Re-design of a baby carrier for intuitive and ergonomic use

Michelle Chin and Marija Curic

DIVISION OF PRODUCT DEVELOPMENT | DEPARTMENT OF DESIGN SCIENCES | FACULTY OF ENGINEERING LTH | LUND UNIVERSITY

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MASTER THESIS

Najell™

Re-design of a Baby Carrier for Intuitive and Ergonomic Use

Ensuring a Simple and Comfortable Way of Putting Babies to Sleep

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Supervisor: Kirsten Rassmus-Gröhn
Co-supervisor: Monique Holmqvist (Najell AB)
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Abstract

This master thesis was performed in collaboration with Najell AB with the purpose to improve their product, the SleepCarrier. The SleepCarrier can be used as a baby nest, a play mat and a soft carry cot. With the additional harness, the product can also be used as a baby carrier. The main focus of this project was to improve the user experience of the harness by focusing on ergonomics and intuitivity. The design process initiated with identifying customer needs through reading reviews online, interviews and user testing of the current product. The key findings along with findings from benchmarking competitive products resulted in the development of six new concepts which were prototyped and tested. The concepts were evaluated and two were chosen, combined and further developed by solving the identified problems through an iterative prototyping process.

The final concept is a three part sling that is carried over one shoulder. The first part wraps around the back and has a zipper to allow size adjustment of the sling. The second part is built up by bunched fabric to offer softer padding and to enable adjustment of the contact area over the shoulder. The last part consists of two fastening points, one buckle that connects to the front of the SleepCarrier and one buckle that offers stability. Both the sling and the front buckle can be tucked away into pockets on their respective sides. User testing of this concept showed that it was easier and more comfortable to use while still offering the same functionality as the current product. The design is simple, minimalistic and corresponds well with Najell's vision.

Keywords: Najell, SleepCarrier, baby nest, harness, concept development, ergonomics, baby carrier, front carrying

Sammanfattning

Detta examensarbete gjordes i samarbete med Najell AB i syfte att förbättra deras produkt, SleepCarrier. SleepCarriern kan användas som ett babynest, en lekmatta och en mjuklift. Med den tillhörande selen kan produkten även användas som en bärsele. Huvudfokuset i projektet var att förbättra användbarheten av selen med avseende på ergonomi och intuitivitet.

Designprocessen påbörjades med att identifiera kundbehov, genom att läsa omdömen online, hålla intervjuer och utföra användartestning med den nuvarande produkten. Utifrån resultatet och genom att benchmarka liknande produkter på marknaden, utvecklades sex koncept, där prototyper framställdes och testades. Koncepten utvärderades och två valdes ut. Dessa kombinerades och vidareutvecklades genom att lösa de identifierade problemen genom en iterativ prototypframtagning.

Det slutgiltiga konceptet är en slinga som bärs över en axel och består av tre delar. Den första delen omsluter ryggen och har en dragkedja som tillåter storleksjustering. Den andra delen är uppbyggd av veckat tyg för att få en mjukare vaddering och möjliggöra justering av kontaktarean över axeln. Den sista delen består av två spännen, varav ett kopplas till framsidan av SleepCarriern och det andra används för stabilisering. Både slingan och det främre spännet kan gömmas i fickor på deras respektive sidor av SleepCarrien. Användartestning av konceptet visade att det uppfattades som mindre komplext, mer bekvämt, samtidigt som det tillåter samma funktionalitet som den nuvarande produkten. Designen är simpel, minimalistisk och överensstämmer med Najell's vision.

Nyckelord: Najell, SleepCarrier, sele, babynest, konceptutveckling, ergonomi, bärsele

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Lund, June 2019
Michelle Chin and Marija Curic

Contents

CHAPTER 1

Introduction

Chapter 1 covers the background of the project and the company Najell AB, as well as the goals and restrictions of the project. An overview of ergonomics, possible implications of carrying activities along with suggestions for ergonomic design are described.

1.1 Background

1.1.1 Baby carrying and its importance

Transporting a baby on the body using some kind of carrying device or clothing item is a practice that has been used throughout the world and human history. The first early baby-carrying products appeared in the 1960s. Since then, lots of new products have introduced many more choices for wrapping, tying or buckling a baby to the body in different ways (Russell, 2014).

A study from The McGill University-Montreal Children's Hospital Research Institute (Hunziker & Barr, 1986) examined the correlation between supplemental carrying and the crying patterns of newborn children. Supplemental carrying includes additional carrying to that which occurs while feeding and in response to crying. According to the study,

the time of peak crying occurs when babies reach 6 weeks of age and thereafter it declines and shifts to evening crying (defined as 4 PM to midnight). The outcome showed that babies that received supplemental carrying in their 6 weeks of age cried and fussed 43% less overall and 51% less during evening hours when compared to babies without supplemental carrying. Further, lack of carrying may predispose to crying and colic in normal infants.

1.1.2 Ergonomics and carrying body parts

What is ergonomics?

According to the International Ergonomics Association (IEA), ergonomics is defined as the understanding of interactions between humans and other elements of a system. The goal is to optimize human well-being and system performance by applying certain theory, principles and methods (International Ergonomics Association, 2019).

Further, the IEA describes the domain of physical ergonomics as the concern with how physical activity is related to human anatomical, anthropometric, physiological and biomechanical characteristics. Topics included could for example regard working postures, repetitive movements, workplace layout and safety.

The spinal column

The weight of the torso, arms and head as well as external loads that are placed on these parts of the body are carried by the spinal column. The spinal column is composed of the coccygeal, sacrum, lumbar, thoracic and cervical regions (see figure 1.1). Between the vertebrae there are discs that act as shock-absorbing elements. The spinal column is held up by several muscle groups, the musculus erector spinae being the most important one. This muscle stops the torso from pitching forward and balances the moments that occur when lifting objects. Due to the short distance between the midpoint of the vertebrae and muscles (about 5 cm), small moderate loads can cause major forces to the back musculature because of the greater distance to the lifting object. These stresses are often greatest in the lowest part of the lumbar region, resulting in higher risk of disc prolapse in this region. Disc prolapse occurs when

part of the discs soft inner section flows out, which could result in pain, loss of sensation and/or partial paralysis (Hägg, Ericson, & Odenrick, 2009).

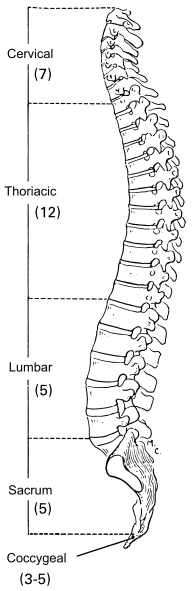

Figure 1.1: The different parts of the spine. The number refers to the amount of vertebrae in the region (Luttgens et al., 1992).

The shoulders

The shoulder joint is a ball-and-socket joint that makes it possible to rotate the upper arm through more than 180 degrees. The joint is stabilised by the rotator cuff that consists of four deeply located muscles around the ball. The shoulder blade that is located in the back is kept in place mostly by the large trapezius muscle. The upper section of the trapezius muscle stabilises and raises the shoulder blade. The middle part stabilises laterally and the lower part pulls the muscle downwards (Hägg et al., 2009).

A study (Abutaleb, 2016) from Cairo University investigated the effect of carrying a shoulder side pack and concluded that using the non-dominant shoulder is recommended when carrying side packs. This is because it would not disturb the postural stability, as carrying on the dominant

side would. Since approximately 90% of the human population are right handed (Scharoun & Bryden, 2014), the majority of people have the left as their non-dominant side.

1.1.3 Implications of carrying activities

Low back disorders (LBDs) are common disorders that can be caused by lifting tasks where large compressive loads are placed on the spine and push-pull tasks where large shear loads are created on the spine. Carrying tasks are considered to be a combination of these tasks. It has been reported that prolonged trunk flexion, often caused by backpack carrying, can lead to an increased risk of lower back pain, according to a study from the University of Southampton (Farhan, White, Warner, & Adam, 2015). However, the risks to the spine associated with various carrying poses have not been fully investigated.

The same study (Farhan et al., 2015) also mentioned that the skin threshold for irritation and redness is 105 mmHg. When carrying a backpack of 10.2 kg the maximal pressure of the shoulder straps could reach up to 203 mmHg. One common strategy to avoid this is to incorporate a frame and a hip belt to the backpack. The findings of the study indicated that the use of the external frame and hip belt lead to approximately 30% of the vertical forces being transferred to the lower back. This suggests that the use of external frame and hip belt could reduce the risk of shoulder injury. However, it addressed that the additional force on the lower back might contribute to lower back pain and increase the compressive loads on the lumbar spine which might cause other problems such as vertebral body damage (Farhan et al., 2015).

A review study of soldier load carriage found in Military Medicine, Vol. 169 (Knapik, 2004) states that hip belts and pack frames reduce shoulder stress. The frame affects the neck and shoulder region while the hip belt affects the mid-trunk and upper legs, in terms of comfort. According to the study, the use of a hip belt was perceived as more comfortable compared to shoulder load carriage.

1.1.4 Womens bodies and infant carrying

During pregnancy, the posture of women changes. A study (Junqueira, Amaral, Iutaka, & Duarte, 2015) showed increases in the thoracic and lumbar curvatures, forward rotation of the pelvis and trunk extension. The changes occur due to the biomechanical adaptions in order to maintain balance with the new body weight distribution. This new body posture often results in pelvic and back pain, especially in the lumbar region. After pregnancy, this problem remains in 25% of women (W. Wu et al., 2004) and continues when carrying the infant with the arms, along with the increasing weight of the infant. This results in an increased lever arm for the mother in the saggital plane (see fig 1.2) and increased trunk muscle activity. This could be a contributing factor to the development of low back pain in mothers, since they already have a reduced muscular endurance after pregnancy (Gutke, Östgaard, & Öberg, 2008).

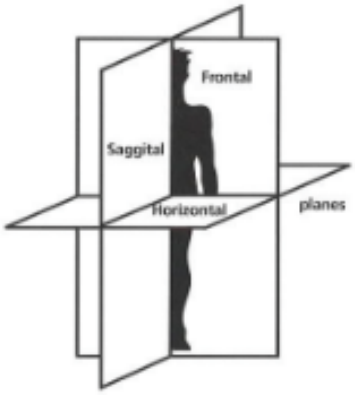

Figure 1.2: The human body divided into three main planes: the frontal, horizontal and saggital planes (Hägg et al., 2009).

Further, the study (Junqueira et al., 2015) states that similar effect to what can be seen in pregnant women, where the body compensates for the shift of the centre of gravity by leaning backwards, can be seen in women carrying a load in the front. Because of this compensation, the centre of gravity of the body with and without load remains the same. This also leads to significant changes in the pelvic and spinal curvatures in the saggital plane of women when carrying an infant while walking and standing still, mainly at the lumbar and thoracic regions (Junqueira

et al., 2015). However, most changes occur in the lumbar spine rather than the thoracic region. The explanation for this could be that the lumbar region offers greater mobility and it requires less energy in order to perform adjustments (Junqueira, Amaral, Iutaka, & Duarte, 2011).

1.1.5 Suggestions for ergonomic design

A study performed at The Ohio State University (Rose, Mendel, & Marras, 2013) suggests that the carrying load should be positioned close to the body, even when carrying relatively light loads, in order to achieve optimal carrying in terms of spine loading. Two of the carrying conditions that were examined in the study showed significantly increased values of anterior and posterior shear compared with the other carrying styles. Both of these two conditions included the load to be carried in front of the body. The increased value appeared to be due to the large moment imposed in front of the body during carrying. Unlike the other carrying styles the anterior and posterior shears were similar when carrying nothing at all.

A study regarding the effect of shoulder strap width and load placement (Golriz, Hebert, Foreman, & Walker, 2017) examined different strap widths (5,6,7 and 8 cm) along with the effect of high and low placement on the shoulders. The study used pressure sensors along the shoulders and chest of a manikin, carrying a backpack load of 20 kg. The findings indicated that 8 cm shoulder straps and a high load placement gave the least amount of pressure on the shoulders. Similarly, a study done at the National TsingHua University (C. Y. Wu, Huang, & Wang, 2016), where three front Baby Carriers were evaluated, suggested that a greater contact area lead to better pressure distribution and thereby a more comfortable wear.

1.2 About Najell

Najell AB was founded in 2012 and is based in Lund, Sweden. Their vision is to develop baby products suitable for urban parents. Najells first product, the SleepCarrier, reached the market in 2014 and today their products are available at retailers in 21 countries around the world.

Today Najell focuses on two main product categories: baby nests and baby carriers, including baby wraps. They pride themselves in having their baby carrier recommended by the International Hip Dysplasia Institute as a hip-healthy baby carrier.

1.3 Project Description

The SleepCarrier was developed so that a parent could rock their baby to sleep and then be able to move or put them down without waking them up. It is designed to create a safe environment for the child, allowing them to feel the closeness of their parent while lessening the strain on the parents body. It also allows the parent to bring the child's familiar sleeping environment with them when travelling. The size of the SleepCarrier is suited for even the smallest strollers on the market today. The product consists of two main parts: the harness and the nest that can act as a baby nest, soft carry cot, play mat and a baby carrier. These four functions can be seen in figure 1.3 and figure 1.4.

Figure 1.3: SleepCarrier used as a carry cot (left) and as a baby carrier with the harness (right) (Najell, 2019).

The main goal of this project was to develop a new harness that was more ergonomic for the parent, to avoid pain and injuries of the shoulders and spine during use. The secondary goal of the project was to make the use of the product more intuitive, as the current product is

Figure 1.4: SleepCarrier as a play mat (left) and as a baby nest in a stroller (right) (Najell, 2019).

complex and hard to understand. At the end of the project a product concept was presented through a functional prototype.

This project was carried out during 20 weeks in spring 2019 and was presented in June 2019. The time plan can be found in appendix A.

1.4 Restrictions

The aim of the project was to re-develop the harness of the SleepCarrier and therefore no major changes regarding the shape, size and materials of the SleepCarrier itself were investigated. The final prototype presented the functionality of the design and was not intended to show the final product.

Since the focus of this project was to re-develop the harness from an ergonomic perspective, costs for manufacturing and production as well as material factors were not analyzed. The metric values of the specifications were based on Najell's current product and no new calculations were made. Since the project was based on a previous product some phases of the product development process were not to be executed.

