Heated Gloves

On the design of heated gloves for women with Raynaud's syndrome

Master thesis by
Doenja Maris

January 2018

TU Delft

On the Design of heated gloves for women with Raynaud's syndrome

By Doenja Maris

In partial fulfilment of the requirements for the degree of

Master of Science
in Industrial Design Engineering

at the Delft University of Technology

Commissioned by
The department of Design Engineering
The department of Product Innovation Management
&
Smart Innovation Development B.V.

Supervisory team
Prof. dr. ir. Jansen, K.M.B.
Dr. Creusen, M.E.H.
bc. Koning, I.M.

February 2018

Delft University of Technology

Acknowledgement

First of all I would like to thank Ingeborg Koning for initiating this project and providing me with this opportunity. Instead of seeing a problem she detected the chance for a better solution and was brave enough to start this journey.

Then I would like to thank Kaspar Jansen, who patiently listened to me when I told him I was looking for a graduation project and gave me the chance to be part of this one. I also want to thank him for being my Chair, challenging me to come up with better solutions and better reports.

I would also like to thank my mentor Marielle Creusen, who despite her busy schedule made time to thoroughly read my reports and answer all of my questions.

Next to my supervisory team I would like to thank Linda. She helped me with countless hours of sewing to create a better prototoype than I was ever able to do on my own and helped me to get everything ready in time for my user tests.

I would like to thank Dorien, Kelly, Joyce, Marja and Rosanna, for testing my prototypes and being both enthusiastic and constructively critical of them.

Last but not least I would like to thank Wessel for being my first cold handed user in my user tests and, above all, for being my amazingly supportive boyfriend.

Summary

Raynaud's syndrome is a common disease which causes arteries to narrow, limiting the blood flow to the skin. An attack can cause someones fingers to turn cold, white and blue and is accompanied with feelings of numbness, prickling and pain.

The most common cause of a Raynaud's attack is a cold environment. Heated gloves could therefore help Raynaud's patients, not only by lowering the painful feelings during attacks, but by raising the ambient temperature in order to prevent them.

By conducting a questionnaire we discovered that even though 70% of participants would be interested in well designed heated gloves only 8% owns and regularly uses them. This means that there is big market potential for a properly designed product.

This questionnaire also helped define the target group: The design is intended for women between the ages of 30 and 60 who experience problems from their Raynaud's in their fingers. They are quite active on facebook and are located in different places around the world. They regularly wear gloves outside the house, in the car, at home, at work and behind the computer.

There are heated gloves available on the market today, but they do not fit the needs and wishes of the target group. These models are expensive and bulky, which means that they are so large that they limit the freedom of hand movement and that wearing them make the user look out of place in many daily situations.

The design should therefore be a pair of elegant looking gloves that would heat the fingers of Raynaud's patients and allow them the optimal freedom to use their hands.

By preventing Raynaud's attacks these gloves can reduce and prevent pain, make the wearer look good and give her back the power to user her hands in any daily situation.

In order to design a successful pair of heated gloves the technical components that are needed for construction had to be analysed as well. Suitable heat actuators (resistive wire) batteries (Lithium Polymer) and ways of user control (simple switches) were found.

Partial solutions were generated, combined and recombined into a concept. This concept was the theoretical model that combined all insights from the analysis phase into a design proposal.

In order to test this design proposal a physical modal had to be made. A pair of inner and outer gloves were sewn and iterated along the way. By integrating the electronic parts, the battery packs and the resistive wires, a working prototype was created that was able to warm the users fingers, could be switched on and off and could be charged via USB.

This prototype was then tested on its heating capacity and evaluated by users on its quality. These user tests found areas of improvement which will help guide further product design and development.

After focusing on the product the project also paid attention to other business elements of the design. Concluding that there is a lot to be gained from promotion that is addressed to the target group directly and that online retailing might be a suitable distribution channel since the target group is located all around the world. Then the biggest cost price in production are the labour costs for sewing the gloves, which is why this activity might be outsourced in order to achieve the desired €80 consumer price.

During this project a pair of heated gloves was designed that is tailored to the needs and wishes of the target group. The resulting insights and design will provide a good foundation for the start-up Smart Innovation Development B.V. to further develop a successful product.

Index

Introduction

Raynaud's syndrome is a disease which causes arteries to narrow, limiting the blood flow to the skin. An attack causes the fingers to turn cold and he colour changes to first white, then blue and finally red or purple. This can have a duration of several minutes or hours and can be very painful. This disease can have a disabling effect on patients, preventing them from using their hands in many daily situations.

Raynaud's syndrome is not a rare condition. Studies estimate it affects 3 to 5% of the population, with a higher prevalence in women than in men.

A number of factors can trigger a Raynaud's attack, but most common is a mild to cold environment. There are products available that can help people warm their hands, but none of them is ideally suited to help women with Raynaud's.

Normal gloves can not actively heat blood deprived fingers and heat packs only warm for a short time. There are heated gloves available on the market, but they are big, bulky and unattractive. These gloves are so large that they limit the users hand movement severely, providing no solution to the problem.

Ingeborg Koning, who is the initiator of this project, is a Raynaud's patient herself. She has looked for well designed heated gloves but could not find any satisfactory products on the market today. This was the starting point for this project.

This project is about designing a pair of heated gloves to help women with Raynaud's in many daily situations. They have to fit the needs of Raynaud's patients better than existing heated gloves by being more thin, light and elegant.

The purpose of this project is not only to design a new solution. It is also intended to help Ingeborg with the with the beginning of her start-up company, Smart Innovation Development B.V.

The research that will be done during the course of this project will contribute to the knowledge this start-up possesses. The product design and prototype that will be created will be the start of a design process which will result in the first product the company could produce in the future.

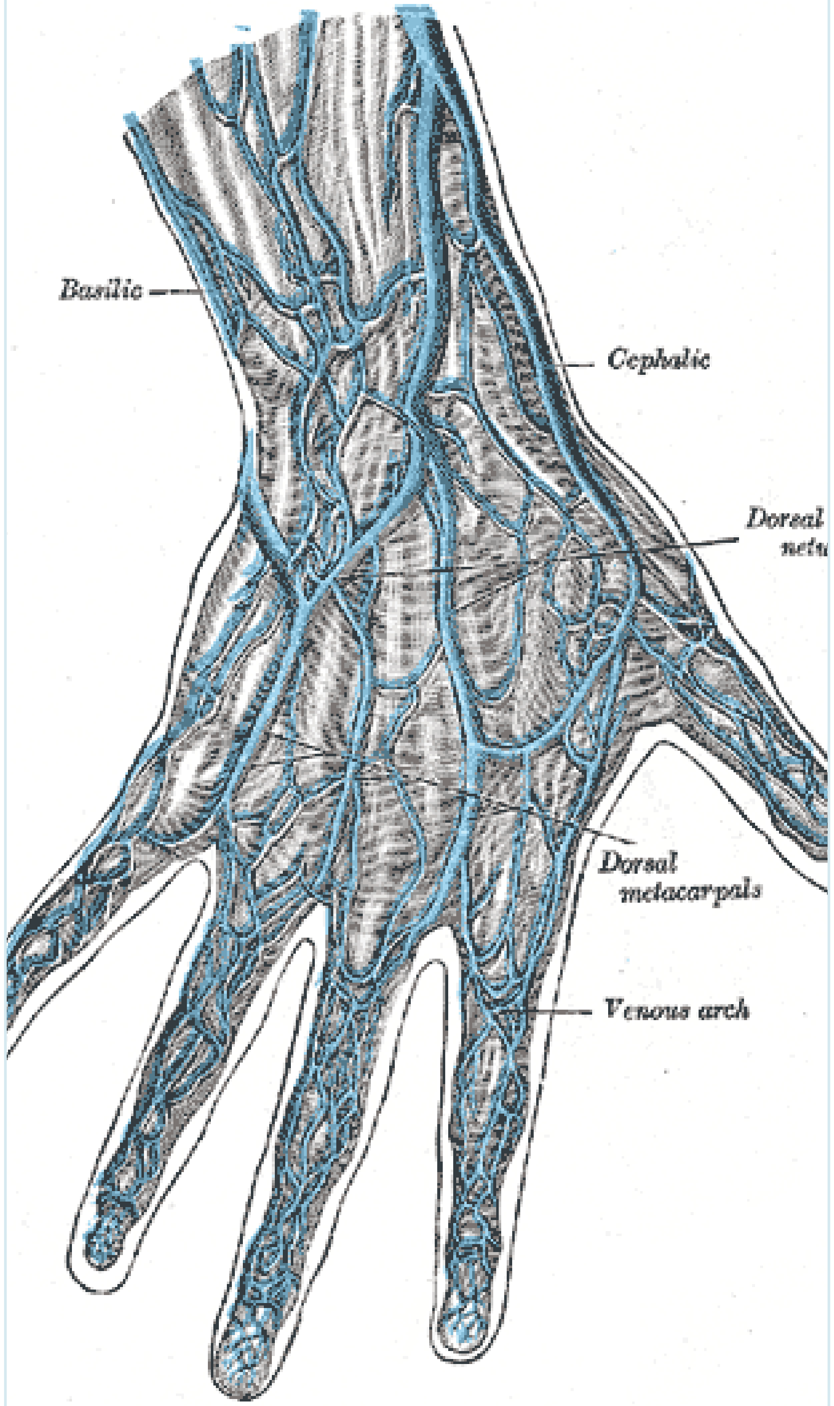
This report consists of five phases. First there is an extensive analysis phase, in which the problem, the target group, competitors and relevant technology are investigated. The insights generated during this analysis phase are combined to form a program of requirements, which is a textual description of what constitutes a successful design according to the research.

The second phase is the ideation phase, in which a range of partial solutions to the problem is generated. These partial solutions are then combined to form three concepts, which get recombined again to form the final concept of this project.

The third phase uses this concept and creates a working prototype. This prototype is a model that simulates the appearance and functionalities of the concept.

Then this prototype is tested in the evaluation phase. It is tested on its heating performance and it is tested with users from inside and outside of the target group. Their opinions on the prototypes heating performance, comfort, appearance and user interaction are relevant indicators of the prototypes qualities and possible improvements.

This report closes with the business plan. Here the relevant insights about promotional activities, distribution channels and pricing of the product are discussed.



I. ANALYSIS PHASE

1 Introduction

This first part of the report addresses the analysis phase of the project. This analysis is created through literature research, a questionnaire conducted with Raynaud's patients, product benchmarking and explorations through physical prototyping.

The analysis phase investigates the problem of Raynaud's and what its implications are for the people who suffer from it. It identifies who the problem owners are and what their needs and wishes are, which is then specifies in a target group definition and product requirements. Then it looks into competing products and product aesthetics before it dives into the context of technology. Two benchmarks are conducted on existing heated gloves and research was done into heating actuators, thermal insulation, glove construction, power delivery and user control.

This chapter combines all the findings from the analysis phase into a program of requirements. This is a textual description of what constitutes a suitable design according to the research. It then concludes with a problem definition and a design goal. The problem definition defines the challenge that needs to be solved via product design and the design goal represents the desired situation in the future.

The insights generated in this phase are meant to increase the knowledge of Smart Innovation Development B.V. about the problem and the relevant context and to guide the design process of this project towards a successful product design.

2 Raynaud's Syndrome

Literature Study into the Raynaud's phenomenon

In order to find out how to help people with the Raynaud's it is important to gain an understanding of this syndrome first. In this chapter its causes, triggers, problems and prevalence are discussed.

The project asks for the design of a pair of heated gloves for Raynaud's patients. In this chapter we look critically at this assignment, confirming that the literature regarding Raynaud's syndrome supports this assignment.

Raynaud's syndrome is a disease which causes arteries to narrow, limiting the blood flow to certain areas of the body. This causes colour changes to the skin and feelings of numbness, prickling and pain. During an attack the skin usually turns white and sometimes blue in a later stage (Figure 3). The fingers during an attack turn cold (Figure 4 and Figure 5) and the discomfort and pain can be severe.

The causes of Raynaud's disease can be classified two ways, primary and secondary. Primary Raynaud's is more common (90% of the cases) and has no identifiable cause. Secondary Raynaud's is when the syndrome presents itself as a consequence of an underlying condition like scleroderma, arthritis or multiple sclerosis ("Ziekte of syndroom van Raynaud", 2017). In this project we choose to focus on the problems caused by Raynaud's specifically, without trying to tackle the large variety of underlying conditions.

Raynaud's symptoms can present itself in different area's of the body, most often in fingers and toes (Silva, Teixeira, Bertão, Mansilha & Vasconcelos, 2016). A questionnaire was conducted with Raynaud's patients (N=567) ("Questionnaire" on page 14) which provides similar results (Figure 1 and Figure 2). When participants were asked where they experienced most problems from their Raynaud's the fingers were mentioned most often, followed by toes and hands. These results suggest that it is appropriate to design for the problem of Raynaud's in the fingers, in order to solve the most common problem.

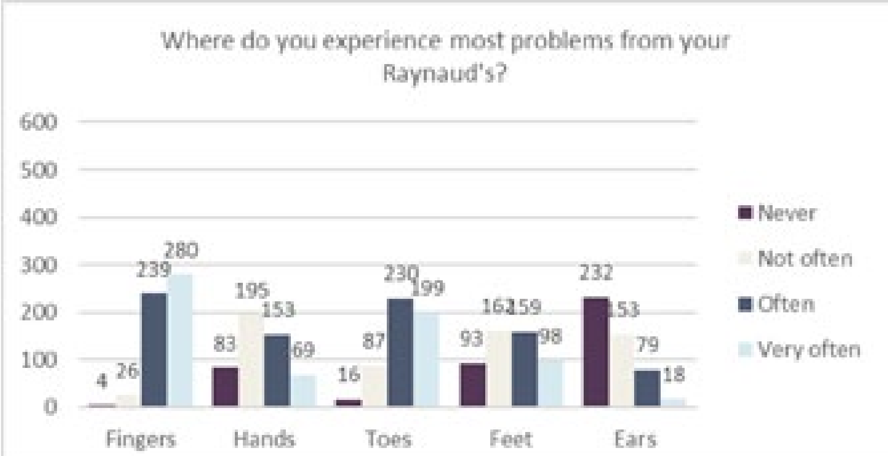


Figure 1 Questionnaire results. Prevalence of experienced Raynaud's symptoms in different body area's.

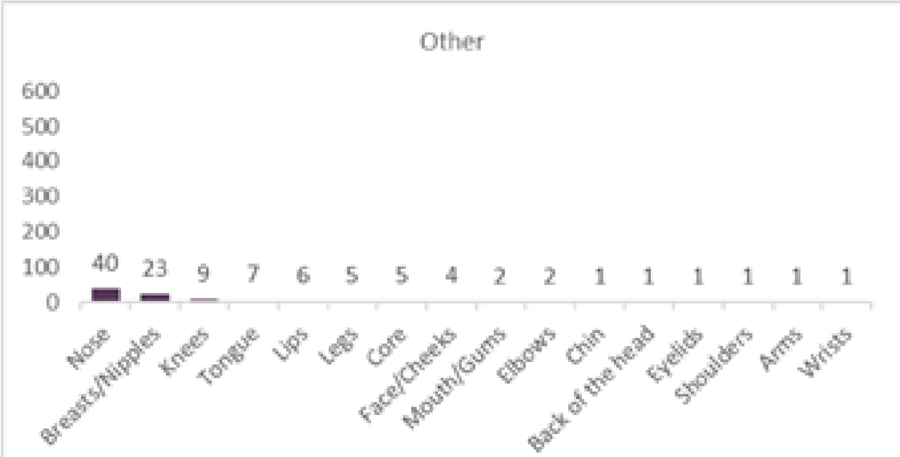


Figure 2 Questionnaire results. Prevalence of Raynaud's symptoms in other body area's.

"I still got difficulty sometimes getting change out of my purse. Because I drop everything. My dexterity is not that good."
Lorraine

"And then the most painful thing is when the circulation comes back. And you can have so many attacks during the day, it is truly debilitating."
Diane

"Because when you are at that stage where you can't feel your hands, you can't use them. So it really affected the way I could work"
Diane

"It just hurts. And I do not feel my hands really. When my hands are all cold I have difficulty removing the lock from my bike. Normally you can feel your keys in your pocket but now I have to look before I can get them because I cannot feel anything."
Joyce

"I almost always have cold hands. It is troublesome in the car because the steering wheel is very cold. It makes it difficult to hold the wheel."
Dorien

Figure 3 Finger discoloration

Different factors can trigger a Raynaud's attack like cold environments, strong emotions, smoking, exposure to vibration (commonly from typing on keyboards or the use of power tools) and specific medications. Temperature related attacks are most common and occur when the environment temperature drops below a certain level (Gayraud, 2007). Heated gloves could therefore help Raynaud's patients, not only by lowering the feelings of coldness during an attack, but by raising the ambient temperature which could help prevent an attack. This can be achieved directly through product design and is therefore a valid approach to this project.

To get a better understanding of the effects Raynaud's attacks have on peoples lives 3 interviews from youtube with sufferers of severe Raynaud's were analysed (Appendix 2) and 5 women with Raynaud's were interviewed and asked to describe the effects of their disease ("Target group interviews" on page 88). These interviews reveal that the syndrome can have a disabling effect. It can lead to loss of dexterity and finger sensitivity to a point where people cannot use their hands. This restricts them in their daily activities, like grocery shopping, handling money, using keys, washing hands or driving a car.

Trying to prevent attacks with warm thick gloves is not an acceptable solution because it too limits hand movement and finger sensitivity. Heated gloves could be a suitable solution because they can be thinner while being warm, which allows users more freedom to use their hands.

Raynaud's syndrome is not a rare condition (Pizzorni et al., 2016). The estimates of Raynaud's prevalence differ between studies, because of the used definitions of the disease and difference in geographic location (Pizzorni et al., 2016). One study estimates that 3 to 5% of the population may be effected, with a higher prevalence in women than in men (Valdovinos & Landry, 2014). A study from the UK even suggests that over 15% of the population may be affected (Herrick, 2012). Even when we consider the lowest percentage from this literature, 3%, this disease affects over 500,000 people in the Netherlands alone. If we look at the world population, this 3% would amount to over 200 million people. This means that there is a large amount of people that could be helped by the design of heated gloves.

Conclusion

This research confirms that Raynaud's syndrome is a serious problem which is worth designing for. It is a disease that affects many people and creates discomfort and difficulties in their lives.

It also indicates that the assignment is justified in requesting the design for heated gloves. They could help patients deal with and even prevent Raynaud's attacks. Heated gloves could do this while allowing the users the freedom to use their hands properly, which traditional warm gloves do not do sufficiently.

The design in this project should therefore be a pair of heated gloves for Raynaud's patients. It should heat their fingers and it should allow for finger dexterity and sensitivity.

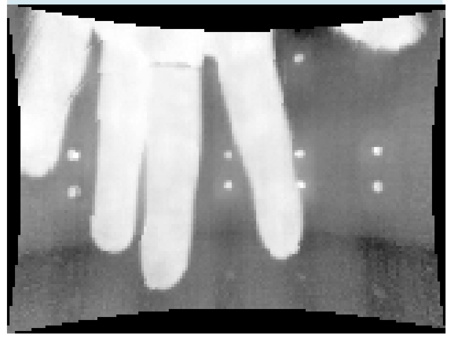


Figure 4 Thermal imaging healthy fingers
Figure 5 Thermal imaging fingers of a Raynaud's patient during an attack

3 Questionnaire

Analysis of the target group

In order to get to know the target group, who they are and what their needs and wishes are, a questionnaire was conducted. This questionnaire was presented to and filled in by people with Raynaud's syndrome that were members of Raynaud's facebook groups.

This chapter discusses the demographics of the people that participated in the questionnaire and how this lead to the definition of the target group. It also discusses what kind of products this target group owns and uses to cope with their Raynaud's and in which situations. It then considers the interest and attitude towards heated gloves in particular.

The questionnaire was created using Google Forms. The complete list of questions can be found in Appendix 1. The data generated was then analysed in excel and clarified in charts which can be found in the coming chapters.

This questionnaire was posted in four closed facebook groups:

- Raynauds Awareness, 6504 members
- Raynaud's Syndrome…, 247 members
- Raynaud's Syndrome sucks, curse cold weather!, 35 members
- Raynaud's Disease, 4005 members

The questionnaire was filled in by 567 people. If we total the amount of people on these facebook groups (10791 members) then we have a response rate of around 5%. It is likely that some of the members are in more than one of these groups, which lowers the total amount of group members and increases the actual response rate.

This response rate indicates an interest in projects concerning Raynaud's disease and a willingness to participate. It was therefore decided to base the target group for this project on the characteristics of these respondents, assuming they are representative for a larger group of Raynaud's patients.

Target group definition

Good design should be tailored to the needs and wishes of a specific group of people. It is therefore important to define a clear and specific target group. A target group is a group with similar characteristics like demographics, interests, needs and desires. In the following paragraphs we discuss the results from the questionnaire and how they lead to the target group description.

From the respondents to the questionnaire an overwhelming 96% is female (Figure 6). This is such a high percentage that it is logical to adapt the target group description to fit this demographic.

476 participants, or 84% of the respondents, is between 30 and 60 years old (Figure 7). Therefore the choice was made to design for females between 30 and 60 years old. Another interesting result is that two participants filled in the questionnaire for their 0 to 9 year old child. This is only a small number, but it is possible that there are more children suffering from Raynaud's. It could be an interesting research possibility for the future.

A traditional descriptor of a target group is their location. From the questionnaire we learnt that participants, and by extrapolation our target group, is not located in a specific country or region. Participants listed many different countries as their location.

