this stage the project goals were set. The first goal was to meet a design challenge with the question: How the product should look like? The second goal was to address the question of unscrambling of the baby's heartbeat data.

Since the product supposed to be composed of two main parts, the design goals were clarified as:

1. Design of the INPUT part - a physical wearable/product for pregnant women with the pressure sensor inside to collect the fetal heartbeat data.
2. Design of the OUTPUT part – a product to represent the fetal heartbeat data (that also could be a physical product or digital representation/visualization).
   Theoretically as the potential users of the OUTPUT part of the product could be not only pregnant women, but also any of the family members who is also interested 'how is it going with a baby?', for example, husband/partner, kids or parents.

The expected deliverables seemed quite ambitious, but were more or less feasible to complete during the seven-month timeframe of the project:

- A system including an application that a pregnant woman can use to monitor the heartbeat of her baby by using it at home
- A working prototype of a 'smart' product that works as the INPUT (with the embedded pressure sensor)
- A working prototype of the second part of the product that works as the OUTPUT and represents data that is detected by the INPUT
- Experiments to test usability of the product
- Preparation work to turn the prototypes into a real industrial product

As about a target user group, the project team decided the focus should be on international users, with trying to take into account Chinese market if possible, because obviously ISHL wanted to include users from their country as well.

The remaining chapters of this report describe all phases of the project, including the research phase, concepts development, prototyping and evaluation, and provide a discussion of the results and recommendations for future development of the presented design concepts of the product.

Research

Literature review

From the beginning of the project some literature was found in purpose to capture details of the technology supposed to be used in the project and also to explore previous studies in the field of the heart rate monitoring. Papers 'Piezoelectric composites. Design, fabrication and performance analysis' [1], 'Signal Conditioning Piezoelectric Sensors' [4], 'HRV Analysis Using Ballistocardiogram with LabVIEW' [3] gave some understanding how the sensors work and how the BCG data can be analyzed. The paper 'On the Fetal Heart Rate Diagnostic Technologies' [7] gave an overview of the technologies used specifically for the fetal heart rate diagnostic. Couple of studies describe the ideas of a sensor for fetal heart rate monitoring at home and a wearable system for remote fetal monitoring ('19.2 cm3 Flexible Fetal Heart Rate Sensor for Improved Quality of Pregnancy Life' [11] and 'Prototype of a wearable system for remote fetal monitoring during pregnancy' [2] respectively).

Some papers were reviewed during the experiments phase with the pressure sensor, couple of which were advised by Dr. Lin Xu from the Electrical Engineering department of TU/e who helped us to analyze the results of the experiments and tried to extract specifically fetal heartbeat from the raw data ('A Review of Fetal ECG Signal Processing; Issues and Promising Directions' [10], 'A robust fetal ECG detection method for abdominal recordings' [6] and 'Low-complexity R-peak detection for ambulatory fetal monitoring' [9]).

Furthermore, an interesting research was found 'Mother & fetus: The start of a relationship' [5] a core aim of which is addressed by investigating the effect of maternal fetal attachment on maternal sensitivity during the postnatal period. Findings have confirmed the developing a relationship with the fetus is critical for a successful physical and psychological adjustment to pregnancy and parenthood. Stronger feelings of attachment towards the fetus have been associated with positive health practices of the mother during pregnancy. Mothers with more positive and stronger feelings towards their fetus report more positive feelings towards their infant in the postnatal period [5].

Benchmarking

In the beginning during the *Research* phase we also wanted to know existing solutions for 'at home' fetal heartbeat monitoring in the market. That is why a brief review was performed of the existing devices for fetal heartbeat 'at home' monitoring. In particular, the *Benchmarking* included the different kind of devices with and without connection to a mobile phone.

The idea to monitor baby's heartbeat at home based context is actually not new. For expectant moms and dads, who wish to bond with their unborn baby, the market offers different kinds of dopplers, listening systems and monitors for listening to baby's heartbeat, hiccups and kicks (Figure 2). Most of them can be used already from 10-12 weeks of pregnancy. These devices use a probe to detect the high frequency sound waves produced by the baby's heart using low emission ultrasound technology.

Figure 2.
Dopplers, listening systems and monitors in the market (from left to right):
Contec Pocket Fetal Doppler, TempIR Angel Heart Fetal Doppler Baby Heartbeat Monitor,
Angelsounds Unborn Baby Heartbeat Listener, Summer Infant Heart to Heart Digital Prenatal Listening System,
Womb Music Heartbeat Baby Monitor

Some of the baby's heartbeat listeners offered by the market are connected to the special Apps on a mobile phone (Figure 3), which is actually an interface to use functions of listening to, recording and sharing of the baby's heartbeat. Moreover, some Apps of the devices, such as *Modoo* and *Baby CTG*, provide 1-on-1 consulting service from a professional medical team based on monitoring data, what gives the great possibility for expecting mothers to be always in contact with professionals just in case.

Figure 3.
Baby's heartbeat listeners offered by the market connected to a mobile phone:
Top (from left to right): Modoo, Baby CTG, Baby Doppler and Fetal Heart Rate Monitor App, Cocoon Life
Bottom (from left to right): Hatch Baby Listen, Shell Bellabeat and XinKaishi

The main findings of the *Benchmarking* show that nowadays there are plenty interactive applications and maternity products already designed (with a bit different technologies, in different shapes and colors) to allow pregnant women to monitor baby's heartbeat at home.

Since we did not want to 'reinvent the wheel', the main intention for us after this benchmark analysis during the following up *User research* phase was to investigate which value these devices – as baby's heartbeat 'representors' – actually give to pregnant women. Mostly we wanted to get somehow an answer on the question: if there is actually practical and/or

emotional component behind? We believed that it could help us in trying to come up with a new idea of the 'at home' fetal heartbeat monitoring product.

User research

After the *Literature review* and *Benchmarking* we started with the questions: How can we design a new 'smart' product that pregnant women actually want? How can we reduce the risk of getting it wrong and avoid investing in a costly flop?

The central premise of User Centered Design is that the best designed products and services result from understanding the needs of the people who will use them. That is why it was vital for us already at the beginning to use all available resources to gather information about the potential users' requirements. We understood that the most successful results we could have been achieved when the users are involved in every step of the design process either through observation, surveys, direct feedback, user testing, or informed evaluation using previously gathered information.

By following the User Centered Design process we wanted to involve our potential users at the beginning of our *Research* phase. Our intention was to dive into deep understanding of pregnant women, their pregnancy routine, more importantly, their emotions, thoughts, feelings and concerns during their pregnancy.

Interviews

Since the field that was chosen to work on is Pregnancy Care, which is quite 'delicate', while performing the *User research*, it was an attempt to use mostly informal ways to interview pregnant women. Real face-to-face interviews that were conducted looked mostly like 'coffee/tea talks', where the women could at ease share their own thoughts, feeling, emotions and concerns while being pregnant. Most of the important for us questions were asked 'on the fly'. The questions were about feelings a baby (mostly how it feels like), also about first feelings and emotions when pregnant women did the first ultrasound and could listen to the baby's heartbeat and about emotions of their partners/husbands if they could join at that moment. Some practical questions were asked participants about if they use any special pregnancy Apps, how it is helpful for them and how often they use it. We also were very interested to know if they are familiar with any existing devices in the market for fetal heartbeat 'at home' monitoring, do they have it or no, and if they do not have it, would they like to have one? It was also interesting to know if they have any favourite maternity things that they use in their pregnancy every day routine.

Some women who had just delivered their baby also were interviewed because we believed that we could get some insights from them as well, since they are still remember their pregnancy time.

In total at that time it was possible to interview and to conduct 'coffee talks' with 10 women from different countries in different ways (7 pregnant women in different stages of pregnancy and 3 who just delivered their baby within 0-12 month ago):

- Real face-to-face interviews: 2 pregnant, 1 just delivered her baby
- Skype interviews: 2 pregnant
- WhatsApp interviews: 3 pregnant, 2 just delivered their baby

At the same time to get some insights from Chinese pregnant women, 8 interviews in China were conducted from the ISHL side based on the list of the questions used for the interview described above. The questions were prepared in advance and translated into Chinese. The results from these interviews then were translated into English and were sent back from ISHL to us for analysis.

As a result, in total 18 women were interviewed – the amount of the participants that was possible to find at the moment from our side as well as from the ISHL side. To get more insights by having more women involved, a decision was made to try to get more data by launching also the *Online survey* based on the questions asked in the interviews.

Online survey

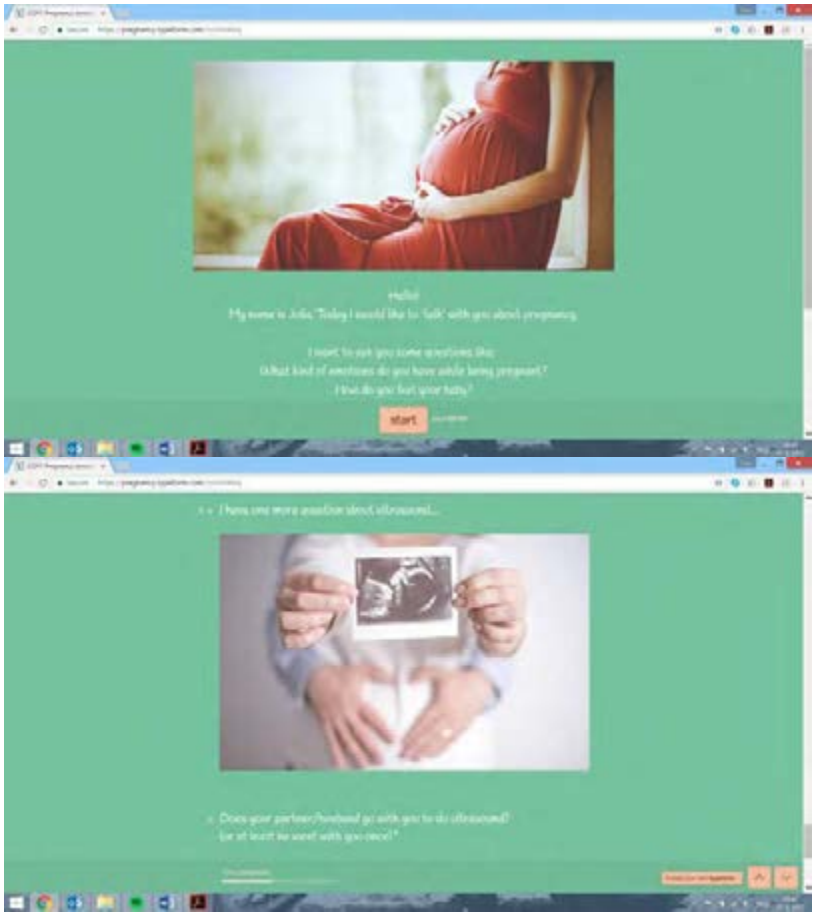

Figure 4.
Some screens from the Online survey
(The list of the questions and the screens see Appendix A)

Since during the user interviews we did not get enough data, it was an idea to create an online version of the questions. For the *Online survey* we wanted to keep an informal way of asking the questions and we wanted the survey to be like a 'conversation', to be interesting and engaging to participate in. It was possible by using for the questions friendly and personal language, different pictures while asking questions and some interactive elements.

For the *Online survey* the TypeForm platform was chosen that helps to create easy nice looking and interactive forms for different kind of surveys and questionnaires. The form for the survey was prepared from the list of the questions, which were used for the interviews described in the chapter above. In the survey participants could step by step in an interactive way answer the questions (Figure 4). (The list of the questions and the screens of the *Online survey* see Appendix A).

The initial version of the *Online survey* was prepared in English, then two more versions were prepared in Chinese and Russian languages based on the English version (see Appendix A). The Russian version was as a duplicate of the English version with literal translation of the questions, meanwhile the Chinese version should have been a bit adapted in terms of rephrasing some of the sentences, deleting couple of questions (otherwise literal translation of the questions could lead confusion) and using a bit different pictures for some questions (for example, changing the picture with a pregnancy test and changing the pictures with European pregnant to Chinese pregnant) (see Appendix A).

All 3 versions of the *Online survey* were shared as links within colleagues, relatives and friends, moreover posted in social medias and special forums for pregnant women.

It was pleasure to get first feedback about the way of conducting the survey from some participants:

> *"I really liked the tool, and the personal touch of it"*
> *"I liked the pictures and the tone of voice"*
> *"I loved the way that you made the questionnaire personal and the way we had to interact with it. It made filling in the questionnaire way more interesting"*

The approach of the both the *Interviews* and the *Online survey* named as 'User research with a specific target user group' (my own experience of reaching users in a Pregnancy Care project) was presented in the beginning of June 2017 in Berlin UXCamp Europe.

Results

The *Online survey* in 3 languages was available online for one month. After this time in total 33 responses were received:

- English version – 14
- Chinese version – 5
- Russian version – 14

Results from this *Online survey* and the *Interviews* were summarized together, since the same questions were asked and quantitative data could be merged. In total 51 women from 13 countries were involved in the *User research* phase with the age range 23-41 y.o. (see infographic in Figure 5).

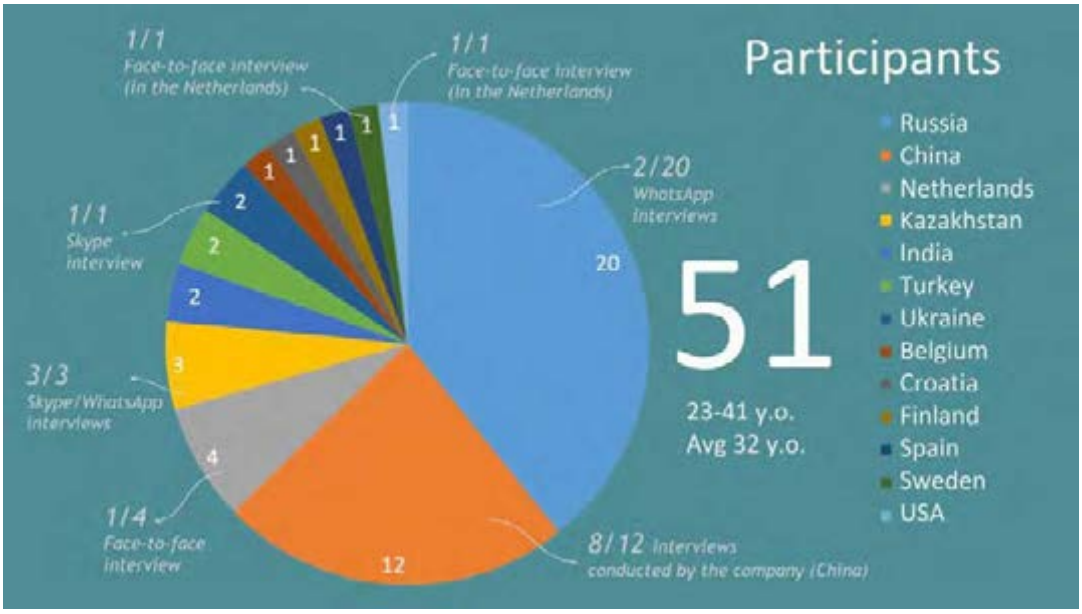

Figure 5.
Infographic: Participants involved in the User research (Interviews + Online survey)

Overall results of the *User research* gave qualitative as well as quantitative data (age, country, pregnancy stage, etc.). But a decision was made to focus on the qualitative data first and leave some quantitative data for later analysis when it will be needed. The qualitative analysis at that moment was more practical – just taking the questions and selecting remarks and quotes that we considered representative for the answers to the questions.

One of the question for the women was about how they feel their baby, mostly how it feels like. To help them a bit some metaphors were used with the pictures of the body art on pregnant women's bellies, and the participants were asked to choose one of the pictures or to describe by using other metaphors what the best represents their feelings a baby (Figure 6). At that moment we thought that the answers on this question could led us for some ideas about visualization and representation for the OUTPUT part of the product.

Figure 6.
Results on the question about feeling a baby

41/51 (80%) of the participants were truly open to express their feelings and emotions from the first ultrasound when they could listen to the heartbeat of their baby, for example:

> *"That is incredible! I still cannot believe that I'm pregnant, but I already can see heartbeat of a tiny person inside me"*
> *"A doctor allowed me to listen the heartbeat of my baby. I didn't know was it good or bad. I was listening to and subconsciously I started to cry, because I was happy"*
> *"We saw our tiny baby… and we heard the heart… That heartbeat was and still is the best music I could ever hear"*
> *"I was surprised about the speed of the heart... it was unrealistic; is this coming from my belly... it was a confirmation we are really pregnant and he is doing 'fine'"*

36/51 (71%) of the women mentioned that their partners/husbands join them to do ultrasound and could describe their emotions, for example:

> *"Till then my husband didn't realized that I was pregnant. After he saw ultrasound he was so excited and he was very happy to hear baby's heartbeat"*
> *"My husband was enthusiastic... Amazed how this little creature is developing inside of me"*

One of the partner even described his emotions by himself:

> *"It was really awesome to see the small squirt in the belly. Mostly because I have no idea of what is going on in there. So it is great to see the small bundle of cells which he started out us"*

By asking pregnant women about special Apps they use, it was find out that 32/51 (63%) of the women use different pregnancy Apps approximately several times per week. All Apps are different, but they have actually a similar idea – a detailed tracker and a pregnancy calendar that shows development of a baby week by week,

moreover, it gives regular advices and recommendations (Figure 7). The idea of showing a baby development process we could take into account further while working on the concepts for visualization in the OUTPUT part for the product.

Figure 7.
Different kind of Apps for pregnant women used by the participants from the User research

Some interesting findings we got out of the responses on a question about awareness of the existing devices for fetal heartbeat 'at home' monitoring. It was found out that only 16/51 (31%) of the participants were familiar with this kind of devices, and only 5 participants at the moment of the *User research* used it:

- 1 doppler (Finland)
- 1 Shell by Bellabeat (Croatia)
- 3 baby heartbeat monitor (China)

From those who was familiar with the devices – 6 participants mentioned that they would like to have one, from those who was not familiar – 13. As a result, 27/51 (53%) of the women expressed their opinion that they would not like to use any of these devices, because they just do not like them, the devices look medical or that the women just do not trust to these devices at all.

For the question about favourite maternity things most of the women mentioned different maternity clothes and also special maternity pillows that are really comfortable for them for sleeping and while having rest and relaxing at home (Figure 8). Some of the pregnant women mentioned also a maternity belt that helps to support their belly especially in the latest stages of the pregnancy (Figure 8). These mentioned favourite maternity things we could take into account further while thinking about the INPUT part for the product.

Figure 8.
Some pictures from the participants of their favourite maternity things

On a question about concerns while being pregnant most of the women answered that it is vital for them to be sure that the baby is doing well in the belly: *"Is the little one still doing okay?"* Especially it is essential in the situations when they do not feel movements of the baby:

> *"How is my baby doing? Is she ok? Feeling her kicking is essential"*
> *"That the baby is safe. That he is alive. If I don't feel it for a long time I get worried"*

Research conclusions

There are some important findings.

Some studies were done and plenty solutions are already exist in the market for fetal heartbeat 'at home' monitoring. As we can see from the *User research*, there is a kind of paradox: Almost all of the pregnant women mentioned that they are really excited when they can see/listen to their baby's heartbeat while doing ultrasound at the hospital (as well as their partners/husbands). But at the same time 53% participants pointed that they would not like to have any existing home based device for fetal heartbeat monitoring.