CHAPTER 2

Methodology

Chapter 2 covers the main approach and methodology. All the methods that have been used in this project are presented in this chapter.

Human-centered design (HCD) is a design philosophy that focuses on understanding and accommodating to the needs, capabilities and behaviours of humans. To do this, the needs that the design is intended to meet must first be understood. People are usually unaware of their needs and why they do things in a particular way so by observing and studying people, as they use products or perform certain actions, helpful insights can be gathered (Norman, 2013). Since the focus of this project was a product which is derived from the human need for closeness and interaction with other humans, the methodology chosen for this project follows the HCD philosophy.

2.1 Main approach

For this project, the product development process presented by Ulrich and Eppinger in *Product Design and Development* (Eppinger & Ulrich, 2012) was followed. The process consists of six phases, but to limit the project according to section *1.4 Restrictions*, focus was put on the Concept Development phase.

The objectives of the Concept Development phase were to understand the needs of customers, generate and evaluate product concepts as well as selecting one or more concepts for further development and testing. The concepts describe the form, features and functions of a potential product. To achieve these objectives a modified version of the Concept Development process presented in *Product Design and Development* was used. This version can be seen in figure 2.1 and consist of the following activities:

- ***Identifying Customer Needs:*** By using tools such as interviews, observations and surveys, raw data can be collected from customers. The data can then be interpreted into customer needs which can be organized in order of importance. The data can also be summarized in to personas, which can be used during the design process.

- ***Establishing Target Specifications:*** To obtain a precise description of the product's requirements, target specifications are set. This is done by translating the customer needs into technical terms, where each specification consists of a metric with ideal values for that metric.

- ***Concept Generation:*** The goal of this activity is to produce concepts that address the customer needs. An external search of patents, literature and benchmarking related products can be used as sources of inspiration. When searching for ideas internally, it is important to suspend judgement and to focus on quantity over quality. This encourages sharing of ideas that might not seem feasible and the large number of ideas has the potential to stimulate generation of more ideas.

- ***Concept Selection:*** To identify the most promising concepts they are analyzed and then sequentially eliminated in an iterative process. This can be done through different methods, such as concept scoring matrices where the concepts are scored based on set criterion.

- ***Concept Testing:*** To verify that the customer needs have been met, the chosen concepts are tested. If necessary, some of the

earlier steps may need to be repeated for further development of the concept.

- ***Setting Final Specification:*** After the concepts have been tested, the target specifications are revisited and the final values of the metrics are set.
- ***Benchmarking:*** Understanding competitive or related products with similar functionality can provide a rich source of ideas while generating concepts.
- ***Modeling and Prototyping:*** During the whole concept development process, different forms of models and prototypes are created to help visualise and evaluate concepts. For example, "proof-of-concept" models help demonstrate feasibility of a concept and experimental test models can be used to set design parameters for robust performance.

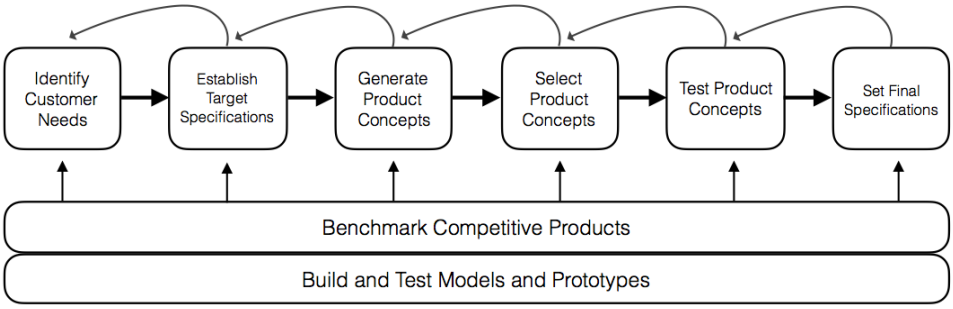

Figure 2.1: Modified Concept Development Process.

2.2 Methods

2.2.1 Brainstorming

Brainstorming is a method that is commonly used to develop and refine ideas. To make the sessions successful, it is important that the goal of the project is clear to the participants and that there is no judgement when sharing ideas (Robertson & Robertson, 2013). By honing in on a specific

problem, it is easier to come up with many ideas as well as making sure that the participants stay on topic (Kelley & Littman, 2008). Using sketches or other physical mediums, since text might be insufficient to describe physical items, is also recommended (Eppinger & Ulrich, 2012).

2.2.2 Concept Combination Table

Since the main problem can be complex, systematically exploring solutions to subproblems within the main problem could simplify the process. This can be done by using a concept combination table (Eppinger & Ulrich, 2012). This method is performed by firstly identifying the subproblems to the main problem and entering them into the columns of a table. Then, potential solutions are found to each subproblem and added in to the corresponding column of the table. By selecting a solution from each column, a solution for the overall problem can be found.

2.2.3 Benchmarking Related Products

Gathering information on related or competitive products can be done by searching for information online, by for example studying online stores, reviews and blogs. Information can also be gathered through searching for and testing products on the physical market. The benchmarking process can either focus on studying solutions to the main problem or target simpler subproblems (Eppinger & Ulrich, 2012).

2.2.4 Interviews

An interview is a conversation with a purpose, where the interviewer asks questions and the interviewee answers. Interviews can be categorized into different types, depending on how much control the interviewer has over the conversation. These are: open-ended or unstructured, structured, semi-structured and group interviews. Open-ended or unstructured interviews are less controlled by the interviewer and the questions are open, for example: *describe a day in your life*. These kind of open questions often lead to a certain depth in the topic. In structured interviews the questions are mostly closed, for example: *How old are you?*, and the interviewer usually has specific questions that they want an answer to. Semi-structured interviews are a combination of structured and unstructured interviews. A basic script is often prepared with both

open and closed questions and is used as guidance during the interview (Preece, Rogers, & Sharp, 2015).

2.2.5 Personas

Personas can be used to summarize the needs of people that have been observed during the process of identify customer needs. A persona is not a real individual but represents a significant portion of the people from the target group. This enables designers to create different designs and focus on some characteristics that are important (Goltz, 2014).

2.2.6 Prototyping

Prototyping is commonly used in the design process in order to explore concepts and ideas. A prototype is a draft version of a product and can be made of paper drawings (low fidelity prototypes) or more functioning (high-fidelity prototypes) such as using software programs to create a first impression of an app. Prototyping is also used to evaluate functionality and design of a product and is a cheap solution during the iterative design process where many changes can occur. Prototypes can be used for user testing and gathered feedback could be very helpful during the design process (Preece et al., 2015).

2.2.7 User testing

User testing can be used as support while developing and choosing between different concepts and ideas. For this reason user testing is an important part in the design process. User testing can be done with different methods, such as usability testing and questionnaires (Preece et al., 2015).

Moderated usability testing is a form of testing that includes a moderator. While the user tests out the prototype or product, the moderator can collect feedback and answer any questions the user might have in real time. This type of test is very helpful as it gives the opportunity to observe the user and ask questions while they are performing certain tasks. It is also important that the test closely simulates the way the product would actually be used. For example, if the product is to be

used by one person, the test should be performed by one person at a time.

To gather quantitative data about user satisfaction and peoples thought processes, questionnaires can be used. To ensure that the correct data is collected, the questions need to be carefully and clearly worded. The questions need to be specific to avoid confusion and closed questions should be asked if possible to get clear answers. The type of response format can differ depending on what type of information is to be gathered. For example rating scales are useful when the respondents are asked to determine how usable or easy something is.

2.2.8 Pugh Concept Selection matrix

The Pugh Concept Selection matrix can be useful to evaluate concepts in a systematic matter. This method uses a matrix where the concepts are scored with either a "better than" (+), "worse than" (-) or "same as" (0) on set criterion, in comparison to a reference concept that is given a 0 score on each criterion. After the concepts have been scored, their scores are summed up into a net sum, where the "better than" and "worse than" scores cancel each other out. The concepts can then be ranked and possible combinations of different concepts could be considered (Eppinger & Ulrich, 2012).

CHAPTER 3

Identify Customer Needs

Chapter 3 covers the process of identifying customer needs and the key findings are presented in subsection 3.1.4.

3.1 Identifying customer needs

The first step in the process was to understand the current harness to the SleepCarrier and identifying its perceived problems. One conceivable problem was the weight distribution of the current harness. For that reason methods to study the weight distribution were discussed. These methods were Electromyography (EMG) and pressure sensors.

EMG investigates the registration and analysis of the electrical signals during a muscle contraction. EMG-activity can be registered by electrodes inserted in the muscles or with electrodes placed on the skin above the muscle (Mills, 2005). This method has previously been used as one of the studied parameters when investigating the physiological responses while carrying babies (C. Y. Wu et al., 2016).

Pressure sensors can be used to measure the pressure distribution over an area. Matrix pressure sensors can measure the pressure between two surfaces, through a thin sensor that is placed in between them (Tekscan,

2019). For this project, pressure measurements of the current harness could have given insights to enhance the design and also could have been used to compare the pressure distribution of the new designs.

An interview was arranged with an expert in ergonomics to gain more knowledge on the topic. Lotta Löfqvist works as an assistant researcher for the Division of Occupational and Environmental Medicine at Lund University. After discussions with Löfqvist it was concluded that EMG wouldn't provide the weight distribution information needed. Pressure sensors would be a better approach. However, after searching for suitable pressure sensors, both within and outside of the university, it was concluded that it was difficult to find the sensors required for this kind of experiment.

Instead, reading reviews online, interviewing users and user testing was the approach taken for identifying the customer needs and the current product's perceived problems.

3.1.1 Reading reviews online

Reviews of the product from Najell's website and other online baby stores, such as BabyWorld, were observed. Information was also gathered by reading reviews in the form of blog posts by popular "Mommy Bloggers". See appendix B for excerpts from the read reviews and blog posts.

3.1.2 Interviews

Interviews were held with two former users. A semi-structured interview script was prepared beforehand (see appendix C) as guidance during the interview. For example, two of the questions were: *Have you or do you use the harness for the SleepCarrier?* and *does the harness fit properly on your body?* Although, if the interviewee was providing insightful information, the guide was ignored for the moment to not disrupt the flow of the conversation and to get more detailed, in-depth information. To avoid biasing the conversation with possible solutions, open questions were asked to understand for example the user journey and underlying needs (Eppinger & Ulrich, 2012). During the interviews, notes were taken on a computer for later reference.

3.1.3 User testing

User testing was carried out in order to get a better understanding of the problems with the current design. Users were instructed to put the harness on and attach the SleepCarrier, with no help. The SleepCarrier was then loaded with a weight of 6 kg. The users were instructed to walk around for 10 minutes, during which they were encouraged to think out loud and express their thoughts on the experience with the product. This lead to discussions with the respondent and insights were gathered and noted down.

A questionnaire was created, including 13 questions about different actions and aspects related to the product and user experience. For example, *how difficult was it to put on the harness?* and *how hard was it to connect the SleepCarrier to the harness?* Likert scales were used as the answer format for majority of the questions, in order to get a better overview of how easy or difficult each action was perceived (Preece et al., 2015). A rating scale question was also included where the respondent had to rank 8 different problems with the product, from easiest to hardest. This gave a better understanding of which action was perceived as hardest and easiest in relation to the other actions. Two questions included free text were the respondents could add additional insights that were not included in the questionnaire. The users were asked to answer the corresponding questionnaire, see appendix E, after the test.

3.1.4 Key findings

Reading reviews online resulted in the impression that the baby carrier function was not used by many users. This because the majority of the blog posts focused mainly on the use of the SleepCarrier as a soft carry cot and baby nest while few mentioned the use of the harness and the baby carrier function. Some of the blog posts had pictures of themselves wearing the harness. It was then observed that majority of them were wearing it wrong. The most common mistakes were that the SleepCarrier was too far down on the body and wasn't angled to prevent the edge of the bottom plate from cutting in to the stomach. This gave the impression that the harness was difficult to understand and user mistakes could easily occur. It was also noted that a majority of the posts were in collaboration with Najell.

The user testing was performed by 8 students (5 men and 3 women). 50% of the participants experienced a slight difficulty with connecting the harness to the SleepCarrier and 75% felt that the harness did not fit them properly. This could be explained by the difficulty to adjust the harness, for example the waist strap, see figure 3.1 for detailed images of the harness. This was mentioned by a shorter participant whom expressed difficulty in tightening the harness properly along with the difficulty of reaching the outer buckles. Additionally, in the rating scale question, the statement regarding *how to adjust the outer straps that connects the harness to the SleepCarrier properly* had the highest ranking (experienced as the most difficult action) among 87,5% of the respondents. The same percentage felt a great load on the shoulders when carrying the SleepCarrier and 50% felt high loads in the back as well. When the users were asked to estimate how long they would be able to carry the SleepCarrier, it ranged from 20 to 40 minutes. Some general comments and wishes that were received both from discussions with the respondents during testing and in the questionnaire were:

- Easier way to adjust the straps evenly
- Easier way of fastening the harness to the SleepCarrier, preferably using one hand
- A more even weight distribution on the body
- An easier way of distinguishing the different straps and less loose ends
- Easier to orient what is front and back of the harness
- Some users experienced difficulty with fastening the inner buckles
- Some users experienced that the bottom plate would cut into the stomach, making it uncomfortable
- An overall lack of understanding of the detailed functions of the harness, for example the loops that are meant to prevent loose ends and the loops along the shoulders of the harness that allow a proper placement of the outer straps

Figure 3.1: Details of the current product

The customer statements from the interviews and user testing, as well as the information found during the online research, were gathered and interpreted into needs. These can be seen in table 3.1.

Table 3.1: Customer Statement and Interpreted Need

Customer Statement	**Interpreted Need**
When he was maybe 1 month old until about 2-3 months he would cry non-stop at night .... sometimes for 15 minutes and up to two hours.	The harness can hold children of different weights and sizes
Usually I didn't need the harness because it would take as much time to put it on as it would to just have him in my arms.	The harness is quick to put on
My back and shoulders would hurt after long sessions especially if I didn't adjust the straps properly. It would sometimes cut into your body a little bit. I would guess the sessions where tops 1 hour but usually around 15 minutes	The harness allows use without pain in the shoulders and lower back
Yes, both me and my partner rock the baby to sleep	The harness suits different body types
No I never read the manual. ...But it also needs to be adjusted properly.	The harness is intuitive to put on and adjust
We used it a lot when we were travelling, on flights and trains.	The SleepCarrier is easy to bring with you
Fits in our small stroller, easy to wash, supercosy for baby.	The SleepCarrier fits in the small strollers

3.2 Personas

Two personas were created from insights gathered during the *Identify Customer phase*. The personas were used to ensure that important characteristics of the users were taken into consideration when generating product concepts.