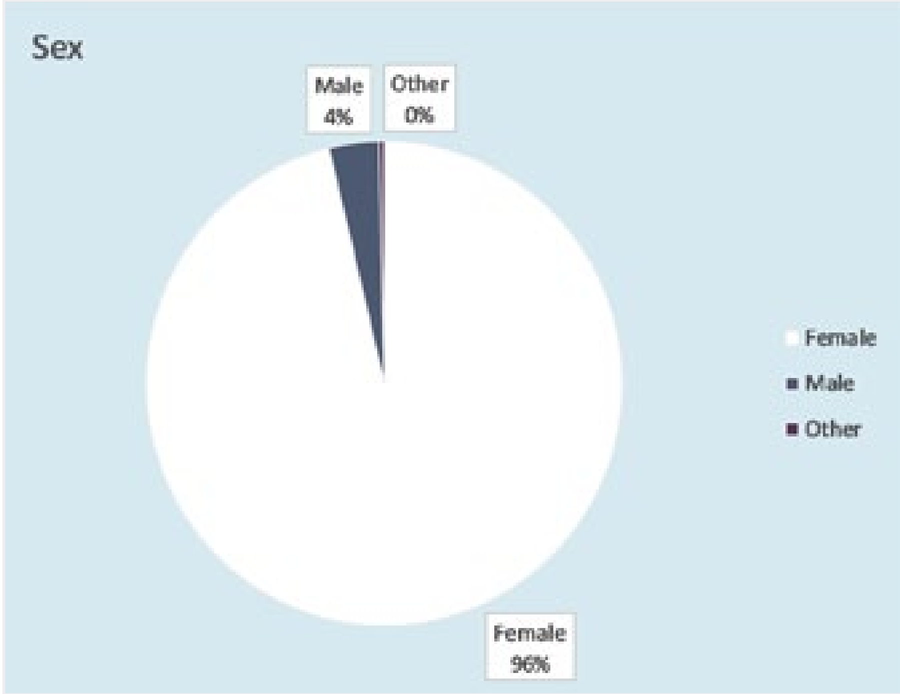


Figure 6 Sex distribution of questionnaire participants

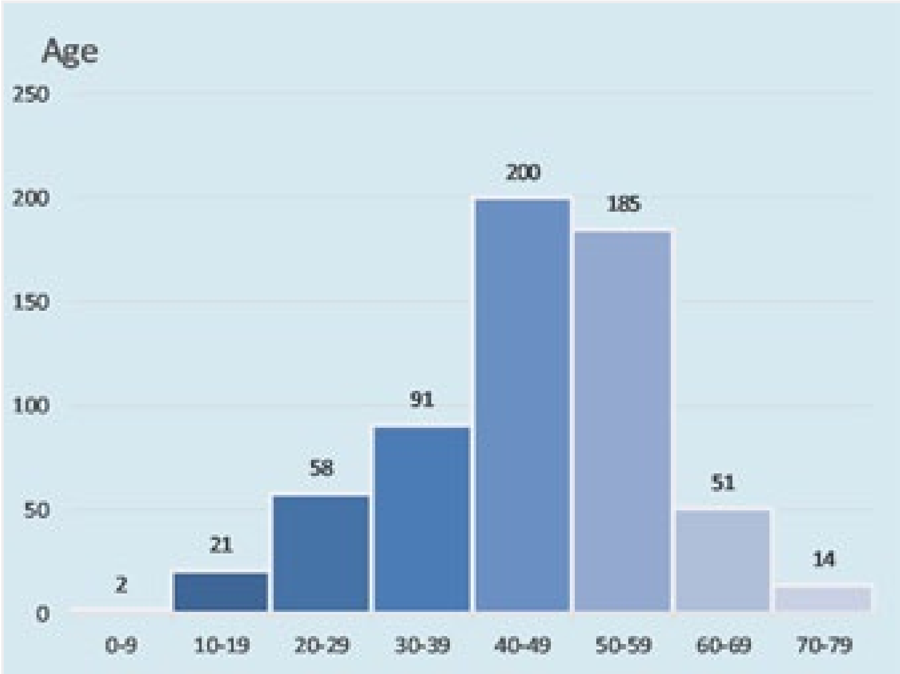


Figure 7 Age distribution of questionnaire participants

To find out in which situations the design has to function the participants were asked in what situations they wear gloves (Figure 8). 66% of participants wear gloves outside the house in mild weather. Therefore it is decided that the design should allow users to wear and use them outside.

A significant results is that 60% of participants regularly wear gloves inside of the car. 36% of participants says they wear gloves inside the house. 29% at work and 24% behind the computer.

Other situations that were mentioned (Figure 9) were ‘‘getting something from the fridge’’ and ‘‘in the supermarket’’. These are interesting situations because they involve picking up objects. Wearing gloves reduces the ability to grip objects and would therefore hinder this activity.

‘‘In air conditioned rooms’’ and ‘‘when it rains’’ were also mentioned. These are logical situations considering the lower environment temperature. Rain has the potential to damage products and can be dangerous in combination with electricity.

‘‘In bed’’ and ‘‘While doing sports’’ are also interesting mentioned situations because these could ask for different materials and aesthetics from the design. Separate categories like soft bed-gloves or vividly coloured breathable sports-gloves might be interesting expansions for a future heated glove product line.

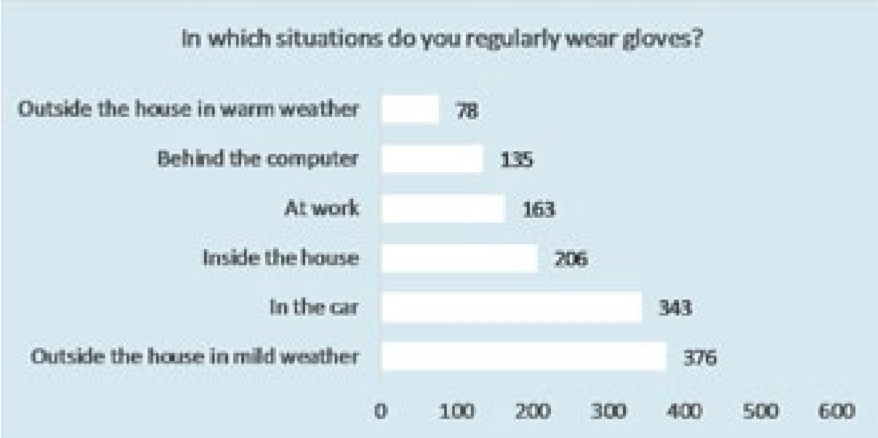


Figure 8 Situations in which participants wear gloves

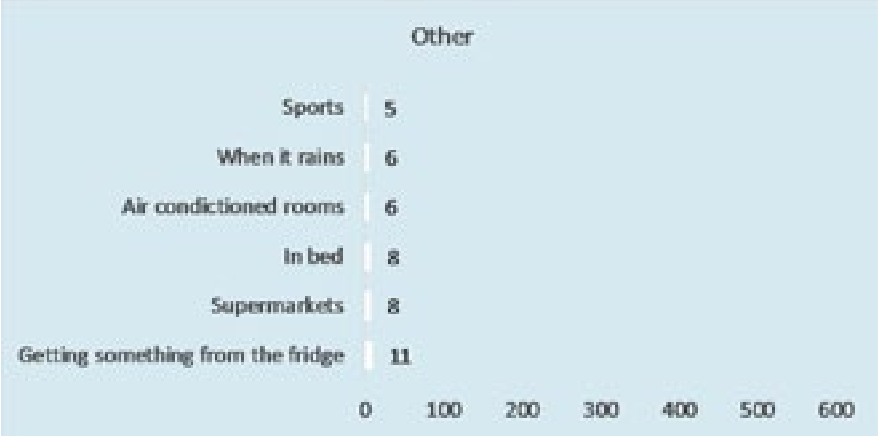


Figure 9 Other situations in which participants wear gloves

Conclusion

Most participants wear gloves outside the house, therefore the design should work in this situation. It could also allow users to use and wear them in the car, at home, at work and behind the computer.

Some participants wear gloves to get something from the fridge or supermarket. Because these activities involve grabbing objects it could be beneficial if the gloves would not reduce the users grip.

Some participants wear gloves when it rains, this means that the gloves should be able to be worn safely in the rain.

Target group definition

The design is intended for women between the ages of 30 and 60 who experience problems from their Raynaud’s in their fingers. They are quite active on facebook and are located in different places around the world. They regularly wear gloves outside the house, in the car, at home, at work and behind the computer.

Interest in heated gloves

In these paragraphs we investigate whether the target group is interested in heated gloves. First we find out whether they do not already own heated gloves from a competing brand, then we ask about the products in which they are interested and ask their opinion on heated gloves.

8% of partakers said they own and regularly use heated gloves (Figure 10). This leaves 92% of participants who do not own or regularly use a pair yet.

Most participants own and regularly use thick gloves and socks/insoles/shoes for their Raynaud’s. Because these regular products are widely available this result is not surprising. Other mentioned products were the heat packs and pads. Almost 10% of participants said that they owned and regularly used them for their Raynaud’s. Blankets and hot water bottles were also mentioned. These products are different from heated gloves but try to satisfy the same need. Therefore they can be viewed as substitute or indirect competition (Keillor, 2007).

An encouraging 70% of participants said that they would be interested in well designed electrically heated gloves (Figure 12). This is a very promising result which indicates a consumer wish or need.

56% said they were interested in well designed heated socks/insoles/shoes. 22% said they were interested in well designed heated hats/scarfs. This signals that these could be interesting for future product design for Smart Innovation Development B.V.

Two participants of the questionnaire were very insistent that they were only interested in mittens, saying that they worked better than gloves or that gloves did not work at all. The theory of thermal conductivity (page 37) does indeed indicate that mittens would retain more heat than gloves. The disadvantage is that they limit the finger dexterity a lot.

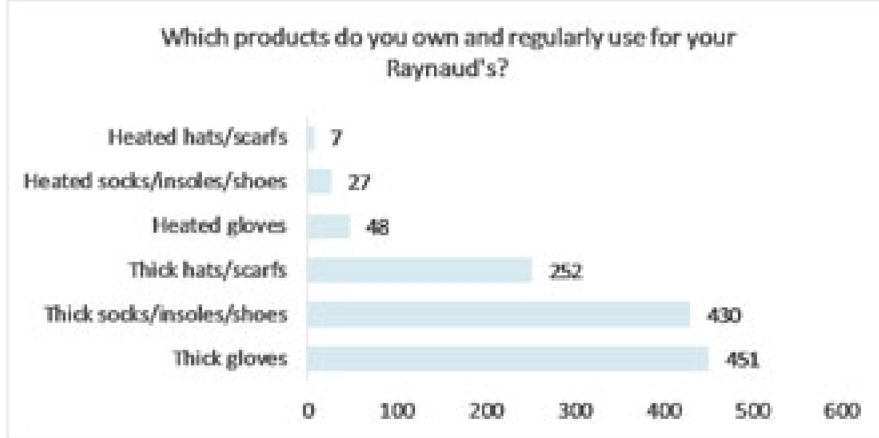


Figure 10 Products owned by participants

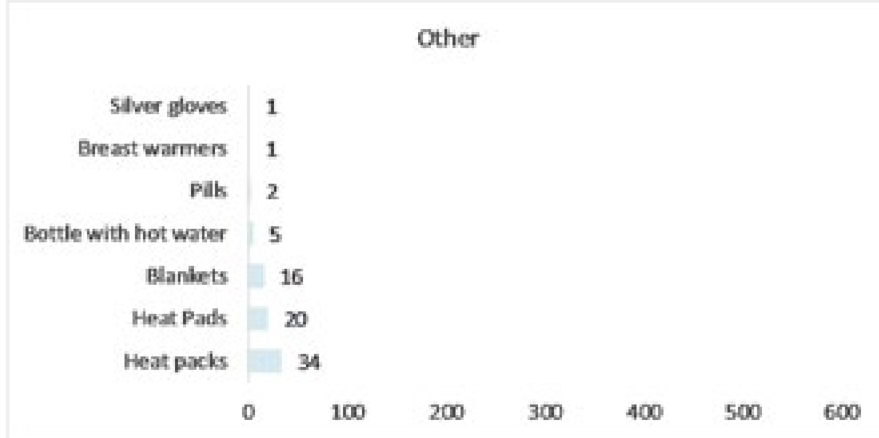


Figure 11 Other products owned by participants

Figure 12 Interest in products from participants

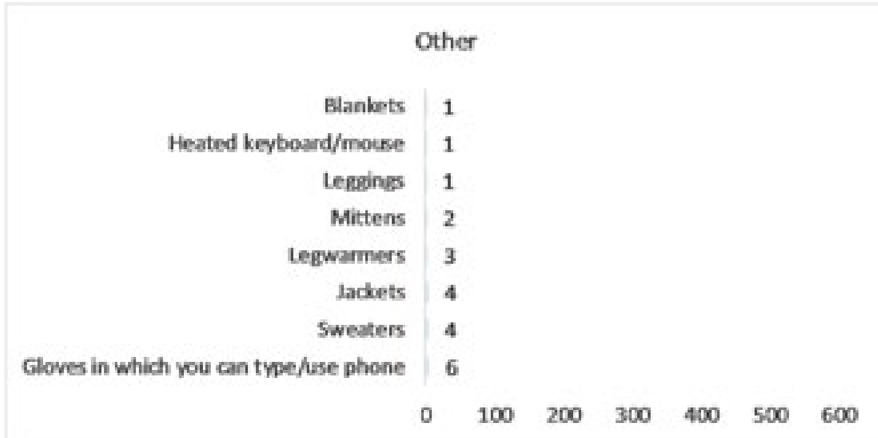


Figure 13 Other products participants are interested in

Another interesting response was the wish for warm gloves that can be worn while using a computer or smartphone. Enabling smartphone use is an easy alteration that can be made with any glove by sewing conductive fabric fingertips to them. These work partially but do still reduce the finger sensitivity. This was later also mentioned in an interview with a member of the target group during (Appendix 10).

A solution for this was mentioned in a facebook post (Figure 14). People recommended to wear fingerless gloves because they allow touchscreen operation. Fingerless gloves would also allow users to grip objects more easily, which would help to get things from the fridge or supermarket (page 16).

Conclusion

92% of participants do not own and regularly use heated gloves yet, while 70% is interested in them. This is an encouraging result which might indicate a big market potential. 56% of participants said that they are interested in well designed electrically heated socks/ insoles/shoes which could be an interesting opportunity in the future.

Some participants were interested in gloves to wear while typing. Other people in the Raynaud's facebook groups suggested to use gloves without fingertips for this purpose. These fingerless gloves fit well with the requirement for finger sensitivity and dexterity, because free fingertips can feel and manipulate the environment much better.

"You simply need your fingertips.
I see that these gloves
(competing heated gloves brand)
have conductive fingertips
but that never really works well."
Kelly

Figure 14 Facebookpost in Raynaud's facebookgroup about fingerless gloves for typing

Heated gloves perception

Heated gloves already do exist. It is therefore interesting to know whether our target group already has experience with these products, whether this experience is positive or negative and why. The questionnaire asked participants these questions and these paragraphs discuss the results.

10% of participants said that they tried heated gloves before and that they liked them (Figure 15). Only five participants explained why (Figure 16). They liked the instant heat, the constant heat, the fact that they were thin and that they plugged into a computer.

13% of participants said that they did try heated gloves before but they did not like them, 59 participants explained why (Figure 17). The reason that was given most often was that they were bulky. This can be interpreted to mean that the visual aesthetics were unsatisfactory, the finger dexterity and sensitivity were too limited or both. Second was the dissatisfaction about the battery which was judged to be too big and having too limited capacity. Then came the heating element, which can be placed in the wrong location, for instance at the back of the hand instead of on the fingers. Also the temperature is sometimes not regulated which can cause users to fear burning their hands. This same problem was found in the benchmark that was conducted on a pair of USB heated gloves from China ("Benchmarking" on page 26). Another complaint was that the gloves were badly designed, which can mean a number of things.

76% of participants said they never tried heated gloves before. The main reasons that were given for not trying them were the costs, followed by not knowing they existed or where to buy them (Figure 18). Also here it was mentioned that the gloves looked big or bulky.

Figure 15 Number of participants who tried heated gloves before

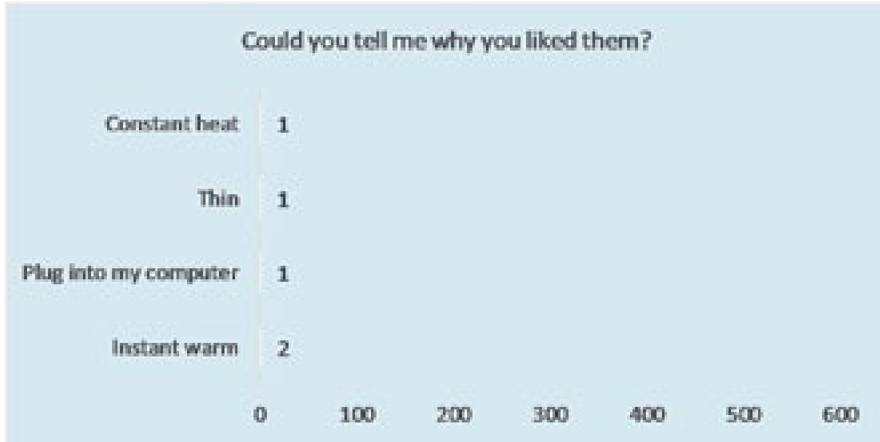


Figure 16 Reasons why the participants liked the heated gloves they tried

Figure 17 Reasons why the participants did not like the heated gloves they tried

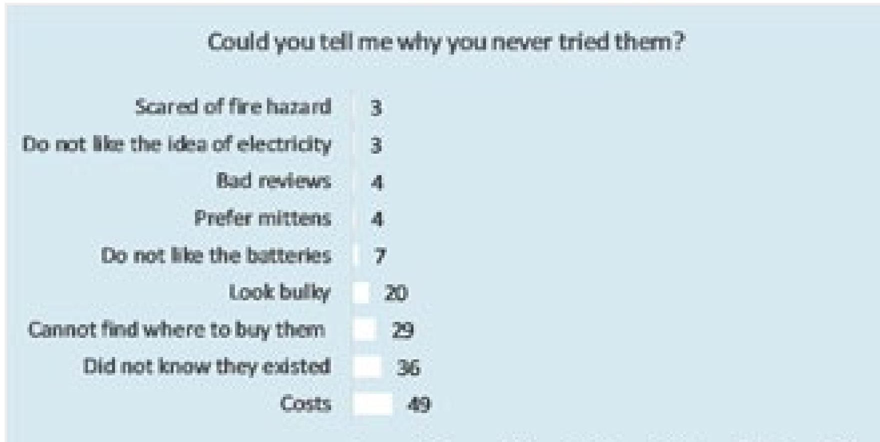


Figure 18 Reasons why the participants never tried heated gloves before

Conclusion

Most participants never tried heated gloves before, predominantly because of the costs, lack of information about the product and the gloves being bulky. 56% of participants who did try heated gloves were unsatisfied.

To design a more successful product the design should be:

- Reasonably priced
- Well known to the target group
- Clear in where and how to buy it
- Thin instead of bulky
- Heating the users fingers
- Have a comfortable battery size
- Have enough battery capacity

From the questionnaire results new questions arise, like what a reasonable price would be or how the product could become well known to the target group. In "Target group interviews" on page 88 we will ask the opinions from women with Raynaud's to make an estimation of this reasonable price. In "Promotion" on page 94 we will discuss how to market the product and in "Power delivery" on page 40 we will discuss battery specifications.

4 Competitor Analysis

A study of competing products and their brands

When designing a product it is important to analyse the competing products on the market. Not only the direct competitors (brands that sell similar products) but also the indirect ones (brands that sell different products solving the same consumer needs) are important.

Direct competitors

Most heated gloves look alike. The stereotypical model is black and large. Figure 19, which shows a pair of gloves from the brand Volt Resistance, illustrates this. These gloves are intended for outdoor activities in cold environments like hunting or skiing. They often have a 7V rechargeable battery pack (Figure 20). This example weighs 120 grams (7.6 x 5 x 2.2 cm). After charging, these the packs are placed and connected in the glove's cuff at the upper side of the wrist.

Questionnaire participants who tried heated gloves but did not like them, often gave the reason that the gloves were too bulky. When looking at the typical model in Figure 19 we can see that the gloves are large and thick which would limit finger dexterity a lot. They also look big and heavy which might look out of place in many regular environments. Wearing them for instance in the grocery store could attract attention to the user.

Then there are the gloves which are specifically intended for motorcyclists (Figure 21). These gloves are powered by plugging them into the motorcycle battery and cannot heat on their own. These are therefore not useful for the target group and are not considered to be competitors.

Slimmer heated gloves are the so called glove liners (Figure 22). Almost all of them are made out of black neoprene material and they are intended to be worn inside regular ski or motor gloves. They are available with battery or with motorcycle connection. Because the glove liners are thinner than the other heated gloves they allow for more finger dexterity and look less bulky. The types with batteries are therefore a better fit with the target groups needs which makes them stronger competitors.

Most participants from the questionnaire never tried heated gloves before because of their price. The gloves from Volt Resistance (Figure 19) are $220 and the one from Venture Heat (Figure 22) are $170. The average price of a pair of glove liners is around $180. This was calculated from a sample of ten products from different brands (Appendix 3).

The cheapest glove liners that were found were the Warmawear Duel Fuel Battery heated gloves (Figure 23). They are €25 and make use of 9V batteries. According to ten individual customer reviews on their website the product does not function well or function at all. Low or no heating capacity, high shipping costs and poor stitching quality are mentioned. These and other reviews indicate that there are poorly made heated gloves on the market that might already have disappointed potential customers.

There are also extremely cheap competing products from China like the USB heated gloves from AliExpress (Figure 24). A similar pair was tested ("Benchmarking" on page 26). These gloves are fingerless

Figure 19 Volt Resistance TITAN Woman's 7v Leather Heated Gloves, $220

Figure 20 Volt Resistance 7V battery pack, $40 and Volt Resistance 7V single charger, $20.

Figure 21 Gerbing G4 womans motorcycle gloves, $120

Figure 22 Ventureheat battery heated glove liners, $170

Figure 23 Warmawear Duel Fuel Battery heated gloves, €25.

Figure 24 USB heated gloves from AliExpress, $4

Figure 25 Verseo Thermoglove promoted by the Raynaud's Association, $120.

Figure 26 Post in Raynaud's facebookgroup about Verseo

"The gloves themselves are very poorly made with stitching not finished off and in fact the touch screen pad on one thumb was already coming undone. Most importantly I experienced very little heat to my palms, despite having the gloves on for over an hour, and no heat at all around the fingers! I will not be buying from this company again unless they develop their gloves to actually work as stated and even then will only accept them if they are sent to me free of charge."
Customer review (Warmawear webstore)

"They do not heat at all, I bought them for my sister because she has a circulation problem in her hands when it's very cold and I had to return them."
Customer review (Warmawear webstore)

"I tried the gloves and they almost don't heat up I am so disappointed !!!"
Customer review (Warmawear webstore)

"Warmth down to the fingertips, maximum dexterity, and not to look like Suzie Ski Bunny. We want it all! Finally we've found one from Verseo that comes closer to meeting the above needs than others we've tried to date."
Raynaud's Association

which allows for great dexterity. However the heating element is placed on the back of the hand, so the fingers are not heated, and the temperature of these elements can get dangerously high.