For us it was a quite crucial insight that triggered us to think about to design a product that is completely different from the devices that already exist for fetal heartbeat monitoring. But definitely it should be something that we can use as an abstract representation based on the real baby's heartbeat that will give pregnant women a real-time 'sign of life' from the baby:

> *"It's good that you get sign of life"*
> *"If he doesn't move, so the heartbeat is really nice confirm, really nice to hear if he is still ok"*

It was known only one disadvantage in advance that by taking into account the technology we use it will not work if a woman is pregnant with more than one baby, for example, twins or triplets.

At the same time we should have been considered that what we were going to design was not for medical treatment and should not be used as a substitute for regular prenatal care.

Design statement

After the *Research* phase the first version of the *Design statement* was created that supposed to help us during the following *Concepts development* phase:

Design several concepts of a tangible interface for pregnant women that allow them to feel a 'connection' with their unborn baby based on the baby's heartbeat

The findings after the *Research* phase also led to create a bit different *Design statement* by using a single sentence, according to William Newman [8]:

Design a <form of solution> to enable <users> in <context> to <perform activity> in/with <target performance>

Design a 'Smart' maternity product to enable pregnant women in home based context to monitor baby's heartbeat by themselves in a more emotional and playful way than existing maternity devices for fetal heartbeat monitoring

Later on the both versions of the design statements were used as a reference during the whole *Concepts development* and *Prototyping* phases.

Concepts development

As it was pointed before, the product we were working on supposed to be composed of two main parts:

1. INPUT part - a physical wearable/product with the pressure sensor inside to collect the data
2. OUTPUT part – a product to represent the data (that also could be a physical product or digital representation/visualization)

Some first ideas and thoughts we had already even before the *User research* phase.

First ideas

The big challenge actually was to come up first with some ideas of the INPUT part of the product that actually suits for the technology we use for the development. Some design ideas were needed about a physical product, which while using by a pregnant woman gives enough pressure between the pressure sensor and the woman's belly, that allows to collect fetal heartbeat data. At the same time we should consider some important things, such as *"sensor is required to have a size and shape that is more comfortable during daily life"* [11] and there is *"no risks of skin irritation"* from the sensor [2]. Moreover, the product should be comfortable and usable in everyday pregnancy life. For example, it should be washable, which means that the sensor needs to be easily removed when needed.

Several variants were considered while brainstorming individually about the options, such as: maternity clothes, mattress for a bed, special chair, belt, fitness ball and different kind of maternity pillows.

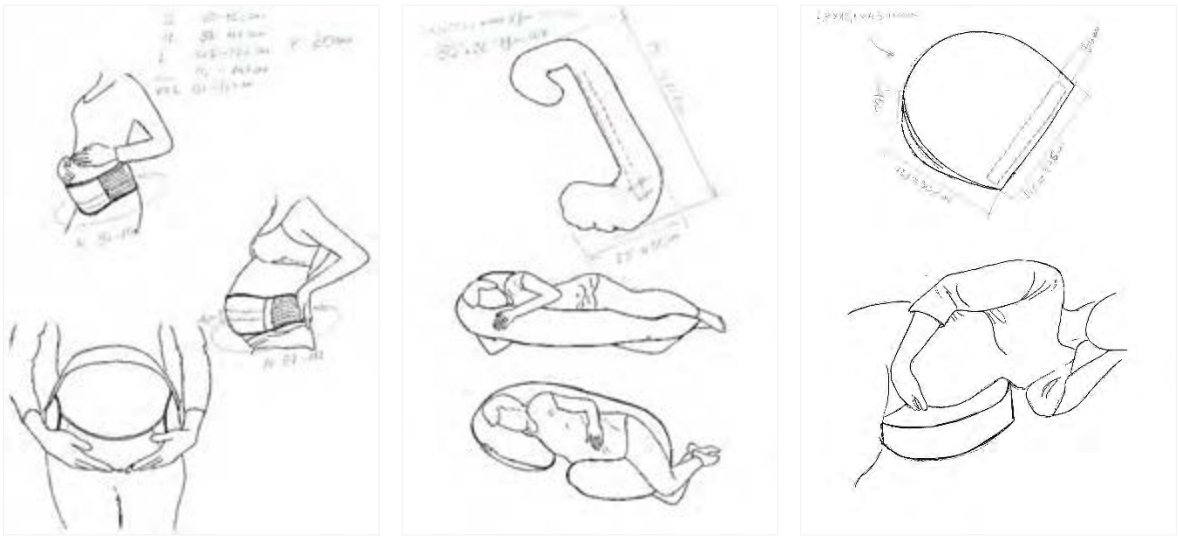

Figure 9.
First sketches of the ideas of a 'smart' belt and 'smart' maternity pillows with the pressure sensor inside

Among all the ideas maternity belt and maternity pillows looked the most promising as the INPUT and seemed to be an easy decision. First sketches were made about the ideas (Figure 9). First of all, both options supposed to give enough pressure between a belly of a pregnant

woman and the sensor inside the products. Second, these products currently already seem popular in the market (especially pillows), what was derived from the *User research* results. Thereby, the initial idea was to make existing maternity belt and pillows 'smart' by putting the pressure sensor inside for being able the products to 'read' baby's heartbeat. The pillows actually theoretically could be used also after when a baby is born (probably, looks like an idea for another branch of the current project).

While working on the ideas for the INPUT, some investigation was already made about the representation and visualization as the OUTPUT of the fetal heartbeat data.

The idea that was presented in the HEART BLOOM project by Bin Yu [12] look pretty nice, but probably for the current project it was tricky to come up with too abstract ideas, since it supposed to be for the mass market.

As about the OUTPUT for this project, at the beginning there was a thought about using a mobile phone as only a device for representation the data. The main questions were only what to visualize and how to visualize the data based on baby's heartbeat? We wanted the representation be different over time to make it more interesting and engaging for our potential users during their everyday life and not boring after couple of time of using.

At that time the two first ideas were considered as the options (Figure 10):

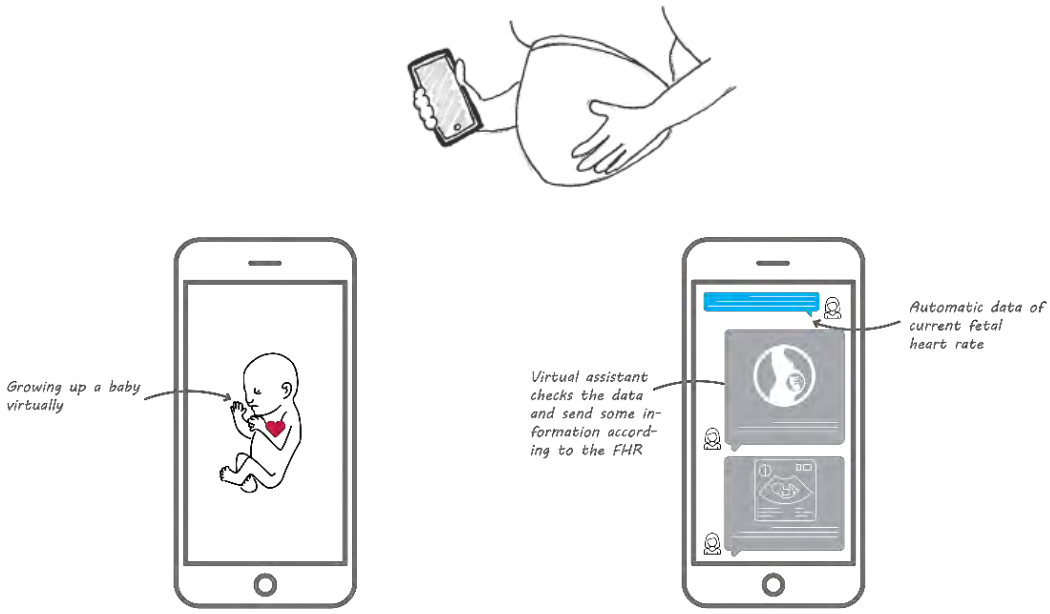

Figure 10.
First ideas for the OUTPUT: Growing baby with a heart and Virtual Assistant

Growing baby – a baby on a screen whose heart actually represents the real baby's heart and the heartbeats while the INPUT detects the real data. The baby on a phone is growing all the time as real baby growing in a belly of a pregnant woman based on the real stage of her pregnancy. The idea of the growing baby was is similar as in some existing pregnancy Apps that show the process of baby's development.

Virtual Assistant – an App that gives suggestions, advices and feedback in a form of a 'chat' from the professionals' point of view on the collected real baby's heartbeat data from the INPUT.

The first idea was trivial, but quite interesting at least to start with. The second idea was interesting as its core idea of professionals' involvement, but seemed difficult to develop.

Already at that moment we understood one of the challenge with the OUTPUT. Even though it is not a medical device, we had to think about the important questions, such as: What if the INPUT cannot detect baby's heartbeat or there is just something wrong because of whatever reasons? In that case what we are going to show in the OUTPUT and in which way?

While working on the concepts generation of the both INPUT and OUTPUT, different mood boards were created for the inspiration with the pictures of the things that might be interesting to start with: pillows, belts, 'smart' bracelets, jewelry, toys, lamps, projections on a wall, things for meditation, headphones, smart mirrors, etc. Some of the options from the mood boards looked promising, thereby they were chosen as the concepts of the product that described in the next chapter. At the time of the creating ideas for clear concepts for the INPUT and the OUTPUT we took into account that the both of them should match each other. By thinking about the OUTPUT part of the product it was essential to understand the context of using of the INPUT part first.

Concepts of the INPUT

The first ideas of the ‘smart’ version already existing maternity belts (Figure 11) and pillows (Figure 13) with the function of ‘reading’ baby’s heartbeat by using the pressure sensor inside turned into the real promising concepts. During the individual brainstorm the concepts named *’Smart’ maternity belt* and *‘Smart’ maternity pillows* were created as the ideas of a first part of the product as the INPUT for collecting the baby’s heartbeat real data. For the belt actually the shortened version of the senor was needed. Since the both concepts are based on existing things that so popular nowadays, they both looked promising for international as well as specifically for Chinese market.

1. Concept: ’Smart’ maternity belt

Figure 11.
Inspirational mood board for the INPUT Concept 1: 'Smart' maternity belt

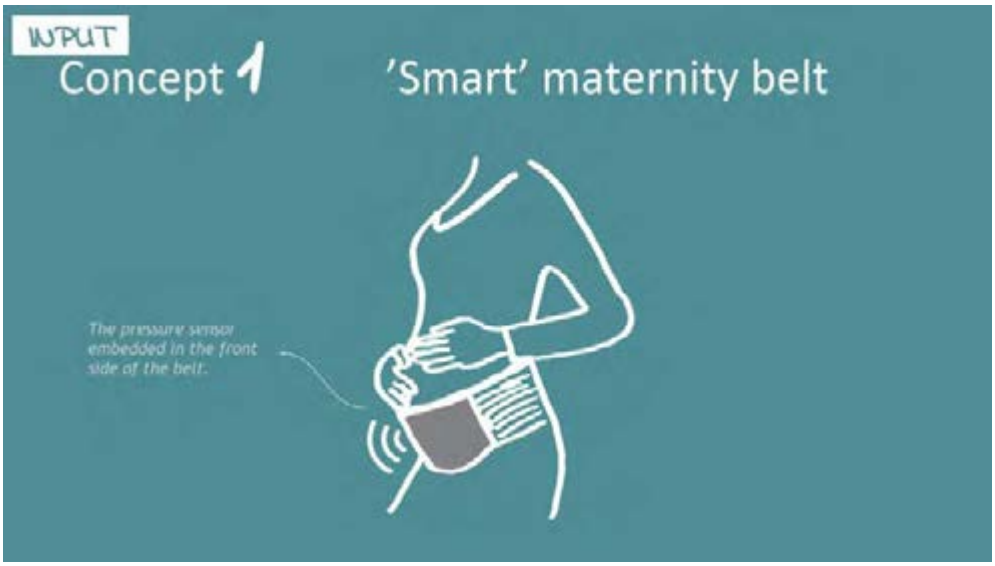

Figure 12.
Sketch for the INPUT Concept 1: 'Smart' maternity belt

2. Concept: 'Smart' maternity pillows

Figure 13.
Inspirational mood board for the INPUT Concept 2: 'Smart' maternity pillows

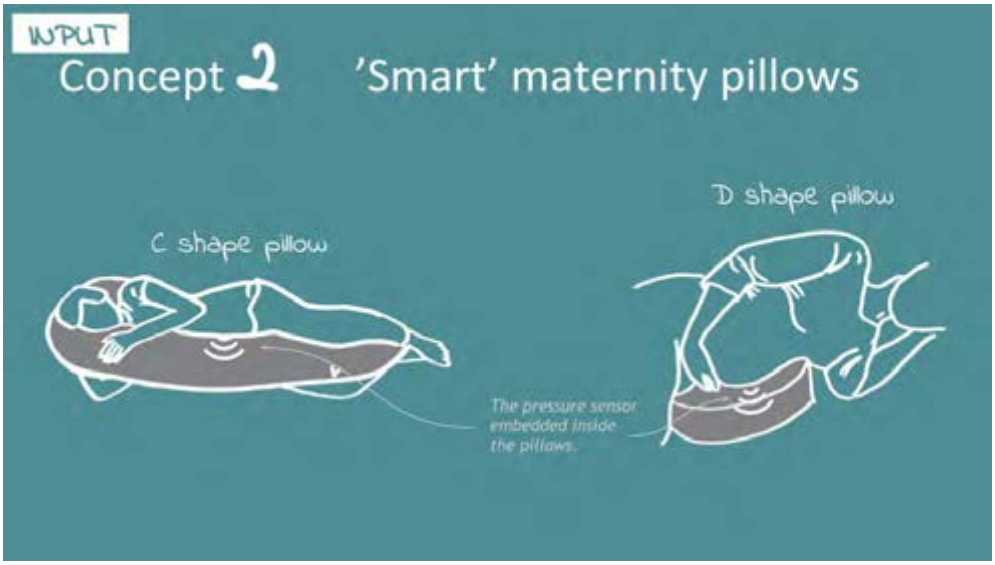

Figure 14.
Sketch for the INPUT Concept 2: 'Smart' maternity pillows

Two different shapes of the existing maternity pillows C and D shapes were chosen. This choice was made for several reasons. The C pillow nowadays is the most popular maternity pillow that was uniquely designed to follow the natural contour and shape of pregnant woman's body from head to toe, and which is perfect for sleeping and relaxing. The D pillow is compact, portable and versatile pregnancy cushion to support pregnant woman's bump, knees and back. The both pillows are different not only in their shapes and sizes, but also the materials they made from: C pillow – polyester, D pillow – foam. For the both pillows the place for the sensor was chosen by taking into account position of pregnant woman's belly (=approximate position of a fetus) when the women is using the pillows (Figure 15). We assumed these places for the sensor as the best cases to get a better signal. Definitely we needed to test further and see which pillow from which material will give us a better signal when the pressure sensor

placed inside the pillows. For the C shape pillow the sensor could fit alongside the whole pillow, but for the pillow D shape actually the shortened version of the senor was needed.

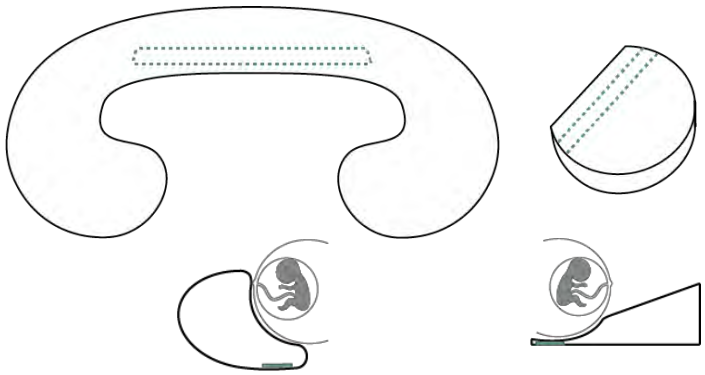

Figure 15.
Positions of the sensor inside the pillows and approximate position of pregnant woman's belly according to the position of the sensor

The presented concepts of the INPUT were discussed with ISHL. During the brainstorm session we discussed that while working on the design concepts of the product, it is very important that we consider whether the product could collect a better quality signal. At that moment some doubts arose whether the belt can collect a good signal that can be used to extract baby's heartbeat. But at the same time we realized that actually we cannot be 100% about any of the concepts before we test them by using at least prototypes. That is why we agreed to make the prototypes and to arrange so-called technical tests as soon as possible.

Concepts of the OUTPUT

As was mentioned before, to start with the ideas for the OUTPUT part of the product it was essential to understand the context of using of the INPUT part first. For example, if there is a maternity belt as the INPUT, then there is much more freedom, such as walking, sitting, standing and lying, but if there is a pillow, then probably we are talking only about lying (and not even sitting).

At the beginning it was a question raised – which kind of baby's data from the sensor we can actually track in addition with the heartbeat? A baby's heart rate is higher than adults, it usually ranges between 120 and 180 beats per minute, and meanwhile, the heart rate of adults in normal conditions is only between 60 to 100 beats per minute. Thereby it is technically possible to extract the fetus' heartbeat data by applying a special algorithm. But we also were interested in detecting specific data from a fetus, such as kicks and hiccups and use them as well for the visualization and representation in the OUPUT. Later on it was discussed that the sensor detects any movements that come from outside, but it is impossible to extract specifically fetus' kicks and hiccups from the raw data, since there is also data coming from pregnant woman's movements. Thereby the focus was only on ideas for the representation of the fetus heartbeat.

As was mentioned above, we did not want to create too abstract representation, but at the same time we also did not want to create a product that represents trivial bare numbers of

the baby's heartbeat. We wanted to come up with an idea of the product that represents 'sign of life' of a baby and gives to a pregnant woman feeling of the 'connection with a baby', as well as for other family members.

During the *Concepts development* phase while brainstorming individually several concepts named *'Smart' bracelet, 'Creature' on a phone* and *'Live' toy* were created as different ideas of a second part of the product as the OUTPUT for visualization and representation of the baby's heartbeat real data.

1. Concept: 'Smart' bracelet

For the first concept as inspiration was a mood board with some existing fancy fitness trackers for women that look like jewelry (Figure 16).