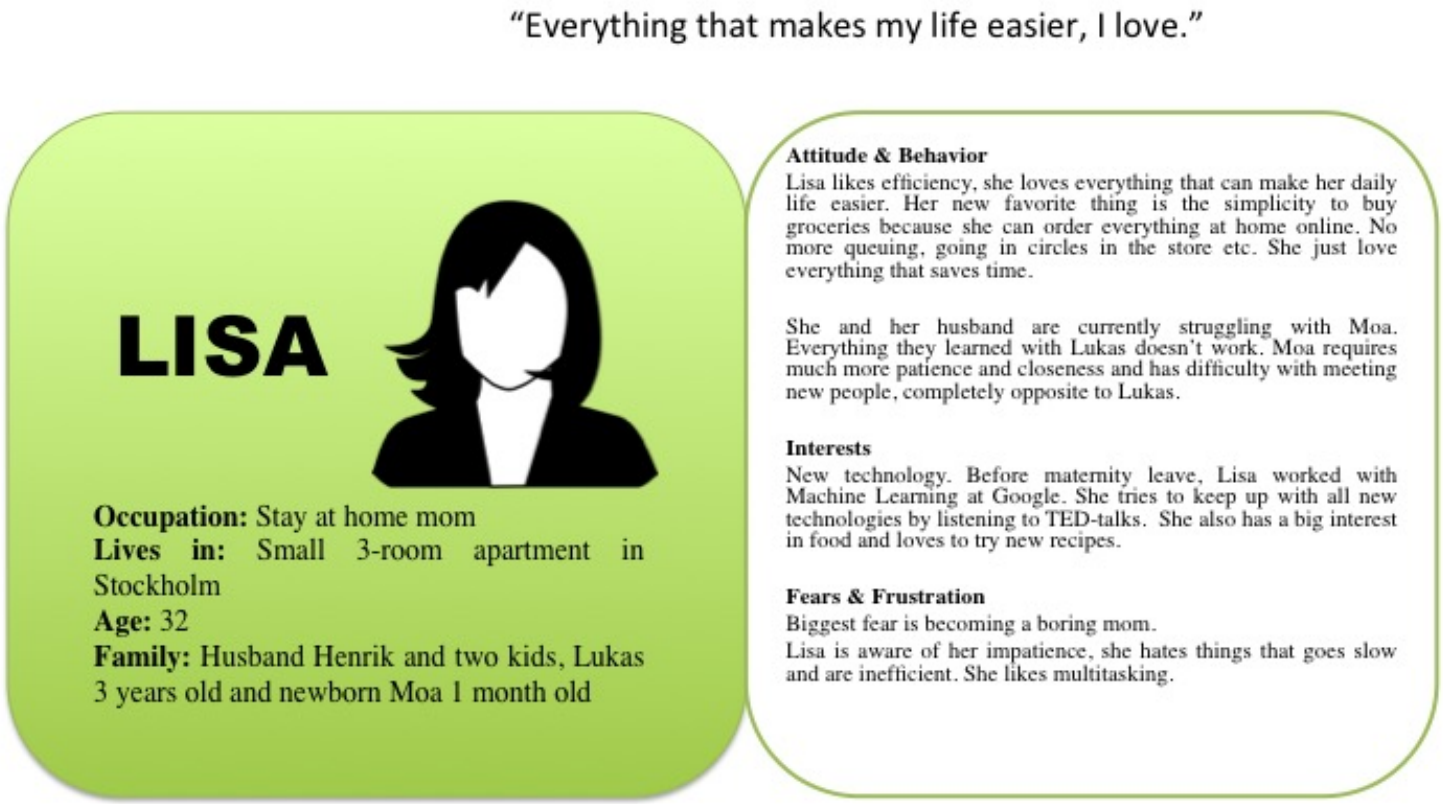

Figure 3.2: Personas Lisa

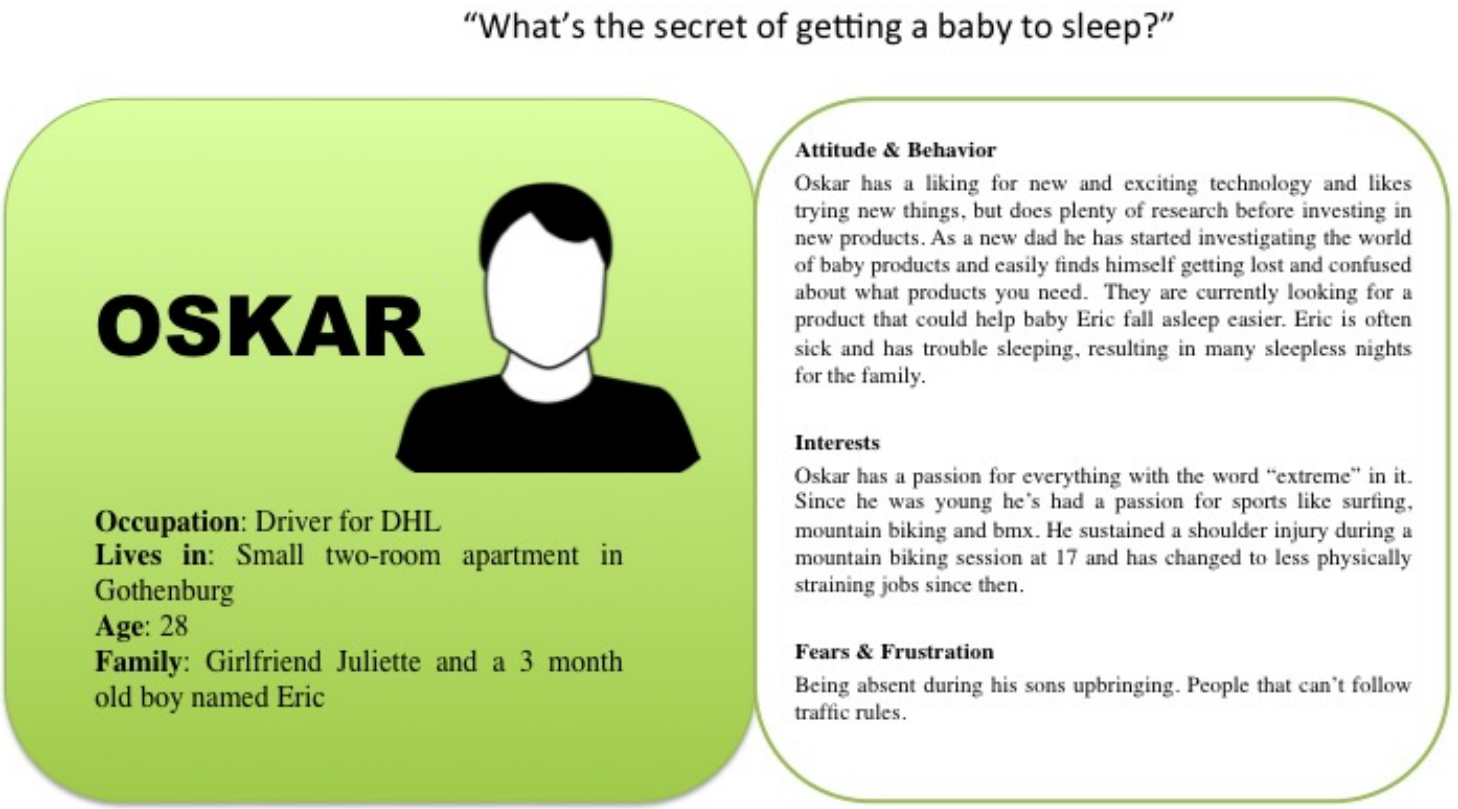

Figure 3.3: Personas Oskar

CHAPTER 4

Establish Target Specifications

Chapter 4 covers the process of establishing the target product specifications.

Since there was already an existing product, product specifications had already been established for that version. These were based on the standards described by the Swedish Standard Institute (SIS) in *Child use and care articles - Carry cots and stands - Safety requirements and test methods* (Swedish Standards Institute (SIS), 2014). By studying those standards, in combination with discussions surrounding the customer needs found in the previous phase, the target specifications seen below were set. The height specification was based on the average heights in Sweden for men and women (Statistiska centralbyrån (SCB), 2010).

- The harness can withstand a maximum weight of 10 kg
- A person can use the harness and SleepCarrier with no help from another person
- The time for putting the harness on does not exceed 1 minute
- The time for adjusting the harness does not exceed 1 minute
- The time for taking the harness off does not exceed 1 minute

- The harness does not compromise the current functions of the SleepCarrier
- The harness fits the design and size of the SleepCarrier
- The harness can be worn by people between 165-180 cm tall
- The harness fulfills the safety and durability standards set by SIS
- The harness suits different body types
- The harness is machine-washable
- The harness can be worn for a minimum of 15 minutes without pain

CHAPTER 5

Generate Product Concepts

Chapter 5 focuses on the generation of product concepts and the methods used during this phase.

5.1 Benchmarking Competitive products

To gather inspiration before generating concepts and to better understand the market of baby carriers, benchmarking of products on the current market was done through online research. Since there are no products with the same functionality as the SleepCarrier on the market, focus was put on baby carriers but harnesses for tools as well as posture harnesses were also of interest. Some of the findings can be seen in figures 5.1-5.9. Local baby stores, such as Lekia and BabyProffsen in Lund, were visited to try out available products, for example the Babybjörn Original in figure 5.7.

Baby Carrier Miracle

The Miracle baby carrier in figure 5.1 from BabyBjörn consist of an H-shaped back design, which connects to a wide waist belt. The belt is said to provide extra support and remove pressure from the users shoulders. The shoulder straps and hip belt can be adjusted by pulling the loose ends at the sides.

Figure 5.1: BabyBjörn Miracle baby carrier (BabyBjörn, 2019a)

Baby Carrier Active

The no longer available baby carrier Active in figure 5.2 by BabyBjörn had a similar design to the Miracle, but consisted of a harder back-plate, for extra support along the back.

Figure 5.2: BabyBjörn Active baby carrier (BabyBjörn, 2004)

Ryobi Saw harness

The harness in figure 5.3 is used by workers using a heavy trimmer or saw, since this kind of equipment could be heavy. The idea behind the wide back is to evenly distribute the weight over a large contact area for a comfortable fit. The belt is used to distribute the weight from the back and shoulders down to the hips.

Figure 5.3: Ryobi RAC805 Harness (Bauhaus, 2019)

Stokke MyCarrier

The back of the Stokke MyCarrier, as seen in figure 5.4, has a wide Y-shaped design that connects to a waist belt which buckles in the front. The belt, as well as the two shoulder straps, can be adjusted in the sides by pulling the adjustment straps.

Contorus Love 3-in-1

The Contours Love 3-in-1, seen in figure 5.5, has a wide H-shaped design in the back, with a waist belt that buckles on one side. It is put on by firstly buckling the hip belt and then lifting the back straps over the head and behind the neck. The straps are then secured to the front by buckles located on each side.

LilleBaby All Seasons

The LilleBaby All Seasons baby carrier is a carrier that allows for either an H-shaped or X-shaped back design, as seen in figure 5.6. It also has

Figure 5.4: Stokke MyCarrier baby carrier (Stokke, 2019)

Figure 5.5: Contours Love 3-In-1 Baby Carrier (Contours, 2019).

a lumbar support plate attached to the waist belt for extra support of the lower back.

Figure 5.6: LilleBabay All Seasons baby carrier (LilleBaby, 2019)

BabyBjörn Original

The BabyBjörn Original, seen in figure 5.7 has a simple X-shaped design in the back. The straps are adjusted at the sides and the buckle in the middle of the back makes sure that the two straps stay in place. It can also be moved up or down depending on the desired fit.

Swedish Posture Flexi Harness

Swedish Posture is a company that makes products for people who wish to improve their posture. For example, the Flexi harness in figure 5.8 helps pull the shoulders back, for a more upright posture.

Babysense Sling

The sling in figure 5.9 comes from Babysense, and can be worn in different positions. It wraps around the body and then buckles around one shoulder, where the size can also be adjusted.

Figure 5.7: BabyBjörn Original baby carrier (BabyBjörn, 2019b).

Figure 5.8: Posture Flexi (SwedishPosture, 2019).

Figure 5.9: (Babysense, 2019).

5.2 Concept Generation

Since the SleepCarrier and harness consist of many different parts, the problem was divided into the following subproblems:

- Design of the front
- Design of the back
- Belt type
- Types of buckles
- Attachment of SleepCarrier to harness
- Adjustment mechanisms
- How to put it on
- Other features

Potential solutions for each subproblem were found individually through further benchmarking and individual brainstorming. While brainstorming ideas for the design of the front and back of the harness, the notes

Table 5.1: Concept combination table

Frontside	**Backside**	**Belt**	**Different kinds of buckles**	**The pairing between harness and SleepCarrier**	**Adjustment**	**How to put it on**	**Other features**
II-shape (current design)	X-shape	Waist belt	Quick release buckle (current design)	Hook-and-loop (Velcro)	TRX-strap	"T-shirt"	Foldable
Y-shape	V-shape	Hip belt	Hook c-shape	4 buckles	Hook - and - loop (Velcro)	"Jacket"	Marking buckles that belong together
"Backpack" straps	H-shape	Hip belt and waist belt	Magnetic buckle	3 buckles	Fixed adjustment points	Side opening (current design)	Indications for even adjustment
-	Y-shape	-	Hook-and-loop (Velcro)	2 buckles (straps around SleepCarrier)	Adjustable strap fixed loop	-	SleepCarrier aligned with waist/hipbelt
-	Double Y-shape	-	Carbine Hook	Forklift	Adjustable strap open end	-	-
-	-	-	Airplane seat belt buckle	-	Cam buckle	-	-
-	-	-	-	-	Double quick release buckle	-	-

gathered from the meeting with Lotta Löfqvist were revised. For example, she mentioned that a symmetric design that distributes the weight over a large area of the back would be most comfortable. The solutions were described through notes and sketches and gathered into a concept combination table, which can be seen in table 5.1. Additional explanation of the concept combination table can be seen in appendix D. Through discussions in the group, along with discussions with Najell, some of the solutions in the table were discarded (colored in red) as they were regarded as not suitable for the desired product. Then, the most promising solutions (colored in green) along with the "OK" solutions (colored in yellow) from each column were combined into five different concepts. By using scrap pieces of fabric along with deconstructing and remodeling old SleepCarrier harnesses and Najell Omni baby carriers, prototypes were made to get a better understanding of the concepts feasibility.