A better quality glove liner was found on the website of the Raynaud's association. The Raynaud's association is a nonprofit organisation created to raise awareness about Raynaud's syndrome. They have a website on which they have a section called "Featured products" ("Featured products", 2017) where they promote products from heating creams to heated gloves. Because their target audience is Raynaud's patients it is possible that out target group finds products through their recommendations. Therefore the heated gloves promoted on their website could be important direct competitors.

The heated glove that the Raynaud's association recommends is the Thermoglove from Verseo (Figure 25), which is a pair of typical looking black neoprene glove liners. They are thick enough to be worn outdoors without an extra glove and they cost $120, which is not expensive for a product of this type (Appendix 3). They are sometimes mentioned on Raynaud's facebook pages as well (Figure 26).

Three of its qualities that are described on the Raynaud's association website match three of our previously stated design criteria.

- "Warmth down to the fingertips" (The product should heat the fingers, page 13)
- "Maximum Dexterity" (The product should allow for finger dexterity, page 13)
- "And not to look like Suzie Ski Bunny" (The product should not bulky, page 19)

This product is an important competitor. To learn more about it a pair was purchased and analysed ("Benchmarking" on page 26). These gloves do warm the fingers and allow for reasonable dexterity. However the back of the hand is warmed more than the fingers and the user controls are unclear.

Indirect competitors

There are also indirect competitors that we need to be aware of. Products different from heated gloves which perform the same task, heating the fingers of Raynaud's patients.

The brands Uniqknits (Figure 27) and IMAK (Figure 28) market their (nonheated) gloves to Raynaud's patients specifically. These brands are also recommended by the Raynaud's association and can be found in peoples posts on the Raynaud's facebook groups (Figure 31, Figure 32, Figure 33).

The Uniqknits claim they are "self heating" and the best performing gloves on the market due to their deep experience in electrical and textile engineering. Their product is not heated and they do not specify how their product works. They promote themselves as the fashionable alternative to therapeutic devices and their products look like colourful versions of standard knitted cotton gloves. Their prices range from $20 to $90 dollar, with most models costing $70.

IMAK sells fingerless therapeutic compression gloves (Figure 28). Its compression is said to help blood circulation which would ease arthritis related issues like Raynaud's. They have open fingertips which allows users to "feel, touch and grip". This makes them suitable to wear in many daily situations.

From the questionnaire we found that the most common products people use for their Raynaud's are (nonheated) thick gloves and heat packs (Figure 10 on page 17).

There are chemical and electrical heat packs (Figure 29 and Figure 30). They are portable heat sources which the user has to hold to warm her hands. Chemical heat packs heat with a maximum temperature of around 50 degrees Celsius for half an hour and can be reused after boiling them in water. The Luckystone hand warmer website claims its product can heat to 42 degrees celsius for 3 to 4 hours.

Figure 27 Uniqknits gloves, $20 to $90

Figure 28 IMAK compression gloves, $24

Figure 29 Reusable chemical heat packs, $7

Figure 30 Electrical heat pack, Luckystone hand warmer, €23.

" We've created a fashionable glove that can act as a therapeutic device. It's easy to wear, inexpensive and works. If you have circulatory problems, we hope you'll find these gloves put an end to your painful and throbbing fingers without making you feel like you're wearing a medical device, or look like a "ski bunny"."
Uniqknits

The Arthritis Gloves are made of soft, breathable cotton material, meaning they are comfortable enough to wear all day and night. The open fingertips allow you complete freedom to feel, touch and grip, so you can perform daily tasks without issue.
IMAK

Figure 31 Post in Raynaud's facebook group about Uniqknits gloves

Figure 32 Post in Raynaud's facebook group about IMAK gloves

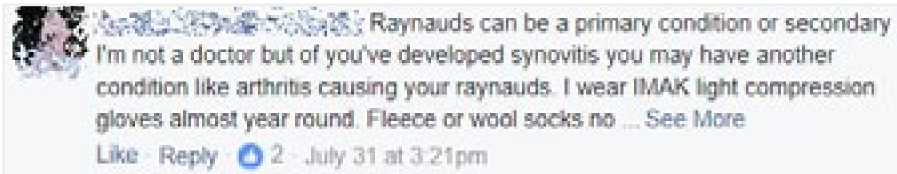


Figure 33 Post in Raynaud's facebook group about IMAK gloves

Conclusion

From this analysis we learnt that the typical electrically heated gloves are very large and thick, which limits the finger dexterity and looks inappropriate in many daily situations. The prices are often well above $100.

Glove liners like the Verseo Thermoglove are thinner, which makes them fit with the needs of the target group better. Our product should therefore be better than the typical gloveliner. This could be achieved for example by:

- Allowing more dexterity with thinner fabrics or fingerless design
- Better aesthetic qualities
- Lower price, the thermoglove is $120
- Better user interactions like easy heat controls and charging
- Smaller lighter batteries

From negative reviews about the poorly designed Warmawear glove liners we can learn that our design should heat up noticeably, be shipped for a reasonable price and have good quality stitching and finishes.

Indirect competitors are the Uniqknits and the IMAK gloves. The Uniqknits look like standard knitted gloves which means that wearing them probably does not attract attention to the user, which the bulky heated gloves would do. The IMAK gloves are thin and have open fingertips which allows users to feel, touch and grip. Our product could emulate these advantages.

Other indirect competitors are nonheated gloves and heat packs. These products are inexpensive compared to heated gloves, but regular gloves do not provide active heating and heat packs cannot be worn. The heat production from chemical heat packs lasts about half an hour, which is short compared to heated gloves. We do not know yet what heat duration is acceptable for our target group, but it should be significantly longer than that of a heating pack.

5 Visual appearance

A study into the aesthetics of gloves

In the previous chapter we discovered that all glove liners, which are in direct competition with our product, look very similar (Appendix 3). One way to stand out from the competition is therefore through more desirable visual aesthetics.

Good looking product also have other benefits, they are perceived as more valuable and having more qualities. Aesthetically pleasing designs make users care more about the product, more loyal towards the brand and more tolerant toward mistakes or failures (Nikolov, 2017).

We are designing a garment which means that our products appearance influences the personal appearance of the wearer. The way people dress matters a great deal in both social and work context and as a consequence women are thoughtful about the way they dress (MacGillivray, Koch & Domina, 1998). This means that our product needs to look good, or at least neutral, according to our intended target group.

Visual preference

Two factors that can greatly influence visual preference are familiarity and novelty, depending on the object category (Liao, Yeh & Shimojo, 2011). In a way, fashion itself is a visual preference based on familiarity, as it can be described as the way in which people choose to dress alike. Fashion is also influenced by novelty, which is why it is not a static phenomenon but a visual preference that evolves through time.

We need to know what the gloves look like that women wear today in order to design for fashion familiarity. Later we can decide if and how much novelty our design needs to achieve visual interest.

Gloves then and now

In the past gloves were worn by women far more often than is done today. Up until the mid-twentieth century gloves were a highly symbolic garment that used to indicate a woman's class (Stankovski, n.d.). The style, colours and decorations of these gloves changed through time according to the fashion trends.

During the first and second World War gloves became a scarce luxury item because of material shortages. Wearing them during the day also became less practical because more women had jobs. After the second World War women's gloves got a short fashion revival. After that they declined in popularity and by the 1970s vintage gloves (Figure 34) were gone from fashion. Today gloves are worn almost exclusively as a functional item, for warmth in cold weather (Sessions, 2016). Wearing them throughout the day is no longer the norm.

This does not mean that there is no longer a visual preference for certain kinds of glove appearances. On the next page we discuss five archetypical glove types that can be seen frequently on the streets today in Europe.

Figure 34 Vintage gloves, advertisement from the '60s

Typical glove appearance

The types of gloves we will discuss are the knitted gloves (Figure 35), fleece and other polyester gloves (Figure 36 and Figure 37) and leather gloves (Figure 38).

Knitted gloves are often very cheap. The gloves in Figure 35 are sold per three pairs, which allows the user to lose or discard gloves without consequences. This type of glove could therefore be perceived to be of low value. They are often made out of cotton and elastic polyester fibres and available in a variety of colours and prints. Because of their knitted elastic fibres and ribbed wrist they stretch to fit any hand size.

Fleece gloves are less stretchable. They are often overdimensioned, making them appear more bulky. To reduce this bulk slightly they often have a elastic gathering around the wrist. Fleece is made out of 100% polyester, and can be produced from recycled plastic. It is often used in outdoor sports clothing and it has a typical napped look and feel to it (Figure 39).

There are also slimmer, more stretchable, gloves made out of polyester and polyester fibre mixes. The typical appearance is black or grey with small embellishments, like bows or buttons, around the wrist area (Figure 37).

Leather gloves (Figure 38) are most expensive. This is due to the material which is more costly and has limited stretch. This limited stretch requires more precise tailoring to create an elegant looking glove. Because of their more exact fit leather gloves are almost always available in multiple sizes, small, medium and large.

Because of the widespread smartphone use a lot of gloves nowadays incorporate conductive textile to be smartphone operable. Sometimes these conductive fingertips are visually accentuated with a contrasting colour (Figure 40).

Figure 35 Knitted gloves, 3 pairs for €6, H&M

Figure 36 Fleece gloves, €7, Bol.com

Figure 37 Polyester-woolmix gloves €10, H&M

Figure 38 Leather gloves €15, H&M

Figure 39 Fleece texture

Figure 40 Smartphone operable knitted glove

Conclusion

In order to design a product that is preferred visually by our target group its aesthetic needs to have the right balance between familiarity and novelty.

Before the 1970s women would wear gloves in many daily situations as a fashion item. Nowadays gloves are seen as a functional item and wearing them throughout the day is not the norm. Therefore the users of our product will stand out in many situations.

If users would want to avoid attracting attention the gloves could try to emulate the appearance of regular gloves, like the Uniqknits (page 22). This approach would lead to an aesthetic that is familiar to the user and fits right in with the current fashion.

Another approach would be to create a pair of gloves that include more visual novelty. The fact that the wearer will stand out in many situations could be embraced as an opportunity, by creating a pair of gloves that the user would be proud to show.

The knitted gloves can be sold this cheaply due to ''fast fashion''. This is the optimization of production and sales cycles which lowered consumer costs, labour conditions and environmental standards (Pookulangara & Shephard, 2013). Our product should not be associated with this because of ethical reasons.

The overdimensioned glove pattern and napped texture of fleece gloves can make the gloves appear less elegant. Our product could avoid this by using smoother fabrics and a pattern that fits better to the shape of the hands of our target group. Other polyester and polyester-mix gloves show that more elegant gloves can be made from similar materials (Figure 37).

Leather gloves can be perceived as being of high value. Downsides are the more expensive materials and fabrication processes.

6 Benchmarking

Testing competing products

There are different heated gloves on the market today (Competitors p. 23-24). These differ in performance, usability and appearance. To establish a benchmark for the designs performance two different products were tested.

The first test looks at the heating performance of a pair of USB heated gloves from China. The second test looks at the heat performance and the working principle of the Verseo Thermoglove.

USB heated gloves

This pair of USB heated gloves was bought online from China by a Raynaud's patient. Her intention was to use them while driving a car but they were found to be inadequate for two main reasons. The gloves heated at the wrong location, the back of the hand instead of the fingers, and did not stop heating. This produced first degree burns on the hands.

Method
The gloves that were tested are a pair of fingerless knit gloves with a ribbed cuff and a finger cap (Figure 41). A heating patch (Figure 42) is attached with Velcro to the glove at the inside, touching the back of the hand. These patches can be connected to the computer via USB (5V).

For this test we measured the temperature performance of the gloves in two different ways.

First the heat was measured outside of the glove. The gloves were worn on the left hand and plugged in the USB port. Every 20 seconds a temperature measurement was done with a Flir TG-165 heat detection camera (Figure 43).

Then the heat was measured inside the glove. The gloves were worn on the left hand and plugged in the USB port. Every 20 seconds a temperature measurement was done with a K-Type 1319A thermometer. The probe of the thermometer was placed in between the heat pad and the hand (Figure 44).

Figure 41 USB heated gloves

Figure 42 Heat patch

Figure 43 Flir heat camera

Figure 44 Measuring with thermometer

The heat patch was opened up to look at its construction and measure the resistance and the voltage over the patch (Figure 42).

Results
The temperature measurements made on the outside of the glove with the heat camera show many deviations. This makes this method of measuring inaccurate. Using a heat camera can still be useful to create images showing the heat distribution (Figure 45).

The USB heated gloves make use of carbon heating patches which are able to produce a noticeable temperature increase. The measured resistance over this heating patch is 16.2 ohm and the voltage 4.73. This corresponds with a current of 0.29 A and a power of around 1.4 Watt.

When the inside of the gloves came above 42 degrees Celsius, the heated gloves started feeling uncomfortable. There is no component in the circuit that limits the temperature rise. The only option to stop the heating is disconnecting the USB.

When the heat patch was taken out of the glove and connected to the USB it did not feel as warm as when it was inside of the glove and connected to the USB. The heat generated by the pad seemed to dissipate faster to the environment.

Conclusion

From the test we can see that an inside measurement with a K-Type thermometer can produce a smooth measurement graph (Figure 46). This method of measuring can therefore be used for further testing during this project.

These gloves use carbon heat patches as their heating actuator. This proves that you can use these in heated gloves. However, the patches are quite large and this shape is not suitable for heating users fingers individually. We will discuss the usability of carbon heat patches as heat actuators in a later chapter, "Producing heat" on page 31.

We see that a USB port is capable of heating two patches beyond a temperature that is comfortable for the user. This means that a comfortable temperature can be reached as well. This makes USB powering a realistic option for the design of heated gloves.

The product keeps heating up and can burn the users hands, which is unacceptable. To keep the user comfortable the temperature inside the glove should not increase above 42 degrees Celsius.

The power of 1.4 Watt produced a noticeable temperature change. This can be used as an indication for further product design.

Outside of the glove the connected heat patch seems to loose a lot of heat to the environment. This is probably because the patches are not insulated by the glove. In chapter 8 on page 37 we will look at the theory of thermal insulation to see if we need to take this into consideration for our design.

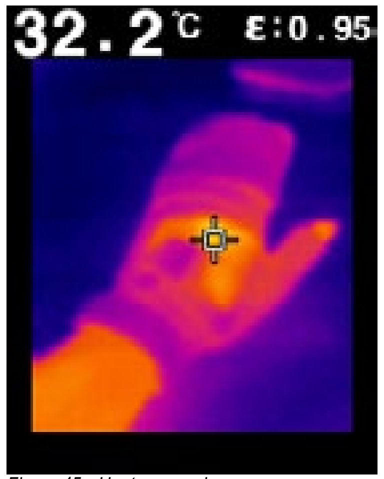


Figure 45 Heat camera image

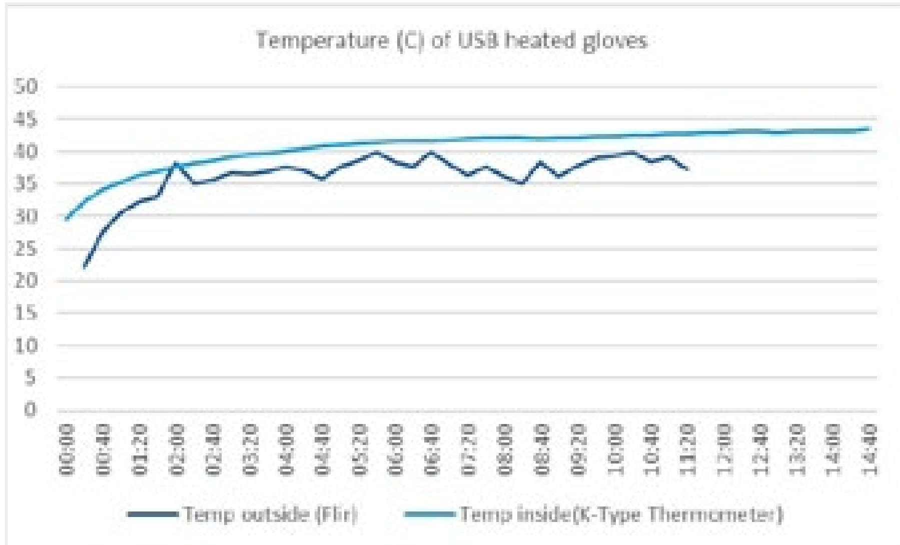


Figure 46 Temperature measurement USB heated glove

Verseo Thermogloves

In the "Competitor Analysis" on page 20 we concluded that the Verseo Thermoglove is a direct competitor to our design. Therefore a pair was purchased and investigated.

This paragraph discusses results of the heat performance test that was done with a Thermoglove and the results of taking it apart and studying its components.

Method
A Verseo Thermoglove was tested on its heating performance. The glove has three different heating settings that are indicated by a coloured LED (Figure 47). The glove heats in two locations, on the back of the hand and around the fingers. All three settings were tested on both locations.

The gloves were worn on the right hand and turned on. Every 20 seconds a temperature measurement was done with a K-Type 1319A thermometer (Figure 48). The first three sets of measurements were taken at the finger where the probe of the thermometer was placed under the heating actuators. The second three sets of measurement were taken at the back of the hand, where the second heating actuator is located.

The room temperature was measured before each test to check for large deviations that could influence the test results. The room temperature was on average 24 degrees Celsius with a maximum deviation of 0.5 degrees. The measurements have been corrected for the room temperature deviations.

After the measurements the glove was taken apart using a seam ripper (Figure 49 and Figure 51). The components were studied and a schematic drawing of the layout of the wires was made (Figure 55).


Figure 47 The Thermoglove and its three settings


Figure 48 Het performance test set-up

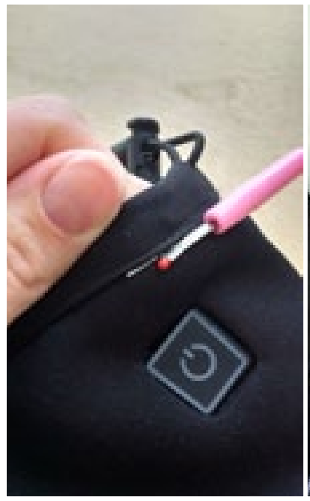
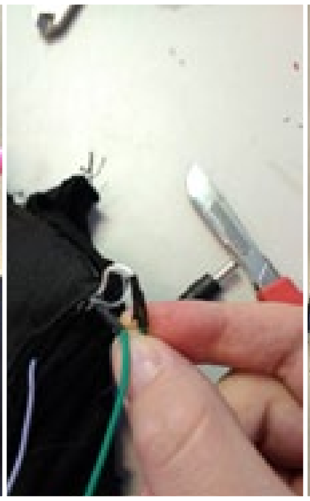
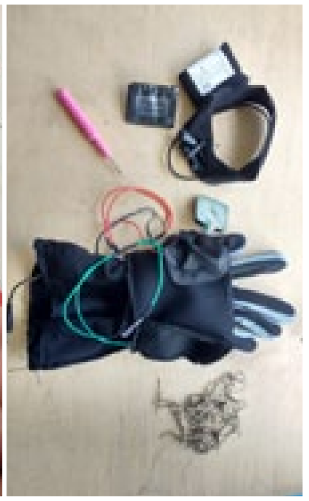




Figure 49 Seamripping the glove
Figure 50 Taking out the resistive wires
Figure 51 Deconstructed Thermoglove

Results performance test
Even though this is called a glove liner the glove is still quite large and dexterity limiting. The loose fit around the fingers makes it difficult to grab objects and impossible to type on a keyboard. The gloves also look different enough from regular ones to be noticed.

Controlling the gloves is not easy. The button has to be pressed hard, which is uncomfortable, and it is not evident how the desired heating mode is reached. Even though the gloves were tried twice before, I had to figure out how the control worked again.

The back of the hand feels warmer than the fingers and the recorded measurements confirms this (Figure 52 and Figure 53). This is despite the fact that there are two resistive wires present at the fingers (Figure 54).

At the index finger the high and medium setting measurements look similar. The same is true for the low and medium setting at the back of the hand measurements. This might be due to the environment and the hand temperature.

The heating actuator that runs along the fingers only heats the fingers at the sides. When the thermometer is placed at the top of the index finger it reads no change in temperature for at least a minute.