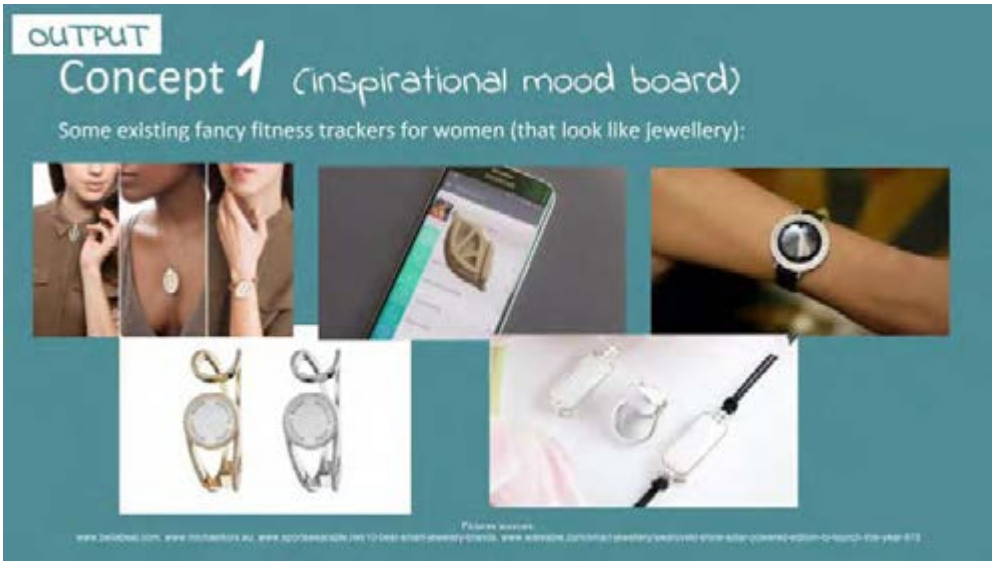

Figure 16.
Inspirational mood board for the OUTPUT Concept 1: Concept: 'Smart' bracelet

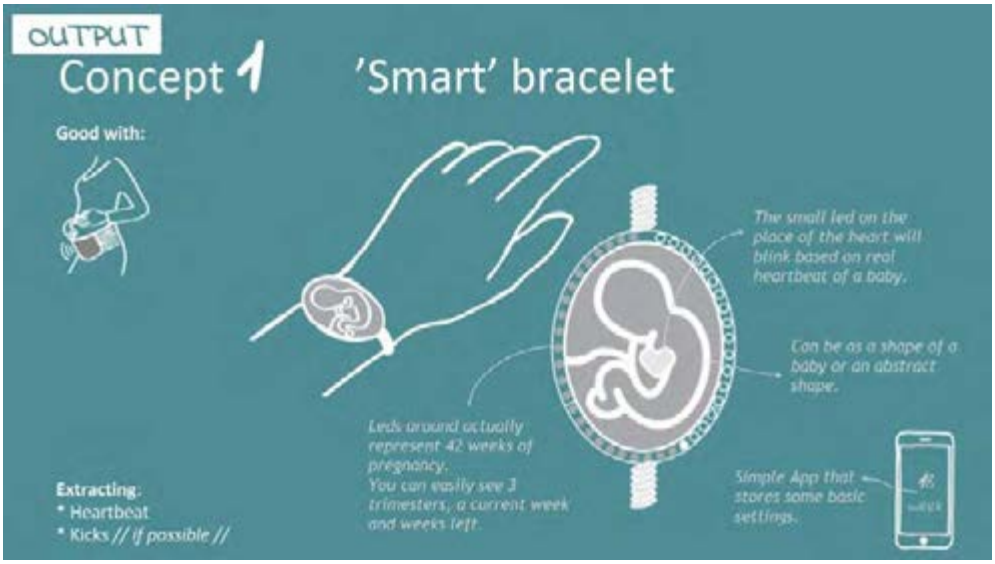

Figure 17.
Sketch for the OUTPUT Concept 1: Concept: 'Smart' bracelet

The concept was named as *'Smart' bracelet* (Figure 17). The form of the main part of the bracelet is the shape of a womb with a baby (or an abstract shape of a fetus) inside. The baby on the bracelet has a small heart that supposed to blink when the real heartbeat of a baby detected by the INPUT. If it could be technically possible and we could extract data such as kicks we could also add indicators on the baby's feet to show kicks as well. On the bracelet there are 42 indicators around the womb shape that actually represent 42 weeks of pregnancy. On the bracelet a pregnant woman can see a current week of her pregnancy and how many weeks approximately left before the birth. The inspiration specifically for the last mentioned feature was the idea of a pregnancy calendar that is used nowadays in the most of the pregnancy Apps. To be able to use this feature on the bracelet, a simple additional App is needed that can store some basic settings and collect data.

After coming up with the concept of the *'Smart' bracelet* some existing ideas of the 'smart' bracelets in Pregnancy Care were found (Figure 18):

- *Lisawatch* – a bracelet that works as an input tool for baby's kicks and the output is displayed a mobile phone App (developed in Beijing, China) [13].
- *Birthstone* – an anti-radiation healthy band smart bracelet for pregnant women.
- *Fibo bracelet* – a smart bracelet for men to feel kicks of their unborn babies (an idea from Danish startup) [14].

Pictures sources: www.lisawatch.com, www.aliexpress.com, www.firstbondwearables.wixsite.com/fibo

Figure 18.
Existing ideas of the bracelets in Pregnancy Care (from left to right): Lisawatch, Birthstone, Fibo bracelet

As we could see, our idea of the *'Smart' bracelet* was completely different from the existing ideas of the bracelets.

2. Concept: 'Creature' on a mobile phone

For the second concept as an inspiration were some beautiful pictures of the body art on pregnant women's bellies, which were used as metaphors for the question in the *Online survey* how pregnant women feel their baby (Figure 19). The answers from the participants actually led us for the current idea about visualization of a 'creature' inside a belly on a mobile phone screen. Moreover, to keep the idea of the visualization to be different over time we were inspired by the idea of the digital game 'tamagotchi' that was so popular in 90s, where creatures in the game grew up during the definite period of time (Figure 19).

Figure 19.
Inspirational mood board for the OUTPUT Concept 2: 'Creature' on a mobile phone

Figure 20.
Sketch for the OUTPUT Concept 2: 'Creature' on a mobile phone

The concept was named as *'Creature' on a mobile phone* (later on as just *Visualization on a mobile phone*). The idea was as a visual representation on a mobile phone screen a belly with a 'creature' inside (Figure 20). A pregnant women can chose representation she likes the most of feeling her baby, for example, baby, clam, fish, butterfly, flower, etc. Movements of these 'creatures' supposed to be based on the real heartbeat of a baby – fish is floating, butterfly is moving her wings, flower is moving its petals, etc. The size of the 'creatures' supposed to be changed over time based on a stage of pregnancy, thereby the 'creatures' will grow.

The concept of the abstract visualization as 'creatures' seemed to be fit to the thoughts of the one of the women from the interviews during the *User research* phase: *"There is kind of interesting idea to represent the data like flowers, kids, creatures, which somehow present wellbeing... demonstrate, that they are in a good condition"*

3. Concept: 'Live' toy

For the third concept as an inspiration was a mood board with different kind of pillows and toys of different shapes and forms, some of which have breathing, warming and lighting effects (Figure 21).

Figure 21.
Inspirational mood board for the OUTPUT Concept 3: 'Live' toy

Figure 22.
Sketch for the OUTPUT Concept 3: 'Live' toy

The concept was named as *'Live' toy*. The shape of the 'live' toy at that moment was not determined yet. It was an idea that actually came out from another idea of having only one pillow that works as the INPUT and the OUTPUT at the same time, for example, a pillow that gives haptic feedback like heartbeat or just can 'breath' based on real heartbeat of a baby. The idea seemed nice, but then it was realized that it is not possible to develop this feature in the same pillow with the pressure sensor, because in this case the sensor could not determine which data is the actual input data. Then it was an idea that as the OUTPUT, for example, in the INPUT pillow some

light effect could be used, such as blinking based on the real heartbeat of a baby. But at that moment it was not clear yet how to design it in such a way that it will be comfortable and useful for a pregnant woman to lay on the pillow and at the same time monitor the light on it. That is why the idea later on was transformed into just an idea of a second pillow or kind of a toy that represents heartbeating by using light, vibration or movements (Figure 22).

4. Other concepts

Figure 23.
Inspirational mood board for the other concepts of the OUTPUT

Some other concepts also were 'on the surface' during the *Concepts development* phase. At least a mood board (Figure 23) with different kind of lamps with projection and reflection inspired for some ideas:

- A 'music' lamp that uses as input the baby's heartbeat and then provides music/sound with beats and also lighting effects based on the real heartbeat of the baby
- A lamp that projects on the wall a picture with movements based on the real baby's heartbeat
- A thing for pregnancy meditation that uses real baby's heartbeat frequency for its lighting effects

But all the ideas, unfortunately, did not find a clear vision of the everyday context of using by pregnant women, especially by taking into account the concepts of the INPUT part of the product we already have (the belt and the pillows).

The concepts of the OUTPUT also were discussed during the brainstorm session with ISHL.

The *'Smart' bracelet* we could treat as a functional product, but the question was here only: What are advantages and disadvantages for our potential users of using a bracelet instead of

just an App as the OUTPUT? We agreed that the answer on this question we can get probably only by testing the idea with potential users. But at the same time the idea looked already promising, since nowadays this kind of wearable is becoming popular and popular as input as well as output for different kind of activities. The existing 'smart' bracelets in Pregnancy Care (Figure 18) have different directions from our idea. That is why at least it was a chance for us to try this direction to offer a new idea for the market.

From the ISHL prospective of view the digital visualization of a *'Creature' on a mobile phone* was logic and a good idea. We were discussing to do something similar like in the HEART BLOOM project by Bin Yu [12]. We could collect the data of a baby, then demonstrate the growing effect in different forms (such as flowers) by using the collected data.

ISHL expressed the feedback that the idea of the *'Live' toy* is nice, since it gives the possibility for an interaction especially for other family members, who are also interested ‘how is it going with a baby?’ and would like to 'feel' it.

As a result, a decision was made to keep the all ideas and include them in the *Prototyping* phase and then test them with potential users.

Prototyping

Prototyping of the INPUT:

To save time all INPUT prototypes were made based on existing maternity belt and maternity pillows C and D shapes. In all of the prototypes a special pocket (approximately 8 cm wide) was created as a place to put the sensor in the prototypes.

1. Prototype: 'Smart' maternity belt

The pocket for the sensor on the belt (Figure 24) was made on the side that closed to a belly when it is worn by a pregnant woman.

Figure 24.
Process of the prototyping of the belt with a pocket for the sensor

2. Prototype: 'Smart' maternity pillows

Figure 25.
Process of the prototyping of the pillows C shape (top) and D shape (bottom) with a pocket for the sensor

On the both pillows C and D shapes the pockets for the sensor were created from both sides of the pillows (Figure 25) in purpose to have two variations to put the sensor inside: on the top – closed to a belly, on the bottom – closed to a surface

where the pillows will be placed (a bed, a sofa, a couch, etc.) when a pregnant woman use it. We wanted to be able to test different positions of the sensor, since we took into account the *"the fetal signal level varies by fetal growth or the distance between [a sensor] on the maternal abdomen and the fetal heart"* [11].

Prototyping of the OUTPUT:

The prototypes of the three OUTPUT concepts *'Smart' bracelet, 'Creature' on a phone* and *'Live' toy* were made in couple of days while working on the preparation for the planned user tests with pregnant women in China (described in the *User tests planning* chapter). For the first iteration of the prototyping fake data was used as input data for visualization and representation of baby's heartbeat.

1. Prototype: 'Smart' bracelet

Since the prototyping of the *'Smart' bracelet* concept from scratch could take quite time, a decision was made to choose for the prototyping an existing smart bracelet from the market. The main requirement was for the smart bracelet is to have a screen and, more important, a platform exist to allow to prototype for this device and see prototyped screens on the device itself. Thereby, Apple Watch as a bracelet and Marvel as a tool for the prototyping were chosen.

The visuals for the screens were designed in Adobe Illustrator. First visuals were based on the sketches made for the concept of the idea – a baby/fetus with a heart in the shape of a womb which has indication around that represents 42 weeks of pregnancy (Figure 26, left). But then the visuals were adapted a bit by taking into account the guidelines for Apple Watch – background color was changed to black, a womb around was transformed into a circle around as usually any indicator of completion shown on Apple Watch (Figure 26, right).

Figure 26.
Evolution of the first screens for Apple Watch

When the screens for Apple Watch were ready, they were uploaded to a project in Marvel (Figure 27, left) and then could be seen on the Apple Watch, which was planned to be used during the user tests (Figure 27, right). To show the effect of the constant heartbeating was possible due to a prepared in advance .gif file with the heart.

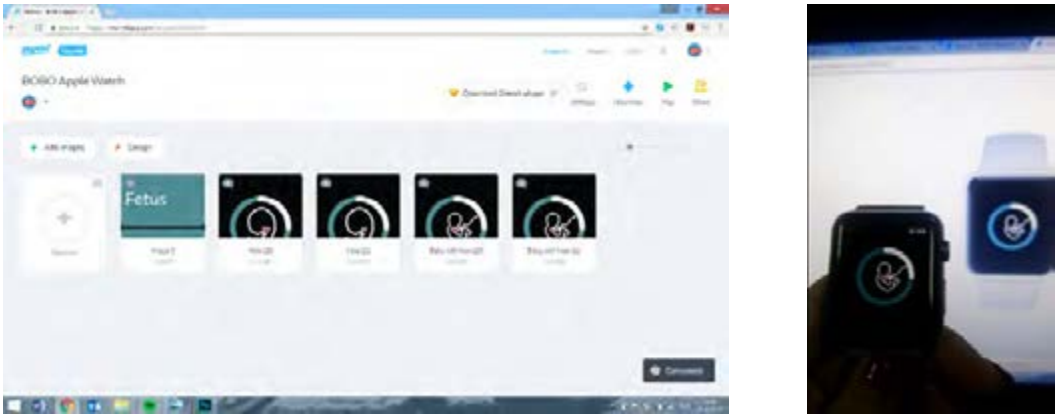

Figure 27.
Left: The prototyped screens for Apple Watch in Marvel
Right: The prototyped screen on the Apple Watch

Since prototyping for Apple watch was about digital representation, we could keep the idea of the visualization to be different over time. That is why later on, already for the video with the concepts (which was used for the *Online User tests*), more screens for the smart bracelet were designed in purpose to show different sizes of a baby on a screen based on the different stages of pregnancy (Figure 28).

Figure 28.
The screens with a baby growing over time based on the stage of pregnancy

2. Prototype: 'Creature' on a mobile phone (Visualization on a mobile phone)

The prototyping of the *'Creature' on a mobile phone (Visualization on a mobile phone)* concept also started with the preparation of the screens and different stages of 'creatures' (to design the effect of movements) in Adobe Illustrator (Figure29).

Figure 29.
First screens for the visualization on a mobile phone

For the visual on a mobile phone as an addition a logo ‘BOBOBelly’ was designed based on the logo of BOBO Technology Ltd.

The screens were uploaded also to a project in Marvel (Figure 30, left) and then could be seen on a screen of the mobile phone, which was also planned to be used during the tests with potential users (Figure 30, right). To show the effect of the movements of the ‘creatures’ on a mobile phone several .gif files were created with different stages of the ‘creatures’ replacing each other at regular intervals (Figure 29).

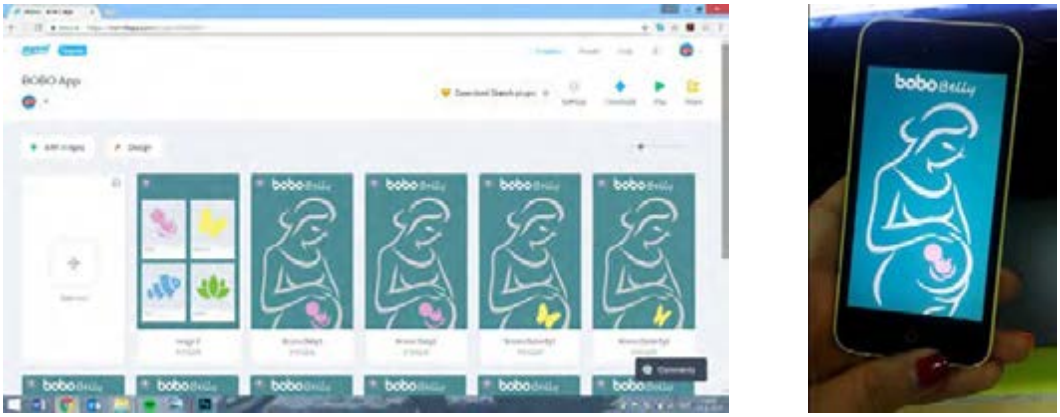

Figure 30.
Left: The prototyped screens in Marvel
Right: The prototyped screen on the mobile phone

Specifically for the video with the concepts (described in the *Online User tests* chapter) more visual screens were prepared for the visualization on a mobile phone. For the all ‘creatures’ several shapes and styles were created to represent different stages of their growing over time as well as a belly of the pregnant woman on a screen (Figure 31). For the final version of the screens the logo and visualization of the pregnant woman were changed a bit (different font of the word ‘Belly’ and long hairs for the pregnant) (Figure 31).

Figure 31.
Different stages of the growing over time ‘creatures’ on a mobile phone

3. Prototype: 'Live' toy

The concept *'Live' toy* during the *Prototyping* phase underwent changes. The first idea was to create a pillow/toy based on the textile pattern of the pillows that used as the INPUT. In this case the INPUT and the OUTPUT could intuitively match each other. A shape of a heart was considered for the pillow/toy first. An idea was to put some LEDs inside and place them accordingly to the pattern, which could blink based on frequency of the detected real heartbeat of a baby. As an addition the pillow/toy could also give a sound of heartbeat (Figure 32, top).

Two samples with embroidery were made in the Wearable Senses Lab of TU/e based on the pattern of the textile of the both pillows that were prototyped as the INPUT – blue curls for the C shape pillow and a branch with colored leaves for the D shape pillow (Figure 32, bottom).

Figure 32.
Top: The sketch of the idea of using the textile pattern of the pillows
Bottom: Embroidered samples

Later on, the embroidered samples, unfortunately, were not used for the following prototyping, because one more idea was found while thinking about a really suitable shape for the *'Live' toy*. The direction of the prototyping of the concept was changed when some photos from the maternity hospital in Hello Kitty style were found (Figure 33). The first ever Hello Kitty-themed maternity hospital has opened in Taiwan with the aim of easing the stress of childbirth with images of the popular cartoon character.

Pictures source: www.dailymail.co.uk/news/article-1092834/First-Hello-Kitty-themed-maternity-hospital-opens-Taiwan-aims-reduce-stress-childbirth.html

Figure 33.
Pictures of the Hello Kitty style maternity hospital in Taiwan

At that moment an idea was aroused that actually the theme of Hello Kitty can be used as a pattern of textile for the maternity pillows we decided to use as the INPUT part of the product. Thereby it was obvious to imagine a Hello Kitty toy with a 'live' heart as the OUTPUT part of the product (Figure 34). This idea, we assumed, could be interesting and promising for the Chinese market.

Figure 34.
Idea of using Hello Kitty pattern for the pillows as the INPUT and Hello Kitty toys with a 'live' heart as the OUTPUT

First simple prototype of the Hello Kitty toy was quickly made from foam with Arduino placed inside (Figure 35). Arduino was connected with 3 LEDs that were set on a place of the heart of the toy. A simple program code was written for the LEDs to blink as a representation of the heartbeating (see Appendix B).

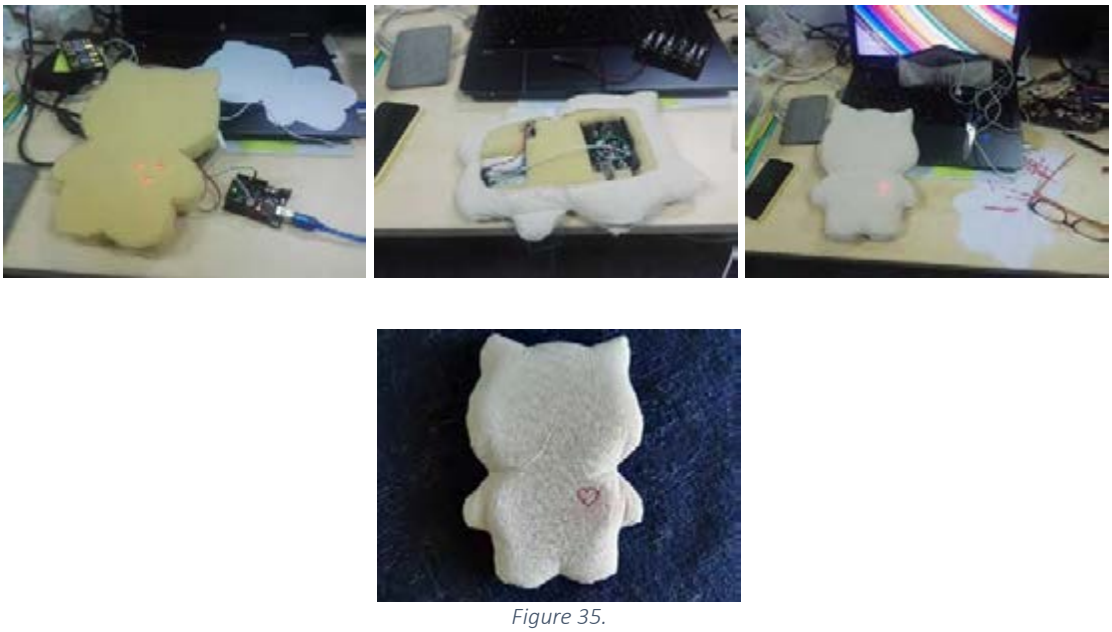

Figure 35.
Process of the prototyping and ready simple prototype of the Hello Kitty toy

Experiments

At the beginning of the project from ISHL side a set of the working sensor was expected that outputs fetus' data, such as heart rate, breathing movements and the original data (that can be used to generate a lot of other data, such as HRV), while a pregnant woman, for example, lies on a bed with the sensor under a mattress. This set of the working sensor supposed to be used for the first pilot tests of the INPUT part of the product.