Concept 1 - The Loop

The back of concept 1 (see figures 5.10-5.12) has a V-shaped design with a waist belt that connects in the front by a quick release buckle with a two sided adjustment. On the waist belt there are two straps that loop around the SleepCarrier and then connects to the shoulders. The two loop-straps are attached to the waist belt in a way so that they can be adjusted sideways, depending on how wide the waist is. For the prototype, one side had a carbine hook and the other had a magnetic buckle, to test which one would be easiest to buckle.

Concept 2 - The Hammock

Concept 2 (see figures 5.13-5.14) has a Y-shaped design at the back and a waist belt with a cam buckle on the side. The front has backpack straps that can be adjusted at both of the sides of the body. In the front middle part of the waist belt there is a magnetic panel that can be connected to a corresponding magnet on the SleepCarrier. The SleepCarrier also consist of built in pieces of fabric on both sides. These are used to enclose the sides of the SleepCarrier, and at the end of the covers there are magnetic buckles that are used to connect the SleepCarrier to the harness.

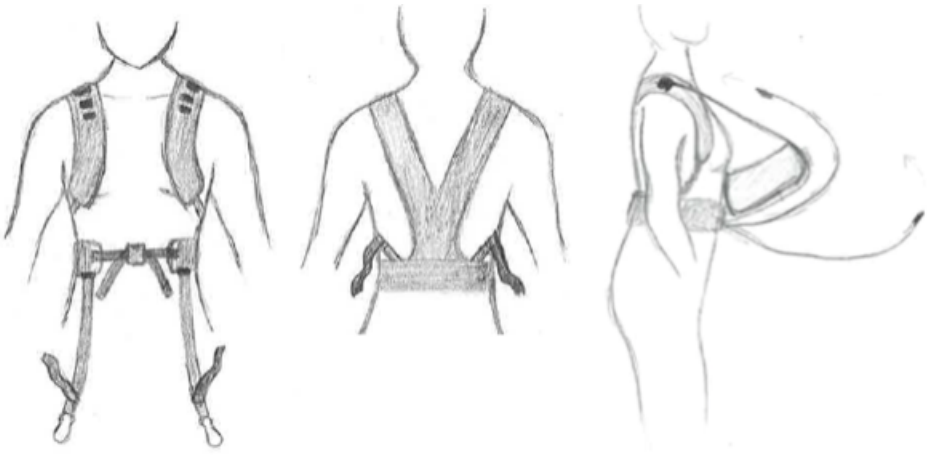

Figure 5.10: First sketch of The Loop

Figure 5.11: Prototype of The Loop

Figure 5.12: Details on the Loop prototype

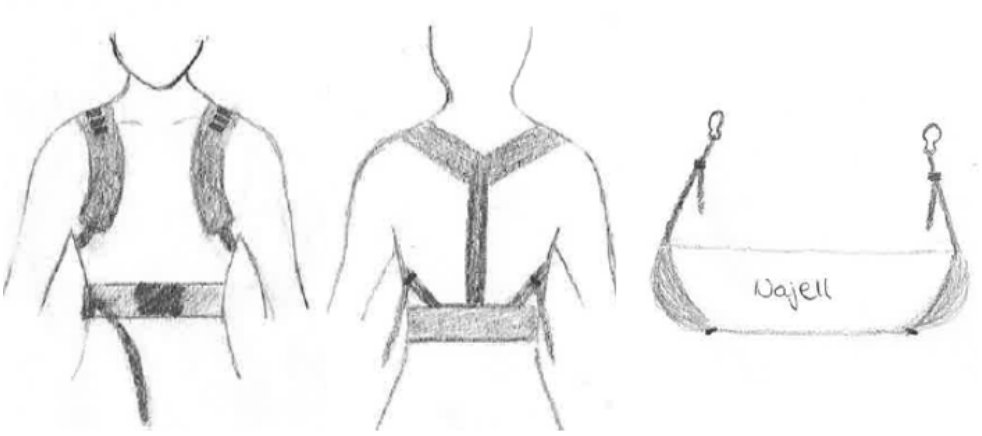

Figure 5.13: First sketch of The Hammock

Figure 5.14: Prototype of The Hammock

Concept 3 - 3 buckles

Concept 3 (see figures 5.15-5.16) consists of an X-shaped design in both the front and back, and is put on over the head. The two loose straps in the sides make it possible to adjust the fit of the harness, so that it can be fitted tightly to the body. Then, the quick release buckle in the front is connected to a matching buckle on the SleepCarrier and the two outer straps on the shoulders are connected to the outer side of the SleepCarrier in a similar manner.

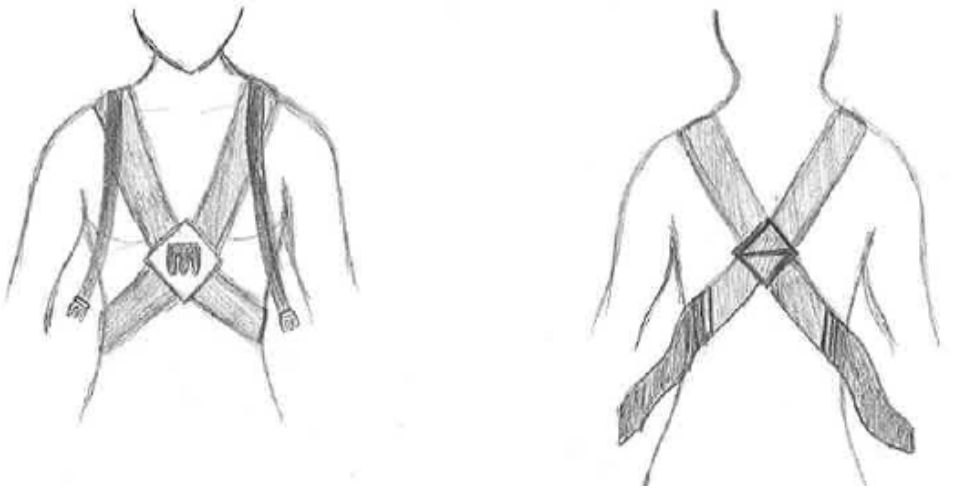

Figure 5.15: First sketches of 3 buckles

Figure 5.16: Prototype of The 3 buckle

Concept 4 - The Ginger Bread

Concept 4 (see figures 5.17-5.18) has a X-shaped back design in the back and the straps are all connected to a front panel. The harness is adjustable at both sides of the body with adjustable straps with open end. In the front there is a long fabric piece that can be used to wrap around the SleepCarrier. Two adjustable straps with quick release buckles are attached at the end of the fabric piece and are used to connect to the shoulder straps on the harness. The fabric piece includes lines of a rubbery material to avoid sliding of the SleepCarrier.

Concept 5 - The Hook

Concept 5 (see figures 5.19-5.21) has a H-shaped design across the back, and the shoulder straps can be adjusted through the adjustment straps on each side. The waist belt, which is connected to the shoulder straps through the front panel, goes around the waist to the back and is fastened by a quick release buckle. The buckle can be adjusted by pulling the two loose strings to each side for a tight fit. The front panel of the harness also has a U-shaper hook, that is attached to the corresponding hook on the SleepCarrier (see figure 5.19). When the SleepCarrier has been hooked on, the two outer straps on the shoulders of the harness are connected to the outer side of the SleepCarrier through quick release buckles.

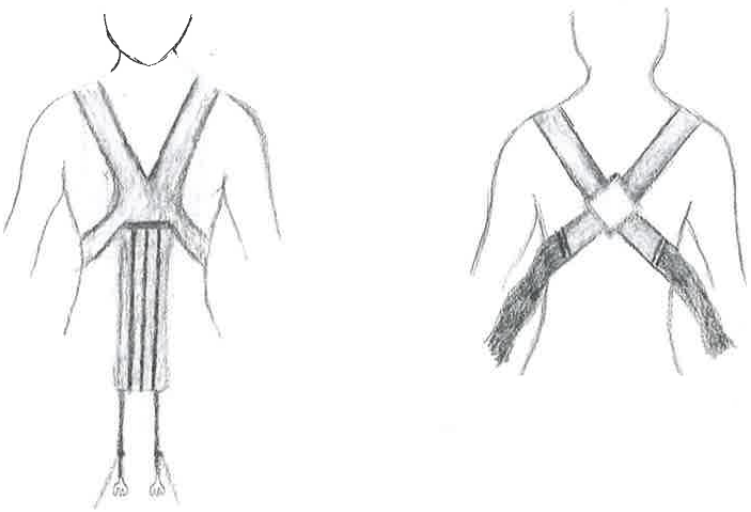

Figure 5.17: First sketches of The Ginger Bread

Figure 5.18: Prototype of The Ginger Bread

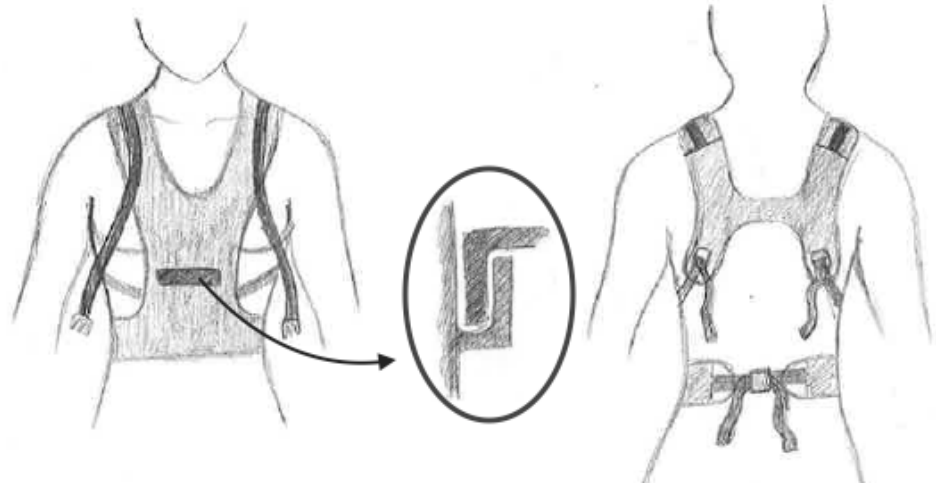

Figure 5.19: First sketches of The Hook

Figure 5.20: Prototype of The Hook

Figure 5.21: Details on the Hook prototype

Concept 6 - The Wrap

Concept 6 (see figures 5.22-5.23) was not developed through the concept combination table, but was instead inspired from The Hammock concept along with the Babysense Sling. It consists of a *wrap* where a large fabric piece is used to wrap the SleepCarrier around the body and connects over one shoulder. The wrap is adjustable when tying the two fabric ends together. The fabric will cover a large area of the back and the SleepCarrier would be fully embraced by the fabric in the front.

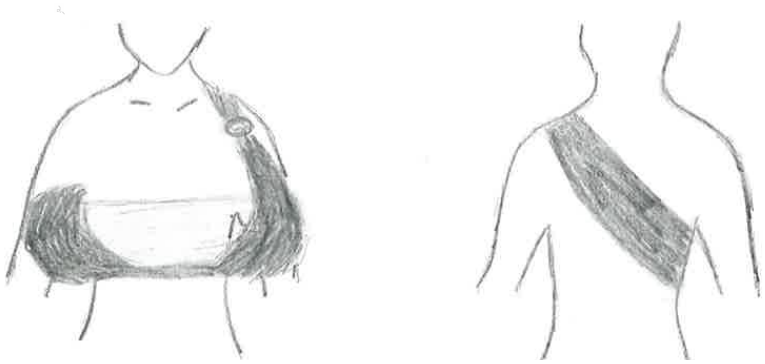

Figure 5.22: First sketches of The Wrap

Figure 5.23: Prototype of The Wrap

CHAPTER 6

Selecting Product Concept

Chapter 6 focuses on evaluating and choosing a concept for further development. The key findings can be found in subsection 6.1.5

6.1 Concept Evaluation

To select the most promising concept, discussions within the project group, Najell and with Lotta Löfqvist were held. User testing of the six concepts was also performed.

6.1.1 Discussions with Najell

During a meeting with the team at Najell, the six concepts and prototypes were presented. Open discussions were held surrounding the positives and negatives of each concept, where each team member was asked to share their opinions. All comments were written down for future reference.

6.1.2 Expert opinion

All of the prototypes were tested by Löfqvist. Open discussions were held and comments were written down for every prototype. Löfqvist's

evaluation of the prototypes focused on the comfortability and how the weight distribution felt across the body. Löfqvist preferred the X-shaped back designs (3 Buckles and The Ginger Bread) and the V-shaped back design of The Loop prototypes, as it covered a large surface area and the weight distribution felt better compared with the other designs. She also liked The Wrap design, since it distributed the weight over a large surface area in the back. However she expressed concern about the asymmetric distribution over the shoulder. From an ergonomic perspective it is always preferable to have a symmetric weight distribution.

Further, Löfqvist mentioned difficulties with designing a waist belt that would suit different body types well. This because the curvature and size of the back can differ significantly between people. She instead speculated that it would be easier to get a good fit with a hip belt, as it is placed lower on the back and uses support from the hips. This area would, according to Löfqvist, be more similar in different body types.

Löfqvist further speculated that women would prefer a harness that did not cover the chest. Pressure on the chest would most likely be uncomfortable for women, especially for those with a larger chest or women who are breastfeeding. Further, she mentioned that there are many nerves around the shoulder and armpit, making those areas sensitive to pressure. For this reason she felt that the The Hammock prototype, which has long straps that go around the shoulder, was uncomfortable in that area. She also felt that the waist belt in The Hammock prototype did not help distribute the weight as much as expected. She assumed that this was because the weight of the SleepCarrier was placed far up on the body.