Results deconstruction
The Thermoglove uses resistive wires as their heating actuator which are sewn in between the inner and outer fabric of the glove. One of them runs over the back of the hand and two of them along the fingers inside the grey fourchettes (Figure 54). These wires that are used in can be felt on the outside of the glove due to the wires thickness, 0.9 mm. The wire connections are secured and insulated with small metal clamps, yellow tape and heat shrink (Figure 50). The clamps secure the soldered connection between the wires. The tape and the heat shrink

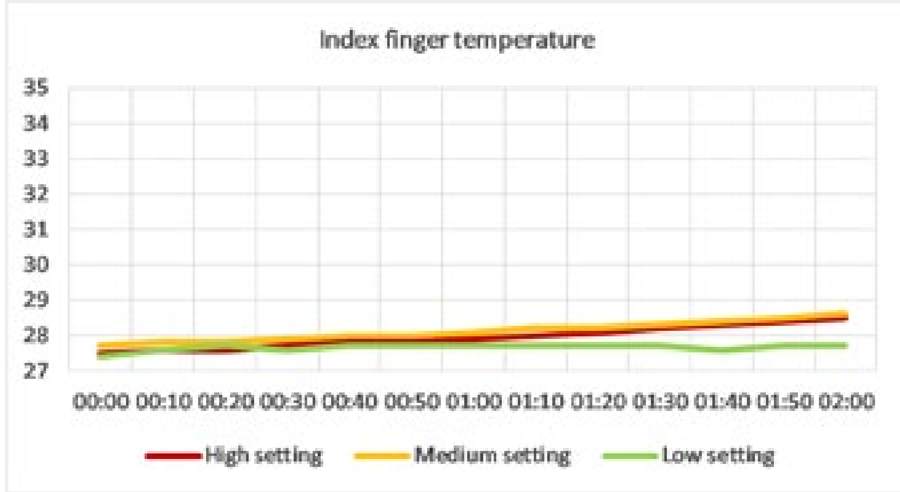


Figure 52 Temperature measurement at the fingers

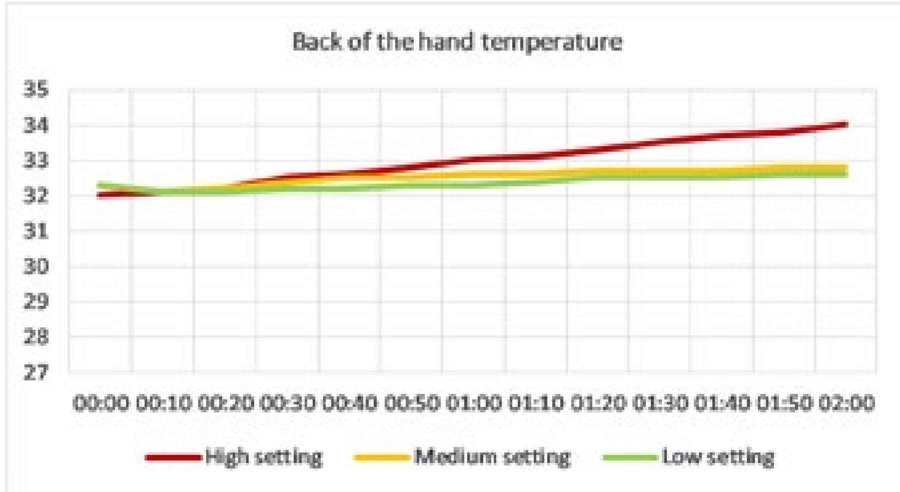


Figure 53 Temperature measurement at the back of the hand

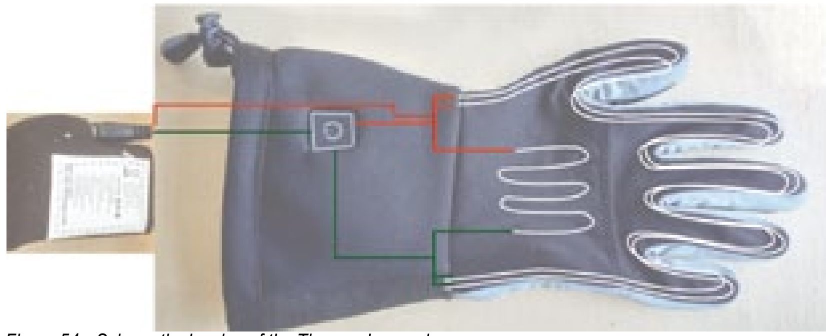


Figure 54 Schematic drawing of the Thermogloves wires.

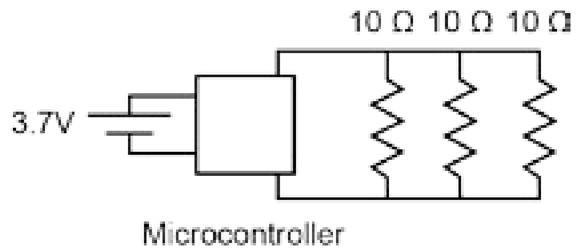


Figure 55 Schematic representation of the circuit

insulate the connections against contact with the outside world, especially water.

The wires each have a resistance of 10 ohm and are connected in parallel (Figure 55 on page 29). The Verseo website says they have a 2.7 Ah battery that can operate for four hours (“ThermoGloves”, 2017). If that is correct the corresponding current would be 0.675 A. With a 3.7 V battery this means that the glove produces 2.5 Watts of power.

The heat actuators are connected to the battery via a switch, which is cast in silicone together with the microchip. This unit allows the user to choose heat settings and it displays the LED feedback.

Each thermoglove makes use of a 3.7 V battery pack which includes two Lithium Polymer batteries connected in series (Figure 56). These battery packs can be connected to the charger or the glove via low-voltage connectors (Figure 57).

The battery packs are placed in small pockets at the underside the wrist. They are quite heavy, 360 grams each, and do not feel very comfortable. They hang from your wrists or press into them when your hands lay on the table. The zipper that closes the pocket is of low quality, as it detached immediately after the first use.

Figure 56 Battery pack 3.7 V contains two lithium polymer batteries

Figure 57 Battery pack with low voltage connector

Conclusion

The loose fit around the fingers limit the dexterity. Our product should create a closer fit, for instance by using stretchable material and a sewing pattern that is better adapted to the female hand form.

These glove liners, like competitors (Appendix 3), look different from regular gloves you see on the streets today (“Visual appearance” on page 24). This means that they could attract attention to the wearer.

Opposed to the USB heated glove (page 27) the Thermoglove can be switched on and off by the user. It also communicates when the heat is turned on. These are useful features that our design should have as well.

The gloves do not have an intuitive way of controlling the heat settings. The user has to press a button uncomfortably hard and the order in which the heat settings will be activated is not self-evident. In order to design a better solution the product should have a switch that can be operated comfortably and the way of operating it should be easy to understand.

The thermoglove heats more at the back of the hand and less at the fingers. This is despite the fact that there are two heating actuators (resistive wires) present at the fingers and only one at the back of the hand. This difference in temperature might occur because the wire at the back of the hand is attached in a dense zigzag pattern. The heat produced over the length of this wire is therefore concentrated in a small location and picked up by the thermometer. At the fingers the heat from the wire is spread out over the full length of the fourchette.

Some of the temperature measurements seem to overlap. Those of the medium and high setting at the fingers and those of the medium and low setting at the back of the hand. This overlap might be due to small deviations in hand temperature, as the deviations in room temperature are already accounted for. It does raise the question whether the different temperature settings are actually necessary when the actual temperature output can be influenced so easily.

The thermoglove heats the fingers at the sides. At this point we do not know whether it would be better to warm the fingers at the top or bottom of the fingers, or that it does not matter.

The thermoglove uses three resistive wires of 10 ohms as its heating actuators. It is able to produce a noticeable temperature increase which proves that you can use resistive wires as heating actuator for heated gloves.

The Thermogloves produce around 2.5 Watts in total which is 1.1 Watts more than the USB heated gloves from the previous benchmark (“Conclusion” on page 27).
This could be explained by the thermoglove heating the fingers as well as the back of the hand, while the USB heated glove only heats the back of the hand.

The Thermoglove secures its wire connections threefold, with clamps, tape and heat shrink. This makes for secure connections. The design should imitate this in order to create strong insulated connections as well.

The battery pack of the thermoglove is quite heavy and located under the users wrist, which feels uncomfortable. Other heated gloves place their battery on top of the wrist (“Competitor Analysis” on page 20) which seems to be a better location.

7 Producing heat

A literature study into heat actuators

When a current flows through a component it converts electric energy into another type of energy, for instance light in an LED. When a current encounters resistance it converts part of this energy into thermal energy, or heat. All components that conduct electricity have their own amount of resistance and therefore produce a certain amount of heat.

When a current flows through a heat actuator, which is basically a resistor, heat is produced and dissipated to the environment. Current can flow fast through low resistance, producing a lot of heat, or it can flow slowly though a high resistance, producing less heat. The rate at which the heat is dissipated is called Power and measured in Watts (“Power and Energy”, 2017).

The heating actuators that were used in the benchmark products were carbon heat patches and resistive wires. Testing these devices proves that these heat actuators can be used to heat gloves. But in order to select a good heating actuator to use in the design more alternatives should be explored. This chapter conducts a literature study into heating actuators, their advantages and disadvantages and compares them on their practicality regarding the product design.

First five types of heating actuators were chosen to study.

- Film heaters
- Peltier elements
- Resistive wires

- Conductive thread
- Conductive yarn
- Conductive fabric

- Carbon heat patches
- Carbon fibres

Film heaters, peltier elements and resistive wire were selected because they are often produced with the intention of using it as a heat element. Their usability is discussed on the next page.

Conductive textiles are not produced to be used as a heat actuator but are interesting as well. They have a metal content, allowing them to conduct electricity. They are available as thread (Figure 58), fabric (Figure 59) and yarn (Figure 60). There are many different types and their textile qualities, like stretchability, make them interesting for garment integration.

From “Benchmarking” on page 26 we see that carbon heat patches can be used to heat up gloves, which is why they are included in this comparison. Carbon is also produced in the form of fibres and woven matts (Figure 61), which have a more fabric- like quality. One company in the United States, carbonheater, actually produces woven fibre strips for people who want to create their own heated garments (Figure 62). Therefore carbon fibres are also included in this analysis.

Figure 58 Conductive thread

Figure 59 Stretchable conductive fabric

Figure 60 Conductive yarn

Figure 61 Woven carbon mat

Figure 62 Heated glove using carbonheater’s tape

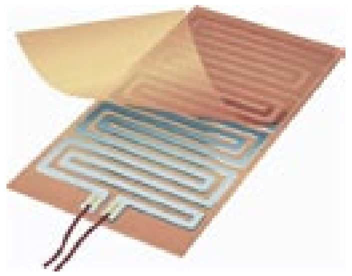


Figure 63 Film heater structure

Figure 64 Carbon film floor heaters

Figure 65 Heated sweater from Polar Seal

Figure 66 Film heater shoe inserts

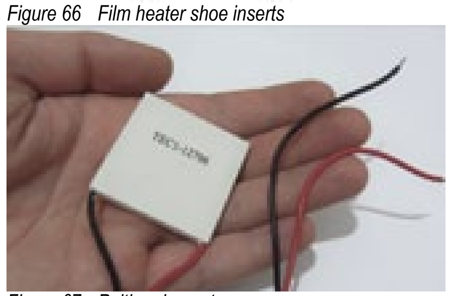


Figure 67 Peltier element

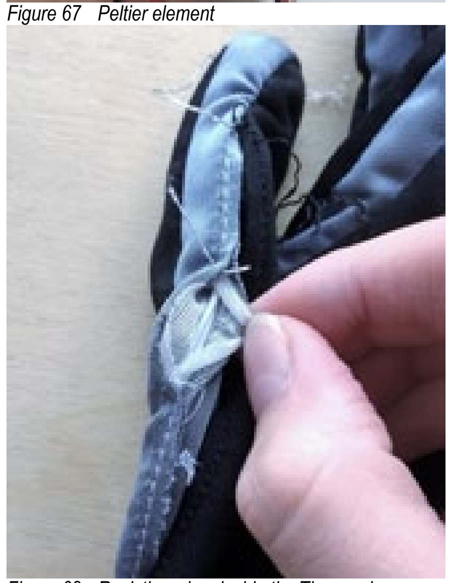


Figure 68 Resistive wires inside the Thermoglove

Film heaters

These type of heaters are made out of a conductive material, often metal film or carbon, with a certain resistance. This material is insulated between two layers of plastic film, which can withstand high temperatures (Figure 63). The metal or carbon is the part that heats up and the plastic film is a way to keep this material in its shape and to provide electrical insulation. They can easily be connected to other components via their wires and can be quite cheap.

Film heaters are available in a variety of sizes and shapes for a wide range of heating applications, from heating floors (Figure 64) to household appliances. There are even some applications for garments like the sweater from Polar Seal (Figure 65) and inserts for shoes that can be found on AliExpress or Ebay (Figure 66).

The film material is bendable but it has limited stretchability. This makes the film useful in places on the body that move a bit, like on the back of a Polar Seal sweater (Figure 65) but not for places where garments need to stretch like on the finger joints.

Peltier elements

A peltier element (Figure 67) is a component uses the thermoelectric effect to transfer heat from one side of the element to the other. When a peltier element is connected one side turns hot and the other side cold. They can be easily connected via their wires and can be quite cheap.

The problem with these elements is that they are even more rigid than the film heaters. They do not bend at all and are hard throughout.

Resistive wires

Resistive wires are mainly produced for the production of resistors and heating applications (Figure 68). Because of these applications specific information about their resistance properties is usually available. Resistive wires are cheap and they can be soldered to other components easily.

Because resistive wires have a metal core or are made entirely out of metal they are far more conductive than conductive textiles or carbon fibres.

The downside of these wires is that they do not have the fabric-feel to them like the conductive textiles and carbon fibres. This makes them less easy to integrate into garments in a way that is unobtrusive to the user. A solution to this might be to use very thin resistive wires that could be hidden in a garment seam.

Figure 69 Sewing conductive thread

Figure 70 Sewing the index finger glove

Figure 71 Testing the index finger glove

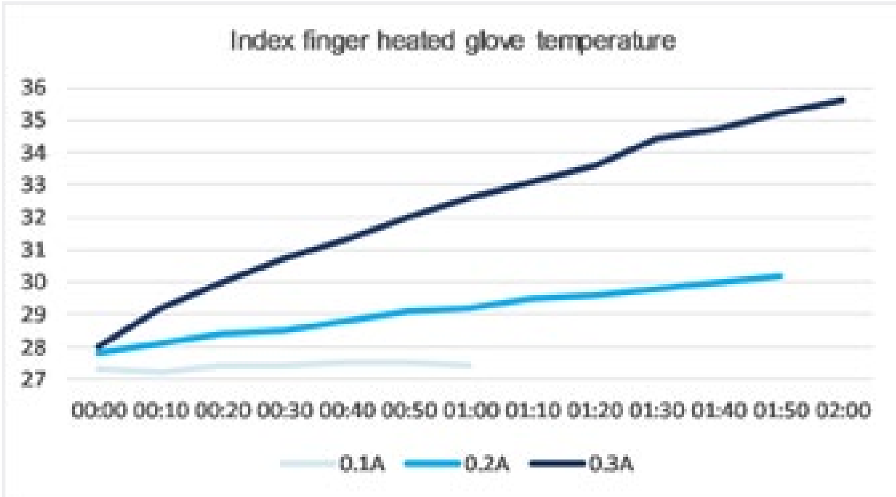


Figure 72 Temperature increase of the index finger glove

Conductive thread test

Because conductive textiles are not produced to be used as a heating actuator a simple prototype, the Index finger heated glove, was created to test the heating possibilities of conductive thread.

Method
The materials used for the index finger glove were

- Black bidirectional stretch tricot
- Black all-purpose sewing machine thread
- Conductive thread bobbin DEV-10867 (28 ohm/ft)

First two index-sized patterns were cut from the tricot. Then a row of zigzag stitches was made on it with the sewing machine, with the black thread on the spool and conductive thread on the bobbin (Figure 69). Long tails of the conductive thread were left on the model. After stitching the conductive thread to the fabric the measured resistance of the sewn thread was 37.4 ohm. Then the second tricot layer was attached, shielding the users skin from the conductive thread. The fabric was then folded and sewn with regular thread to form the index finger glove (Figure 70). Excess fabric was trimmed and the glove was turned inside out to hide the raw edges.

This one-fingered glove was then connected with its conductive thread tails to a variable power supply (Figure 71). 0.1, 0.2 and 0.3 A were applied and the increase in temperature measured (Figure 72).

Results
With the 0.2 A,1.5 W and 0.3 A, 2.2 W a temperature increase could be noticed and measured. At 0.2 A the temperature increase was 0.02 degrees Celsius per second.

Conclusion
From this test we can conclude that conductive thread can be used as a heating actuator and it can be sewn into a garment. A temperature increase of 0.02 degrees Celsius per second can be felt by a user. With this prototype this temperature increase was produced by 1.5 Watt.

Conductive thread

From the test we can see that it is possible to use conductive thread to heat up a glove and that it can be sewn directly to the fabric.

A large downside of conductive threads is that they are not solderable or hard to solder to. In most projects in which they are used they are connected by tying a knot around the components leads (Stern, n.d.). This might be sufficient for a DIY project, but not for a consumer product. The connections could be broken more easily then a button falling off a shirt.

There are conductive threads available that are solderable. The best of them have a wire core (Satomi & Perner-Wilson, 2009). But when a thread contains a wire it does not have the same textile-like behaviour and sewability.

Possible solutions to the soldering problem might be to use a crimp bead for connection (Figure 73) (“How to Solder (Stainless Steel) Conductive Thread”, 2017). The long term reliability of these connections should be tested before it could be used in a consumer product.

If you would stitch conductive thread directly on the fingers of the gloves they would be visible as a top stitch (Figure 74). One solution to this could be to make this top stitching decorative as is done in jeans. This would lead to a very atypical looking pair of gloves. The conductive thread could also be hidden in the seams (Figure 76). The conductive thread then becomes the thread that holds the glove together, which is an integrated solution.

When examining these ideas the biggest problem of conductive thread is revealed. When you measure the length along the fingers you come to the conclusion that you need about 50 centimetres to 1 meter of heated thread to trace the whole length (Figure 75). Conductive wire has quite a high resistance, the lowest

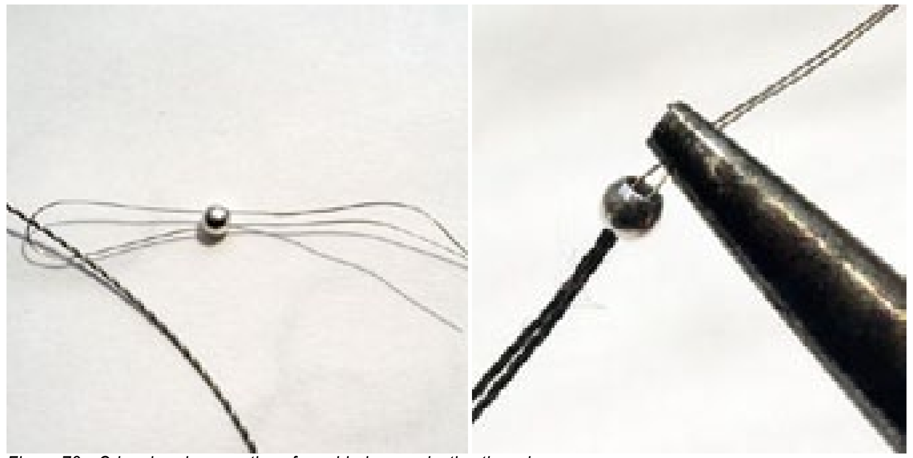


Figure 73 Crimp bead connections for soldering conductive thread

Figure 74 Visible top stitch

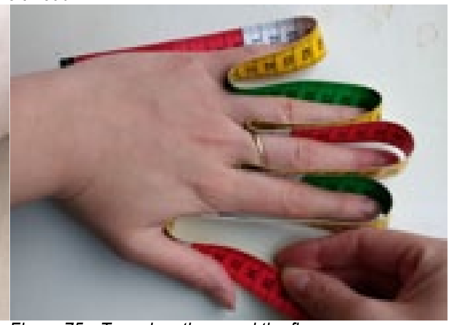


Figure 75 Trace length around the fingers

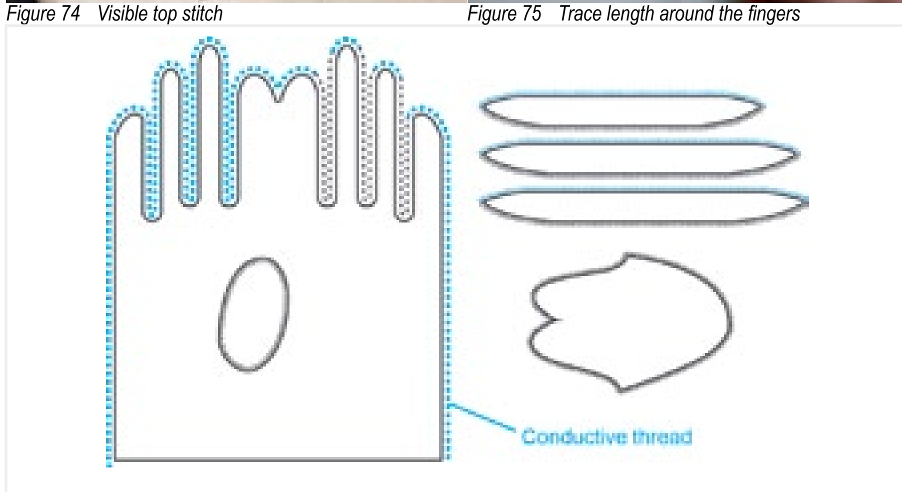


Figure 76 Using conductive thread in the seams

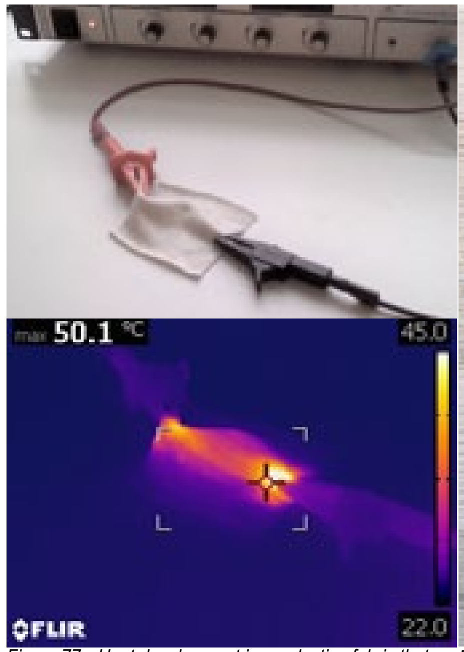


Figure 77 Heat development in conductive fabric that is connected in two points

Figure 78 Lowering the resistance of conductive fabric by connecting it over the entire length

resistance thread that was found was 30 ohms per meter (Satomi & Perner-Wilson, 2009). In order to produce even a minimal 1.5 Watts like in the index finger glove (page 36) with a similar battery like the thermoglove of 3.7 V (page 26) we need a thread resistance of 9.1 ohm. The resistance of half a meter of conductive thread would already be too high.

Stitching the threads on each finger in parallel would reduce the overall resistance, but then each pair of gloves would need twenty conductive thread connections.

Conductive yarn

Conductive yarn could be integrated into gloves by knitting them into the fabric. Some smartphone operable gloves already have conductive yarn integrated in their fingertips (Figure 80).

Here the same problems with high resistance and difficult wire connections are present as with the conductive thread.

Conductive fabric

Electricity behaves differently when it is conducted through a wire then when it is conducted through a sheet of conductive material. Resistance of conductive fabric is often given as ohms per square, meaning that the resistance of this fabric is constant when it is cut into a square of any size. The resistance of a rectangular sample is expressed as R=Rs*Ar. Where Rs is the sheet resistance of the fabric in Ohm/sq and Ar is the aspect ratio of the sample (Gilleo, 1996). This means that a sample with a low aspect ratio, on that is wider than it is long, has a lower resistance.

When a conductive fabric is connected in two points to a power source the electricity and heat production will travel straight between the connections (Figure 77). In this situation the resistance is high. But when a sample is connected over its full length the electricity can travel through the whole square, lowering the resistance (Figure 78). We could use this phenomenon to create heaters out of conductive fabric with a lower resistance (Figure 79).

The connection over the length could be made using copper as can be seen in Figure 78. How this copper would bond securely to the fabric is something that needs further experimentation and testing.