Actually the system – not only the PVDF, but also Printed Circuit Board (PCB) and the software inside – developed by ISHL can generate heart rate, breathing movements, movement data and raw data. In fact, all the data listed above is derived from the raw data. After some analysis done by ISHL, it was found out that, since at that moment we did not require live data, we let the system generate the raw data and we will do other calculation offline.

First different pilot experiments were done with a prototype of the pressure sensor made by ISHL (Figure 36, left). The sensor (Figure 1, left) was covered and connected to a PCB (Figure 37) with program code written by developers from ISHL. Intention for these experiments was to collect some raw data at least from normal adults first (not pregnant women yet) and then investigate possibility to extract specifically heartbeat data.

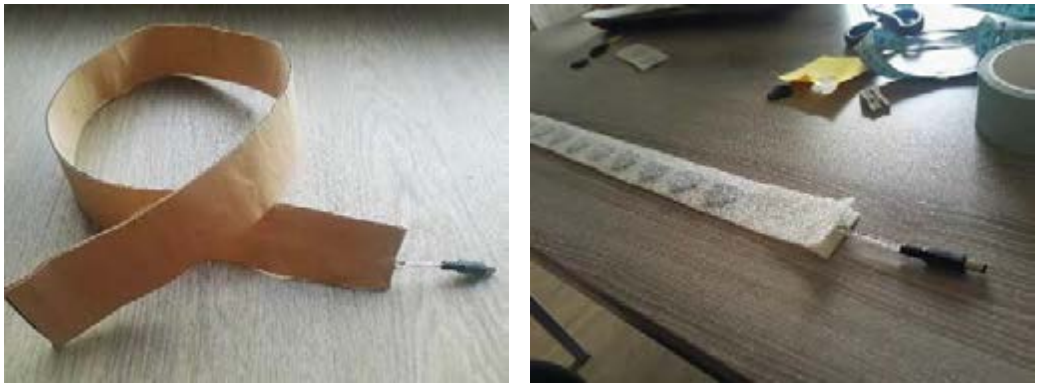

Figure 36.
Prototypes of the covered pressure sensors, which were used in the experiments

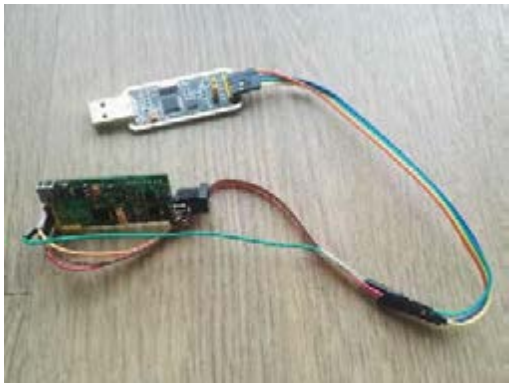

Figure 37.
PCB with program code

Figure 38.
Experiments with the sensor

The sensor (Figure 36, left) was placed under the mattress of the bed (Figure 38) and connected with a laptop to collect the data by using Processing. Some raw data was collected from participants for around 2-3 minutes during each experiment:

- One person on the bed
- Two persons on the bed (in this experiment the participants has different heart beats: one - normal, another one - high after some cardio exercises)

Each time the bpm (beats per minute) of the participants was controlled by using a smart wrist band and a finger pulse oximeter to use this data as samples to analyze the raw data later on. The purpose of the experiment with two persons on the bed was to get two different heartbeats at the same time as an attempt to simulate a situation when the sensor gets as input two heartbeats where one is normal and another one is high.

Files with the raw data from the experiments were analyzed by Dr. Lin Xu from the Electrical Engineering department of TU/e. The result for the first experiment with one person on the bed seemed pretty good (Figure 39). However, from the results of the experiment with two adults laying on the bed at the same time it was difficult to detect the heartbeat for each one.

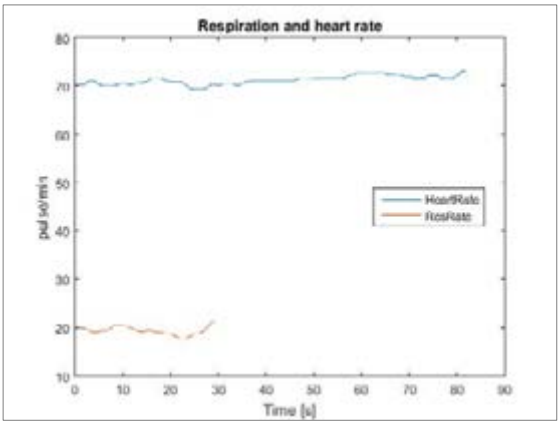

Figure 39.
Result of the experiment with one person on the bed

Later on some more experiments were performed with the same sensor and with a new sensor designed with a different cover and parts for the 'bridge' structure inside (Figure 36, right).

The raw data was collected from the both sensors while one normal adult (again not pregnant woman yet) was laying on the bed in purpose to compare quality of the signal from the both sensors. The both sensors were quite flexible to put in/out the prototypes. The sensor that gives a better quality signal supposed to be chosen for the tests of the INPUT prototypes (the belts and the pillows) with pregnant women.

Since it was not possible anyhow to simulate getting the data from pregnant women, some set of the tests with real pregnant women should have been planned. Before the planning of the tests with pregnant women, some sets of the experiments were performed with the INPUT prototypes by trying both sensors placed alternately in the pockets of the belt and the pillows C and D shapes. All prototypes were tested with a normal adult. The belt during the tests was worn just around a chest of the person. The pillows were tested while the person just laying down on them.

The analysis from Dr. Lin Xu of the raw data from the last experiments with the INPUT prototypes (that supposed to be already used with pregnant women) this time showed that the quality of the data is too bad and therefore none of the sensors could be unfortunately used for the pilot tests with pregnant women. Last time his attention was only on the results, but not on the raw data, even though the quality of the old and new data is almost the same. The reason of the problem was found out – the firmware that was loaded to the PCB was different from the one used by ISHL in Hangzhou (China). The definitions of the data package sent were different. In this case, the decoding code used for the raw data gave wrong results. This issue with the sensors caused to postpone the tests with pregnant women and perform first pilot tests with the INPUT prototypes in the ISHL's lab in Hangzhou (China) with a new set of the pressure sensors used by ISHL for their experiments.

Evaluation

As was mentioned, first pilot tests with pregnant women were planned to perform in the lab of ISHL in Hangzhou (China), where ISHL could provide the new sets of the working sensors, which can be embedded to the INPUT prototypes (the belt and the pillows C and D shapes). During the pilot tests first of all we wanted to check, which INPUT prototype gives a higher quality signal. Moreover, out intention was to get some more data for the analysis. We realized that for the tests at least 8-12 pregnant women were needed preferably in different stages of pregnancy from whom we could collect the data while asking them using the prototypes. This amount of the participants was chosen in purpose to get enough raw data for the first analysis, since as it was derived from the studies during the *Literature review*:

> *"The fetal signal level varies by fetal growth or the distance between [a sensor] on the maternal abdomen and the fetal heart" [11]*
> *"The quality of the FECG signals strongly depends on the position of the fetus inside the maternal abdomen" [2]*

Pilot tests with the INPUT prototypes

Couple of the pilot tests could be performed at the ISHL's lab with pregnant women (Figure 40 and Figure 42).

For the first pilot test only one INPUT prototype – C shape pillow – and with only one 5 month pregnant woman could be tested with a new sensor provided by ISHL.

Figure 40.
First pilot test in ISHL's lab with pregnant

The results of the first pilot test showed not good quality of the signal, because of the not completely working system of the hardware of the sensor, since ISHL was still working on its development. At that moment a decision was made to change the sensor for the tests to another already existing sensor, which ISHL uses for some experiments (Figure 41). The new sensor is flexible, but made from plastic material. This fact made the sensor impossible to put to the belt prototyped as the INPUT. This fact made the belt out of scope to use during the pilot tests, moreover, to use the belt for future development within current project as the INPUT part of the product.

Figure 41.
New sensor that was chosen for the second pilot test

Second pilot test was performed with the both pillows C and D shapes with another one 5 month pregnant woman (Figure 42). For this test the new sensor (Figure 41) was placed under the pillows.

Figure 42.
Second pilot test in ISHL's lab with pregnant

Raw data from the second pilot test was analyzed by Dr. Lin Xu (Figure 43). The result was quite positive. He analyzed peaks as harmonics of the mECG and fECG (values of the mother's heart rate and fetal heart rate respectively) on the graph shown in the Figure 43 and assumed that one of the peaks is the heart rate of the fECG (about 134 bpm). Among all datasets that were sent to Dr. Lin Xu for the analysis, the data from the C pillow prototype gave the best signal quality, although there were some motion artifacts. Dr. Lin Xu also mentioned that it would be helpful during the following tests with pregnant women to get somehow values of the mECG and fECG, which can be used as standard references for the future analysis of the raw data.

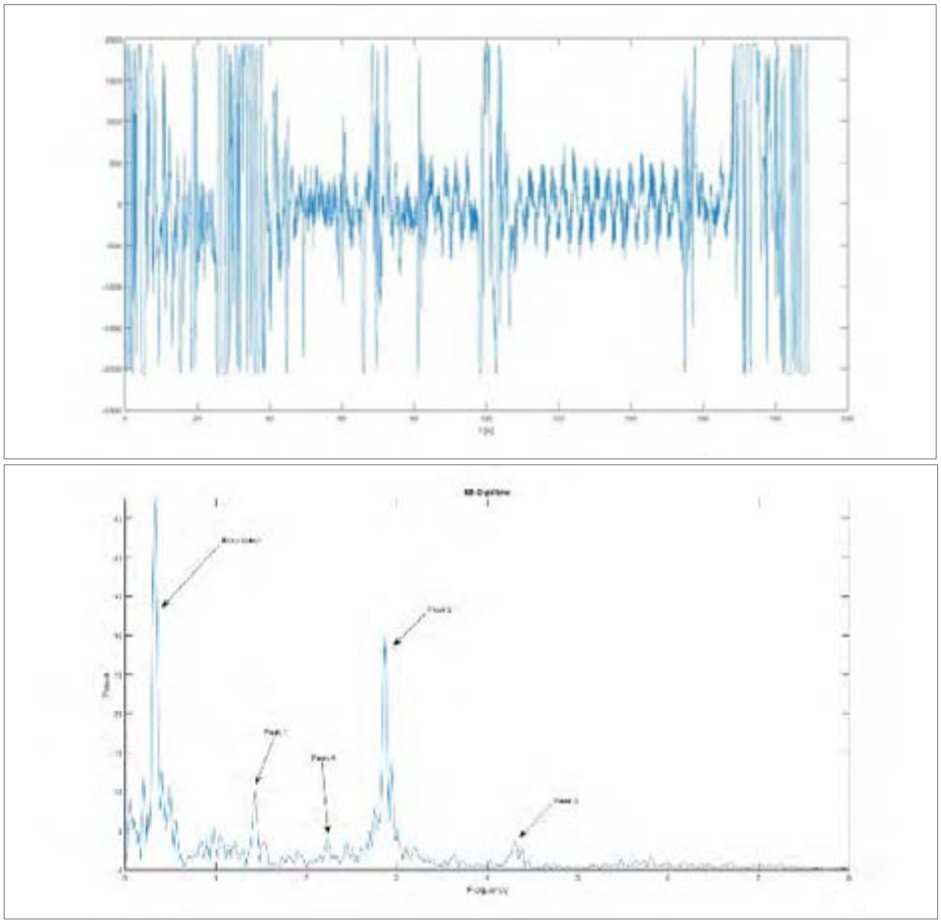

Figure 43.
Analysis of the raw data from the second pilot test with pregnant

User tests planning

Since the result of the second pilot test was promising, it showed us the possibility to continue with the analysis by performing more tests. Hence, more pregnant women were needed as participants for the tests with the pillows, from whom we could get more raw data for the analysis. At the same time the pillows could be tested from the usability prospective of view.

For the following tests, unfortunately, it was not easy to find pregnant women to participate in the tests with the prototypes. That is why a decision was made to contact maternity hospitals in Hangzhou (China), to ask them to be open for collaboration and give us possibility one day to arrange our tests with the pillows in a hospital, where a lot of pregnant women come every day.

During the preparation for the tests in a hospital, one more maternity pillow was prototyped as the INPUT based on the existing maternity pillow so-called double D shape (Figure 44).

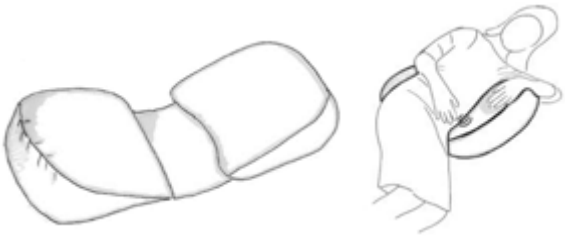

Figure 44.
Prototyping of the new INPUT – double D pillow

In this prototype a special pocket (approximately 8 cm wide) was created as a place to put the sensor in the pillow as it was done previously also for the pillows C and D shapes. The material of the inner part of the pillow was the same polyester as for the C pillow. The main difference of the new pillow from the others was the fact that the sensor could be placed perpendicularly, thereby it was a possibility to test a new condition when the sensor is getting a signal while also a lower back of a pregnant woman contacted with the sensor and not only her belly (Figure 45).

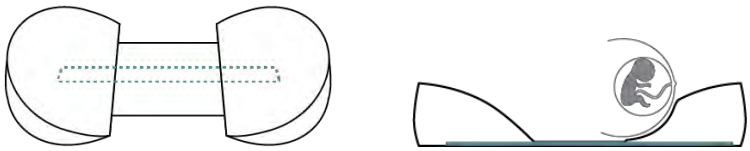

Figure 45.
Position of the sensor inside the Double D shape pillow and approximate position of a pregnant woman's belly according to the position of the sensor

As a result, for the tests 3 prototypes of the different maternity pillows were prepared, which all were designed to put in/out the pressure sensor (Figure 46). Several schemes were created, such as dimensions of the prototypes, positions of pregnant women during the tests and places for the sensor inside the prototypes (see Appendix E).

Figure 46.
All 3 prototypes of the maternity pillows prepared for the tests

For the planned tests in hospitals it was also a decision made to try to test the concepts of the OUTPUT part of the product (with the fake data first), since we could at the same time already get some insights and feedback from pregnant women about the ideas. Therefore, at that moment the simple prototypes of the OUTPUT were created in couple of days (described in the *Prototyping of the OUTPUT* chapter). As a result all OUTPUT prototypes supposed to be used with the pillows during the planned tests.

Even though the context of using of the product supposed to be completely different from hospital environment, the main intention of the tests in a hospital was to get as much raw data as possible from different pregnant women for the analysis. Theoretically it was also an additional benefit, since it seemed possible to get from doctors of the hospital data such as mECG and fECG from each pregnant woman. This data could be very helpful in our analysis of the raw data (what was mentioned by Dr. Lin Xu). Results of the tests could show us the proof or disproof of the possibility to get fetal heartbeat data by using the pressure sensor inside the maternity pillows and probably different factors that could affect on the quality of a signal.

For the communication with several maternity hospitals in Hangzhou couple of documents were prepared (Figure 47). One document was an official letter to the hospitals with explanation of the intention for the tests and what is going to be done during the tests. Some gifts were prepared for participants, which was also mentioned in the document. Another document was a questionnaire for participants. Both documents were translated into Chinese (see English versions of the documents in Appendix C).

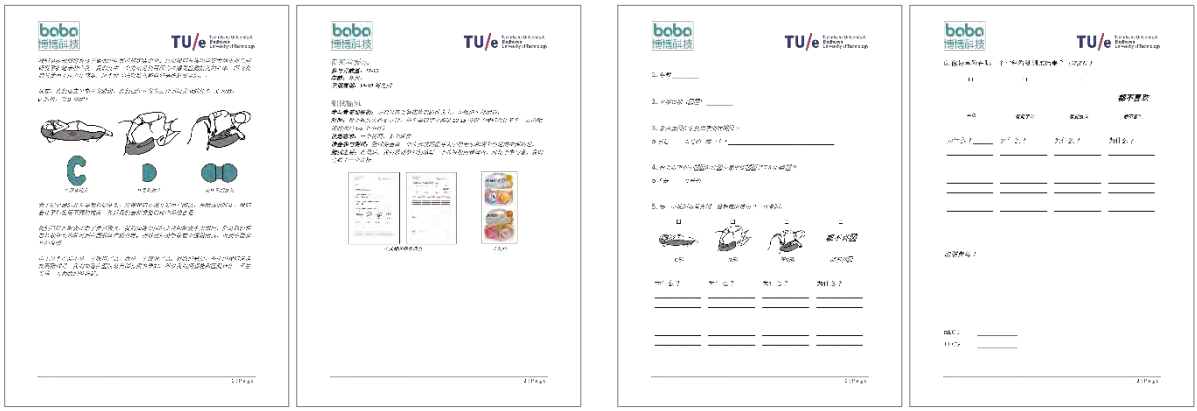

Figure 47.
Documents prepared for the tests in hospitals (see also Appendix C):
Left: Letter to hospitals
Right: Questionnaire for participants

Several hospitals were contacted in Hangzhou from the ISHL side, with which ISHL had connections before. When the hospitals realized that the prototypes for the tests with pregnant women have the sensor embedded, they assumed that it might be risky for their patients. Therefore, the hospitals asked ISHL to go for the official research process that takes up few months, which meant for us to postpone the tests with pregnant women for unknown period of time.

At the moment when we realized that it is not possible to perform the proper user tests with pregnant women for a while, we decided at least try to test already the overall idea of the

product with potential users. To do that we wanted to create and show to our users a video with the concepts and ask them in the form of an online survey to give their feedback about the ideas. This approach could help us to get already in advance insights from potential users and show more or less if the idea actually looks promising for the market in the future.

Online User tests

Since the proper tests with pregnant women were postponed for unknown period of time, the Online User tests were prepared, launched and analyzed after couple of weeks.

Process

First of all, a video with the concepts was created. The idea was to show in the video the all 3 pillows (C, D and Double D shapes) with an explanation that they are actually 'smart' version of the existing maternity pillows with the pressure sensors embedded inside that help the pillows detect baby's heartbeat (Figure 48). In the video after showing the pillows all 3 ideas of the OUPUT were shown – *'Smart' bracelet, 'Creature' on a phone* and *'Live' toy* as they were prepared (Figure 48). The idea of the *'Creature' on a phone* for the *Online User tests* was renamed to a simple *Visualization on a mobile phone*. Since it was not possible to record a video with the prototypes we made with any pregnant woman in the home context with the pillows, for the video some part of the existing videos of the maternity pillows C, D and Double D shapes were used. Thus in the video the references to the video originals were mentioned: Leachco - Snoogle® (as C pillow), Boppy® Pregnancy Wedge (as D pillow) and Boppy® Bump & Back Support Pillow (as Double D pillow).