Every prototype had a different fastening solution to the SleepCarrier. The magnetic buckles were preferred, while the carbine hooks and quick release buckles were both more difficult to attach according to Löfqvist. She preferred the fastening solution with The Ginger Bread prototype over The Loop since it was less confusing to attach the harness to the SleepCarrier. The easiest fastening solution according to Löfqvist was The Hammock design as it only required two actions. Further, she did not quite like the 3 buckle design as a lot of weight was distributed to the neck and it also made the SleepCarrier less stable.

6.1.3 User testing

To broaden the basis of the concept selection, the same people who took part in the user testing of the current product were asked to test the prototypes. Similarly to the previous test, they were asked to put the harness and SleepCarrier on, and carry it around for a few minutes with a 3 kg load. The reason behind the lower load was that the prototypes were more sensitive and might not had withstood a higher load.

During the testing, open discussions were held with the participants to understand their opinions of the different concepts. As previously, the participants were asked to fill out a questionnaire with similar questions to the first questionnaire, see appendix E. This was done so that a comparison between the current product and the concepts could be made. The gathered information from the user testing was analyzed by going through the questionnaire and reading the comments.

6.1.4 Pugh concept selection matrix

A concept selection matrix was created and the set criterion were divided into 4 categories: intuitivity, use, ergonomics and esthetics. Each and one of the concepts were then rated against the reference which was the current harness to the SleepCarrier. See appendix F. The criterion chosen for the matrix were based on the customer needs and products specifications set in sections 3.1 and 4. The concepts were ranked based on how it would have been perceived by someone who has an understanding of the purpose of the product but has never used it before.

6.1.5 Key Findings

After the concepts had been presented to the team at Najell, the main topics of discussion were:

- Is simplicity more important than comfortability?
- Having the harness built in to the SleepCarrier would be a convenient solution
- The harness has to *feel* safe

- Including the harness in the SleepCarrier would make the material and manufacturing cost lower

One suggestion, inspired by The Hammock concept, was to have The Wrap built in to the SleepCarrier, as it would be more convenient and easy to use. Najell's opinion was that the customers would be more likely to use a product that was simple but less comfortable over a product that was complicated but more comfortable. Therefore, Najell's two most favourable concepts were The Hammock and The Wrap.

To conclude the discussion with Löfqvist, the main insights gathered were:

- A symmetric weight distribution is preferred
- The weight should be distributed over a large surface area
- The weight should not be distributed over sensitive areas such as areas with lots of bones and nerves
- The weight distribution over the shoulders should be placed high up
- The weight should be drawn towards the centre of the upper back
- Little to no pressure should be placed across the chest

It was understood from the user testing that every concept had its pros and cons. In general, the magnetic buckles were preferred compared to the other types of buckles that were tested. Tables 6.1 - 6.6 below show some of the pros and cons with each concept and also the percentage of how many thought the tested concept was better than the current harness.

The highest rated concept from the concept selection matrix was The Hammock, and the second highest was The Wrap. The concepts with the lowest scores were The Loop, 3 buckles and The Hook.

Table 6.1: The Loop

Pros	Cons
Comfortable harness	Difficult with carbine hook
Easy to put on	Confusing with the long straps
Better weight distribution than the current harness	Unstable SleepCarrier

87,5% thought that this concept was better than the current one

Table 6.2: The Hammock

Pros	Cons
Easy to connect the SleepCarrier	Difficult to connect and adjust the shoulder straps as they were too far back
The shoulder straps pulled back the shoulders resulting in better posture	The cam buckle was located too far back
Less loading on the back	High load on the shoulders

87,5% thought that this concept was better than the current one

Table 6.3: The Ginger Bread

Pros	Cons
Easy to adjust the harness	Difficult to reach the fastening straps
Very good fit, liked the X-shaped back	The SleepCarrier is unstable
Good pressure distribution	Difficult to fix the back by yourself
Easy to put on	

100% thought that this concept was better than the current one

Table 6.4: 3 buckles

Pros	Cons
Easy to adjust	Difficulty with connecting the middle quick release buckle with the SleepCarrier
Comfortable harness with the X-shaped back	Unstable
Easy to put on	Pulls a lot in the neck and shoulders

50% thought that this concept was better than the current one

Table 6.5: The Hook

Pros	Cons
Easy with the hooks	Difficult to adjust the shoulder straps, are placed too far back The front panel is too long for short people The hipbelt did not help

62,5% thought that this concept was better than the current one

Table 6.6: The Wrap

Pros	Cons
Good fit	Difficult to put on and get a good fitting by themselves
Comfortable on the back, evenly distributed weight	Divided feelings regarding the weight distribution
Easy to put take off	Feels unsafe

87,5% thought that this concept was better than the current one

6.2 Concept Selection

After careful consideration based on all the gathered information from discussions with Najell's team members, the interview with Löfqvist, user testing, concept selection matrix and the project groups own opinions it was decided that the chosen concept for further development would be a combination of The Hammock and The Wrap.

The new idea consisted of having two fabric pieces inbedded in the SleepCarrier, which could then be used as a wrap around the body. The concept of having everything inbedded in the SleepCarrier would provide many benefits in regards to convenience and simplicity. The most challenging problem would be to find an optimal solution in regards to the balance of simplicity and ergonomics. The next chapter will continue with the further development of the new concept.

CHAPTER 7

Further Development and Final concept

Chapter 7 focuses on the chosen concept and the iterative development process that was performed until a final concept was reached. The key findings can be found in subsection 7.2.5

7.1 Brainstorming and sketching

The main insights gathered from the previous chapter were that users would prefer a solution where the harness was embedded in the SleepCarrier and that an X-shaped back design was most comfortable. A brainstorming session was held within the group, which resulted in the Pretzel concept, see figure 7.1. The Pretzel concept consisted of two slings, where the ends would be attached to the SleepCarrier and the other ends would connect to the other side of the SleepCarrier through quick release buckles. While putting it on, the two slings would cross each other in the back to create an X before being fastened and adjusted in the front.

7.2 Development of the new concept

The Pretzel concept was prototyped (see figure 7.2) and tested through a basic prototype made of fabric pieces, pinned to the SleepCarrier.

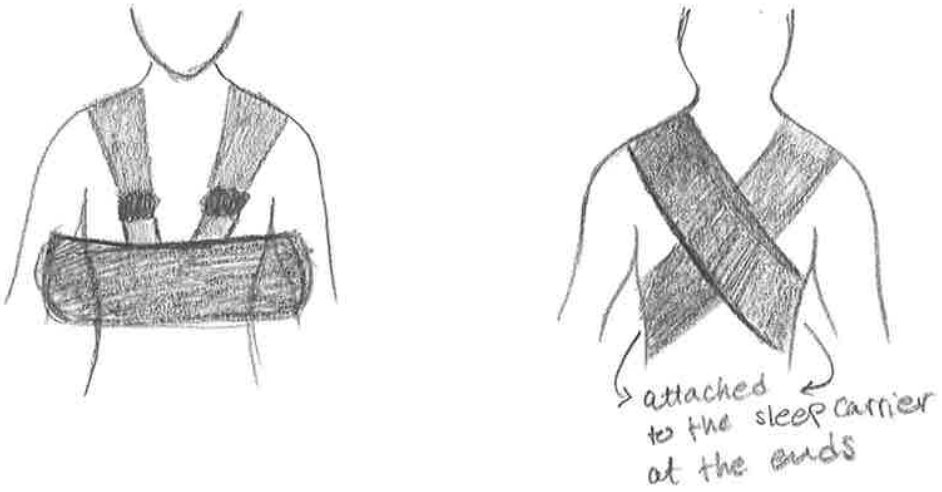

Figure 7.1: First sketch of The Pretzel

During testing it was discussed if it would be possible to use only one sling instead of two, in order to simplify the design. This new idea was prototyped (see figure 7.3) and after discussions within the project group and the Najell team, it was decided to continue with the one sling concept due to its simplicity. However, this new concept had several problems that needed to be solved. For example:

- Ensuring that the design of the harness with the SleepCarrier is safe and stable
- Providing comfortability over the back and shoulder
- Ensuring a good fit for different body types
- Creating a design that would allow the harness to be tucked away

Figure 7.2: The back and front of the Pretzel concept

Figure 7.3: The Pretzel concept with only one sling

7.2.1 Benchmarking

After deciding to move forward with a sling-like design, benchmarking of similar products was done to gain inspiration for the new designs.

Baby Wrap Carrier Ring Sling

The Hip Baby Wrap carrier in figure 7.4 is a traditional ring sling with one large piece of fabric that wraps around the body and connects with two rings over one shoulder. The two rings allow for size adjustment of the sling.

Figure 7.4: Baby Wrap Carrier Ring Sling (Hip Baby Wrap, 2019)

Minimonkey Sling Classic 4-in-1

The Classic 4-in-1 sling from Minimokey in figure 7.5 has a basic design, with a padded shoulder part along with a buckle that allows for size adjustment.

Figure 7.5: Minimonkey Classic 4-in-1 sling (Minimonkey, 2019)

7.2.2 Iterative prototyping & final concept

Through discussion within the project group and with Najell, along with a process of iterative prototyping using scrap pieces of fabric and an old version of the SleepCarrier, solutions to the problems mentioned above were found and the final concept was created (see figures 7.10-7.14).

The Stability and safety of the SleepCarrier

After removing one of the slings from the Pretzel concept it was observed that the design was not stable, as the SleepCarrier would tip over at the ends. Mainly by the left corner closest to the body.

For that reason, an extra strap with a quick release buckle was added to the inside of the shoulder section, which connected to one of the existing inner buckles on the SleepCarrier (see number 1 in figures 7.10 and 7.11). This strap could also be adjusted depending on the height and size of the user.

To gain more stability in the front, a front buckle was attached to the SleepCarrier by a piece of fabric in a wide triangle shape. This provided support and prevented the front ends of the SleepCarrier from tipping to the sides. Different designs (see figure 7.6) and placements of the triangle were tested until the desired support was achieved.

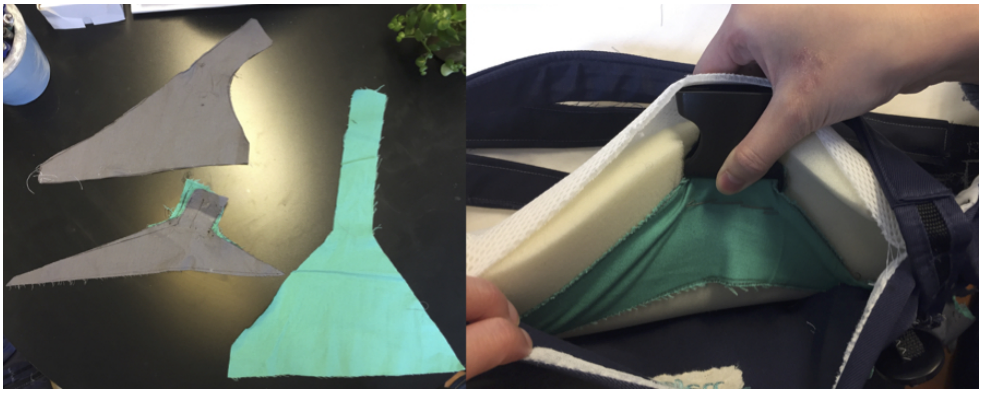

Figure 7.6: Different designs of the triangle and how it is attached to the front of the SleepCarrier

Comfortability

A lot of consideration and time was put into making the sling comfortable for the back and shoulder. Different shapes of the sling were tested, see figure 7.7, as well as different textiles and foams. It was kept in mind to have a large area covering the back to distribute the weight and having a softer cover around the shoulder. It was also important to achieve a tight fit so that the weight would be as close to the body as possible.

To create a soft area for the shoulder, different prototypes of the shoulder section were made. The first iteration included a section of foam (see number 1 in figure 7.7) that was supposed to help minimize the pressure on the shoulder. It proved to be difficult to achieve a good, tight fit over the shoulder because of the texture of the foam. To achieve a similar softness, the next iteration included a soft jersey fabric piece across the back and shoulder. However, as weight was put in the SleepCarrier the weight would stretch out the fabric, pulling the SleepCarrier down too far.

For the last iteration, a combination of woven and Jersey fabrics were used. By layering the two fabrics, the jersey (white coloured) would provide comfortability while the woven (grey coloured) fabric would help keep the structure. Two large pieces of each of the fabrics were sown on top of each other and then bunched at the ends to fit the back and front sections of the sling (see number 2 and 3 in figure 7.7). This construction gave the ability to adjust the shoulder section as it could either cover a large area or be used to create a thicker padding across depending on the preference of the user (see number 7 in figure 7.11).

Fitting on different body types

Since, according to the target specifications, the product had to fit different body types and heights, various ways and points of adjustment were tested.

The first iteration had a double sided adjustment buckle in the front, see figure 7.8. This was to have as much room for adjustment as possible, without risking that the buckle would slide up too far on the shoulder when being used by a smaller person.

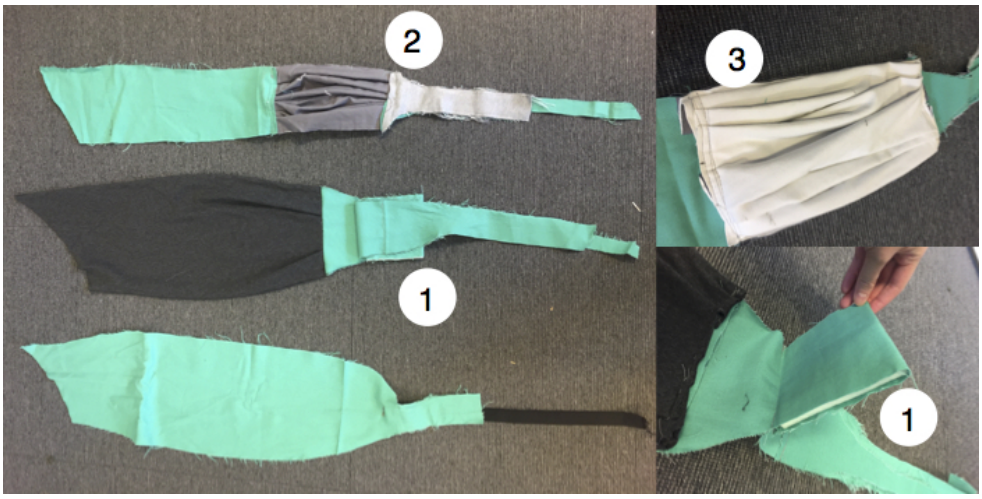

Figure 7.7: Different designs of the sling

Figure 7.8: Double sided adjustment

During several user tests it was realized that the space for adjustment in front of the body did not significantly differ between body types. The main difference was the size of the back. For this reason and to simplify the adjustment, it was changed to a one sided adjustment buckle with the female end being fixed in the front of the SleepCarrier. To gain more room for adjustment the female end buckle was moved further down until satisfied adjustment room was achieved. This resulted in the female end of the buckle being inside the side of the SleepCarrier, as seen in figure 7.6. This concluded the second iteration.