Carbon heat patches

Connecting over the full length to lower the resistance can also be done with carbon fibres. This is actually how the heat patches from the USB heated glove are constructed (Figure 81) (“Benchmarking” on page 26). These patches are relatively stiff and do not stretch, which make them difficult to integrate at places of movement, like at the finger joints.

Carbon fibres

If carbon can be used to create heat patches carbon yarn and woven textiles could heat up as well. Carbon fibres are relatively cheap and have a more fabric-like feel to them than the carbon heat patches.

The company carbonheaters has a tutorial on how to create a heated glove using their woven carbon fibre strips (Figure 82). This tutorial shows the two main downsides of using carbon fibres. The first is that it is not solderable at all. The tutorial advises to hand sew a wire to the carbon strip with conductive thread and inject it with silver glue (Figure 83). This is a labour intensive process that might not produce reliable results.

Because of their high aspect ratio the resistance of carbon strips is quite high. The gloves from the tutorial make use of two 3.7 V 3400 mAH batteries per glove to get it to heat (Figure 84). The initial glove is already quite large but in order to attach the large battery pack they use an even larger outer glove. This makes for a very bulky glove and a big battery pack which would not be acceptable for our requirements.

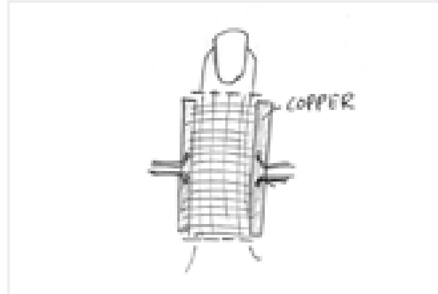


Figure 79 Connecting conductive fabric over the total length, lowering the resistance

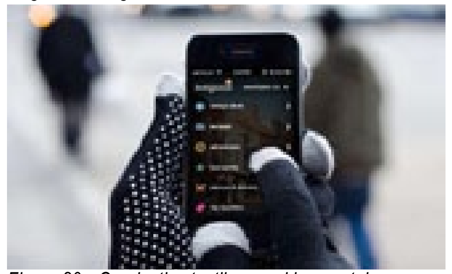


Figure 80 Conductive textiles used in smartphone operable gloves

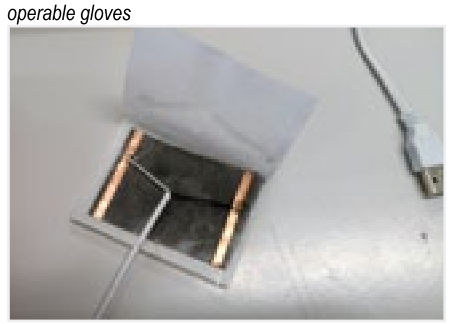


Figure 81 Carbon fibre heat patch, USB heated glove

Figure 82 Heated glove using carbonheater’s tape

Figure 83 Attaching a wire to the tape with silver glue

Figure 84 External battery pack

	FILM HEATERS	PELTIER ELEMENTS	RESISTIVE WIRE	CONDUCTIVE THREAD	CONDUCTIVE YARN	CONDUCTIVE FABRIC	CARBON HEAT PATCHES	CARBON FIBRES
LOW RESISTANCE FOR HEAT PRODUCTION	++	+	++	--	--	+	+	-
FABRIC-LIKE QUALITIES FOR GARMENT INTEGRATION AND USER COMFORT	--	--	-	++	++	++	-	+
EASY TO CONNECT TO WIRES OR BATTERY	++	++	++	-	-	-	+	--
PRICE	+	+	++	-	-	-	+	++
TOTAL	+3	+2	+5	-2	-2	+1	+2	0

Figure 85 Comparison between heat actuators

Comparison

To conclude this chapter we will summarize the advantages and disadvantages of the discussed heat actuators (Figure 85).

Conclusion

The best heat actuator for the design, considering its resistance, fabric like qualities, ease of connection and price, is the resistive wire. It is followed by the film heaters, peltier elements and carbon heat patches. These are easy to connect and to produce heat but are harder to integrate. The carbon fibre and the conductive textiles have good textile-like qualities but are harder to connect to the other components.

In this chapter we have seen that each of these materials has interesting qualities. Leaving out some of them in the ideation phase could possibly lead to less creative product ideas. Therefore it is decided to use each of these materials in the ideation phase for the idea generation.

8 Thermal insulation

Literature study into reducing thermal conduction

The gloves design might be able to produce heat but it is also important to keep that heat from escaping to the environment. To get an understanding on which factors influence the heat transfer to the environment we look at the equation for thermal conductivity.

MATERIAL	K W/(M*K)
Cotton	0.4
Leather	0.14
Wool	0.4
Neoprene	0.05
Polyester	0.05
Air	0.024
Water	0.58

Figure 86 Thermal conductivity constants ("Thermal Conductivity of common Materials and Gases", 2017)

The equation for thermal conduction is

$$\frac{Q}{t} = \frac{kA\Delta T}{d}$$

Where Q is the amount of heat that is transferred per time t. k is the material constant for thermal conductivity, A is the area over which the heat transfer occurs, dT is the temperature difference between the two sides of the material and d is the thickness of the material ("What is thermal conductivity?", 2017).

Lets consider gloves with the same size in the same temperature conditions. If we choose a material with a lower thermal conductivity constant, k, we lower the amount of heat that is lost to the environment, Q. In Figure 86 you can find different thermal conductivity constants for materials that are commonly used for constructing gloves.

Other factors that could be considered are the amount of air and water present. Air has a low thermal conductivity factor, which means that gloves with a lot of air trapped in transfer less heat to the environment. Water on the other hand has a very high thermal conductivity constant. Meaning that wet gloves, from rain or sweat, lose heat to the environment faster.

A smaller contact area, A, also reduces the heat transfer. When you compare gloves and mittens, the mittens have a smaller contact area with the air outside.

The last factor in the equation is the thickness. When you increase the thickness the heat transfer to the environment will go down.

Conclusion

In order to retain more heat we could:

- Choose a glove material with a low thermal conductivity constant, like polyester.
- Create a lot of air-traps, like with a rough knit or woven fabric or with a loose fit, because air insulates well.
- Protect the gloves from getting wet by making them water resistant.
- Reduce the area over which the heat transfer occurs, for instance by choosing the form of a mitten.
- Make the gloves thicker.

From the theory in this chapter we can understand why thick mittens retain more heat than thin gloves. However this type of bulky design directly opposes the wishes from the target group (page 19).

We will make the assumption that for this design heat retention will be less important than finger dexterity, as the gloves will be actively heated. This means the design should make use of thinner fabric to allow for finger dexterity despite the fact that will reduce the heat retention.

Whether this assumption is correct will be tested in the evaluation phase by testing thin heated gloves with users and asking whether they are satisfied with the heating performance and finger dexterity the gloves provide ("Target group interviews" on page 88).

9 Constructing gloves

A sewing exploration into glove anatomy

In order to create a prototype in the embodiment phase it will be necessary to either change existing gloves or sew new ones. To test if simple gloves could be sewn for prototyping four sewing methods were tried.

Figure 87 shows a general glove pattern and Figure 88 shows how these components fit together to form the glove. The main part of the glove, which consists of the back, the palm, the wrist and the fingers, is called the trank. The thumb is cut from a separate piece as are the fourchettes. Fourchettes can be made from three short pieces or from one long piece, like in the thermoglove (Figure 48 on page 28). The gauntlet is the part below the wrist (Close, 1950).

Construction

Three different gloves were sewn on a domestic sewing machine, Lewenstein Amazon 595. The fabric that was used was a highly stretchable tricot.

Glove 1

A closed finger pattern was cut on the fold of the fabric (Figure 89) and sewn together without fourchettes or separate thumb. The seam allowances were trimmed and fingers were cut apart (Figure 90). The gloves were then turned right side out. The cutting of the fingers was unsuccessful as can be seen in the resulting glove (Figure 91). The seams were close together, which resulted in cutting errors and created holes in between the fingers.

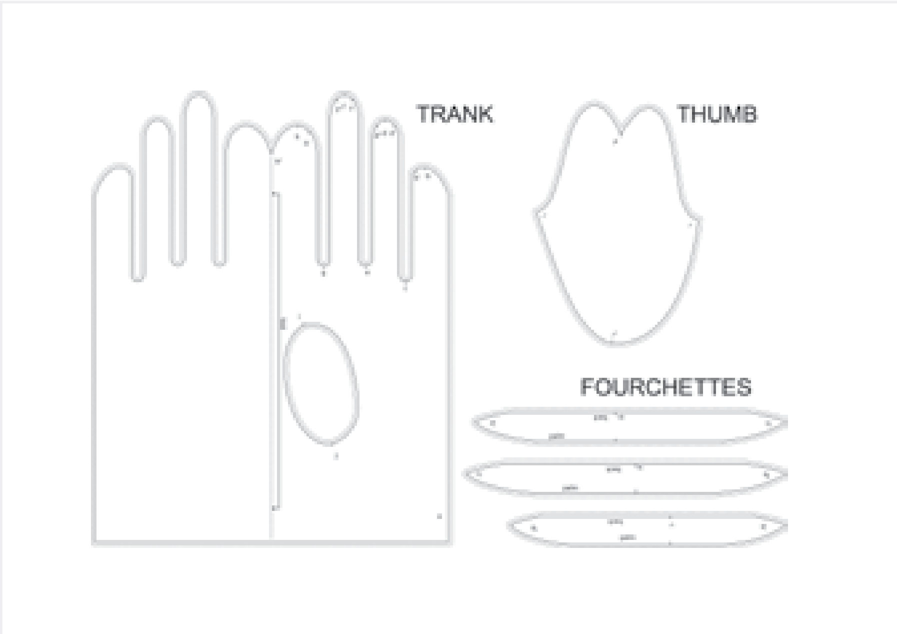


Figure 87 General glove pattern

Figure 88 Glove parts

Figure 89 Glove pattern pinned to the fabric

Figure 90 Cutting apart the fingers

Figure 91 Glove 1 result

Glove 2

A simple glove pattern was made by tracing around the hand with spread fingers on a double layer of fabric. The fabric was then pinned together, sewn on the crated outline, cut and turned inside out. Because the fabric was stretchable it produced an acceptable result (Figure 91 and Figure 93). In between the fingers the fabric gathered together, creating creases.

Glove 3

An attempt at sewing gloves with fourchettes was made. Figure 94 and Figure 95 are pictures made during the embodiment phase which show the process of attaching fourchettes more clearly.

First the trank and fourchettes were cut, then the fourchettes were attached to one side of the fingers of the trank (Figure 94). At this stage of constructing a glove the thumb needs to be sewn and attached, a step that was left out in this particular sewing exploration. Then the trank was folded so that the other side of the fingers touched the fourchettes. The fourchettes were then sewn to the opposite side of the fingers of the trank (Figure 95). As a last step the trank was closed along the side of the little finger of the pattern.

Sewing fourchettes is a difficult process requiring a lot of sewing precision. This is because the fingertips have small radii and because there is only a few millimetres of seam allowance. The seam allowance is this small because there is little fabric available in between the fingers of the sewing pattern (Figure 87). Glove 3 was not completed (Figure 96).

Conclusion

Gloves are hard to sew because of two main reasons, the tight sewing curves and the small seam allowance. This small seam allowance leaves very little room for error, causing the formation of holes where the row of stitching diverges slightly from its path. It also causes the fabric to displace easily in the machine. Therefore manufacturing of the gloves should be done by experienced tailors.

Figure 92 Results glove 2 back of the hand

Figure 93 Results glove 2 palm

Figure 94 Fourchettes attached to one side of the fingers of the trank

Figure 95 Attaching fourchettes to other side of the fingers of the trank

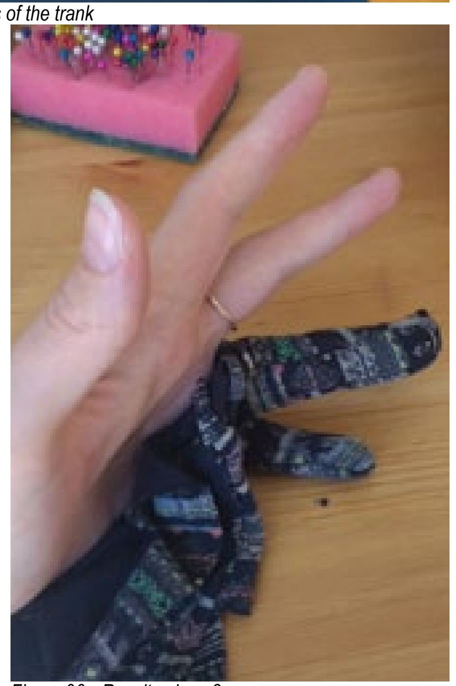


Figure 96 Results glove 3

10 Power delivery

A literature and prototype exploration into batteries

Batteries

In order to produce heat the gloves will need a source of electricity. The way to provide this electricity was researched via a literature study.

From the questionnaire we learnt that most participants regularly use gloves outside (page 16), which means that the product should be able to store some electricity. Because we need the design to be elegant and small we are looking for a way to store as much energy in the smallest size possible. The amount of energy stored in a given volume is called energy density.

Lithium Ion batteries are the latest in rechargeable battery technology. They are rapidly becoming the standard in consumer electronics due to their small size, small weight, and high energy density (Figure 97) ("All About Batteries", 2017). This small size and weight are exactly what we are looking for when designing a small wearable like a glove. Competitors like the Thermoglove also use Lithium Ion batteries.

The battery needs to have enough capacity, which is the amount of energy it stores measured in ampere hours (Ah). Lithium Ion batteries with higher capacities are also bigger in size. A good compromise between size and capacity was found in a 3.7 V 1.2 Ah Lithium Ion battery (Appendix 4). It is small (34mm x 62mm x 5mm) and can fit on a wrist (Figure 98). It could theoretically provide 1.5 Watts (like the index finger glove (page 36)) for 3 hours.

These batteries are rechargeable. It would be possible for our product to use batteries that need to be replaced but the environmental impact and the extra steps required from the user make this a less interesting option.

A good way to charge these batteries is via USB. It has become the standard for connecting power to portable devices ("The basics of USB battery charging", 2017) and it fits well with results from the questionnaire. 84% of participants regularly uses gloves behind the computer or inside the car, where it would be possible to charge the gloves via an USB port or cigarette lighter inverter.

Charging the gloves while working on the computer or driving the car would also be beneficial for the user in terms of product interaction. Plugging your gloves in the wall socket every day is an activity people could easily forget. But when you are using your gloves behind the computer your environment, the computer with USB ports, reminds you to charge them. Externalizing your memory in this way can be very effective (Levitin, 2016).

Batteries have their own internal resistance. This means that, just like other components, they will heat up when a current passes through ("Producing heat" on page 31). Lithium Polymer batteries which get too hot are dangerous because they can explode. Therefore it is important to protect the battery from excess current when it is (dis) charging. In order to limit the current while charging the battery the design

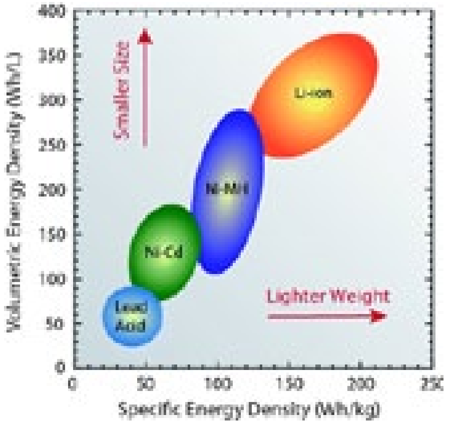


Figure 97 Energy density comparison (Hanania, Stenhouse & Donev, n.d.)

Figure 98 Battery fits on the wrist

should make use of a current limiting charging chip.

The battery datasheet (Appendix 4) recommends a standard discharge current of 0.5 A. To produce a current of 0.5 A with a battery of 3.7 V you need a resistance of 7.4 ohm. This would produce a power of 1.85 Watts. This is higher than the 1.4 Watts of the USB heated glove (page 26) or the 1.5 Watts of the index finger glove (page 33), which both produced a noticeable heat output. Therefore we suspect that this battery could produce a noticeable heat output as well. This assumption is tested with a prototype in the coming paragraphs.

Conclusion

From the questionnaire we learnt that participants wanted a battery with a small size and a large capacity. Therefore we need to pick a battery which is high in energy density, in which case a lithium polymer battery is the best choice.

Based on these factors a 4.2 V rechargeable Lithium Ion battery was chosen. It has a weight of 23 grams, fits on a wrist and has a capacity of 1.2 Ah. These batteries are also available in other sizes and multiple cell packages, with more the capacity.

The batteries should be charged via the appropriate charging chip and it should allow the user to charge the battery while the gloves are being used.

Figure 99 Opening up the seam of the lining

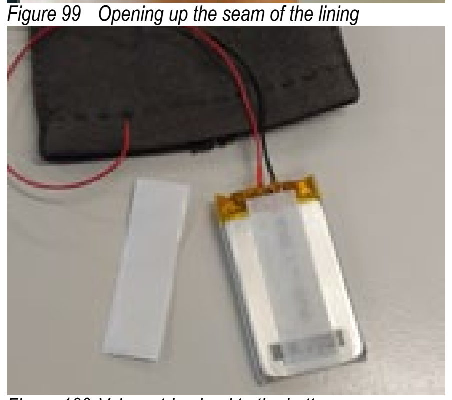


Figure 100 Velcro strip glued to the battery

Figure 101 Openings to reach the wires
Figure 102 Restitching the lining

Figure 103 Placing the resistive wire

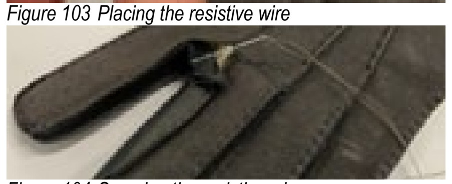


Figure 104 Securing the resistive wire

Figure 105 Attaching the snap buttons

Heated leather glove

In order to test the performance of the battery a prototype was created and tested.

Construction

A heat actuator had to be selected in order to convert the electric energy from the battery into heat. From Chapter 7 Producing heat we learnt that resistive wire would be the best option considering its resistance, solderability and price. In the same chapter we also learnt that the length we need to run a thread along the fingers is about 50 cm to 1 meter. Then we want the thread to have a resistance of about 7.4 ohm in order to create a standard discharge current with this battery.

A suitable resistive wire was found for that covered the mentioned criteria, the Isotan 10 ohm/m laquer coated resistive wire from the company Isabellenhütte (Appendix 5). It has a diameter of 0.25 mm and is coated to be electrically insulated.

The prototype was made with one leather glove, the selected battery, 74 cm of Isotan resistive wire (7.4 ohm), a piece of Velcro, some regular thread and one uncoated metal snap button.

First the inner seam of the gloves liner was torn carefully (Figure 99). Then the Velcro strip was glued to the battery and the inside of the glove (Figure 100). Openings in the sides of the glove were torn to reach the batteries wires (Figure 101) and the lining was restitched with a running stitch (Figure 102). Seams were ripped in strategic placed and the resistive wire was put along the fingers of the glove (Figure 103). The resistive wire was secured at the fingertips and in between the fingers with stitches (Figure 104). The snap buttons were sewn at the gloves thumb and index finger and ends of the resistive wires were soldered to them (Figure 105). This way the user could touch the snap buttons on their thumb and their index finger together to close the circuit between battery and resistive wire. This functions

as the switch, heating up the glove when the switch was closed.
In order to protect the switch from accidentally closing when the glove was not in use, insulating button covers were made. Heat shrink was placed over a second pair of snap buttons to create these covers (Figure 106 and Figure 107).
In order to charge the battery an opening was made in the little finger of the glove. Velcro was attached to allow it to be opened and closed. In order to charge the battery you could open the little finger, desolder the connection between wire and resistive wire and temporarily attach a USB connectable charging chip. The other end of the charging chip could be attached to one side of the button switch (Figure 108). When the chip was connected via USB the battery could charge. After charging, the connection in the little finger had to be resoldered again and the opening closed with the Velcro.

Performance test

To see if the battery and heating actuator were strong enough to create a noticeable heat change the glove was tested.

Materials and methods
For this test a K-Type thermometer was used to measure the temperature at the fingers while the glove was turned on. The probe was placed in between the glove and index finger (Figure 109). The heat measurement was done 4 times and each time the room temperature was measured before the reading. The average room temperature was 21.8 degrees Celsius with a maximum deviation of 0.3 degrees. The measurement results have been corrected for the deviations in temperature and the results are shown in Figure 110.

Results
The prototype heated up with an average speed of around 0.01 degrees Celsius per second.

In between reading 2 and 3 I took something from the refrigerator. The temperature drop in my hand was 2 degrees Celsius. This explains why eleven participants in the


Figure 106 Button cover materials


Figure 107 Covered buttons


Figure 108 Charging the prototype


Figure 109 Heat performance test setup

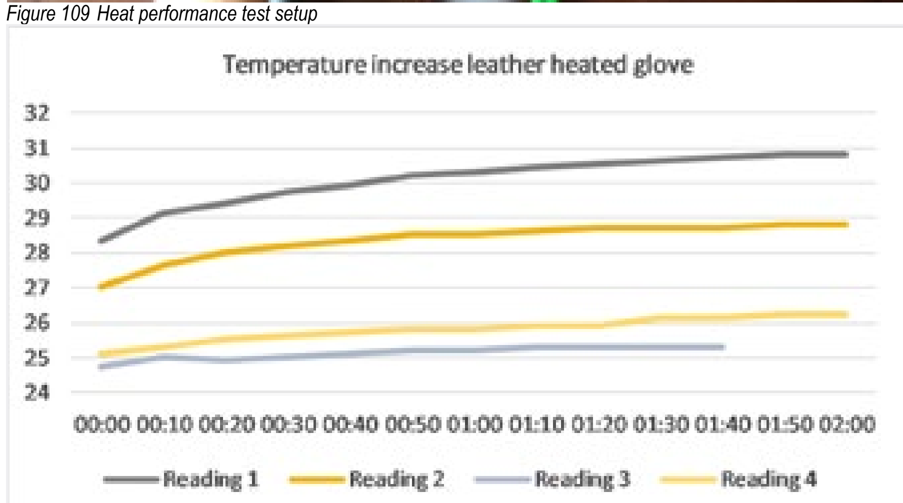


Figure 110 Temperature increase leather heated glove

questionnaire said they wear gloves when getting something from the fridge (Figure 9 on page 16).