Figure 48.
Screens of the video with the INPUT and the OUTPUT concepts

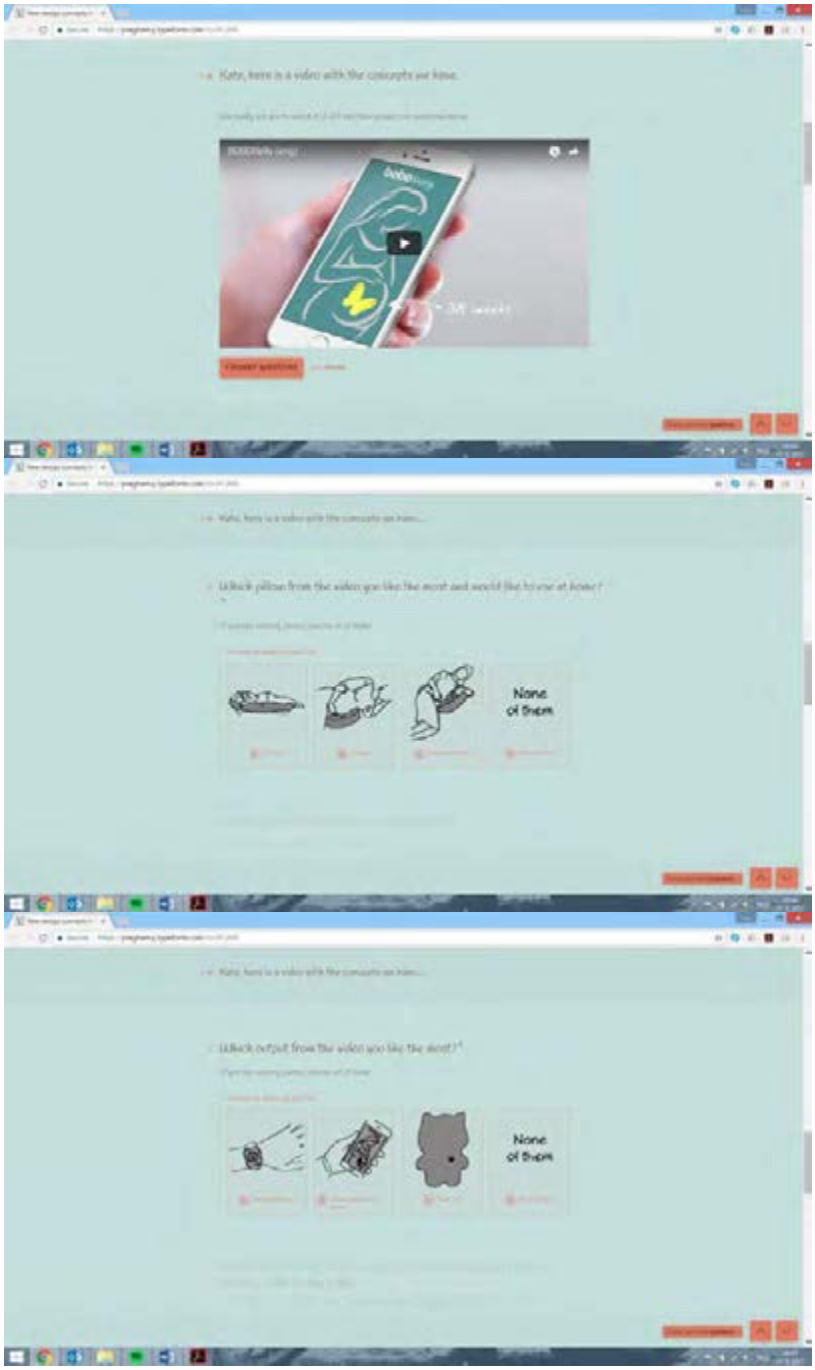

Figure 49.
Some screens from the Online survey during the Online User tests
(for the whole list of questions and screens of the Online survey see Appendix D)

When the video was ready, a short survey was created by using the same platform TypeForm (Figure 49) as was used at the beginning for the *Online survey* during the *User Research* phase. Current survey had a link to the video with the concepts and several questions according to the video, such as:

- Would the participants like to have at home a 'Smart' pillow that can 'read' baby's heartbeat?
- Which pillow from the video the participants like the most and would like to use at home?
- Which output from the video the participants like the most?

(for the whole list of questions and screens of the *Online survey* see Appendix D).

The initial version of the video and questions were prepared in English, then two more versions were prepared in Chinese and Russian languages (see Appendix D) based on the English version as it was at the beginning also for the first survey during the *User Research* phase. The both Chinese and English versions were as duplicates of the English version with literal translation of the questions. In the Chinese and Russian versions the same video was used with the same voice-over, but with the subtitles in Chinese and in Russian respectively.

All 3 versions of the *Online survey* were shared as links within colleagues, relatives and friends and posted again in social medias and special forums for pregnant. This time in the *Online survey* could participate not only pregnant women, but also women who had just delivered their baby 0-12 month ago, what was mentioned on the main page of the surveys.

Results

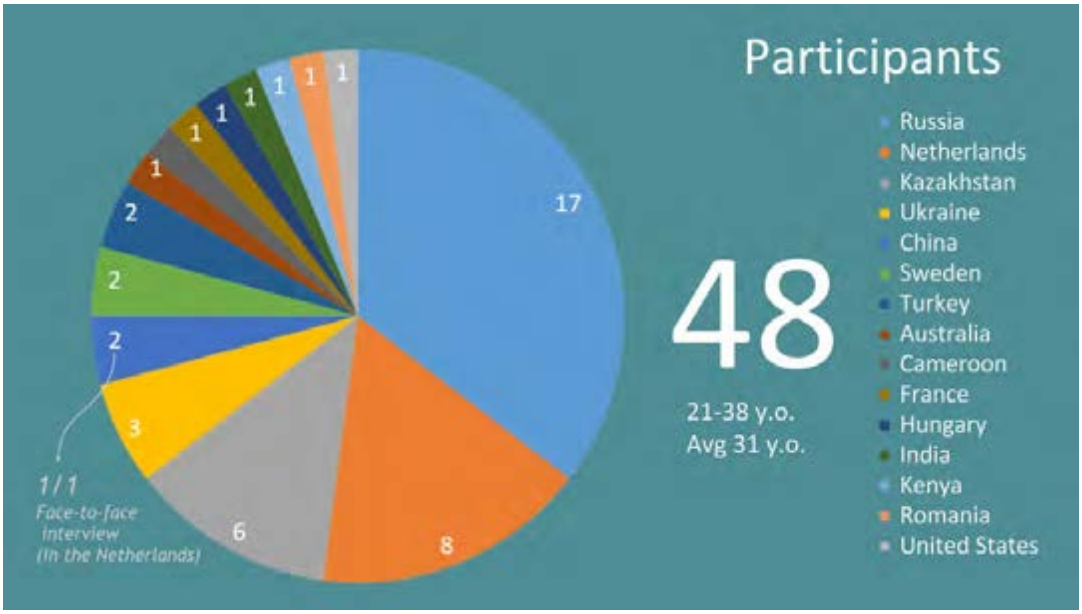

Figure 50.
Infographic: Participants involved in the Online User tests

The *Online survey* in 3 languages are still available online at the time of writing the current report (14/09/2017). After 3 weeks following amount responses were received:

- English version – 27
- Chinese version – 2
- Russian version – 19

In total 48 women from 15 countries at the time of deriving the data were involved in the *Online User tests* with the age range 21-38 y.o. (see infographic on Figure 50) in different pregnancy stages and also who had just delivered their baby:

- 1st Trimester – 4
- 2nd Trimester – 5
- 3rd Trimester – 17
- Gave birth (0-12 m.a.) – 22

It was possible to arrange a face-to-face interview with one pregnant woman, who participated in the *Online User tests* and watched the video, who could answer on the questions afterwards and share her opinions in person.

Many positive expressions from the participants about the ideas presented in the video were received, such as:

> *"It's a nice idea", "Good idea", "I like everything!", "Nice concept!"*
> *"I wished this be exist when I was pregnant!"*
> *"It takes away some fear when you don't feel your baby"*
> *"I like the idea with baby's heartbeat detection. It would be super nice to know how is my baby is doing in my belly"*

Couple of the participants pointed that the ideas are good especially for the first pregnancy:

> *"I think it will be interesting especially during the first pregnancy!"*
> *"Really good ideas, especially for those who pregnant first time and don't have experience"*

Couple of the women commented that they would prefer to have the sensor, which monitors the baby's heartbeat, not only when using the pillows:

> *"It would be great if I would have this kind of sensor always with me and not only on a horizontal position only by using the pillow"*
> *"It's pity that the sensors only in the pillows. I think that it would be good if you can monitor constantly the heartbeat of a baby. For example, a comfortable belt with the sensors for everyday usage would be good"*

The last comment was about a belt, which idea we actually had as a concept.

29/48 (60%) women mentioned that they would like to have a 'smart' pillow that can detect baby's heartbeat at home. All the participants, regardless of their answer if they would like or would not like to have a 'smart' pillow at home, could make their choice which ideas they like from the video – which pillow and which idea of the visualization/representation (Figure 51 and Figure 52).

As a result, the C pillow became a winner from the all pillows presented in the video according to the votes (36 women) (Figure 51).

Plenty of positive feedback was received about the initial idea about the 'smart' maternity pillows that can detect baby's heartbeat:

> *"I like that it is integrated in something I already use (the pillow)"*
> *"It's a good idea to create such pillows which can calm down the always worried mommy"*
> *"I love the idea of pregnancy pillow with heartbeat detector!!"*

"Awesome idea to use pillows! It's very necessary for a pregnant woman. But the greatest here that using the pillow you can not only rest, but also get a heartbeat of your baby! Very interesting!"
"I like your idea with the pillow very much. Most of the pregnant women use special pillows to sleep and rest comfortably. But if such pillows combine more functions it is even better! You don't need to purchase a number of things - you have your pillow and it is multifunctional"
"The idea of the smart pillows that can detect baby's heartbeat is very interesting! Somehow it gives you a kind of control and calm... I could listen to the heartbeat of my baby and know other things only when I was visiting my doctor. And with this new product I would know everything by myself"
"I'm using C maternity pillow even after my baby was born. Very comfortable. I'm sure that the functional pillow will be even better!"

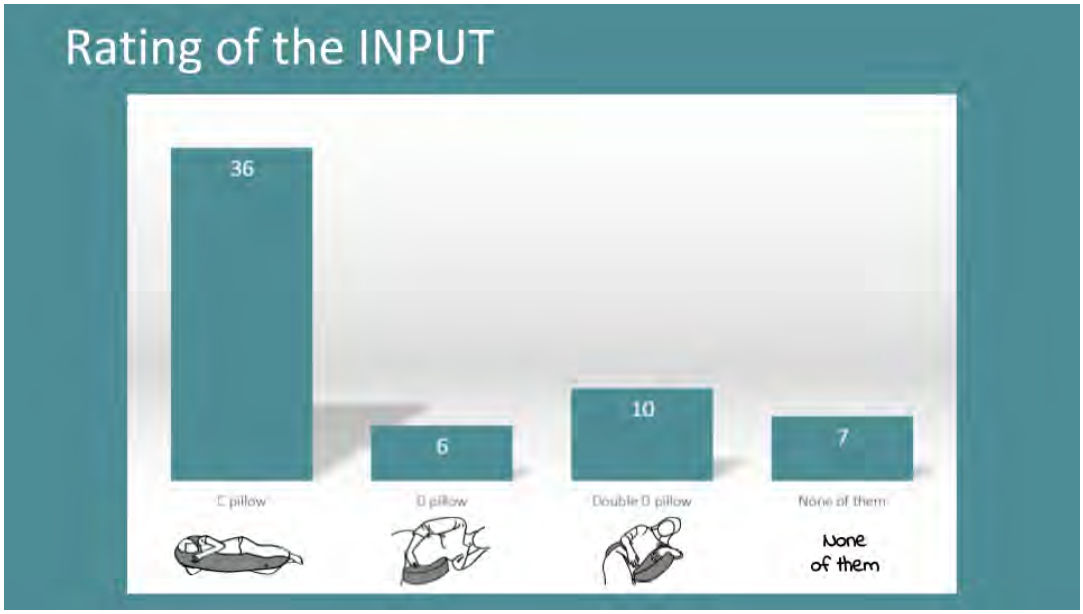

Figure 51.
Rating of the INPUT ideas

At the same time there were some participants who expressed their skeptical opinions about the ideas:

"I'm … not sure if I need such a pillow on my second half of pregnancy as I constantly feel my baby's movement so that I know that everything is OK. I would probably prefer cheaper, but non-smart pillow for my comfort"
"Why do you want to measure the heartbeat with the pillow when there are so many compact technologies present in the market? I don't see a reason why I would prefer this one over others. Moreover, it only measures the heartbeat"
"I've never felt concern over my baby's heartbeat. I trust my body is doing what it needs to do and I rely on my midwife to tell me otherwise. I think this is an unnecessary item playing into people with stressful personalities"

One of the women expressed her doubts by comparing the 'smart' pillow with a Doppler she currently uses:

"I own a doppler which can be used much earlier than the pillow (I imagine)… I cannot imagine it to be nearly as accurate as a doppler"

Also different concerns were expressed from the participants about situations if something can be wrong, what we should definitely take into account:

"I would worry if… somethings goes wrong with technology. This results in stress and that is not a good thing"

"What if something will go wrong with the system and panic will happen? I had a situation when before the labor doctors checked the heartbeat of my baby. Something went wrong with a device, all values were shown not correctly, everyone started to panic"

Different opinions were received about the ideas of the visualization/representation of the baby's heartbeat data. There were participants who liked different ideas:

"I like the idea with the bracelet"

"I prefer the smartphone as a main device to connect to the pillow"

Since in the video very simple prototypes were shown, we can assume that the visualization style might have effect on the opinion of the participants.

Couple of the women seems specifically did not like the visual and representation:

"I don't like the idea of representation as blinking butterfly/fish etc. I'd better prefer to see the baby's heartbeat rate"

"I'd like not to compare my child to an animal (fish or cat or whoever). Baby is a baby. I am waiting for Baby, not for butterfly or a flower"

"I don't like a toy… Looks like for a kinder garden"

One woman expressed the idea about representation of the baby's heartbeat in the same pillow (actually we had similar idea during the *Concepts development* phase):

"I think there is enough to have kind of indicator on the pillows C and D shapes looks like a small heart which will be beating based on your baby's heartbeat. And you don't need any additional stuff"

Some of the concerns from the participants about the idea of the *'Smart' bracelet* mostly were about the fact that it is an extra thing that they need to buy and wear, or because they just do not like it:

"I would like it to be cost efficient. I won't buy a smart watch just for this case"

"I don't really like the smart bracelet. While being pregnant for example I didn't really like anything on my wrists"

"I don't like smart watches"

"I don't wear a watch, and wouldn't want to start wearing one during pregnancy"

Among all ideas the idea of the *Visualization on a mobile phone* got the most amount of votes (31 women) (Figure 52). Most of the opinions were that it is the best idea:

"I think that the App is the best!"

"The app is the best variant!"

"For the functional inspection, I think, the mobile would be the best!"

"The phone is the most accessible for me"
"As about visualization I prefer a mobile phone. Mobile phone is always with me and no needed to buy and carry new devices"

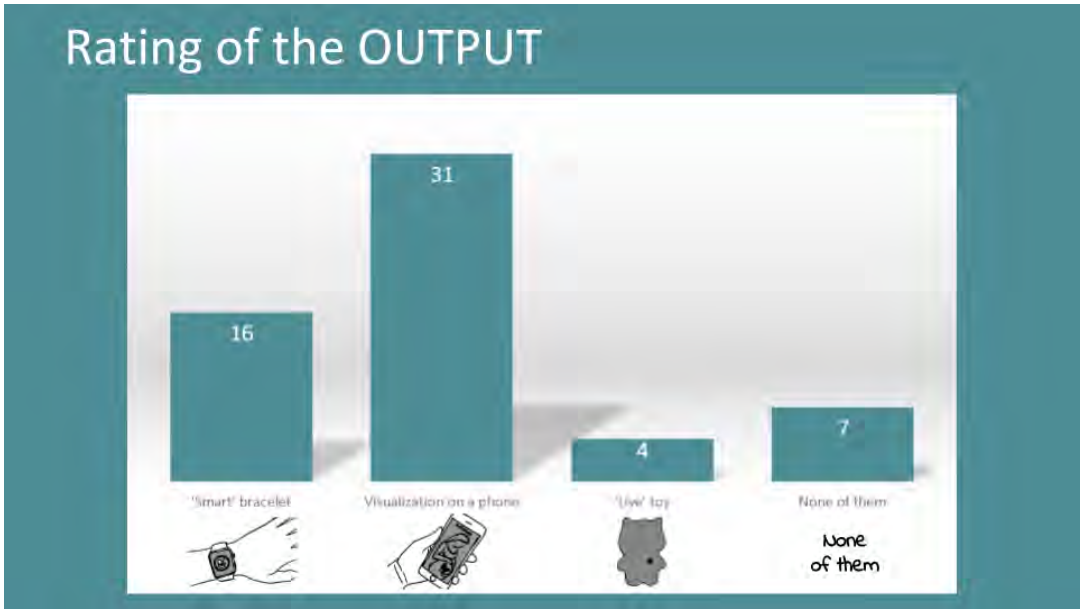

Figure 52.
Rating of the OUTPUT ideas

Only 4 women have chosen the *'Live' toy* idea. Some of them commented:
"Toy I don't mind because it is something cute and maybe useful for the baby later on?"
"The idea of the toy is cute!"
The low amount of votes for this idea could be probably because the initial idea could not be shown clear in the video and participants did not get sense that the pillows and the toy actually match each other. Or maybe the prototype was not good enough. This fact we should take into account by performing following user tests in the future.

The women, with whom a face-to-face interview was conducted, mentioned that she liked actually all ideas, but she prefers to have a mobile phone as a main device. But the bracelet and the toy could be only as additional and extra things, because the last ones *"give less data for this monitoring"*. Moreover she told that from the mobile visualization she expects more *"for example, some data or more history record"*.

It seemed that except for visualization of the heartbeat of a baby in metaphors women really want to see practical data:
"An interesting idea, but there is also needed to show information about the normal heartbeat of a baby, because a pregnant woman can have concerns about if the heartbeat of her baby is too fast or slow"
"And give more advice like… for example, I'm on the 5th month of the pregnancy… on this stage… what range of heartbeating is normal... Give me more detailed inspection and I feel more professional on this device"

One of the comment was about expecting from the OUPUT a medical suggestion based on collected data (this idea in form of a Virtual Assistant we actually had during the *Concepts development* phase):

> *"For example, the data… some medical suggestion. For example, on the late stage if the heartbeat is really quick or really slow is abnormal… it can pop out some warning or this kind of reminder 'Mother, you should be careful. Maybe you need to visit a doctor or have more rest…' Things that actually help me to protect my baby"*

Some women wanted to be able to see more data from a baby and not only heartbeat:

> *"Would be great if it can detect the hiccups and imitate the different movements also"*
> *"Also it would be nice to know if the baby is sleeping or no"*

By performing the *Online user tests* with a video with the concepts we could get preliminary feedback from the potential users if the ideas are actually attractive for them. Of course, for the real user tests women need to try the prototypes in live – check how comfortable the pillows are with the sensor inside, and at the same time test how usable the OUTPUT prototypes.