To get the shoulder section to fit properly on people of different heights, it was realized that an adjustment for the back section was also needed. For this reason, the third iteration included a zipper along the back section (see number 6 in figure 7.11). When the zipper is closed, the back section is shortened, allowing a better fit for shorter users.

Tucking away the harness in the SleepCarrier

The harness includes both the sling and the front buckle. To be able to hide the female buckle when not in use, a pocket was created along the front side of the SleepCarrier (see number 2 and 4 in figure 7.10).

A pocket was also created on the back side of the SleepCarrier, so that the sling could be tucked away (see number 3 in figure 7.10 and figure 7.12). To make tucking the sling away easier, the pocket would have openings on both sides. To avoid the sides having an uneven appearance when the sling is not in use, the previously one layer of foam was divided into two thinner ones, creating space between them for the sling. This resulted in a less uneven appearance and also gave a more rounded side.

Overall improvements

The rounded appearance of the side with the sling pocket was appreciated by the team at Najell as it gave a "cozier" appearance and resembled other popular baby nests on the market. For that reason, the other side was also redesigned in a similar way to achieve a symmetric, more

”cozy” feeling.

A suggestion from Najell was to find a way to hide the handles as the SleepCarrier might look cozier without them. Several ideas were discussed and a solution that incorporated buttons so that the handles could be removed was prototyped, as seen in figure 7.9. After discussions with Najell and during user testing it was concluded that this solution would not be practical and would not feel safe. For these reasons this solution was dismissed. It was instead decided, together with Najell, to keep the current design of the handles.

Figure 7.9: A prototype of the removable handles

At request by Najell, the size of the SleepCarrier was changed by removing 2 cm from the width and adding 5 cm to the length. The reason for this was to ensure that the SleepCarrier could fit better into the majority of strollers on the market.

7.2.3 User testing

Similarly to the previous user testing, the users were asked to put the prototype on and carry a 4 kg doll for a few minutes. During the testing, open discussions were held with the participants to understand their opinions of the concept. As previously, the participants were asked to fill out a questionnaire at the end of the test, with questions regarding the new concept as well as comparative questions of the new concept and the current product. For example, the users were asked to choose which one they would prefer depending on different criterion such as safety

Figure 7.10: Details of the final concept

Figure 7.11: Overview of the final concept

Figure 7.12: Close-up of the sling pocket empty (left) and with the sling inside (right)

Figure 7.13: Overview of the slings attachment to the SleepCarrier

Figure 7.14: The SleepCarrier from the front (top) and back (bottom)

and comfortability. See appendix E for the questionnaire. The gathered information from the user testing was analyzed by going through the questionnaire and reading the comments.

7.2.4 Expert opinion

A meeting with Löfqvist was held to get her opinions on the final concept. She carried a 3.5 kg doll in the prototype for approximately 10 minutes. During carrying, she expressed that the back and shoulder felt comfortable as the weight was distributed over a large area of the back. She preferred to have the shoulder section stretched slightly over the shoulder, to distribute the weight better.

The project group members mentioned the concern regarding the asymmetric load and the restriction of only using one shoulder. Löfqvist understood this concern, but mentioned the importance of taking the purpose of the function and user time into consideration. The user time is relatively short compared to other carrying activities and an older baby with its increased size and activity might not be appropriate for this function. Meaning that the likelihood that a parent would carry

the maximum allowed load (10 kg) would be small. For that reason, the asymmetric load might not be a concern.

Löfqvist liked the simplicity of putting the harness on and off and the solution of having the harness built in the SleepCarrier. She also agreed with that the possibility for parents to actually use the carrying function would be higher if the harness was easily accessible.

7.2.5 Key Findings

Majority of the users had the opinion that the new concept was easier to use and understand than the current design. Many appreciated the tuck-in solution and having everything embedded in the SleepCarrier.

One of the main difficulties that the users expressed was that the inner strap would get caught behind the back and that the sling itself could twist and end up in the wrong position. Another difficulty was connecting the sling to the front with only one hand as the buckle would move downwards when pressing on it. However, when the harness was on, a majority of the users felt comfortable and all users enjoyed the adjustability of the shoulder section. Because only one shoulder would carry the weight, several users assumed that the used shoulder would become tired after longer periods of use. It was also mentioned that the main disadvantages with the new concept were that only one shoulder was loaded and not allowing for the possibility to chose which shoulder to use.

The placement of the baby was also mentioned by a few users. Some felt that the natural way to face their baby would be on the left side. However, in this concept, it is more natural to put the baby's head on the right side as it offers more open space. The reason for this is that the sling partly covers the view of the left side of the SleepCarrier, since the buckle is placed slightly off center to the left. There were also discussions regarding the easiest way of putting the SleepCarrier on and if the baby should be in the SleepCarrier when putting it on or if it should be placed inside after.

Insights from the questionnaire were that some users thought that the new concept felt less safe and stable in comparison to the current prod-

uct. The users also thought that the bottom plate felt uncomfortable as it's edge pressed against the stomach.

The zipper adjustment worked well and allowed a good fit for all participants, which were in the height range of 155cm and 195cm.

Feedback from Löfqvist were positive as she thought the new concept was comfortable on the back and shoulder, even with the asymmetric loading. She emphasized that it is important to take in to account the intended use of the concept and the user time. The main purpose of the carrying function is to act as an alternative way of putting babies to sleep and help parents reduce carrying with the arms. It is not meant to be used as a traditional baby carrier where user times are longer.

Overall, the advantages and improvements outweighed the drawbacks with the final concept. This was confirmed as all test users preferred the new concept on many criterion. For example it was easier to put on and take off, easy to adjust, more comfortable than the current product as it allowed a better fit, the users felt closer to the baby and it has everything built in to the SleepCarrier.

7.3 Technical drawings for factory order

To be able to evaluate the concept further, a high quality prototype was ordered from Najell's partnering factory. To do this, Adobe Illustrator was used to make technical drawings of the final concept, including all of the changes mentioned above. Parts of the drawings can be seen in appendix G.

CHAPTER 8

Setting Final Specifications

Chapter 8 presents the final specifications of the final concept.

After prototyping, user testing and consulting with the team at Najell, the following specifications were set:

- The harness can withstand a maximum weight of 10 kg
- A person can use the harness and SleepCarrier with no help from another person
- The time for putting the harness on does not exceed 1 minute
- The time for adjusting the harness does not exceed 1 minute
- The time for taking the harness off does not exceed 1 minute
- *The harness can be worn by people between 155-195 cm tall*
- The harness fulfills the safety and durability standards set by SIS
- The harness suits different body types.
- The harness is machine-washable

- The harness can be worn for a minimum of 15 minutes without notable pain
- *The weight of the SleepCarrier is not increased more than 0.5 kg compared to the current product*
- *The total manufacturing cost does not exceed the manufacturing cost of the current design*

The specifications in cursive are either newly added or edited from the previously set target specifications.

CHAPTER 9

Discussion & Conclusion

Chapter 9 will cover a discussion regarding the project process, used methods, final concept and its future improvements, work distribution and ends with a conclusion.

9.1 The project process

The concept development process presented by Ulrich and Eppinger (Eppinger & Ulrich, 2012) in *Product Design and Development* was followed throughout the project. Since this process is well known and had been used by the group members previously, during courses taught at Lund University, it was seen as a suitable method for this project. Limiting the project to focus on the concept development phase of the design process proved to be a good choice, as it would have been too time-consuming to perform all of the phases. Having a clear model to follow throughout the project made it easier to set goals and make a clear time plan for the different activities. Even though an economic analysis of the final concept was not performed, economic factors were considered during the design process in regards to materials and the complexity of the concept. This to make sure that the concept agreed with Najell's future goals.

The concept selection step was a critical stage in the project. Multiple methods were used to gather as many insights as possible in order to make sure that the different perspectives were considered. This gave the project group important support when choosing which concept to continue with.

According to the restrictions in section 1.4, the original goal did not include making any changes to the SleepCarrier itself. However, while brainstorming, an idea regarding having the harness embedded in the SleepCarrier was suggested. This idea was further explored which then led to it being included in the final concept. This idea was also encouraged by the team at Najell. During prototyping of the final concept with the embedded solution, Najell's team saw an opportunity to change the appearance of the SleepCarrier, in order to make it "cozier" and look less technical. This lead to the change of the shape of the SleepCarrier's sides.

9.1.1 Time planning

A Gantt chart was created in the beginning of the project, see appendix A. The chart was used as guidance throughout the whole project and was followed well. Some of the activities took less time than expected, for example prototyping started a few weeks earlier than planned. This gave time for making technical drawings and sending an order to the factory, which had not been a part of the original plan.

The project group wrote weekly diaries and planned accordingly after each week. Every Friday the project group would go through the past week as well as plan for the next week. Weekly meetings were held every Monday with the team at Najell, where the previous and coming weeks were discussed. These meetings gave the group members informative insights in to how a company producing consumer products functions. The report was updated regularly throughout the project.

9.1.2 Challenges of identifying customer needs

A challenge during the identify customer needs process was to gather substantial information from the end users, in this case parents with children aged 0-1 year. The main purpose of the SleepCarrier is to help

parents put their baby to sleep and it would therefore have been insightful to be able to observe parents performing this task. It would also have been helpful to observe people using the SleepCarrier as a baby carrier. However, that proved to be difficult to arrange since people could feel that it would be too intrusive to be observed during this activity.

After discussion with Najell, having a better understanding and knowledge about parents in general, it was understood that all parents are unique and have their own ways and tricks to put their baby to sleep. For that reason focus was instead put on identifying problems with the current product by interviewing previous users of the SleepCarrier, reading reviews and performing user tests.

9.1.3 Expert opinion

An expert in ergonomics was involved throughout the project. Löfqvist's insights were focused on the ergonomic perspective compared to the Najell team, where a more business perspective was given. She provided important information and helped find the pros and cons of each concept. The company hopes that this new product can be launched in the near future and for that reason it was important to keep cost and selling ability in mind. Both perspectives were important in the design process and the main challenge when developing the final concept was to find a balance between comfortability and simplicity.

9.1.4 Trade-off between ergonomic carrying and complexity

Before choosing which of the six concept to continue with, a trade-off between ergonomic carrying and complexity was debated. Based on the research that was done about ergonomic carrying and the expert opinion it was understood that only carrying on one shoulder would not be preferable. However, in order to achieve symmetric loading the product would be more complex and have lower usability, as defined by the ISO standard (International Organization for Standardization (ISO), 2018). Also, a more complex product would be more expensive and difficult to produce, which for the company would not be beneficial. This reasoning was used when deciding on which concepts to move forward

with and was also kept in mind throughout the rest of the development process.

9.1.5 Credibility of sources

Section 1.1 of this report included an overview in ergonomics and topics that were relevant to the project. Most of the information was taken from scientific reports or books and was therefore considered to have high credibility. Other sources were well established institutions and associations.

While searching for information about the implications of front carrying it was found that not many studies had been done on this topic. For this reason, some of the studies regarding backpack carrying were still regarded as useful since the shoulders would be used whether the load was carried in the back or the front.

A source of error could be that in some studies, such as the studies done by Abutaleb (2016) and Junqueira et al. (2011 and 2015), only women were involved. This was also mentioned as a limitation in their reports.

Other information sources that have been used in this project are knowledge from experts in the topic. For example, Löfqvist contributed with expertise in ergonomics and the Najell team contributed with their knowledge from years of experience in the industry.

9.2 The used methods

Brainstorming

Performing the first brainstorming session individually proved to be valuable, as both project members could generate ideas without influencing each other. All ideas were later discussed together which lead to the development of new ideas.

The later brainstorming processes were performed together by honing in on a specific problem and having open discussions about the solution alternatives. This made the process more time efficient and allowed the group members to be inspired by each other.

Benchmarking

Since there were no products on the market with the same functionality as the SleepCarrier, related products such as baby carriers and harnesses of other kinds were researched instead. This gave plenty of inspiration for different designs of harnesses. Because baby carries consist of many different parts, it was decided that dividing the problem into subproblems would be a good method to prevent the group members from getting overwhelmed when generating ideas. When generating ideas for potential solutions to the subproblems, benchmarking proved to be a very useful method because new solution alternatives that had not previously been discussed were discovered.

Throughout the project the group members visited baby stores multiple times. This gave insights in to for example the comfortability and usability of certain products that had previously been researched online. When the final concept had been designed and prototyped, a visit was made to Lekia in Lund to make sure that the new design would fit in the smallest strollers when being used as a carry cot.

Concept combination table

The use of the concept combination table simplified the concept generation process by allowing the group members to focus fully on one problem at a time. It also allowed the members to generate many ideas. An issue with using this method was that it restricted the thought process to mainly focus on creating a new, separate harness. Concepts like the wrap arose only after the group members decided to break away from the concept generation table and instead focus on brainstorming ideas "outside of the box".

Interviews

Semi-structured interviews were held with two users during the identify customer needs phase. The structure of the interviews worked well as it gave the interviewee more freedom to speak freely about topics they found important. The script that had been prepared beforehand was used as a guide when discussions faded and to not forget any important topics or questions. Both interviews held were approximately 30-60 minutes long, which gave enough time for in depth discussions regarding the

product and the parents methods as well as struggles with putting their children to sleep.

The group members had an aspiration of interviewing more users, to increase the amount of insights and needs found during this phase. Due to the inability to get in contact with more users of the harness to the SleepCarrier this was not a possibility.

Personas

The insights from the interviews, user testing and online research was kept in mind during the whole design process, making the personas somewhat redundant. This method could have been more useful if a new target user group had to be identified.

Prototyping

Prototyping was one of the most important and useful methods during the design process. Prototypes allowed user testing, which helped the project group understand the problems with each generated concept, identifying new problems that were not discussed before and getting a better understanding of the user process.

Furthermore, prototyping was an useful way to evaluate the functionality of many ideas. The development of the final concept went through many changes as new solution ideas were prototyped and tested until the desired result was reached.