If the thermometer probe is not placed under the heating wire directly the temperature increase is hard to detect on the thermometer. This means that the heat does not spread quickly over the whole finger. The heat of the wire can be felt on the outside of the glove as well. This means there is some heat loss to the environment.

User test

To see if the prototype would perform well in outdoor conditions the prototype was tested with a user, Wessel, who has a mild form of Raynaud's.

Materials and methods
We walked outside for one hour and 20 minutes. Every ten minutes we stopped and recorded the environment temperature, Wessels left hand and Wessels right hand temperature. The first ten minutes Wessel wore no gloves, to induce cold hands as a starting temperature. After the first ten minutes Wessel put on the gloves (Figure 111). The left glove was the heated leather glove (Figure 109), the right glove was the second leather glove which was unheated. After an hour outside a short break was taken where Wessel was indoors for about ten minutes. This warmed up his hands which can be seen in the temperature measurements (Figure 113).

In order to record the temperature of the hands the gloves were taken off temporarily and the probe of a K-type thermometer was held. After the measurement the gloves were put on again (Figure 112).

Results
These are the statements made by Wessel during the test:
00:10 *"It feels nice to wear gloves. It seems to heat up within a minute, maybe that is psychological."*
00:12 *"Left hand feels quite good. Right hand is still tingling."*
"I do not feel the presence of the wire."
00:17 *"My right hand does not tingle as much as in the beginning. It is not uncomfortable anymore but I do feel that it was cold before. Maybe the right hand feels OK because the (nonheated) glove stops the wind."*
20:03 *"My right hand is starting to feel less comfortable again. The wind seems colder now."*
00:00 *"There is a difference with wearing gloves over cold or warm hands. My right hand feels fine now, it is able to warm itself. Left feels even better."*

The temperature of the hand wearing the heated glove prototype was on average 2 degrees higher than the temperature of the hand wearing the regular glove. This difference can be seen clearly in the first half of the graph (Figure 113). After the participant was indoors for about 10 minutes both hands started heating up more quickly while wearing the gloves.

Conclusion

A prototype was created that made use of the selected battery (Figure 98 on page 40) and the Isotan resistive wire (page 41) and it was able to heat up with 0.01 degrees Celsius per second.

It was tested by a user outside in weather of 16 degrees Celsius. The prototype increased the hand temperature with an average of 2 degrees Celsius and there was positive user feedback, the hand with the heated glove felt better. Therefore it is decided to continue with this selected battery.


Figure 111 Participant wearing the gloves

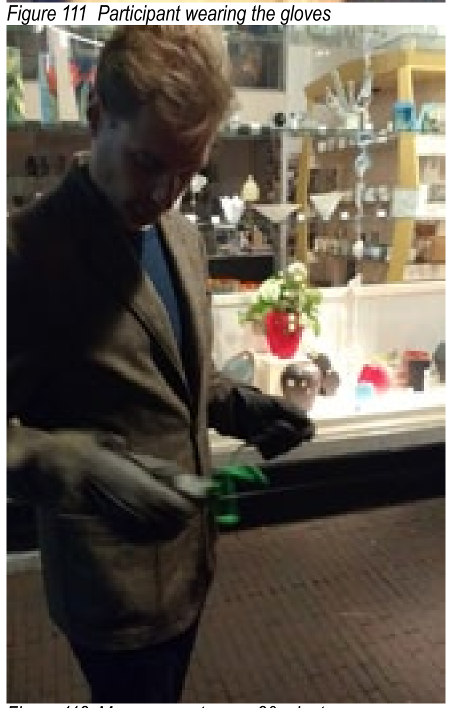


Figure 112 Measurement every 20 minutes

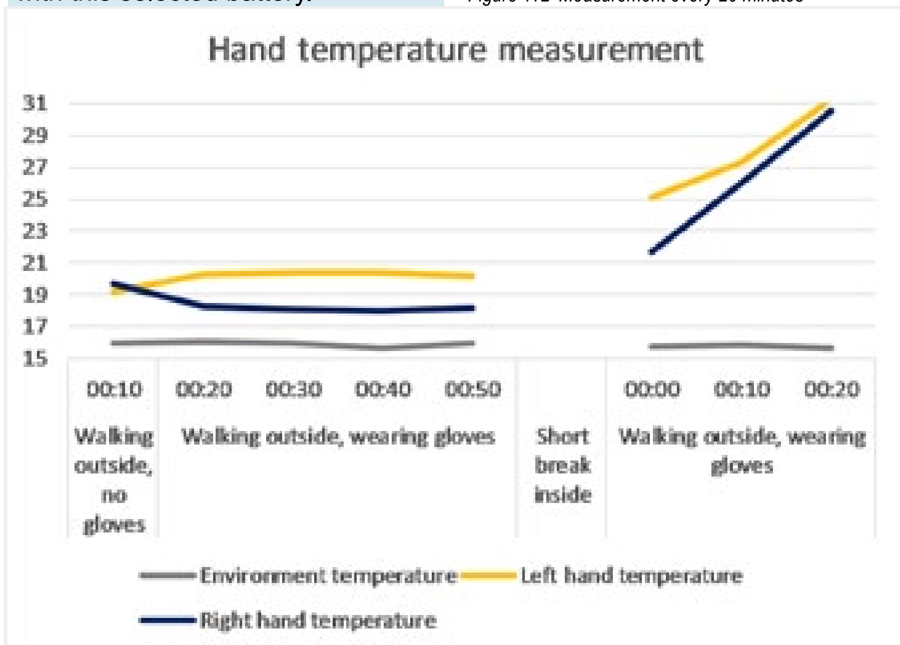


Figure 113 Measurement results user test leather heated gloves

11 User control & feedback

A prototype exploration into smart controls

Next to producing heat it is important that the design enables the user to control it. The user has to be able to turn the device on and off and has to receive feedback from the product.

There are many types of small switches that can close our circuit to let a current run. There are switches that close momentarily (Figure 114), only when the user interacts with them, and switches that will stay in an on or off state (Figure 115). There are also switches that can connect to more than one channel, like rotary switches (Figure 116), which could for be used to create multiple heat settings. Then there are the electronic switches, like the mosfet (Figure 116). They have no moving parts but switch according to the electrical input they receive. Another interesting component is the potentiometer (Figure 116). By turning the knob the user can change its resistance, allowing them to control the current in a more gradual manner.

The product could also be controlled in a more sophisticated way using a microcontroller. They can be programmed to create a certain output according to the input they receive. This makes it possible to create a product that reacts to sensors that sense its environment, for instance a change in light, pressure or temperature.

Figure 114 Two types of momentary switches

Figure 115 Rocker switch, toggle switch, on/off pushbutton, sliding switch

Figure 116 Rotary switch, mosfet, potentiometer

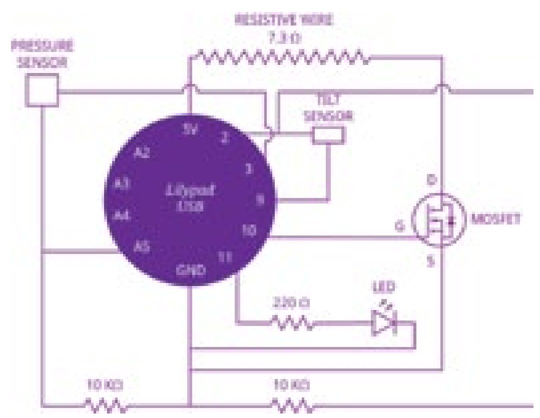


Figure 117 First circuit design gesture controlled glove

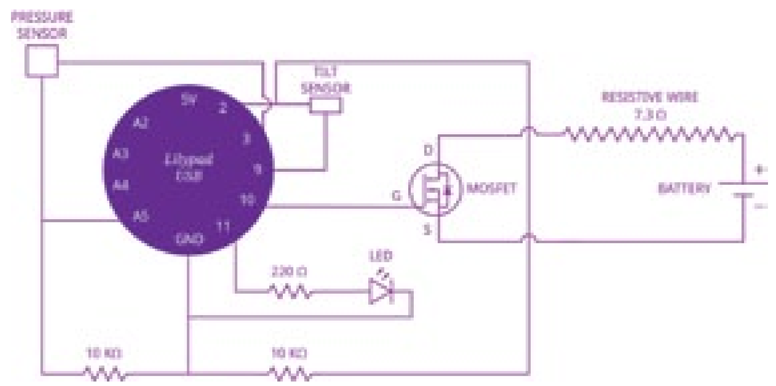


Figure 118 Second circuit design gesture controlled glove

Sensor controlled glove

The possibility of sensor based user control was explored by creating a sensor controlled glove. It was designed so that it could react to a gesture of turning an imaginary knob in mid-air. The index finger and the thumb would be pressed together while the wrist turned a quarter circle to the right. This "turning up the heat" would then actuate the resistive wire and an LED.

Construction

The prototype was made from:

- Approximately 25x25 cm of black bi-stretch tricot fabric
- 3 cm of black Velcro
- The selected battery
- 74 cm of Isotan wire (7.4 ohm)
- An Arduino Lilypad USB microchip
- A mosfet FQP30N06L
- A tilt sensor BL-XT660
- A small fsr pressure sensor
- Two 10 kΩ resistors
- One 220 ohm resistor
- One high intensity bright white led 504WC
- Wires, diameter 0.6 mm
- Heat shrink

A circuit was designed to control the resistive wire and the LED. In this first circuit design (Figure 117) the resistive wire was connected to the positive pin of the lilypad. This positive pin supplies 5V when the lilypad is connected via USB to a computer. It supplies 3.7V when it is connected to the battery. In order to switch the power to the wire on and off a mosfet was connected to pin 10. An LED was connected to pin 11 and programmed to switch on simultaneously with the resistive wire. The pressure sensor and tilt sensor got separate power supplies from digital pins 3 and 9 that were programmed to give a high digital output. Their values were read by pin A5 and pin 2. The 10 kΩ pull-down resistors prevented the pins from floating.

An Arduino code was written to control this circuit (Appendix 6) and uploaded. It read the value of the pressure- and tilt sensor and actuated the resistive wire and LED according to these values. The components were tested using alligator clips and the needed components (Figure 119).

Having a high current component, like the resistive wire, directly connected to the Lilypad is not a problem on its own. However, when other components needed to be read and/or actuated by the Lilypad simultaneously this resulted into errors that shut down the microcontroller.

To solve this problem a second circuit design was created. It was similar to the first design, except the resistive wire was separated from the circuit and connected to its own battery (Figure 118).

The components were drawn out on my hand to plan and see the physical circuit layout (Figure 120). It allowed evaluation of the circuit design in 3D full size.

A glove was sewn from the fabric (Figure 121) in a similar manner as in the constructing gloves sewing test ("Glove 3" on page 39). A wristband, with Velcro closings and a pouch for the battery (Figure 123), were created using the same fabric. A zigzag top stitch was done on the right side of the fabric. This top stitch was made in order to hold the components and guide the wires into place, this can be seen in Figure 122 on a test piece of fabric.

Figure 119 Testing the circuit design using alligator clips

Figure 120 Drawing out the component layout

Figure 121 Sewn glove

Figure 122 Zigzag topstitch for holding components

Figure 123 Pouch to hold the battery

Because of the thinness and flexibility of the resistive wire it could be threaded through a needle (Figure 125). This made it easy to get the wire underneath the zigzag stitch that was created for this purpose. The other components and the Lilypad were stitched on the right side of the glove using black thread (Figure 124). The components were connected via the wires and the soldering was protected with heat shrink.

Results
The result was wearable glove (Figure 126) that could sense touch and tilt and could activate a LED based on these values (Figure 127). Unfortunately, controlling the resistive wire with the mosfet was not achieved. The mosfet was not able to shut the power to the resistive wire off when the gate pin was switched low. This resulted in the resistive wire receiving power all the time, draining the battery. This remained the case even after a pull-down resistor was built in to prevent the gate pin from floating. One explanation could be that the mosfet was damaged during construction.

Conclusion

From creating this prototype we learnt that there are possibilities for gesture control gloves, but there are two main downsides. The first is that, when you use a sensor as an on/off switch, it has to stay stand-by constantly to notice a change and translate that into action. This stand-by state will use electricity all the time. Because we want a small battery we already need to compromise on battery capacity (“Power delivery” on page 40). Therefore it would not be sensible to use part of this electricity for smart control when other non-power consuming options are available (page 44).

The second disadvantage of smart control is that the sensors need to be read by a microchip. A chip like that would probably need to be custom designed and produced, making it a relatively expensive part. It might therefore be beneficial to design the product in a way that requires no chip at all.

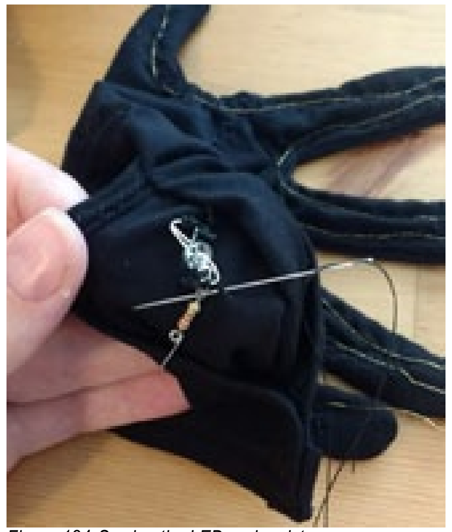


Figure 124 Sewing the LED and resistor

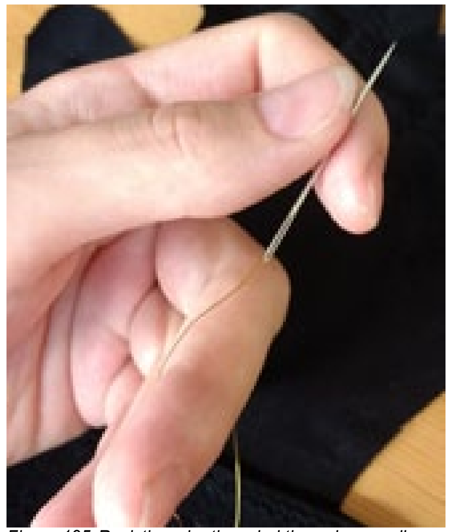


Figure 125 Resistive wire threaded through a needle

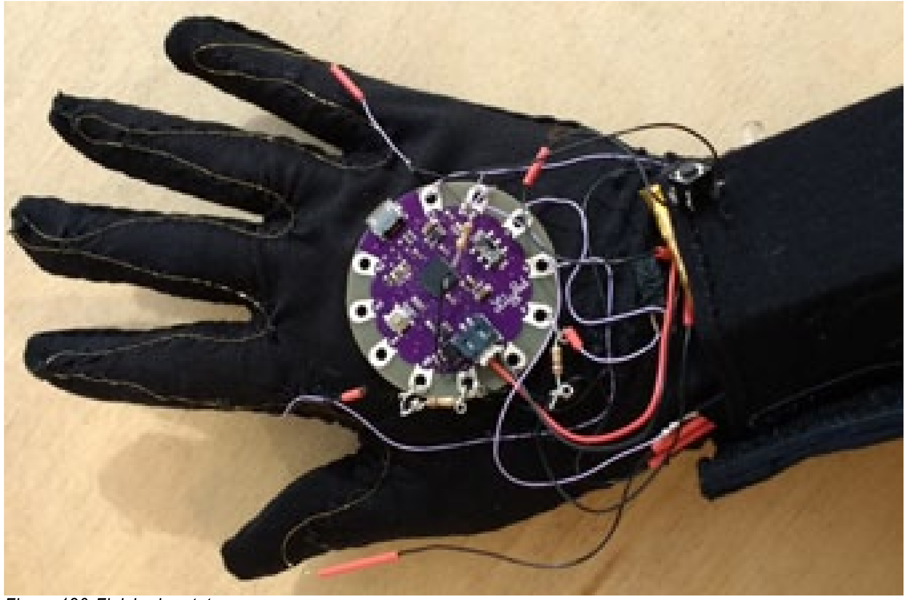


Figure 126 Finished prototype

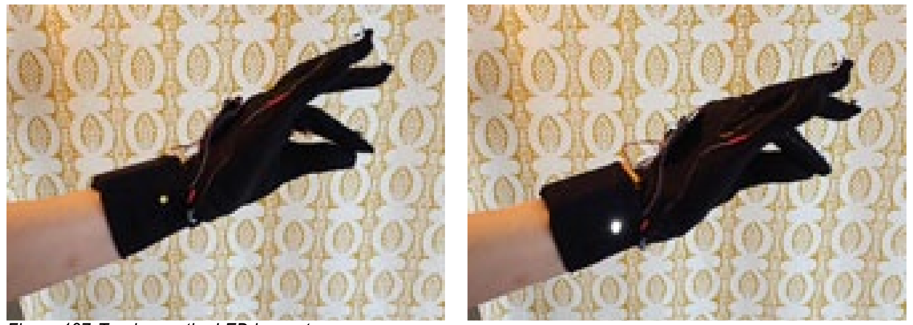


Figure 127 Turning on the LED by gesture

12 Program of requirements

A summary of design decisions based on analysis

In this analysis phase we looked into topics that are relevant to the product design. The insights that were generated in each of the previous chapters need to be taken into account in order to create a valid product design.

The design decisions that were made in these chapters are therefore summarized in a program of requirements. It outlines what the prospected product should be in order to be considered successful.

Product requirements

1. The design should be a pair of heated gloves (Chapter 2 Raynaud’s Syndrome)
2. It’s cost price should be low enough that the product can be reasonably priced (Chapter 3 Questionnaire)
3. It should allow users to wear and use them outside the house (Chapter 3 Questionnaire)

Heating

4. It should heat the users fingers (Chapter 2 Raynaud’s Syndrome)
5. It should heat up noticeably, with a minimum speed of 0.01 degrees Celsius per second (“Competitor Analysis” on page 20) (“Power delivery” on page 40)

Dexterity

6. It should allow the users finger dexterity (Chapter 2 Raynaud’s Syndrome)
7. It should allow the users finger sensitivity (Chapter 2 Raynaud’s Syndrome)
8. It should not be bulky but made out of thin fabric (Chapter 3 Questionnaire) (Chapter 8 Thermal insulation)
9. It should create a close fit around the fingers by using stretchable fabric and a sewing pattern which is adapted to the female hand form (Chapter 6 Benchmarking) (“Visual appearance” on page 24)

Aesthetics

10. It should have better aesthetic qualities than the typical glove liner (“Competitor Analysis” on page 20)
11. Its visual appearance should have enough familiarity to fit in with the fashion of today (“Visual appearance” on page 24)
12. It should have good quality stitching and finishes (“Competitor Analysis” on page 20)

User control

13. It should allow the user to turn the heat on or off (Chapter 6 Benchmarking)
14. It should use no electricity when the heat is turned off (Chapter 11 ‘’User control & feedback’’ on page 44)
15. It should communicate to the user whether the heat is turned on or off (Chapter 6 Benchmarking)
16. It should have a switch which operation is easy to understand (Chapter 6

Benchmarking)

17. It should have a switch which operation is comfortable for the user (Chapter 6 Benchmarking)

Batteries

18. It should make use of a lithium polymer battery, because it is small, light, rechargeable and has a high energy density (Chapter 10 Power delivery)
19. It should have enough battery capacity to heat the glove significantly longer than 30 minutes. (Chapter 3 Questionnaire) (“Competitor Analysis” on page 20)
20. It should have a comfortable battery placement (Chapter 6 Benchmarking)
21. It should allow the user to charge the batteries via USB (Chapter 10 Power delivery)
22. It should allow the user to use the product while it is charging (Chapter 10 Power delivery)

Safety

23. It should not heat the users fingers over 42 degrees Celsius (Chapter 6 Benchmarking)
24. It should allow users to wear and use them safely in the rain (Chapter 3 Questionnaire)
25. It should have a circuit with sufficient resistance to limit the produced current below the maximum discharge current of the battery (Chapter 10 Power delivery)
26. It should be safely charged via a current limiting charging chip (Chapter 10 Power delivery)
27. It should connect its wires securely with clamps, tape and heat shrink (Chapter 6 Benchmarking)

Product wishes

28. It could allow users to wear them in the car, at home, at work and behind the computer (Chapter 3 Questionnaire)
29. Its cost price could be low enough to sell the product at a lower price than the Thermoglove, which is $120 (“Competitor Analysis” on page 20)
30. It could have open fingertips to allow the user to feel, touch and grip (Chapter 3 Questionnaire) (“Competitor Analysis” on page 20)
31. It could look like a pair of normal gloves to avoid attracting attention to the user (“Competitor Analysis” on page 20) (“Visual appearance” on page 24)
32. Alternatively, it could attract positive attention with an attractive appearance that visually differentiates from regular gloves (“Visual appearance” on page 24)

13 Conclusion

Conclusion of the analysis phase

In this analysis phase we gained further insights into the problems that Raynaud’s presents. We defined the target group and confirmed their need for well designed electrically heated gloves. From analysing the competition we can conclude that many models on the market today are large, limit hand movement and do not fit with the aesthetics of modern glove fashion.

By investigating two existing heated glove models we created a benchmark for the product that is to be designed. By looking into heat actuators, thermal insulation, glove construction, power delivery and user control we gained technical insights that will help guide the further product design.

All insights generated in this analysis phase were combined into the program of requirements.

Problem definition

Raynaud’s syndrome is a common vascular disease which effects an estimated 200 million people worldwide, especially women. An attack can produce cold, numb and discoloured fingers and is accompanied by discomfort and pain.

Actively heated gloves could help these women by reducing discomfort and even preventing attacks. But the heated gloves that are available on the market today are not suited to the needs and wishes of this group of people.