Overall, the results from the *Online User tests* are quite positive, which show that the idea of the *'Smart' maternity pillows* seem attractive for potential users. The question is only to see which product as the OUTPUT actually will be the best in the real context of using the pillows, by taking into account not only practical matters, but also possibility of playful and emotional interactions.

Conclusion and recommendations for future development

At the beginning of the project the two main goals were set. The first goal was to meet a design challenge with the question: How the product should look like? The second goal was to address the question of unscrambling of the baby's heartbeat data.

The aim of the project was to come up with the design of a new 'smart' product for pregnant women which consists two parts as the INPUT – a physical wearable/product for pregnant women with the pressure sensor inside to collect the fetal heartbeat data, and as the OUTPUT – a product to represent the fetal heartbeat data (which theoretically could be also used by other family members who is also interested 'how is it going with a baby?').

Even though the seven-month timeframe of the project was not enough to develop a ready prototype of the whole new product, we were able to come up with the concept of the *'Smart' maternity pillows* (as the INPUT) with the pressure sensors embedded and with several different concepts of representation and visualization of real data such as *'Smart' bracelet, 'Creature' on a phone (Visualization on a mobile phone)* and *'Live' toy* (as the OUTPUT). All concepts were turned into the prototypes that were ready to be tested with potential users and perhaps further developed by ISHL.

Just by using approaches as *Prototyping* and *Online User tests* by showing a video with the concepts we could quickly check the ideas with our potential users and get some positive insights and feedback from them. The results show that the main idea of making existing maternity pillows 'smart' by embedding the pressure sensor inside for baby's heartbeat monitoring looks quite attractive for our potential users. The ideas of the *'Creature' on a phone (Visualization on a mobile phone)* and *'Smart' bracelet* seem more promising for representation and visualization of the real data.

To turn the prototypes into useable devices, a series of technical tests specifically of the INPUT prototypes are needed. ISHL took a responsibility to perform all series of the technical tests needed with the INPUT prototypes in the near future. Special schemes were prepared for ISHL that explains how to perform the technical tests and how to adapt the inner materials of the pillows if needed in case of trying out to get a better signal (for example trying out the 'smart' foam as a part of the C pillow or making the D pillow completely from the 'smart' foam). The schemes include also positions of pregnant women during the tests, dimensions of the prototypes, positions for the sensor, etc. (see Appendix E).

To continue this project, first of all, long-term technical tests need to be conducted with larger number of pregnant women in different stages of pregnancy with the *'Smart' maternity pillows* prototypes in purpose to get plenty of raw data for future analysis. This analysis should include many important answers to questions, such as:

- From which stage of pregnancy the technology we use allows us to get fetal heartbeat data?
- How accurate will be measurements based on a stage of pregnancy? How does the stage of pregnancy influence the quality of a signal? From which stage of pregnancy the product can be used?

- In which ways could the prototype give a higher quality signal? How does the material of the prototype have effect on the quality of a signal? How the material of the prototype should be adapted accordingly to get a better signal?
- What is the best position of the sensor inside the pillow?
- Which specific condition for using the pillow have effect on context of using the pillow? (For example, if it is about only specific not too soft surface for the pillow, no movements and no distractions at all, otherwise the signal of the fetal heartbeat cannot be detected, in that case we might have a big challenge).
- What should be done to make technically possible to get live data and represent it at the same time (preferably wirelessly) without any delay?

The answers to these questions should give clear understanding of the capability of the sensor we use; hence, the requirements and the context of using this sensor specifically in the maternity products, which concepts were presented in this work.

Even for the technical tests it is recommended to make all the INPUT prototypes looking as much as possible like real products. For example, to use good quality textile for the pillows. Moreover, to try to embed the sensor in such a way that it will be not visible for users. It is important, since it will give more trust from the user's side during the tests. Our users are pregnant women, who worried not only about their health and also about health of their unborn baby. Even though the sensor we use is absolutely safe, anyway it might be difficult to convince pregnant women to take part in the tests if the prototypes of the pillows they need to lay on have some technical parts of the sensor visible, such as wires and board chips.

By performing the technical tests at the same time we need take into account also how comfortable are the pillows for users, since the initial idea is to create a product for home based context that supposed to be used during the everyday pregnancy routine.

It seems that theoretically even the idea of the *'Smart' belt* can be tested (which was also presented in this work, but could not be tested yet) when the flexible working pressure sensor will be available. It still can be promising to get the fetal heartbeat by being the belt with the sensor placed around a pregnant woman's belly.

Only by knowing clear answers to the important questions listed above can we be sure whether the idea of the presented 'smart' maternity product is worth further development. Only after performing all technical tests needed it should be clear which INPUT prototype works the best and can be used for the future development. Then the second part of a product for visualization and representation of the data can be implemented easily based on the concepts presented in this project, which were already preliminary tested with potential users. It is recommended that the representation and visualization can be adapted by taking into account international market and/or Chinese market. ISHL can even try to explore the OUTPUT ideas that was mentioned in the *Concepts development* phase, but did not find continuation during this project.

After all the overall concept in forms of hi-fi prototypes of the INPUT and the OUTPUT can be tested with pregnant women in the aspects of usability and implementation before starting actual development for the market.

For any future analysis of the direction, which was chosen for the project, ISHL can use the quantitative data from the results of the *User research* performed during the *Research* phase of the project and also from the results of the *Online User tests*. If needed ISHL can also perform the online user research and online user tests one more time by using the same versions of the surveys or adapt them a bit for new purposes.

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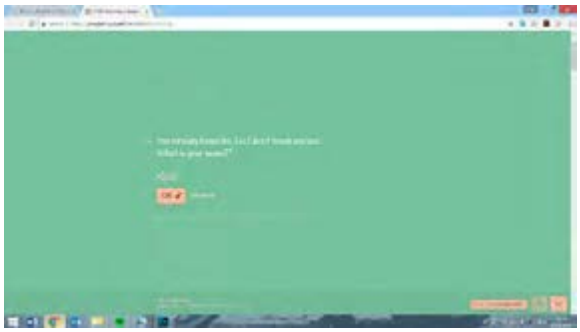
Appendices

Appendix A

Screens and text of the *Online survey* during the *User research* phase.
(Text for the Chinese and Russian versions can be find below the English version).

Screen	English text
	*Pregnancy (emotions, thoughts, feelings)* Hello! My name is Julia. Today I would like to 'talk' with you about pregnancy. I want to ask you some questions like: What kind of emotions do you have while being pregnant? How do you feel your baby? How were your emotions after the first ultrasound? What are your favourite things for pregnant? etc. Your answers will help me a lot to understand how it is for you to be pregnant. *(It will take approximately 10-15 minutes)* *I'm asking this, because currently I'm working on the design of a new thing that will help women during pregnancy.*
	1. You already know me, but I don't know you yet. What is your name?

2. *NAME*, on which stage of pregnancy are you?

1st Trimester
2nd Trimester
3rd Trimester

3. You are pregnant _ time

First
Second
Other

4. *NAME*, let's 'mentally' come back to the moment when you first time realized that you are pregnant...

For the Chinese version a picture was different:

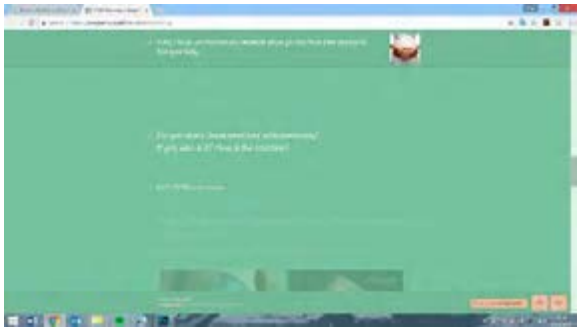
4a. What first came to your mind? Describe, please, your thoughts, emotions and feelings at that moment.

4b. Did you share these first emotions with somebody?
If yes, who was it? How was the reaction?

5. *NAME*, I hope you remember a moment when you the first time started to feel your baby...

5a. How was it? How it felt like?
Which thoughts, emotions and feelings did you have at that moment?

5b. Did these feelings change over time?
What are your emotions now when you feel your baby (when it is moving or kicking)?



5c. Do you share these emotions with somebody?
If yes, who is it? How is the reaction?

5d. Please, choose one of the pictures that the best represents how do you feel your baby now:

(All pictures are from www.daizydesign.com, all rights reserved Daizy Design Face Painting)

6. *NAME*, could you please describe what 'connection with a baby' during pregnancy means for you?

(for example, by meditating, talking to, listening to music together... or just singing songs or reading books for your baby... etc.)

7. *NAME*, let's talk about your impression when you first time did ultrasound...

7a. Did a doctor show you heartbeat of your baby?

Yes *logic jump -> 7b*
No *logic jump -> 8*

7b. Could you listen to it?

Yes *logic jump -> 7c*
No *logic jump -> 8*

7c. How was it?
What did you feel at that moment?

8. I have one more question about ultrasound...

8a. Does your partner/husband go with you to do ultrasound?
(or at least he went with you once)

Yes *logic jump -> 8c*
No *logic jump -> 8b*

8b. Do you share pictures and your feelings with your partner/husband after ultrasound?

Yes *logic jump -> 8c*
No *logic jump -> 9*

8c. I'm interested which kind of emotions he has at that moment.
What is his reaction?

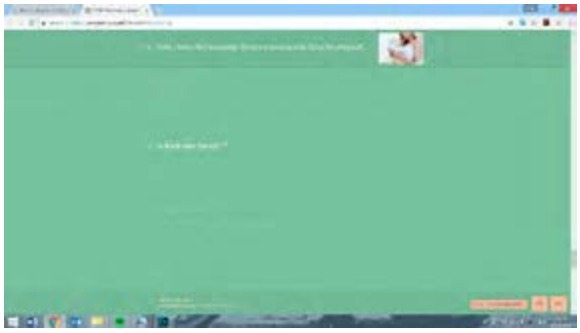
If possible, it would be nice if your partner/husband can answer this question by himself :)

9. *NAME*, I know that nowadays there are some special Apps for pregnant...

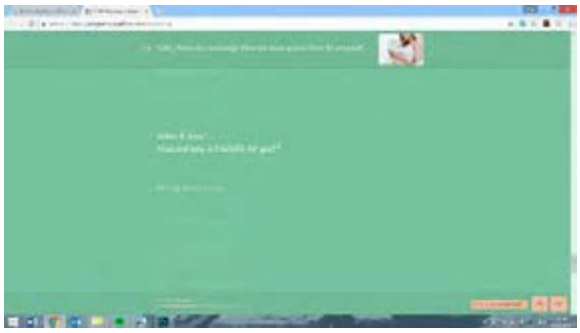
For the Chinese version a picture was different:

9a. Do you use any special App for pregnant?

Yes *logic jump -> 9b*
No *logic jump -> 10*



9b. Which one (ones)?



9c. What it does?
How and why is it helpful for you?

9d. How often do you use it?

Several times per day
Once per day
Several times per week
Once per week
Several times per month
Ones per month

10. Moreover, I know that there are also some devices that you can just use at home and that can measure and allow you to see, hear and even record heartbeat of your baby...

10a. Are you familiar with these kind of devices?

Yes *logic jump -> 10b*
No *logic jump -> 10f*

10b. Do you currently have some of them?

Yes *logic jump -> 10c*
No *logic jump -> 10f*

10c. Which one (ones)?

10d. Why, where and when do you use it?

10e. How often do you use it?

Several times per day
Once per day
Several times per week
Once per week
Several times per month
Ones per month
logic jump -> 11

10f. Would you like to have one (ones)?

Yes *logic jump -> 10g*
No *logic jump -> 11*

10g. Which one (ones)?

10h. How often would you like to use it?

Several times per day
Once per day
Several times per week
Once per week
Several times per month
Ones per month

11. *NAME*, could you please describe any your concerns while being pregnant? What are your concerns mostly about?

For the Chinese version a picture was different:

12. *NAME*, let's have a look at your favourite things that you really like to use while you are pregnant...

12a. Do you have something special for pregnant that you really like?

(like special maternity clothes, pillows, belts, etc.)

Yes *logic jump -> 12b*
No *logic jump -> 13*

12b. What is it?

12c. If possible, could you please upload a picture of this favourite thing (things)?

12d. Why do you like it?

12e. How often do you use it?

Several times per day
Once per day
Several times per week
Once per week
Several times per month
Ones per month

13. *NAME*, I would like to know your age.
How old are you?

14. And the last question :)
Where are you from?

15. *NAME*, that's it for now :)
You can ask me any additional questions or share something more with me just by sending an email to:
lebedeva.iuliia@gmail.com

Or feel free just in case to share your email (optional):

(I promise, I will not spam you)

NAME, thank you a lot for your time :)

I really appreciate that you could participate in this informal virtual 'talk' with me.
I wish you all the best to you and your baby.
Take care!

Text for the Chinese and Russian versions of the *Online survey (User research)*:

Chinese text	Russian text
关于孕期的情绪和感受 您好！我的名字叫尤莉亚，来自荷兰，今天我想和您谈谈孕期的那些事。 我希望您可以分享一些和怀孕相关的事情，比如和怀孕前相比怀孕时，您的情绪和感觉有哪些变化。 *(我现在在设计一个能够帮助女性孕期的产品 大概需要您花 10-15 分钟的时间来完成这份问卷 谢谢！)*	*Беременность (эмоции, мысли, чувства)* Здравствуйте! Меня зовут Юлия. Мне бы хотелось "поговорить" с вами о беременности. Меня интересует несколько вопросов, таких как: Какие эмоции вы испытываете на протяжении беременности? Как вы чувствуете своего малыша? Какими были ваши эмоции после первого УЗИ? Есть ли у вас что-то особо любимое для беременных? и т.д. Ваши ответы помогут мне понять каково это для вас быть беременной. *(Это займет примерно 10-15 минут)* *Я интересуюсь всем этим, потому что в настоящее время я провожу исследование для одного их своих проектов. Я работаю над дизайном новой вещи, которая, я надеюсь, будет интересна и полезна в использовании во время беременности.*
1. 请问您的名字是？	1. Я уже представилась. Но я до сих пор не знаю как вас зовут. Как ваше имя?
2. *NAME*, 您怀孕多久了? 12 周以内(孕早期) 13 – 27 周(孕中期) 28 周以后(孕晚期)	2. *NAME*, на каком сроке беременности вы в данный момент? 1й Триместр 2й Триместр 3й Триместр
3. 这是您第_次怀孕？ 第一次 第二次 其他	3. Вы беременны _ раз Первый Второй Другое
4. 让我们回忆一下您发现自己怀孕的那一刻	4. *NAME*, хочется мысленно вернуться к моменту, когда вы первый раз обнаружили, что беременны...
4a. 您当时的表现/想法？ 请描述一下您当时的想法与感受	4a. Что первое промелькнуло в голове? Опишите, пожалуйста, свои мысли, эмоции и чувства в тот момент.
4b. 您有没有和其他人分享您的感受，如果有，是谁？	4b. Поделились ли вы с кем-то этими первыми эмоциями?

他(她)当时的反应是怎样的？	Если да, кто это был? И как человек отреагировал?
5. *NAME*, 您是否还记得您第一次感觉到您宝宝的那一刻	5. *NAME*, я надеюсь, вы помните тот момент, когда первый раз почувствовали, что в животике что-то происходит...
5a. 这种感觉是怎样的 您当时的心情是怎样的？	5a. Как это было? На что это похоже? Какие мысли, эмоции и чувства были в тот момент?
5b. 这些感觉是否随这时间的变化而变化 ？ 当您感觉到宝宝在动或者踢您的时候您的情绪是怎样的？	5b. Изменились ли эти ощущения с течением времени? Какие эмоции вы испытываете сейчас, когда чувствуете своего малыша (когда он шевелится и пр.)?
5c. 您有没有和其他人分享您的感受，如果有，是谁？ 他(她)当时是的反应是怎样的？	5c. Делитесь ли вы с кем-то этими ощущениями? Если да, кто это? И как человек реагирует?
5d. 如果让您从下面选择一张图片，哪一张最贴近您想象中肚里宝宝的样子？ *（图片源于www.daizydesign.com，图片保留所有权）*	5d. Пожалуйста, выберите одну из картинок, которая наиболее близко отображает, как вы чувствуете своего малыша сейчас: *(Фотографии с сайта www.daizydesign.com, все права защищены Daizy Design Face Painting)*
6. 您可以描述一下在您怀孕的时候，有没有想过如何给宝宝 "胎教"？ *（胎教的方法包括：冥想，和宝宝聊天，和宝宝一起听音乐，或者给宝宝唱歌或读书给宝宝听）*	6. *NAME*, можете ли вы описать, пожалуйста, что для вас значит "контакт с малышом" пока вы беременны? *(например, вы медитируете, разговариваете с малышом, слушаете музыку... или поёте ему песни или читаете книги... и т.д.)*
7. 让我们聊一下您第一次做 B 超时候的印象？	7. *NAME*, мне хочется узнать о вашем впечатлении от первого УЗИ...
7a. 医生有没有给您听宝宝的心跳？ 是 *-> 7b* 否 *-> 8*	7a. Показывал ли вам доктор сердцебиение малыша? Да *-> 7b* Нет *-> 8*
7b. 您能听到吗？ 是 *-> 7c* 否 *-> 8*	7b. Могли ли вы его послушать? Да *-> 7c* Нет *-> 8*
7c. 心跳是怎样的，您的感觉是怎样的？	7c. Как это было? Какие чувства были в тот момент?
8. 关于做 B 超，我还有一个问题：	8. И еще один ворос об УЗИ...
8a. 您的爱人有没有和您一起去做过 B 超（至少和您一起去过一次）？ 是 *-> 8c* 否 *-> 8b*	8a. Ходит ли будущий отец малыша с вами на УЗИ? (или как минимум был с вами один раз) Да *-> 8c* Нет *-> 8b*