User testing

User testing was performed throughout the project to gather insights on the various concepts generated. This method helped the group members to understand opinions from people who had never before seen or used the SleepCarrier or any similar products. It also helped the group members to understand problems that had previously not been discovered.

To make the user testing more reliable, a larger group of people, with a larger variation in for example age had been useful to make the testing more credible. The majority of the participants were not parents, which might have affected their opinions regarding safety and the estimated

usage time for example. The two participants that were parents, both of them mothers, were the only ones that mentioned opinions that were not brought up before. For example which side they would prefer to face their baby and wanting to have their dominant hand free to be able to take care of the baby. Since the final concept loads only one shoulder, it would also have been beneficial to have participants who were left handed.

In some cases, the participants were given help from the project group members when for example putting the harness on or putting the weights in the SleepCarrier after it had been attached to the harness. Because of this, the participants might not have received a full user experience.

The difficulty with the inner strap getting caught behind the back or twisting itself can be solved by instructing the users to hold on to both of the straps when putting the harness on. Therefore, better instructions to the users could have avoided this problem.

In all user tests the bottom plate was perceived as uncomfortable since its edge would press against the stomach. It was then discovered that the SleepCarrier that was being used for prototyping was an old version and the design of the bottom plate had since been changed. Meaning that the current SleepCarrier has a different shaped bottom plate, which is meant to follow the curve of the stomach (see figure 9.1), and the problem with the edge pressing against the stomach would therefore be improved. The sample prototype from the factory had this change made.

The perceived stability and safety of the new concept were often discussed during user testing. The first impression of the new concept was that it looked less stable and safe compared to the current product. However when putting weight in the SleepCarrier, many said that it felt more stable and safe than expected. Another important factor to mention is that the prototype that the participants tested was self made, with many parts sewn by hand. This could give the impression of an unsafe and unstable concept.

During user testing, discussions regarding if the baby should be put in the SleepCarrier before of after putting it on were brought up. After discussion in the project group it was decided that both ways would

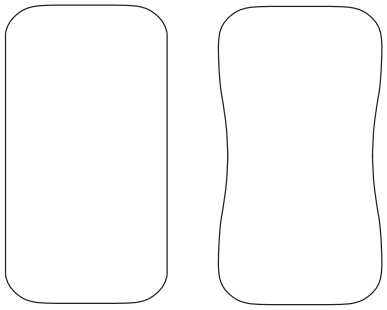

Figure 9.1: Old (left) and new (right) shapes of the bottom plate

work and the user could choose based on their own preferences. During testing some put the baby in first and held the SleepCarrier in front of them when fastening the sling. This action requires quite a lot of arm strength. Another user preferred sitting down, fasten the sling and then putting the baby in to avoid using the arm as much. Hence, the user process can look differently depending on the users preferences.

Pugh concept selection matrix

When setting the criterion for the Pugh concept matrix in subsection 2.2.8, the most important aspects of the product were considered. These being; intuitivity, use, ergonomics and esthetics. The criterion were then set based on those aspects.

When setting the criterion it was difficult to make them clear so that they couldn't be interpreted in different ways. Further, The Pugh method did not take account to that the criterion could be considered unequally important. For example the perceived safety of the baby might be more important to some users than being able to identify the front and back of the harness. Further, it was difficult for the project group to be objective while ranking the different concepts. Hence, the result might have been different if someone else would have done the same process. Even though a concept might have had a low total score, aspects of that concept that scored well were taken into consideration when moving forward with the development process.

9.3 Final Concept

The final concept has the same functionality as the current product, but offers a simpler product with a more comfortable carrying experience. The simple design of the harness makes the overall product look less technical and instead has a more cozy appearance, due to for example the rounded sides and removal of three quick release buckles. This increases its chances of competing with other baby nests on the market while still offering additional functions.

The information gathered from the studies examined in section 1.1 was kept in mind throughout the whole design process.

The back section was made as wide as possible to increase the contact area and thereby distributing the pressure over a larger area. The size of the shoulder section was made adjustable to suit different user preferences. It can either be worn folded in with a placement high up on the shoulder, or be worn folded out to spread the pressure over a larger surface area.

The three adjustment points (two buckles and one zipper) gives the user the ability to adjust the harness to fit their body properly and bring the SleepCarrier as close to their body as possible.

The studies (see subsection 1.1.3) that investigated the use of hip belts while carrying agreed that the use of a hip belt did in fact lessen the load on the shoulders during carrying activities. For this reason, some of the first concepts included a hip belt. During the first user testing it was discovered that since the load of the SleepCarrier was placed so far up in front of the body, the use of a hip belt did not contribute to lowering the pressure on the shoulders. Therefore, using a hip belt was disregarded when designing the final concept.

As previously mentioned, a trade-off was made between the ergonomics and complexity of the design of the final concept. During the design process it was realized that a symmetric loading would increase the complexity of the concept and hinder the development of making the concept more intuitive and user friendly than the current product. For this reason, a un-symmetric design was favoured.

Since 90% of the human population are right handed, making the left shoulder their non-dominant one, the left shoulder was chosen as the carrying side for the final concept.

9.3.1 Specifications

As seen in chapter 4, the target specification for the user height range was set to 165-185 cm, which was based on the average height of males and females in Europe. This range was used during the design process when setting the measurements for the harness. An optimal fit of the concept can therefore be achieved for people in this range. However, during testing it was discovered that a good fit could be achieved by people in the range of 155-195 cm and therefore the final specification of the height range was changed.

The times set in chapter 4, for putting the harness on, adjusting it and taking it off, proved to be achievable and were therefore kept for the final specifications. As it was discovered in chapter 3.1, a reason for people not using the harness was because it was too complicated and time consuming to put on and adjust properly. For this reason a shorter time for these activities were desired.

To make sure that the new concept fulfills the final specifications set in chapter 8 and the SIS safety standards, it needs to be properly tested. The prototype received from the factory could withstand a load of 10 kg but further testing needs to be performed to ensure the durability and lifetime of the design.

9.3.2 Factory order

A prototype of the final concept is currently being made by Najell's partner factory. The order was sent in April and the project group had intentions to perform user testing with the new prototype. Due to delayed production by the factory the prototype has not yet been received, making user testing not possible. Because of the concerns regarding the perceived safety and stability with the self made prototype, the main purpose of testing the new prototype would be to see if it could lessen this concern. Additionally, the production team at the factory

could evaluate if a large scale production of the new design is possible, or if changes have to be made.

9.4 Future improvements

A disadvantage with the final concept is the left carrying shoulder. Some people might prefer using the right shoulder because of that being their non-dominant side or because of for example an injury. For that reason, a future improvement could be to develop the concept to allow the user to choose their preferred carrying side. This would also give the user the choice to choose the optimal side to face their baby. A suggested solution to this problem would be to place the sling in the middle of the sling pocket instead of having it on the right side. This would allow the ability to pull it out of the pocket on either side. However, in order for it to work, the front buckle would need to be relocated as it is now placed slightly off center and the sling would have to be the same on both sides. Issues with this solution would be where to place the zipper for the adjustment of the back and making sure that the carrier would be stable on both sides.

9.5 Work distribution

The project group members worked equally throughout the project. The different backgrounds in Engineering, Michelle having a more ergonomic perspective while Marija having more knowledge in product development processes, complemented each other well during the project.

9.6 Conclusion

The goals presented in section 1.3 are considered to be met. Due to a well planned project schedule and an effective execution, the project developed further than expected. A factory order was made and the final prototype is currently being made by Najell's partner factory. The final concept fulfills the expectations set by Najell. They are planning on presenting the final concept at Kind + Jugend, the leading international trade fair for premium baby and toddler products, which takes place in Cologne in September 2019.

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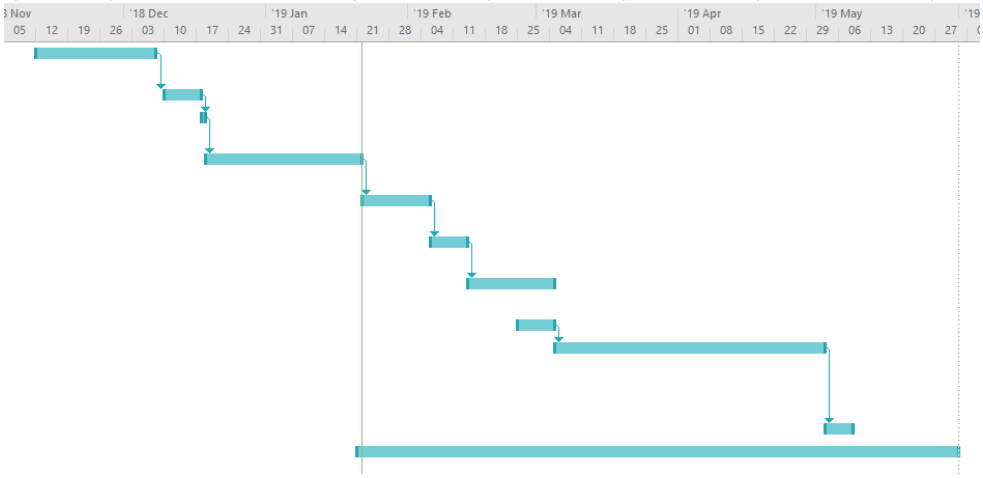
APPENDIX A

Time planning & Gantt schedule

Task Mode	Task Name	Duration	Start	Finish	Predecessors
	Document defining the degree project	4 wks	Mon 18-11-12	Fri 18-12-07	
	Planning phase	6 days	Mon 18-12-1	Mon 18-12-1	1
	Start-up meeting with Najell	1 day	Tue 18-12-18	Tue 18-12-18	2
	Pre-study of the subject	24 days	Wed 18-12-19	Mon 19-01-21	3
	Identify customer needs - User study	11 days	Tue 19-01-22	Tue 19-02-05	4
	Establish target specification	6 days	Wed 19-02-06	Wed 19-02-13	5
	Concept development	13 days	Thu 19-02-14	Mon 19-03-04	6
	Concept selection	6 days	Mon 19-02-2	Mon 19-03-0	
	Iterative prototyping - Development and testing	43 days	Tue 19-03-05	Thu 19-05-02	8
	Final specifications	4 days	Fri 19-05-03	Wed 19-05-0	9
	Writing report	95 days	Mon 19-01-2	Fri 19-05-31	



APPENDIX B

Gathered excerpts from reviews online

På Smällen is a blog by a mother named Emma. In June 2016 she posted a review of the Najell SleepCarrier. The excerpts below were taken from this post (På Smällen, 2016):

"Bästa ordet att beskriva SleepCarrier är att den är praktisk, särskilt om man bor i lägenhet utan hiss!"

"...då sov hon faktiskt exakt hela dagen (7 timmar!!) i SleepCarrier trots att vi lyfte ur och i SleepCarrier från vagnen flera gånger. "

"När Lucas var bebis så läste jag att bebisar ska vakna på den platsen dom har somnat, det ger tryggare bebisar som lättare kan somna om. SleepCarrier ger den möjligheten."

"När Isadora var helt nykläckt så tyckte jag inte att SleepCarrier var tillräckligt trångt för att ge den där ombonade känslan som ett babynest ger, men det hade inte varit så bra om den hade varit så trång för då hade den blivit liten för snabbt. "

"Vi har testat bärselefunktionen för att bilda oss en uppfattning, men än så länge har vi inte varit i behov av den. Isadora har somnat snabbt och enkelt utan några problem bara hon har fått sin snutte och sin napp. Just nu är hon väldigt lätt att söva, men det brukar ju gå över när bebbarna blir lite större. "

Anna Lavfors is a mother of four and runs the blog Allt om barnvagnar. In May 2015 she posted a review of the SleepCarrier. The excerpts below were taken from this post (Anna Lavfors - Allt om barnvagnar, 2015):

"SleepCarriern visade sig sedan fylla en annan funktion minst lika bra – den som en liten mjuklift lagom att passa i de allra flesta barnvagnars liggdelar"..."Najell SleepCarrier som mjuklift är liten nog att rymmas i liggdelen, och det är något som ofta efterfrågas"

"...sedan kan det vara något bökigt att komma åt den inre selspännens och framför allt att hålla liften bra balanserad medan man knäpper på

och av”

”Barnet på bilderna är vid tillfället omkring 4-5 månader gammal, och föräldrarna använde SleepCarriern just när inget annat funkade för att söva”

”Han hade stort närhetsbehov men sov ändå bäst en bit ifrån oss, så att kunna söva honom nära och sedan relativt ostört placera honom i hans egen säng hade varit toppen.”

Monica Nyhus wrote a review post about Najell’s SleepCarrier in June 2016. The excerpt below were taken from this post (Monica Nyhus, 2016):

”Emilio often falls asleep in his sleepcarrier and it’s so great that I can put him straight to bed without risking to wake him up.”

Pricerunner is a website for consumers to compare prices from different online stores. One comment was found about the SleepCarrier.

”Smart multiprodukt! Som bärdon fungerar den helt okej även om alla bebisar inte accepterar den, men det är superpraktiskt att den även kan användas som en liten mjuklift, som lekmatta och som ett slags babynest.”

Reviews from the Najell website:

”We’ ve just been on summer holiday. The carrier is a very good travel bed. It doesn’t take much space and is not heavy. Just perfect.”

”As we live on the 3rd floor, it was perfect that we could carry him and put him in the pram then”

”Fits in our small stroller, easy to wash, supercosy for baby”

”We bought the carrier cause it fits in our Bugaboo. Our son loves it because it surrounds him so he feels safe. We simply love that the product has several functions and we also use it when we eat as a playmat and put it on our dinnertable. My only complaint is that the fabric gets a bit fluffy because dust getting stucked to it.”

APPENDIX C

Basic script for the interviews

1. Have you or do you use the harness for the SleepCarrier? If yes: When did/do you use it? For how long did/do you use it per session?

2. Do you rock your baby to sleep? How long does it usually take?

3. Do both you and your partner rock your baby to sleep?

4. Have you ever felt pain in any part of your body after carrying your baby? If yes: Where? And for how long did the pain last?