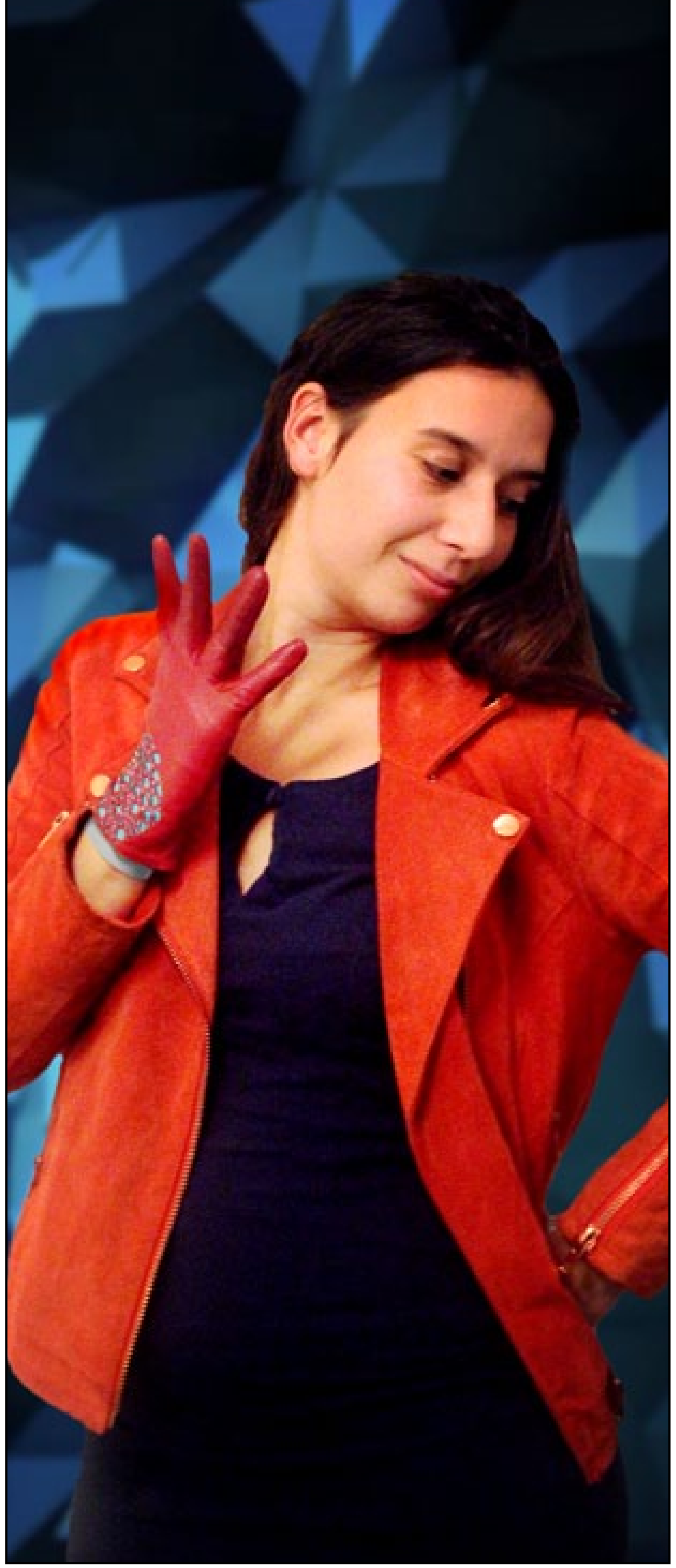
Available heated gloves do not allow wearers to use their hands properly which makes them not practical for daily life. They are also unattractive and expensive.

Design goal

To solve this problem we are going to design a product that will warm the fingers of women between the ages of 30 and 60 who experience problems from their Raynaud’s in their fingers.

The design has to look good and allow for sufficient finger dexterity which gives users the control over their environment back. They need to perform well in terms of heating, comfort and user control while being light and elegant.

With the design of this product we have the opportunity to help the start-up Smart Innovation Development B.V. to improve the lives of many women in the world. By preventing Raynaud’s attacks these gloves can reduce and prevent pain, make the wearer look good and give her back the power to use her hands in any situation.



II. IDEATION PHASE

14 Introduction

The ideation phase addresses the ideation process and the resulting concept. This concept is a design proposal which fits the criteria from the analysis phase and will serve as the proposed design that will be prototyped and tested in later phases of the project.

In order to create a suitable concept the morphological design method was used. In this method partial solutions, to the categories of problems the design needs to tackle, are generated. Then these solutions are sketched out, evaluated and put into an overview chart, the morphological chart. From this chart partial solutions are combined to form concepts.

This phase describes the process and results of this morphological method that was applied to the design challenge that was formulated in the previous chapters. It starts with the idea generation, which focuses on the five categories from the program of requirements: heating, dexterity, aesthetics, user control, batteries and safety. Then the morphological chart and the combination of ideas is shown which results in the three concepts. The chapter concludes with the final concept, which is an iteration created from the three concepts recombined.

15 Ideation process

Generating the partial design solutions

In this ideation phase ideas are generated using creative association methods. The starting point for each of these creative explorations is based upon subdivisions of the program of requirements:

- **Heating**
- **Dexterity**
- **Aesthetics**
- **User control**
- **Batteries**
- **Safety**

Because these ideas are meant to be partial solutions they do not fulfil all boundary conditions stated in the "Program of requirements". They will later be combined into concepts that do implement all of them.

After the idea generation each of the ideas is sketched and described with its advantages and disadvantages. This information is visualized in this chapter (Figure 128 and Figure 129 on page 55).

Heating

First ideas were generated from the starting point of the heating actuators. In Chapter 7 we concluded that all of the discussed actuators have benefits, which is why all of them are included in this idea generation. The indirectly competing heat packs are also added.

Dexterity

A compromise needs to be made between finger dexterity and heat retention. Ideations were made that take both these factors into account.

#	Description	Advantages	Disadvantages
	Heating		
01	Incorporate film heaters by placing them where the fingers do not bend and connect them with flexible wires over the knuckles. Also possible with carbon heating patches.	Heating the fingers without limiting the bending of the knuckles.	Sharp edges of the heater might be felt by the user.
02	Idea for a fingerless glove with a finger cap which incorporates a film heater, carbon heating patch or peltier.	Finger dexterity when the cap is off, heating when the cap is on.	When the finger cap is on it limits the finger dexterity.
03	Conductive traces are printed directly on the glove fabric to create the circuit.	Flexible fabric is the "film" of this heater.	Print might break from hand movement.
04	External "blood vessels". Channels that contain a highly thermal conductive fluid which gets heated and spread through the channels by the users hand movement.	User can control the flow of heat by moving their hand.	Fluid is relatively heavy and fluid channels have a risk of being punctured.
05	Conductive thread is decoratively sewn in parallel rows.	Reduced thread resistance.	Many connections and wires needed.
06	Carbon fibres or conductive yarn are knitted directly into the gloves construction.	Integrated heat actuators.	Difficult to connect (solder) the threads.
07	Mitten with two conductive carbon or textile layers that make contact to produce heat by pressing the layers together.	Heat can be directed by the user with finger pressure.	User has to keep pressing to keep heating.
08	Conductive textile or carbon fibre patches connected over the length of the square.	Lower resistance over the material.	Hand movement might pull on the connections.
09	Conductive thread which is hidden in the gloves seams.	Hidden heat actuator, integrated solution.	Hand movement might pull the connections.
10	Interchangeable chemical heat packs for the fingers. Bending activates the heat.	No electricity needed.	Short heat duration, limits finger dexterity.
	Dexterity		
11	A thin fingerless glove for indoor use is covered with a thicker outer glove outside.	Finger dexterity indoor, double gloves outdoor.	Gloves could interact with friction.
12	A three fingered mitten. Index and thumb are separate while middle- ring and the little finger are together like a mitten.	Gives more dexterity than a mitten and is warmer than a glove.	Index finger and thumb are colder. Less elegant than gloves.
13	Finger cap like the USB heated gloves (page 26).	Dexterity without cap, heat retention with cap	More bulky and less elegant than gloves.
14	Interchangeable finger caps for different weather conditions.	Adaptable to the environment.	More bulky and less elegant than gloves.
15	Individual finger caps.	Adaptable to the users individual fingers.	More effort on the users part.
16	Elastic individual finger caps. Slit opening at the palm side of each fingertip.	Adaptable to the users individual fingers.	Open finger caps could look less pleasing.
17	Pull chord closings for individual fingers.	Adaptable to the users individual fingers.	Pull chord might not close fully.
18	Soft silicone fingertips.	Warm finger sensitivity.	Not breathable.
19	Small zipper fingertips.	Adaptable to the users individual fingers.	More effort on the users part.
20	Fingertips are held open or close by small snap buttons.	Adaptable to the users individual fingers.	More effort on the users part.

Figure 128 Idea descriptions for the partial solutions regarding heat actuators and finger dexterity

#	Description	Advantages	Disadvantages
	Aesthetics		
21	Straps with buckles or buttons can improve appearance and stabilize the battery.	Concealing battery stabilization.	
22	Hide the battery under decorative elements like fur.	Distracts attention from battery bulk.	More wrist volume.
23	Ruffled cuff.	Battery concealment.	More wrist volume.
24	Cuff with zipper closes to fit neatly around the battery and wrist.	Slim cuff battery stabilization.	Battery bulk would be visible.
25	Different colours on the gloves palm- and backside to create visual interest.	Colourful visual interest.	
26	Colour gradient.	Colourful visual interest.	
27	Lace-like patterns created with laser cutting.	Colourful see-through effect, colour interaction	Wind and rain could get through the holes.
28	Fabric scale-like textures.	Visual texture interest.	Stiffer glove.
	User control		
29	Interlocked fingers close connections between heat actuator and battery.	Gesture control.	Only heats when fingers are interlocked.
30	Turning up the heat by invisible knob like the gesture controlled glove (page 45).	Gesture control.	Consumes energy in standby mode.
31	Rubbing hands together.	Gesture control.	Needs to be standby.
32	Point upwards to signal “higher” heat.	Gesture control.	Needs to be standby.
33	Strap closes the glove and the circuit.	Integrated solution.	Vulnerable connection.
34	Capacitive touch fabric switch.	Integrated solution.	Needs to be standby.
35	Turning fingertips to create connections in parallel.	Individual heat control for the fingers.	Vulnerable connections from moving parts.
36	Turning “bracelet” that moves a sliding switch.	Interesting visual possibilities.	Needs to be big to allow a hand to enter.
37	Mechanical switches (page 44).	Simple, inexpensive.	Less interesting.
	Batteries		
38	Separate battery adapter like the thermoglove (page 30), but via USB.	Universal USB charging connector.	Cannot charge and heat at the same time.
39	You have four battery packs you can swap. Two on the gloves and two in the charger.	Always full batteries to the users disposal.	Need four batteries, which is expensive.
40	Direct connection from USB to glove.	Charges and works at the same time.	Chords could get in the users way.
41	Extra power banks.	Longer heat output.	Extra weight.
41	The battery is not located in the glove at all but in a scarf or jacket.	Lighter more comfortable gloves.	Only warm when connected.
	Safety		
43	A sensor keeps the temperature at the fingers below 42 degrees Celsius.	Increased user comfort and safety.	Extra component needed.
44	The electrical circuit of the glove could be protected by using water resistant fabrics.	Less probability for shortages.	Fabric less breathable or more expensive.

Figure 129 Idea descriptions for the partial solutions regarding aesthetics, user control and batteries and charging

Aesthetics

In order to differentiate our product from the competing glove liners our product needs a good visual aesthetic. This can be done by making our product look like regular gloves that do not attract negative attention, like the Uniqknits (page 22), or by design gloves that attract positive attention with their divergence. One of the ways our products appearance will differ from regular gloves is the bulk that is created by the battery. Ideas were generated in order to conceal this.

User control

The way in which the user controls the gloves can be done in interesting ways that make a difference to the user experience. Looking at gestures that people make when they have cold hands or when they want to turn something (like the heat) up inspired some of the ideas. Gesture control makes the user interaction more intuitive and is sometimes considered to be attractive.

Charging batteries

The interactions associated with charging the batteries can also influence the way the user experiences the product. Different partial solutions were generated.

Safety

Then we have the issue of safety. Protecting the users from excessive heat and electrical shortages are not partial solutions but should be included in any concept combination. They are mentioned in this table nonetheless.

Conclusion

In this chapter 44 ideas were generated, drawn and discussed. These partial solutions are ready to be combined into concepts in the next chapter.

16 Concepts

Combining partial solutions

On this page the morphological chart is shown, in which all ideas that were generated in the previous chapter are presented. This overview of ideas facilitates the combination of sub solutions to form three concepts.

On the following pages you can find visualizations of these three concepts with accompanying descriptions and drawings.

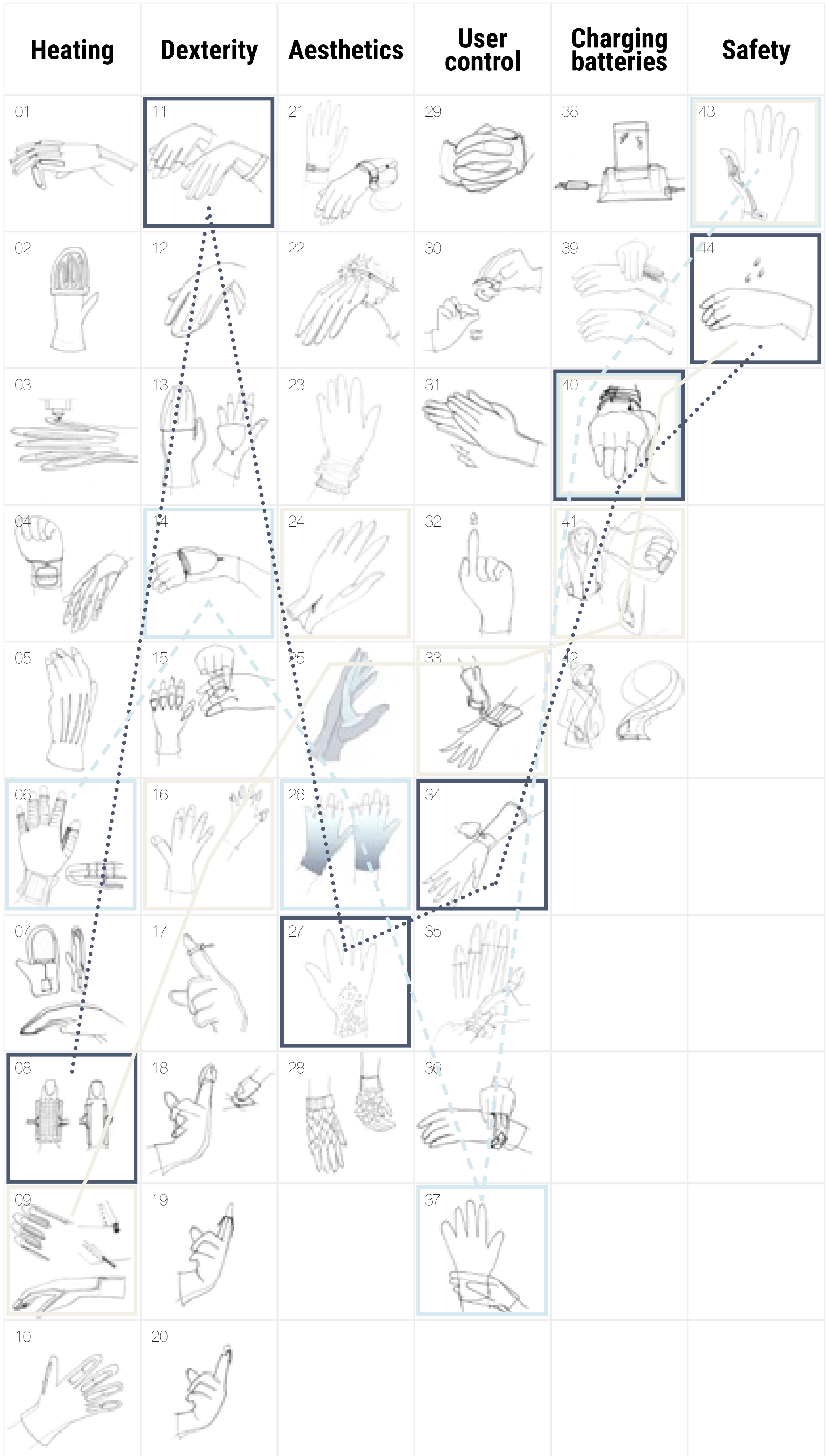
A photo shoot and Photoshop image adaptations were done in order to create visualizations that express the intended character of the concepts.

Combination 1
Concept 1 started from the aesthetic laser lace idea (27) which would show what was underneath the glove. This would combine well with the inner-outer glove idea (11) to create possibilities for interesting colour combinations and interactions. The conductive tactile switch (33) was chosen because of its elegant interaction which fits well with the laced gloves, that can also be associated with elegance. The choice for carbon heat patches was made because they have been proven to be able to heat gloves, are relatively inexpensive and can be easily connected to other electrical components (page 36). Direct USB connection (40) requires less action from the user than taking the battery out (36) or off (27) to charge and is therefore chosen for all three concepts. The outer glove idea (11) combines well with waterproof (14) because it protects the inner glove with the electrical circuit. However the safety ideas (43) and (44) are not exclusive and can therefore be applied to all concepts.

Combination 2
Concept 2 was created from the integrated solution of knitting conductive fibres into the glove itself (06). Knits can be associated with cosiness which combines well with the finger caps (14) and soft silicone buttons (37). Knitted mittens could be perceived as old fashioned. To diverge from old fashioned mittens the gradient colour was (25) added.

Combination 3
Concept 3 started with the interesting adaptable fingertips that worked with the elasticity of the gloves material. This elasticity could be found in polyester fleece fabrics, who have the added advantage that they can be produced via recycling.

The resistive wires were included in this concept because they were found to be the best choice of heating actuator (page 36) and have been proven to heat gloves in both the thermoglove and leather glove prototype (page 40).



Fashionable double gloves

The statement piece to keep you warm

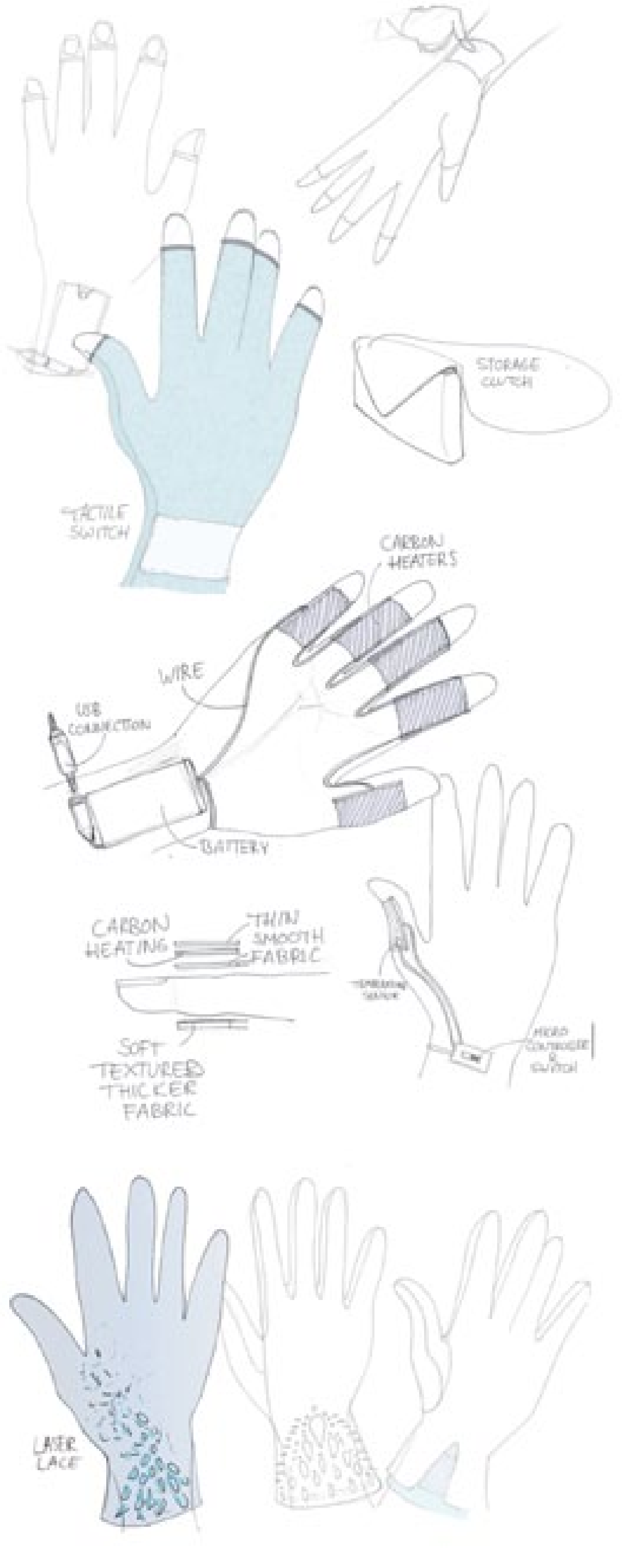
These heated gloves are a pair to be seen. Dependent on the colour combination you create they either become an **elegant item or a fashion statement** piece.

These gloves consist of an i**nner and a separate outer glove**. The inner glove is fingerless, thin and smooth. It is perfect for indoor use where more finger dexterity and sensitivity is required. These gloves are so smooth they slip easily in the outer gloves.

These luxury outer gloves are made out of water repellent fabric and come in a variety of colours. A beautiful **lace-like pattern is laser cut** into the gauntlet. This shows the matching or contrasting colour of the inner glove underneath.

The inner gloves are heated by thin **carbon heaters** that are wrapped around the fingers in between two layers of smooth fabric. They can be turned on and off with the slightest touch using the **conductive tactile switch** at the inner wrist. You can **directly plug them into an USB** while you are working to charge the batteries.

The outer gloves have conductive fingertips which help you navigate your phone while wearing them. They are water resistant and come with a matching storage clutch to keep them with you at all times.