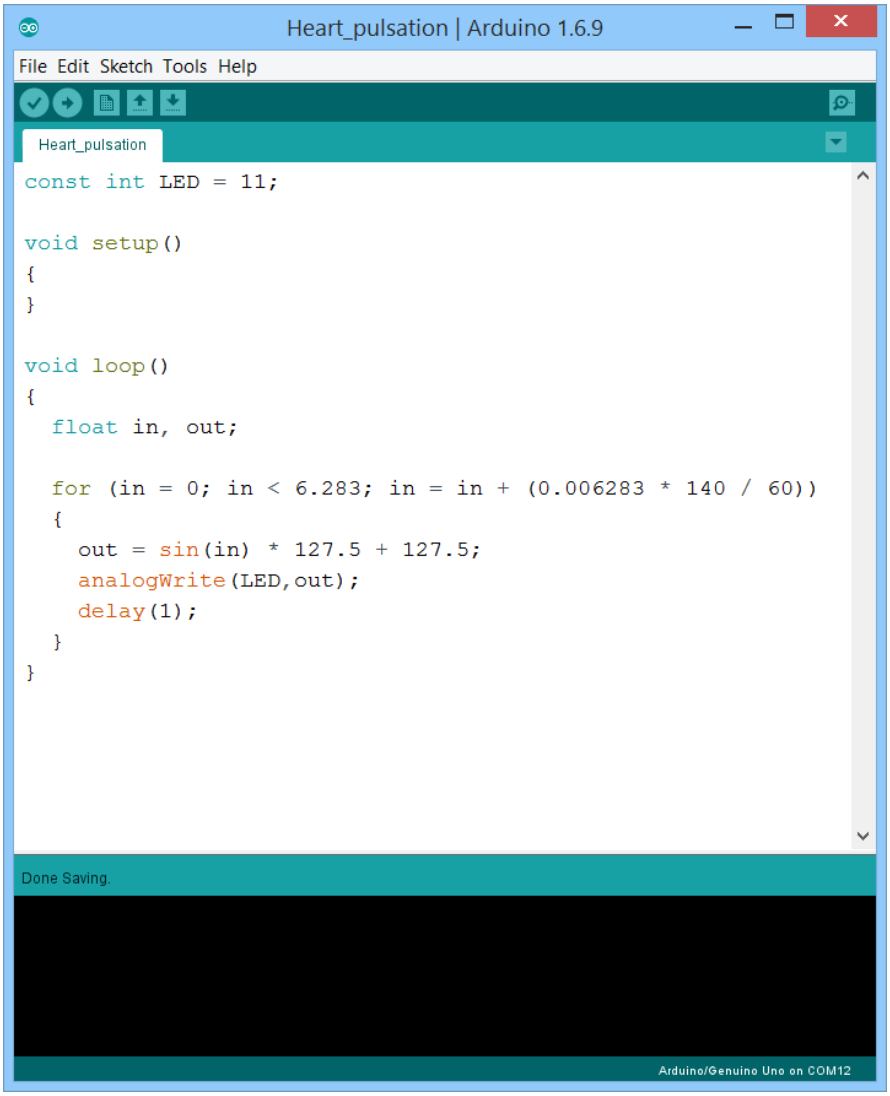
8b. 您有没有分享宝宝 B 超的照片和您自己的感觉给您的爱人？ 是 *-> 8c* 否 *-> 9*	8b. Делитесь ли вы с будущим отцом малыша фотографиями (если вам распечатывают) и вашими эмоциями после УЗИ? Да *-> 8c* Нет *-> 9*
8c. 您爱人当时是什么感受？ 他当时的反应是怎样的？ *（如果可以，希望您爱人能回答这个问题）*	8c. Мне очень интересно, какие эмоции он испытывает в данный момент. Какова его реакция? *Если это возможно, было бы замечательно, если будущий отец малыша может сам ответить на этот ворос :)*
9. *NAME*, 现在有很多和怀孕相关的 App (应用)	9. *NAME*, я знаю, что сейчас существует безумное множество мобильных приложений для беременных...
9a. 您有没有使用其中的一些 App？ 是 *-> 9b* 否 *-> 10*	9a. Пользуетесь ли вы каким-либо из них? Да *logic jump -> 9b* Нет *logic jump -> 10*
9b. 哪些 App？	9b. Каким(и)?
9c. 有些什么功能 为什么这些功能对您有帮助？	9c. Что в нём? Почему оно полезно для вас?
9d. 您经常使用这些 App 吗？ 天几次 天一次 个星期几次 个星期一次 个月几次 个月一次	9d. Как часто вы им пользуетесь? Несколько раз в день Один раз в день Несколько раз в неделю Один раз в неделю Несколько раз в месяц Один раз в месяц
10. 另外， 现在有一些家用的智能硬件可以帮助您看到，听到或者记录宝宝的心跳？	10. Более того, я слышала, что сейчас есть ещё и специальные приспособления, которые позволяют вам в домашних условиях :) измерять, видеть, слышать и даже записывать сердцебиение малышей в животике...
10a. 您对这些设备熟悉吗？ 是 *-> 10b* 否 *-> 10f*	10a. Знакомы ли вам подобные приспособления? Да *-> 10b* Нет *-> 10f*
10b. 您现在有使用其中的一些设备吗？ 是 *-> 10c* 否 *-> 10f*	10b. Пользуетесь ли вы в данный момент каким-либо из них? Да *-> 10c* Нет *-> 10f*
10c. 哪一种？	10c. Каким(и)?
10d. 您为什么会用这个设备？ 您在什么时间，什么场合会用这个设备？	10d. Почему, где и когда вы им пользуетесь?

10e. 您多久用一次这个设备？ 天几次 天一次 个星期几次 个星期一次 个月几次 个月一次 *-> 11*	10e. Как часто вы им пользуетесь? Несколько раз в день Один раз в день Несколько раз в неделю Один раз в неделю Несколько раз в месяц Один раз в месяц *-> 11*
10f. 您是否希望有一个/几个这样的设备？ 是 *-> 10g* 否 *-> 11*	10f. Хотелось бы вам иметь что-то подобное у себя дома? Да *-> 10g* Нет *-> 11*
10g. 哪一个/哪几个？	10g. Какое (какие)?
10h. 您想多久使用一次？ 天几次 天一次 个星期几次 个星期一次 个月几次 个月一次	10h. Как часто вы бы им пользовались? Несколько раз в день Один раз в день Несколько раз в неделю Один раз в неделю Несколько раз в месяц Один раз в месяц
11. 您可以描述一下您怀孕时候的顾虑吗？ 您最担心的是什么？	11. *NAME*, можете ли вы описать любые ваши переживания во время беременности? О чём они?
12. 让我们看一下您怀孕的时候最喜欢用的一些东西	12. *NAME*, мне безумно интересно узнать о ваших любимых вещах для беременных...
12a. 您有没有一些您特别喜欢的，专门给孕妇用的东西？ *（比如，孕妇衣服，枕头，带子）* 是 *-> 12b* 否 *-> 13*	12a. Есть ли у вас что-то особенно любимое из вещей для беременных? *(например, специальная одежда, подушки, пояса, и т.д.)* Да *-> 12b* Нет *-> 13*
12b. 是什么？	12b. Что это?
12c. 您可以上传一张它的照片吗？	12c. Если возможно, можете ли сделать фотографию этой любимой вещи (или нескольких вещей) и прикрепить её сюда?
12d. 为什么你觉得它好用？	12d. Почему вам это нравится?
12e. 您多久用一次？ 天几次 天一次 个星期几次	12e. Как часто вы этим пользуетесь? Несколько раз в день Один раз в день Несколько раз в неделю Один раз в неделю

个星期一次 个月几次 个月一次	Несколько раз в месяц Один раз в месяц
13. *NAME*, 您今年几岁？	13. *NAME*, мне бы очень хотелось узнать ваш возраст.
14. *Country (the question was not asked in Chinese version)*	14. И последний вопрос :) Вы откуда?
15. *E-mail (the question was not asked in Chinese version)*	15. *NAME*, это всё, что я хотела узнать :) Вы можете задать мне любые вопросы или поделиться чем-то больше, просто отправив мне email на адрес: lebedeva.iuliia@gmail.com Или просто оставьте на всякий случай свой email (по желанию): *(Я обещаю, я не буду вас спамить)*
NAME, 感谢您抽空填写这个问卷 祝您身体健康，祝您的宝宝快乐成长！	*NAME*, спасибо вам огромное за потраченное время :) Я очень признательна, что вы смогли поучаствовать в этом неформальном "разговоре" со мной о беременности. Я желаю всего самого хорошего вам и вашему малышу. Берегите себя! С наилучшими пожеланиями. Юлия.

Appendix B

Program code for Arduino for LEDs pulsation used for the heart of the *'Live' toy*.

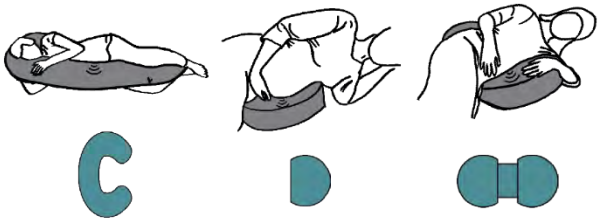


baba 博博科技

TU/e Technische Universiteit Eindhoven University of Technology

我们是杭州博博科技下属的国际智能健康实验室。目前我们与埃因霍芬大学正在共同研发孕护健康的产品。我们其中一个方案是使用压力传感器监测胎儿的心率。因为我们只使用了压力传感器，这个种方法对胎儿和孕妇是绝对安全的，。

现在，我们还在早期开发阶段，我们已经开发出三种不同类型的枕头（C 形状，D 形状，双 D 形状）



C 形状枕头　　*D 形状枕头*　　*双 D 形状枕头*

为了能更好的开发孕期智能枕头，现在我们正在开展用户测试。在测试的时候，我们会让孕妇使用不同的枕头。然后我们会征求他们对产品的意见。

我们已经在欧洲在做了很多研究。我们知道中国的文化和欧洲不太相同，但是我们相信智能枕头也能得到中国的客户的青睐。所以我们希望能在中国做测试，得到中国客户的反馈。

由于这个产品不是一个医用产品，而是一个商业产品。对我们来说，在中国我们很难找到测试者。我们知道在医院每天都有很多孕妇。所以我们期望能和医院合作，尽量安排一天为我们做测试。

baba 博博科技

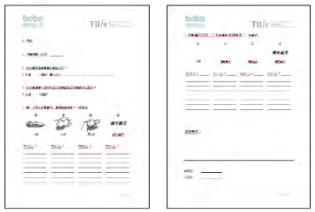
TU/e Technische Universiteit Eindhoven University of Technology

参加者要求

参与者数量： *12-15*
年龄： *任何，*
孕期周期： *14-40 周之间*

测试描述

参与者需要做的： *孕妇只需要躺在我们的枕头上，并保持平静状态。*
时间： *每个枕头大约 3 分钟，每个孕妇整个测试 10-15 分钟（我们预计整个一天的测试时间是 4-5 个小时）*
设施需求： *一个房间，多个床位*
谁会参与测试： *测试将会由一个来自埃因霍芬大学的专家和两个当地的中国助理。*
测试之后： *在最后，我们需要孕妇们填写一个简短的问卷调查，对每个参与者，我们会给予一个礼物。*

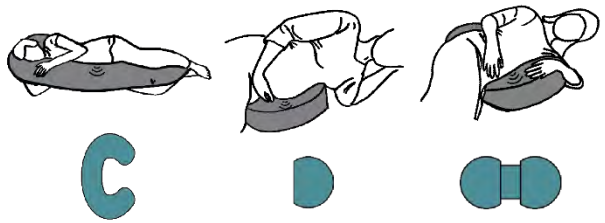


个简短的问卷调查

个礼物

We are the International SmartHealth Lab, BOBO Technology Ltd. (Hangzhou, China) in collaboration with the Eindhoven University of Technology (Eindhoven, the Netherlands) are working on Smart healthcare solution in Pregnancy care. One of our proposal is a Maternity Smart Pillow that just by using pressure and connected with an output device is able to detect fetal heartbeat. Because it's only pressure, it's absolutely safe for a baby and a pregnant woman.

Currently we are on the early stages of development and already have created three versions of prototypes of different pillows (based on **existing** maternity pillows C shape, D shape and Double D shape).



C shape pillow *D shape pillow* *Double D shape pillow*

To be able to proceed with our development of a Maternity Smart Pillow, currently we are conducting user tests with different pregnant women. During the tests we are asking them to use our prototypes of pillows with several output devices. Then we are asking if they like the idea and which pillow and output device look more interesting and attractive for them.

We already did some user research in Europe and got insights from pregnant women there.
We know that Chinese culture is different, but we believe that our idea of a Smart Pillow can be also interesting in China. That's why we came here and want to test our prototypes with Chinese pregnant women and ask them if they like our idea.

It's not medical equipment, it's a new and mostly commercial product.

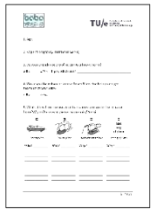
Unfortunately, it's not easy for us to find enough pregnant women here in China to do the user tests. We know that a lot of pregnant women are coming to the hospital every day. That's why we would like to collaborate and ask about possibility to arrange our tests in the hospital for one day.

Requirements for participants needed

Amount of participants: 12-15
Age: any
Pregnancy stage: preferably between 14 - 40 weeks

Tests description

Participants need to do: What is needed for the tests from each pregnant woman is just by turns to lay down and relax on the pillows while the pillows are attached to output devices.
Time: Approximately 3 minutes needed for one prototype and 10-15 minutes in total for the test with each pregnant woman (we expect 4-5 hours for all tests in one day).
Facilities needed: A room in the hospital with several beds (if possible) where we can do the tests.
Who is involved to conduct the tests: The tests will be conducted by one of our expert from the Eindhoven University of Technology (English speaker) and two of our local assistants from the SmartHealth Lab (Chinese).
After the tests: By the end of each test we will ask pregnant women to fill in a short form about their experience of using the pillows and output devices (see below). For each pregnant women who will participate in our tests we will give a gift.



Form with questions to a participant

Gift for participation

1. *年龄*_____

2. *孕期周期（时间）*_____

3. *你会喜欢在家使用孕期枕头吗？*

o *不是* o*是的* *哪一个？*_____

4. *你会希望有个这样的枕头在家里能监测宝宝的心跳吗？*

o *不是* o*是的*

5. *哪一个枕头你最喜欢，最想在家使用？（可多选）*

□	□	□	□
			***都不喜欢***
C形	*D形*	*双D形*	*都不喜欢*
为什么？_____	为什么？_____	为什么？_____	为什么？_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____

6. 你最喜欢在哪一个平台看到测试结果？ *（可多选）*

□	□	□	□
			都不喜欢
手机	*智能手环*	*智能枕头*	*都不喜欢*
为什么？_____	为什么？_____	为什么？_____	为什么？_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____

谢谢参与！

mECG _____

fECG _____

1. Age: _____

2. Stage of pregnancy (number of weeks): _____

3. Do you currently use any of maternity pillow at home?

○ No ○ Yes If yes, which one? _____

4. Would you like to have at home a Smart Pillow that help you to get heartbeat of your baby?

○ No ○ Yes

5. Which pillow from the tests you like the most and would like to use at home? *(if you like several, please, choose all of them)*

☐	☐	☐	☐
			**Not any of them**
C shape pillow	*D shape pillow*	*Double D shape pillow*	*Not any of them*
Why? _____	Why? _____	Why? _____	Why? _____

6. Which output from the tests you like the most? *(if you like several, please, choose all of them)*

☐	☐	☐	☐
			Not any of them
Mobile phone	*Smart bracelet*	*'Live' pillow*	*Not any of them*
Why? _____	Why? _____	Why? _____	Why? _____

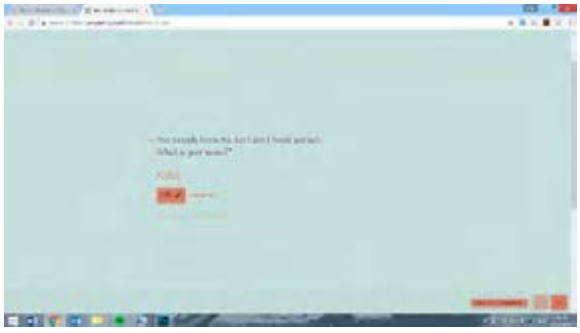
Thank you for your participation!

mECG _____

fECG _____

Appendix D

Screens and text of the *Online survey* during the *Online User tests*.
(Text for the Chinese and Russian versions can be find below the English version).

Screen	English text
	*New design concepts in Pregnancy Care* Hello! My name is Julia. In collaboration with the International SmartHealth Lab I'm working on a new 'Smart' design solution in Pregnancy Care. Currently we are on the early stages of development. For now we are doing Online User tests where we are showing our concepts and asking women if they like our ideas. If you are pregnant or just gave birth (your child is 0-12 month old and you still remember your feelings and emotions during pregnancy) we would love to hear your feedback. *(It will take approximately 10 minutes)* *We are doing this Online User tests, because we believe that only insights from our real users from the beginning could lead us to the right design decision.*
	1. You already know me, but I don't know you yet. What is your name?

2. Currently you are

1st Trimester pregnant
2nd Trimester pregnant
3rd Trimester pregnant
Already gave birth (0-12 month ago)

3. NAME, here is a video with the concepts we have.

We kindly ask you to watch it (2:20) and then answer our questions below.

Video

Subtitles
When being pregnant, it's so important to have a connection with a baby.
You always want to know if the baby is doing well.

"Hello mommy! I'm feeling good!"

Baby's heartbeat is the best sign of life.

There is a new design idea of 'smart' pillows for pregnant women, which can 'read' your baby's heartbeat.

There are 3 different shapes of the existing maternity pillows:
C shape
D shape
And so-called Double D shape

While having some rest and relaxation at home the heartbeat of a baby can be detected by the pillows just by using a pressure sensor embedded inside.

It's absolutely safe for you as well as for your baby!

'Live' data can be represented in different ways from any of these pillows:

1. The first idea is a 'smart' bracelet that shows you a little baby and your baby's heartbeat while you are using the pillow. Moreover, the bracelet knows how long you are pregnant and how much time is approximately left before the birth.
The baby on the bracelet is growing all the time as your baby is growing in your belly.

2. The second idea is visualisation on a mobile phone. On the App you can choose any metaphors you like. For example: butterfly, little fish, flower or baby.
The movements of the creatures vary dynamically with the heartbeat of your baby. The faster your baby's heartbeat, the faster they move.
All of them will grow over time as your baby will grow in your belly.

3. The third idea is a ‘live’ toy whose heart actually represents the heart of your baby. As soon as the pillow detects your baby’s real heartbeat, the heart of the toy starts beating.

3 different shapes of the ‘smart’ pillows
3 different representations

Do you like these ideas?
Which ones would you choose?

3a. Would you like to have at home a ‘Smart’ Pillow that can ‘read’ heartbeat of your baby?

Yes
No

3b. Which pillow from the video you like the most and would like to use at home?

(if you like several, please, choose all of them)

C pillow
D pillow
Double D pillow
None of them

3c. Which output from the video you like the most?

(if you like several, please, choose all of them)

'Smart' bracelet
Visualization on a phone
'Live' toy
None of them

4. NAME, please, feel free to leave your feedback here about the ideas.
What you ***like*** or ***don't like***?
I would love to hear any comments and suggestions from you :)

5. Thanks a lot for your feedback!

NAME, I would like to know your age.
How old are you?

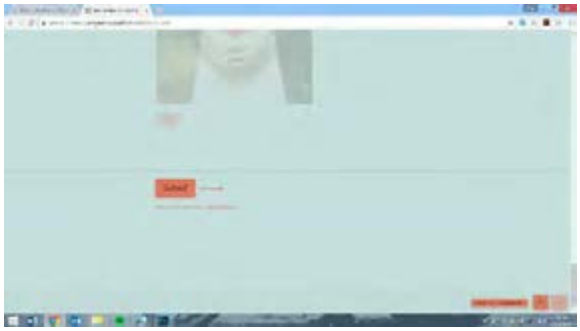
6. And the last question :)
Where are you from?

NAME, thank you a lot for your time :)
I really appreciate that you could participate in this Online User tests.

I wish you all the best to you and your baby.
Take care!