5. Does the harness fit on your body? Is it comfortable?

6. Did you need to read the manual to understand the use of the harness? Did you read it more than once?

7. Do you have any other comments you would like to add on the product and its use?

APPENDIX D

Concept combination table explanation

Quick release buckle

Hook c-shape

Hook-and-loop

Carbine hook

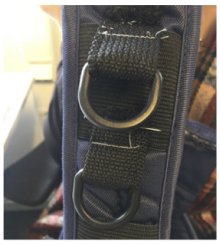
Airplane seat belt buckle

Magnetic buckle

Cam buckle

Adjustable strap fixed loop

Adjustable strap open end



Fixed adjustment points

TRX-strap

X-shape (back)

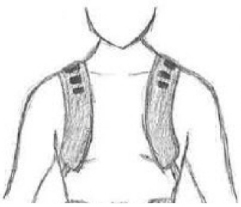
Y-shape (back)

V-shape (back)

H-shape

Double Y-shape

Y-shape



Backpack straps

II-shape

APPENDIX E

Questionnaires

Användartestning av Najells SleepCarrier

Kön
- *Man*
- *Kvinna*

Hur lång är du? (cm)
- *Fri text*

Skatta nedanstående frågor på en skala från lätt (1) till mycket svårt (5)
Hur svårt var det att ta på sig bärselen?
Hur svårt var det att koppla ihop bärselen med SleepCarriern?
Hur svår upplevde du att justeringen var?
Hur satt bärselen på dig?

Vad var svårast att förstå? Rangordna de olika alternativen från 1 (lättast) till 8 (svårast)
- Vilken sida av selen som är fram och bak
- Hur man knäpper ihop selens midjespännen
- Hur man justerar selens midjespänne
- Hur man justerar selens axelband
- Vilken sida av SleepCarriern som är fram och bak
- Hur man knäpper ihop selen till SleepCarriern
- Hur man justerar selens yttre spännband som kopplas till SleepCarriern
- Var de olika spännena på selen och SleepCarriern ska kopplas ihop

Skatta nedanstående frågor mellan ingen (1) och mycket stor (5)
Hur stor belastning kände du på axlarna?
Hur stor belastning kände du i ryggen?
Hur stor belastning kände du på magen?

Hur många minuter uppskattar du att du skulle orka bära runt på
- *Fri text*

Vad skulle du vilja ha annorlunda?
- *Fri text*

Prototyptestning av sele till SleepCarrier

Kön
- *Man*
- *Kvinna*

Hur lång är du? (cm)
- *Fri text*

Nedanstående avsnitt besvaras för varje prototyp

Skatta nedanstående frågor från lätt (1) till mycket svårt (5)
Hur svårt var det att ta på sig bärselen?
Hur svårt var det att koppla ihop bärselen med SleepCarriern?
Hur svår upplevde du att justeringen var?

Skatta nedanstående fråga från mycket bra (1) till dåligt (5)
Hur satt bärselen på dig?

Var det något annat som inte nämnts ovan som upplevdes svårt?
- *Fri text*

Skatta nedanstående frågor mellan ingen (1) och mycket stor (5)
Hur stor belastning kände du på axlarna?
Hur stor belastning kände du i ryggen?
Hur stor belastning kände du på magen?

Vad var bäst med denna prototyp?
- *Fri text*

Vad var sämst med denna prototyp?
- *Fri text*

Är denna prototyp bättre eller sämre än den nuvarande produkten?
- *Bättre*
- *Sämre*

(Denna fråga förekom endast en gång)
Vad skulle du föredra?
- Enkelhet framför bekvämlighet
- Bekvämlighet framför enkelhet

Prototyptestning av final concept

Kön
- *Man*
- *Kvinna*

Hur lång är du? (cm)
- *Fri text*

Utvärdering av det nya konceptet
Skatta nedanstående påståenden från instämmer inte alls (1) till instämmer helt (5)
Det var svårt att ta på sig bärselen
Det var svårt att ta av sig bärselen
Det var svårt att justera selen
Bärselen passade min kropp dåligt
Undanstoppning av bärselen var lätt att utföra

Var det något annat som inte nämnts ovan som upplevdes svårt?
- *Fri text*

Skatta nedanstående påståenden från instämmer inte alls (1) till instämmer helt (5)
Jag kände stor belastning på axeln
Jag kände stor belastning på ryggen
Jag kände stor belastning på magen

Vad var bäst med detta koncept?
- *Fri text*

Vad var sämst med detta koncept?
- *Fri text*

Jämförelse med den ordinarie bärselen
För nedanstående frågor fanns alternativen Orginalkonceptet och Nya konceptet
Vilken bärsele är mest intuitiv?
Vilken bärsele var lättast att ta på sig enligt dig?
Vilken bärsele var lättast att ta av sig enligt dig?
Vilken bärsele var mest bekväm?
Vilken bärsele känns mest stabilt enligt dig?
Vilken bärsele känns mest säker enligt dig?
Vilken bärsele skulle du vilja använda?

Övriga kommentarer
- *Fri text*

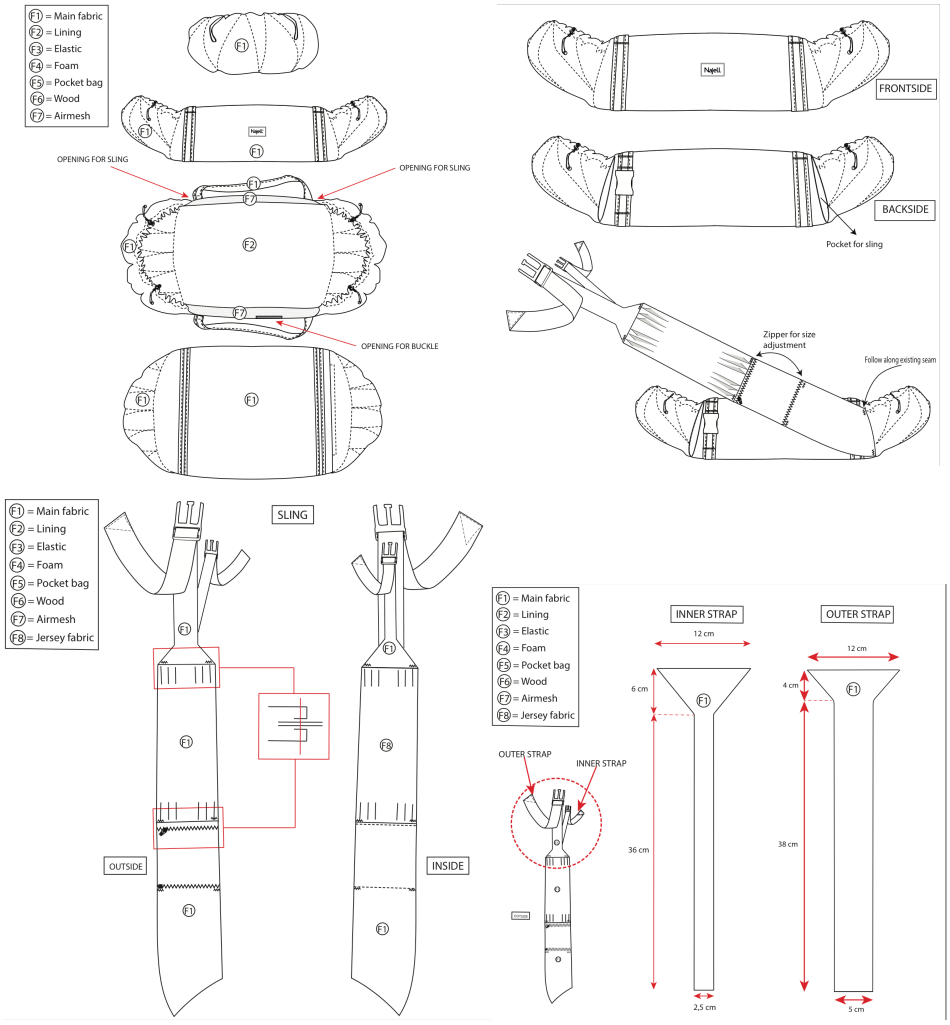
APPENDIX F

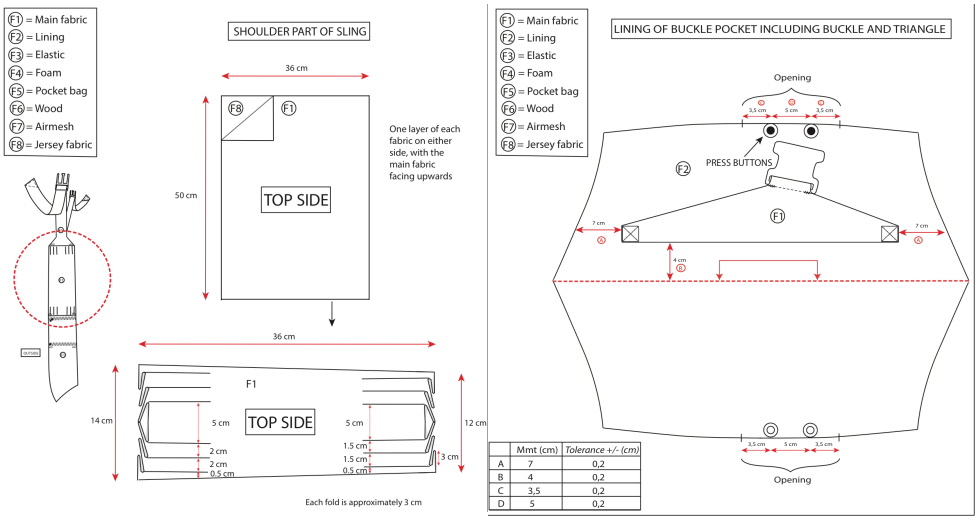
Pugh concept selection matrix

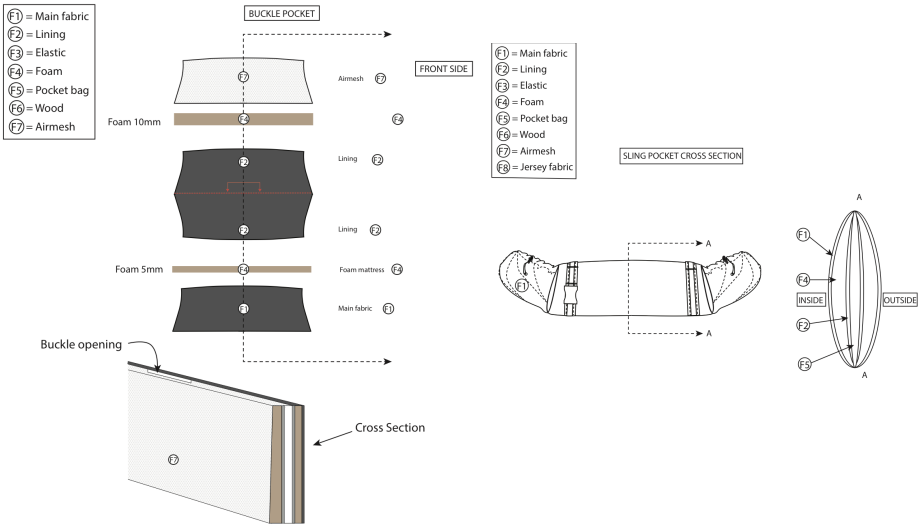
Category	Criteria	Ref	1 - The Loop	2 - The Hammock	3 - 3 Buckle	4 - The Ginger Bread	5 - The Hook	6 - The Wrap
Intuitivity	Identification of front and back	0	+	+	+	+	0	0
	Understanding of how to put it on	0	+	+	0	0	0	-
	Identification of correlating buckles	0	+	+	+	+	+	0
	Understanding of buckle adjustments	0	0	0	0	0	0	0
	Understanding of how to attach the SleepCarrier	0	-	+	+	-	+	+
Use	Number and difficulty of actions	0	+	+	0	+	0	0
	Time to properly fit the harness on the body	0	+	0	+	+	-	0
	Quick attachment of SleepCarrier	0	0	+	+	0	0	0
	Quick detachment of SleepCarrier	0	+	+	+	+	+	+
	Number of loose strings	0	-	+	+	+	+	+
	Easy adjustments	0	0	0	0	0	0	+
	Perceived safety of the baby	0	-	-	-	0	0	-
Ergonomics	Suitable for differents body types	0	0	+	0	0	0	+
	Lightweight	0	0	-	0	-	-	0
	Comfortability	0	+	+	0	+	0	+
	Weight distribution	0	+	-	-	+	0	0
	Ease of buckling the harness	0	0	0	0	0	-	0
	Ease of putting the harness on	0	+	+	0	0	+	+
	Ease (easy to reach and force needed) of attaching the SleepCarrier	0	-	+	0	-	+	+
Esthetics	Easy to store	0	0	0	0	0	0	+
	Noise level during detachment of SleepCarrier	0	+	+	0	+	0	+
Number of +		0	9	13	7	9	6	10
Number of 0		21	7	5	11	9	12	9
Number of -		0	4	3	2	3	3	2
Sum			5	10	5	6	3	8
Ranking			**4**	**1**	**4**	**3**	**5**	**2**

APPENDIX G

Technical drawings for the factory order




F1 = Main fabric
F2 = Lining
F3 = Elastic
F4 = Foam
F5 = Pocket bag
F6 = Wood
F7 = Airmesh
F8 = Jersey fabric
SHOULDER PART OF SLING
36 cm
50 cm
TOP SIDE
One layer of each fabric on either side, with the main fabric facing upwards
36 cm
F1
14 cm
5 cm
TOP SIDE
5 cm
12 cm
2 cm
2 cm
0,5 cm
1,5 cm
1,5 cm
0,5 cm
3 cm
Each fold is approximately 3 cm
LINING OF BUCKLE POCKET INCLUDING BUCKLE AND TRIANGLE
Opening
PRESS BUTTONS
7 cm
4 cm
Opening
Mmt (cm)
Tolerance +/- (cm)
A 7 0,2
B 4 0,2
C 3,5 0,2
D 5 0,2


F1 = Main fabric
F2 = Lining
F3 = Elastic
F4 = Foam
F5 = Pocket bag
F6 = Wood
F7 = Airmesh
BUCKLE POCKET
FRONT SIDE
Airmesh
Foam 10mm
Lining
Lining
Foam 5mm
Foam mattress
Main fabric
Buckle opening
Cross Section
F1 = Main fabric
F2 = Lining
F3 = Elastic
F4 = Foam
F5 = Pocket bag
F6 = Wood
F7 = Airmesh
F8 = Jersey fabric
SLING POCKET CROSS SECTION
A
A
A
INSIDE
OUTSIDE