Julia

Please, click the 'Submit' button on the next page



Text for the Chinese and Russian versions of the *Online survey (Online User tests)*:

Chinese text	Russian text
孕妇产品的新设计理念 您好！我的名字叫尤莉亚. 我们团队正在和国际智能健康实验室合作，我们在针对孕妇研发一种新的智能设计。 现在，我们还在前期开发阶段。我们正在做一些网上用户调查，想知道你们是否喜欢我们的设计。 如果你是一名孕妇，或者你刚刚生了孩子（你的孩子在 0-12 个月，然后你还记得你当时的感受) 我们很乐意你给我们一些意见。 这个链接是关于我们设计的小影片（大概两分钟左右）： http://v.youku.com/v_show/id_XMjk4NDgzODAyMA 看完之后希望你能帮助我们完成这份问卷。 *(大概需要您花 10 分钟的时间完成这份问卷 谢谢！)* *我们很看重用户们的体验，我们希望能够通过这个网上用户调研做出正确的设计决定。*	*New design concepts in Pregnancy Care* Здравствуйте! Меня зовут Юлия. Вместе с International SmartHealth Lab я работаю над идеей нового 'smart' продукта для беременных. В настоящее время мы находимся на начальных стадиях разработки. И в данный момент мы проводим так называемое онлайн тестирование, где мы показываем в виде видео наши концепты и спрашиваем нравятся ли вам наши идеи. Если в настоящее время вы беременны или вы только недавно родили (вашему малышу от 0 до 12 месяцев, и вы до сих пор помните ваши ощущения и эмоции во время беременности) мы будем очень рады услышать ваше мнение. *(Это займет примерно 10 минут)* *Мы проводим данный онлайн тест, потому что верим, что только мнение со стороны наших потенциальных пользователей на начальных стадиях разработки поможет нам сделать действительно хорошее и правильное дизайн решение.*
1. 请问您的名字是？	1. Я уже представилась. Но я до сих пор не знаю как вас зовут. Как ваше имя?
2. 您现在的孕期 12 周以内(孕早期) 13 – 27 周(孕中期) 28 周以后(孕晚期) 已经生产（宝宝 0-12 月大）	2. В настоящее время вы На 1м триместре беременности На 2м триместре беременности На 3м триместре беременности Недавно родили (0-12 месяцев назад)
3. *(the link to the video for the Chinese version was on the main page)*	3. *NAME*, вот видео наших концептов. *Мы просим вас посмотреть видео (2:20) и потом ответить на несколько наших вопросов ниже.*
在怀孕期间，母亲和宝宝的联系是很重要的。 你总是想知道宝宝的情况。	Будучи беременной, очень важно чувствовать связь с малышом. Вам всегда хочется знать, все ли в порядке с малышом

“你好，妈妈，我现在感觉很好！” 宝宝的心跳是生命最好的象征。	«Мамочка, привет! Я здесь в полном порядке!» Сердцебиение малыша – наилуший показатель его жизнеспособности
这是一个给孕妇使用的智能枕头，它能够让你知道宝宝的心跳。	В настоящее время есть идея «умных» подушек для беременных, которые могут «читать» сердцебиение малышей
这里有三种不同形状的设计: C 形 D 形 双 D 形状	Вот 3 варианта подушек для беременных уже существующих форм В виде буквы «С» В виде латинской буквы «D» И в виде двойной латинской буквы «D»
当你在休息的时候，通过枕头的压力感应器可以侦测到宝宝的心跳。 这对你和对你的宝宝是绝对安全的!	Пока вы отдыхаете дома, лежа на одной из этих подушек, сердцебиние малыша «читается» благодаря используемым встроенным сенсорам давления. Это абсолютно безопасно для вас, и тем более для вашего малыша!
这些枕头采集的实时数据可以以不同的形式展现出来	В то же время данные могут быть визулизированы и представлены разными способами:
我们的第一个想法是，当你使用枕头的时候，通过智能手环来显示宝宝的心跳。手环可以告诉你怀孕了多久，你的宝宝还有多久出生。根据你肚子的宝宝的情况，手环上的宝宝会相应的成长。	1. Первая идея – это «умный» браслет, который показывает ребеночка и реальное сердцебиение вашего малыша, пока вы используете подушку. Более того, браслет «знает» как долго вы уже беременны и сколько времени примерно осталось до родов. Ребеночек на браслате растет со временем, так же как и настоящий малыш растет в вашем животике.
第二个想法是，当你使用枕头的时候，通过手机 app 选择不同的图像来表达宝宝的心跳。例如，你可以选择蝴蝶，小鱼，小花，或者宝宝。 这些图像会根据宝宝的心跳而变动，宝宝的心跳越快，图像动的越快。 宝宝在你肚子里成长的同时，图像也会相应的变化。	2. Вторая идея – это визуализация на мобильном телефоне. В приложении вы можете выбрать любой вариант визуализации, Например, это может быть: бабочка, маленькая рыбка, цветочек или же просто малыш. Их движения основаны исключительно на реальном сердцебиении вашего малыша. Если

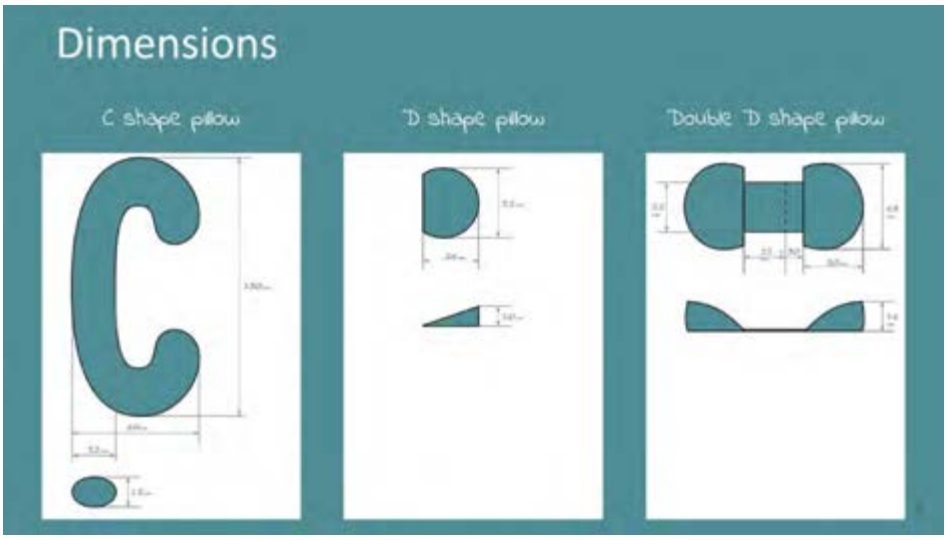
	сердечко бьется быстро, то и они будут двигаться быстро. Все они растут со временем, так же как и ваш малыш растет в животике.
第三个想法是，当你使用枕头的时候，通过一个有'生命'的小玩具来表达宝宝的心跳。当枕头侦测到宝宝的心跳，小玩具的心脏部分也会跟着跳动。	3. Третья идея – это так называемая «живая» игрушка, чье сердце на самом деле является как бы сердечком вашего малыша. Как только подушка начинает «читать» сердцебиение вашего малыша, сердечко игрушки начинает биться.
三种不同的枕头，三种不同的表达方式。 你最喜欢哪个想法？	3 разных фомы «умных» подушек 3 разных идеи репрезентации Нравятся ли вам идеи? Что бы вы выбрали?
3a. 你会想要这样一个能够让你随时知道宝宝心跳的智能枕头吗？ 想要 不想要	3a. Хотелось бы вам дома иметь «умную» подушку, которая может «читать» сердцебиение малыша? Да Нет
3b. 在小影片中的枕头，你最喜欢哪一个？ *（可多选）* C 形状枕头 D 形状枕头 双 D 形状枕头 都不喜欢	3b. Какая подушка из видео вам понравилась больше всего и вы бы хотели иметь дома? *(если вам понравилось несколько вариантов, пожалуйста, выберите их все)* В виде буквы «C» В виде латинской буквы «D» В виде двойной лат. буквы «D» Не понравилось ничего из них
3c. 你最喜欢使用哪一个设备来显示宝宝的心跳？ *（可多选）* 智能手环 手机 有'生命'的小玩具 都不喜欢	3c. Какая репрезентация данных из видео вам понравилась больше всего? *(если вам понравилось несколько вариантов, пожалуйста, выберите их все)* «Умный» браслет Визуализация на моб. телефоне «Живая» игрушка Не понравилось ничего из них
4. *NAME*, 如果您有任何的想法和建议， 您可以在这里给我们留言。	4. *NAME*, пожалуйста, оставьте свое мнение о представленных идеях. Что вам понравилось или что не понравилось? Мне будет приятно услышать любые ваши комментарии и предложения от вас :)
5. 感谢您宝贵的意见！ *NAME*, 您的年龄是？	5. Спасибо большое за ваше мнение! *NAME*, мне бы очень хотелось узнать ваш возраст.

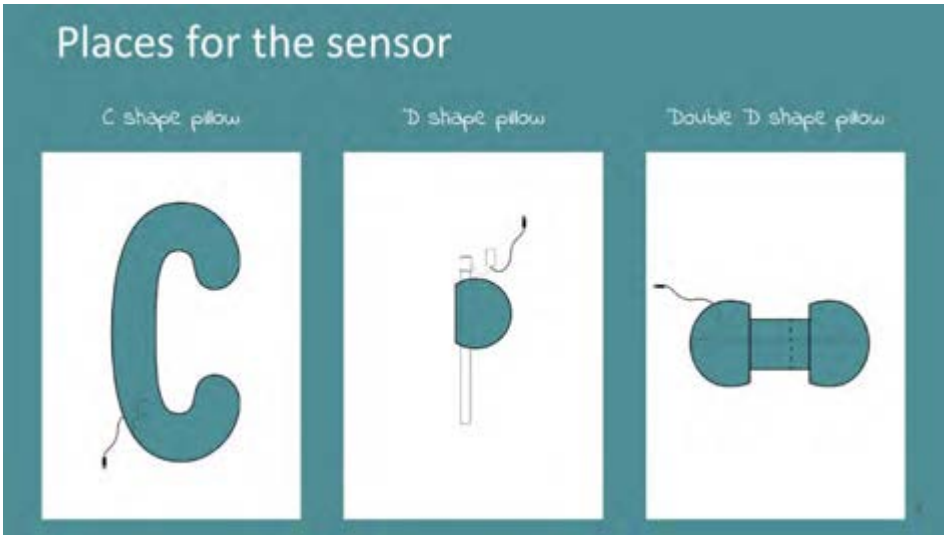
	Сколько вам лет?
6. 最后一个问题 您来自哪里？	6. И последний вопрос :) Вы откуда?
NAME, 感谢您抽空填写这个问卷 祝您身体健康。 祝您的宝宝快乐成长。 尤莉亚	*NAME*, спасибо вам большое за потраченное время :) Я очень признательна, что вы смогли поучаствовать в данном онлайн тесте. Я желаю всего самого хорошего вам и вашему малышу. Берегите себя и будьте всегда здоровы! С наилучшими пожеланиями. Юлия. *Для отправки своих ответов, пожалуйста, нажмите на следующей странице кнопку 'Отправить'.*

Appendix E

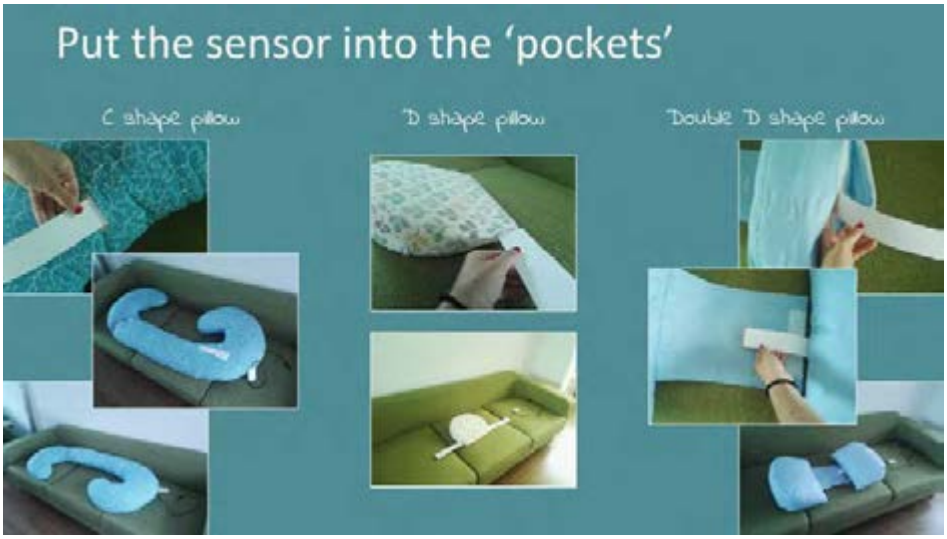
Schemes.

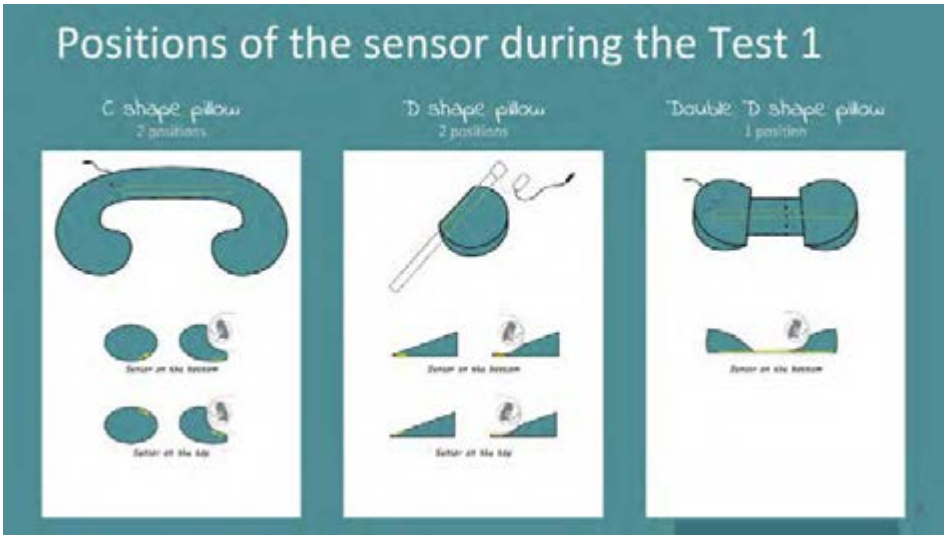
This part includes the schemes with the dimensions of the prototypes, places for the sensor and positions of pregnant women during the technical tests and explanation how to put the sensor inside the prototypes to perform the tests (Test 1 and Test 2) and a description how to adapt materials of the INPUT prototypes in case of trying out to get a better signal and then perform the second set of the tests (Test 2).



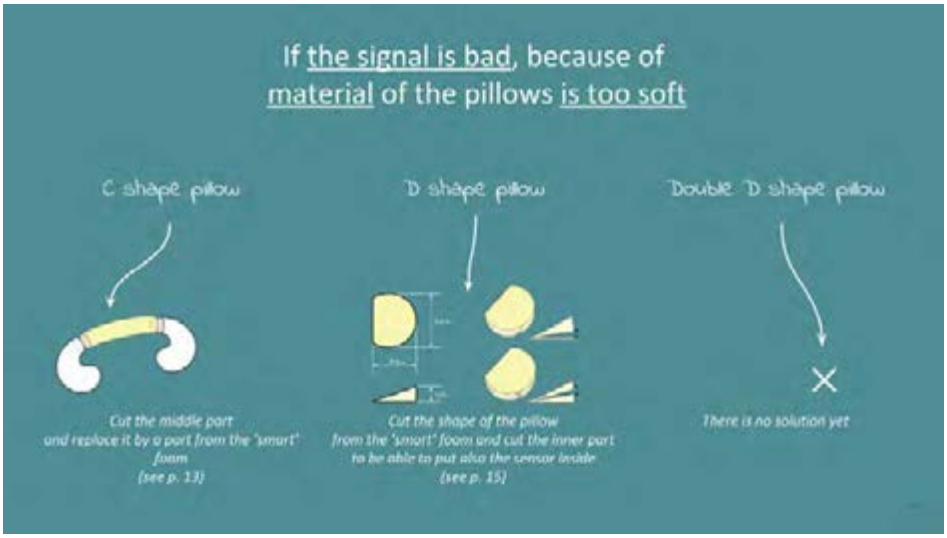


Performing Test 1 (pillows as they are).
The pictures how to put the sensor (from Figure 41) into the pillows:





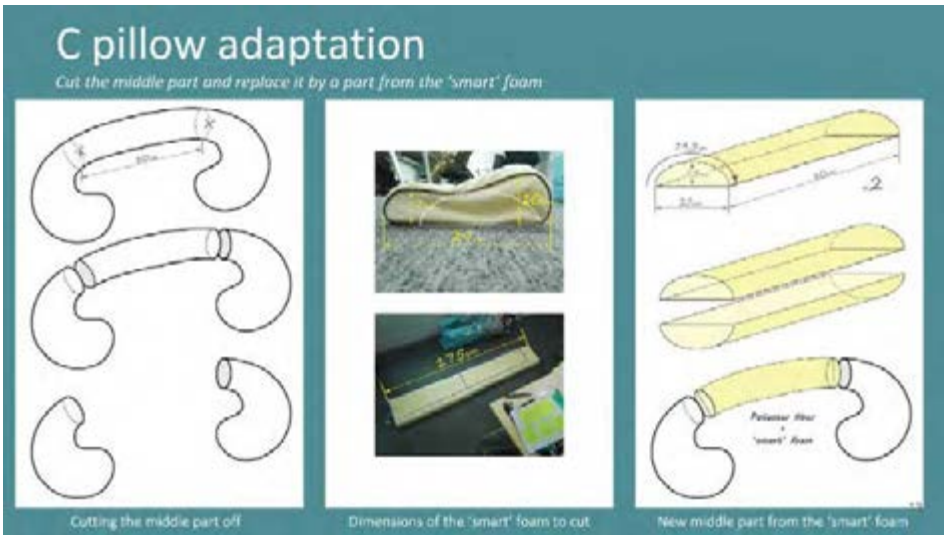
Analyzing the results of the Test 1:

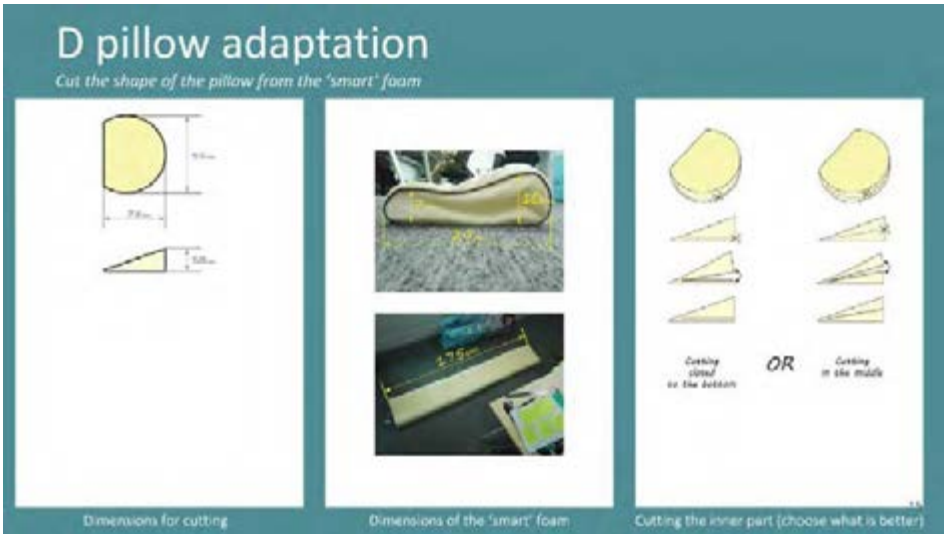


Since at the moment of the experiments in China it was found out that a material called ‘smart’ foam allows get a higher quality signal, when the pressure sensor embedded in the prototype made from the ‘smart’ foam, this material was taking into account for the future prototypes’ adaptation if needed – to use this foam as a part for the C pillow or to make the whole D pillow from this foam (for the Double D pillow no solution yet).

During the tests we need to pay attention on how comfortable pillows are with the ‘smart’ foam as a new inner material.

Prototyping (adaptation based on the results of the Test 1):





Performing Test 2 (adapted pillows):