Cozy heated knits

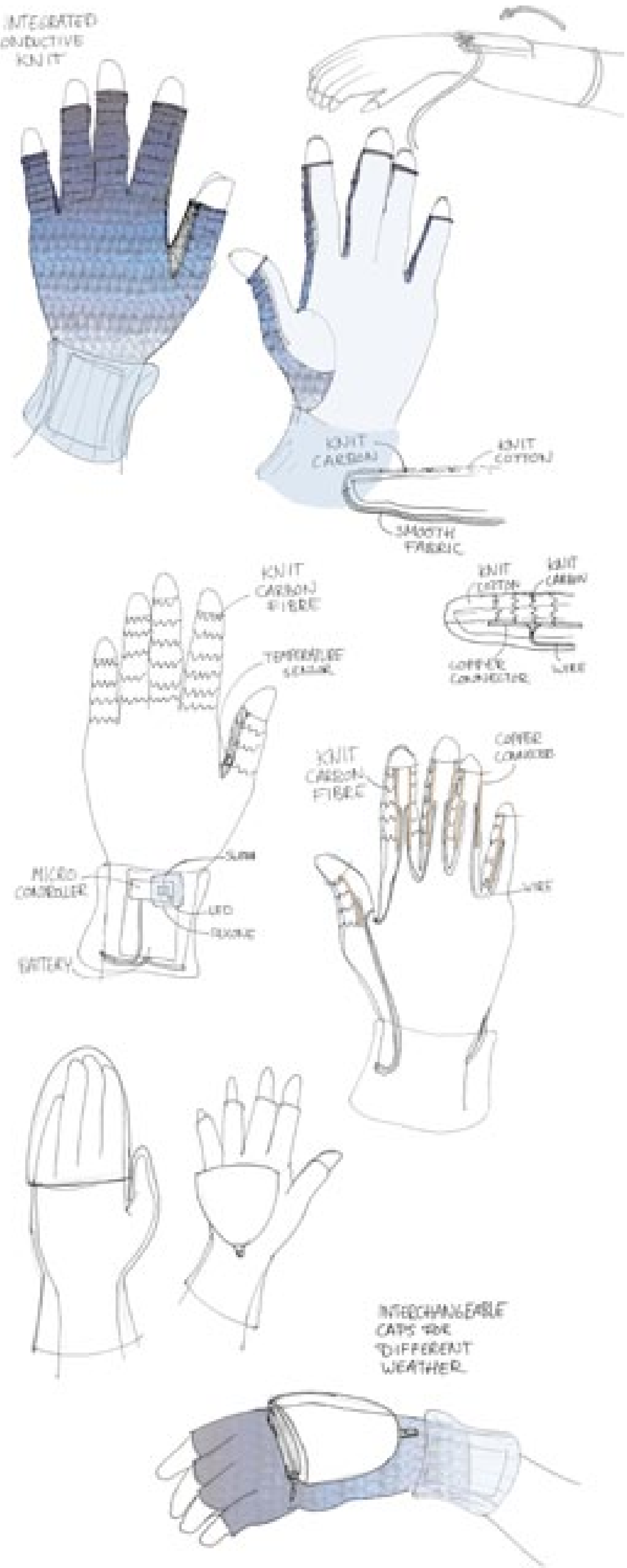
Fingerless gloves with convertible caps

These cozy gloves are heated by the **conductive fibres that are knit into the gloves design**. The conductive thread is integrated with the soft cotton strands that form the glove.

The carbon fibres are connected with **copper connectors** that are hidden underneath the fabric at the palm of the hand. The battery and other electric components are neatly hidden in the **folded sleeve**. Simply press the **soft silicone button** to activate the heat. The **temperature sensor** will make sure that they stay nice and warm.

These fingerless gloves are easily transformed into warm mittens by **zipping on a finger cap**. They can be swapped for lighter or heavier fabric caps for different styles and weather conditions.

Because of its coarse knit in various **different colours and colour gradients** these gloves will keep you warm and looking good.



Casual chic gloves

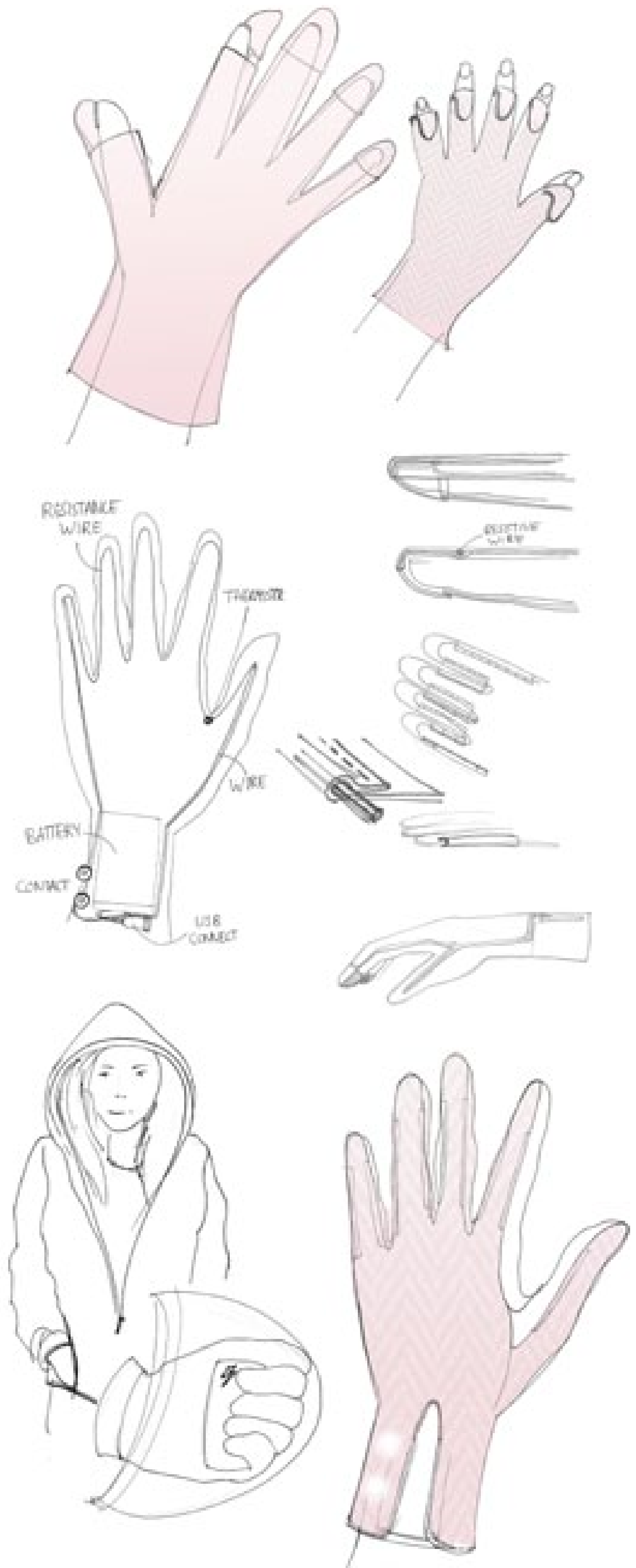
At work and on the go

This all-in one heated glove has **fingertips that can be individually opened**. This gives your hands maximal freedom to feel and navigate the environment.

The fingers are warmed by **resistive wires sewn in** between the seams of the fabric. The heat is activated by closing the **interactive buttons** at the wrist.

The battery is located at the top of the wrist. Here the glove has an opening for easy access to the battery, which can be charged via USB. For extra warmth and power you can take the **glove power bank** with you. It is slim, light, pretty and fits in any pocket.

The fabric is an **water repellent eco-friendly fleece**, made out of recycled plastic waste. It is stretchable and thin, which allows for good finger dexterity and an elegant look. The fabric at the **palm and back of the hand differ in colour**, creating interesting visual combinations.

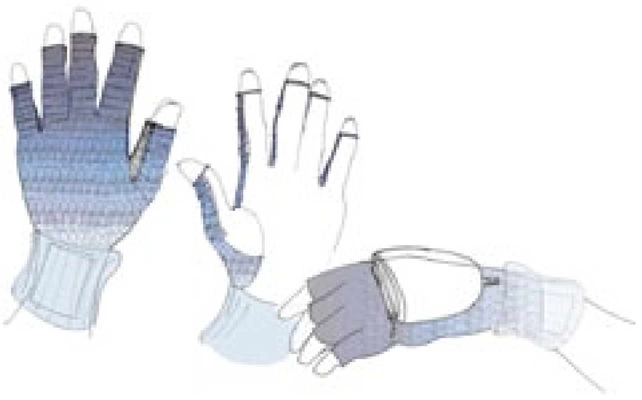


Fashionable double gloves

The statement piece to keep you warm

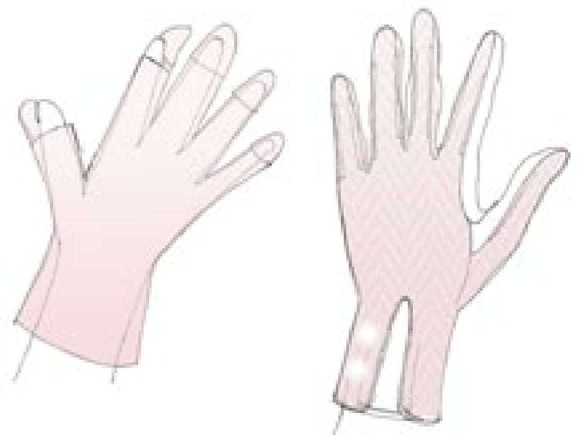
Cozy heated knits

Fingerless knits with convertible caps



Casual chic gloves

At work and on the go



Concept choice

The three concepts all have appealing qualities. Therefore it was decided to make an iteration by combining the best elements of each into a final concept.

Heating
According to the comparison between heat actuators the resistive wire was the best choice (“Producing heat” on page 31) considering its resistance, ease of connection and price. Therefore this should be the heat actuator for the final concept.

Aesthetics
The double laser cut glove from concept 1 was chosen. The laser cut details and contrasting colours make it a visually interesting item that a wearer would be proud to show. This characteristic fits very well with the empowering effect that a well designed heated glove could have for a women with Raynaud’s.

User control
Because relatively low costs and small batteries are important it was decided to not include a microchip or stand-by sensors in the design. The conservative but dependable choice was made to use simple on/off switches and feedback LEDs to control the device.

Batteries
All three concepts made use of the same battery and charging solution, the direct USB connection. It is easy and quick to connect and it does not require the user to swap any batteries.

Safety
Both the water resistant fabric and temperature sensor are important for keeping the user safe and should therefore be included in the concept.

17 Conclusion

Conclusion of the ideation phase

The proposed concept is a fashionable double glove with is heated by a resistive wire. This visually interesting appearance attracts positive attention which suits this empowering product.

The combination of water resistant outer glove and thin flexible heated inner glove make the design practical for both inside and outside environments.

The heat can be switched on or off via a simple button and the gloves give feedback about their state via LED. The user is protected from excessive heat through the temperature sensor. The batteries can be directly charged via USB while the gloves are being used, for instance behind a computer or in the car.

This created concept can now serve as the design proposal, which will be prototyped and tested in the coming phases of the project.

III. EMBODIMENT PHASE

18 Introduction

This phase of the project addresses the embodiment of the design concept which was created in the previous phase. Now that a design concept has been proposed it is time to create a physical model that represents the desired product functionality and appearance.

This phase is divided into two main pieces, the construction of the (inner and outer) gloves and the construction of the battery packs. The construction of the gloves focuses on the fabric selection, the aesthetics of the laser cutout pattern, the iterations on the sewing patterns and the way the gloves are stitched together. The construction of the battery pack focuses on the circuit, switch, LED, charging connector, battery pack cover, wire connection and the battery charger.

During the creation of these prototypes different obstacles were encountered and design iterations were made to solve them. In the following chapters these iterations and the insights they provided are part of the description of the embodiment process.

19 Constructing gloves

On fabrics patterns and stitching


Figure 130 Bartotex blauw, € 12/meter


Figure 131 Polar fleece rood, € 7.50/meter

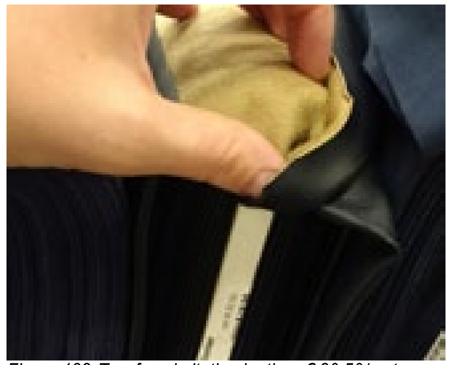


Figure 132 Two face imitation leather, € 20.50/meter


Figure 133 Heavy suede luxe navy, € 22/meter

In order to create the final prototype a pair of inner and outer gloves were sewn. They were iterated along the way, choosing different fabrics, adjusting the pattern and the way of sewing.

Material selection

The first step in creating the gloves was the material selection. Fabrics were compared during a visit to Textielstad in Tilburg. From the program of requirements (page 47) we see that the fabrics should be reasonably priced and should differ from typical glove liner fabric, which is a black neoprene. The fabric of the inner glove has to be thin, to create a close fit around the users fingers, to increase dexterity and avoid creating a bulky glove. The outer glove fabric should be water repellent to protect the electrical circuit of the inner glove in outdoor situations.

Outer glove fabric

The fabric that was selected for the outer glove was Bartotex (Figure 130). A double faced polyester fabric with a water-repellent knit on the right side and fleece on the wrong side. An employee of Textielstad advised this fabric because it is water repellent, wind-tight yet breathable and relatively thin. Regular fleece (Figure 131), imitation leather (Figure 132) and suède (Figure 133) were also considered but were advised against, because they would not be protective against rain and cold.

Haptics

One aspect of aesthetics is the element of touch and for a garment it is important that the fabrics feel good against the skin. The Bartotex feels smooth and supple on the right side and soft on the wrong side.

It was suggested to rub the fabrics together to feel whether they would slide well or create resistance. By testing different fabric combinations it was discovered that fabrics with a similar surface texture slide better than fabrics with different textures.

Colour

Because of the open pattern in the outer glove the inner glove is visible. Combining different fabric colours together can therefore create visual interest.

Bartotex is available in blue, grey and petrol. The dark rich blue was chosen (Figure 130), paired with a green blue tone (Figure 134) for the inner glove. This combination is pleasing to the eye because the hues are adjacent in the colour wheel, creating an analogous colour scheme ("Basic colour schemes", 2017).

Initially Three Yarn Fleece Mint Uni (Figure 134) from Textielstad was selected for the inner glove on its colour and haptics. It also interacted well when the Bartotex was glided over it. After creating a model using this fabric (Figure 135) it became clear that the thickness of the fabric was too high to create a glove that fitted closely around the fingers. It was decided to choose a thinner fabric with more stretch (Figure 138).

At A Boeken in Amsterdam fabrics for the inner glove were found. The thin 82% nylon 18% polyurethane elastomer was found to be soft, supple and stretchable. Its blue-green and light blue colour variations interacted well with the dark blue Bartotex (Figure 137). For the gauntlet some ribbing was found. Ribbing can be stretched in one direction, to make space for the hand to enter, after which it contracts again to fit the wrist. Blue-green ribbing (Figure 139) which matched to the blue-green elastomer was selected.


Figure 134 Three Yarn Fleece Mint Uni, €13/ meter


Figure 135 Inner Glove Three Yarn Fleece Mint


Figure 136 Blue-green nylon elastomer, €16.50/meter


Figure 137 Bartotex blauw, blue-green and light blue nylon elastomere, white ribbing


Figure 138 Inner glove blue-green nylon elastomer


Figure 139 Blue-green ribbing, €16/meter

Linda, who is a fashion designer that helped with the glove construction, suggested to use an extra elastic band inside the gauntlet to make the ribbing fit closely and prevent it from sagging. Thin elastics band (Figure 140) was purchased at Jan de Grote Kleinvakman in Amsterdam. Wide elastic band (Figure 141) inside a layer of elastomer, was considered as alternative to the ribbing. An inner glove model was created using this for the gauntlet (Figure 143). This resulted in a large ridge and crease at the top of the wrist. This idea was rejected based on the visual appearance and the model created with the blue green ribbing (Figure 142) was continued with for the evaluation phase.

Laser cutout pattern

The design of the outer glove has a cutout pattern which shows the inner glove underneath. The first proposed pattern was a patterned honeycomb (Figure 144), which had no meaning in relation to the products design or functionality.

To find suitable symbolism that has connection to our products main function, which is warmth, an exploration into symbolism was done (Appendix 7). The sun and sunrise were chosen as symbol for their associations with warmth and the overcoming of difficult situations.

Visual representations of suns were investigated through the making of collages (Figure 145, Figure 146, Figure 147 and Figure 149). These collages reveal that suns are often abstracted into circles and sunrises can be represented in colour schemes with great contrast in light/dark and cool/warm colours. This was used as inspiration for the pattern and colour interactions of the outer glove. A circular pattern was designed representing a sunrise. It was laser cut into the dark outer glove which showed the lighter fabric underneath (Figure 148). The warm/cool contrast (Figure 150) was not used because there was no fabric found that had both a light warm colour and the advantageous qualities of the elastomer.


Figure 140 Thin elastic band, €10/meter


Figure 142 Inner glove prototype with ribbing an thin elastic band.


Figure 144 Honeycomb laser cut pattern in Bartotex


Figure 141 Wide elastic band, €15/meter


Figure 143 Gauntlet test using the wide elastic band covered with elastomer. A ridge is formed at the wrist.

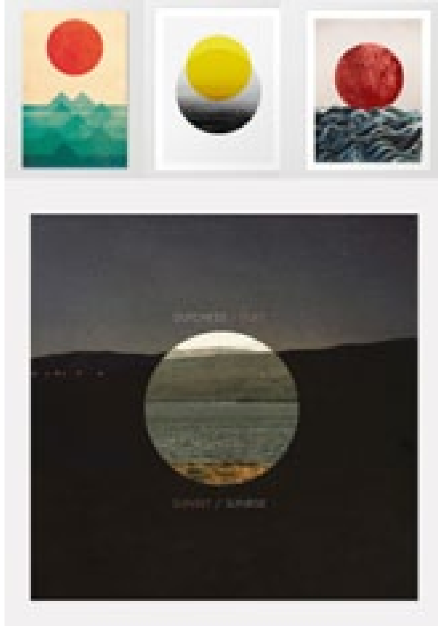


Figure 145 Collage. Suns abstracted as circles.

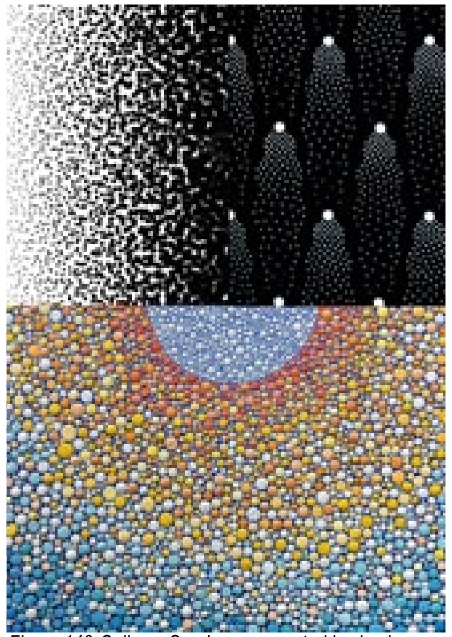


Figure 146 Collage. Sunrise represented in circular patterns, light/dark and cool/warm colour contrast.


Figure 147 Collage. Sunrise represented in light/dark contrast.


Figure 148 Pattern design representing sunrise.


Figure 149 Collage. Sunrise represented in cool/warm colour contrast.

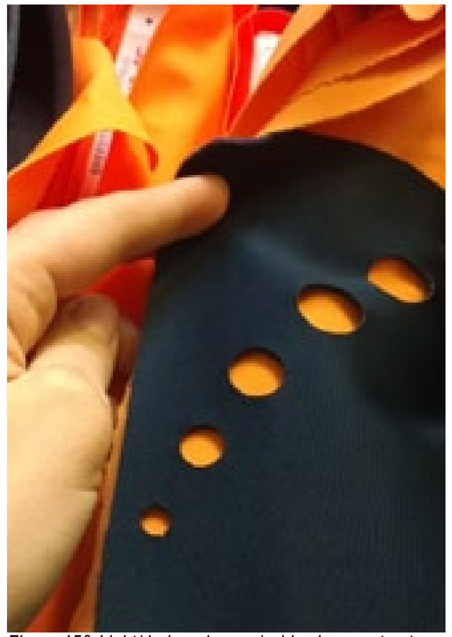


Figure 150 Light/dark and warm/cold colour contrast with a lower quality orange fabric.

Sewing pattern

The pattern that was used as starting point was a free online glove pattern (Figure 151) (“How to make gloves”, n.d.). It was altered in several iterations to create a suitable inner and outer glove pattern.

Adjusting the pattern size
Resizing, or grading, a pattern is not as simple as scaling it up a few percent. This was tried for the outer glove, creating a model that fit around the palm but had very long fingers (Figure 152).

Because the gloves need to fit the hands of our target group the anthropometric database DINED was consulted. According to the most recent measurements (2004) the mean hand width of females between the age of 31-60 is 81 mm with a standard deviation of 4. The mean hand length is 179 mm with a standard deviation of 8. The mean hand size corresponded with the hand size of Linda, who used her own hand as a size reference when grading the patterns.

The basic glove pattern was created for thicker fabrics than the elastomer that was selected for the inner glove. When the first inner glove was created from this basic pattern (Figure 153) it did not fit closely around the hand and fingers which was necessary according to the product requirements (page 47). Therefore new seams to tighten the gloves fit were sewn until a satisfactory fit was achieved (Figure 154). The excess seams were carefully ripped afterwards (Figure 155).

Adjusting the pattern shape
The pattern of the outer glove was adjusted to be a bit bigger than the original pattern in order to fit nicely over the inner glove. The pattern was also adjusted by adding the laser cutout pattern (page 70).

For the inner glove, that was designed to be fingerless, the pattern needed to alter the fingertips from round closed tips to seam allowance at both the ends of the fingers and of the fourchettes. Sewing together the

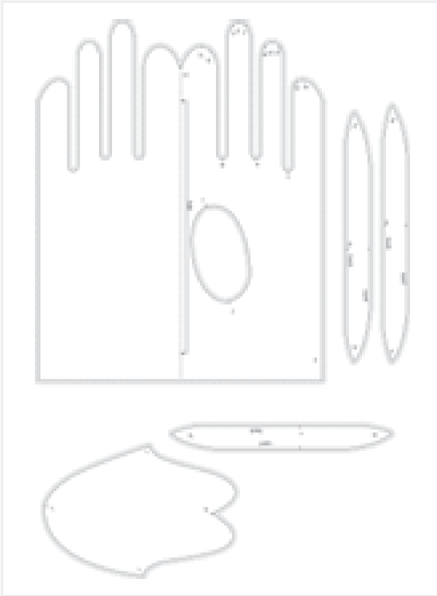


Figure 151 Basic glove pattern


Figure 152 Long fingered outer glove


Figure 153 Linda tracing the basic glove pattern on the elastomer to create the first version of the inner glove

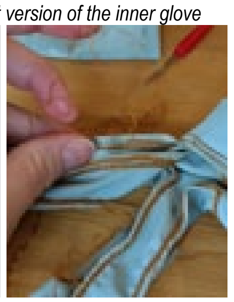



Figure 154 Inner glove with excess seams
Figure 155 Ripping excess seams


Figure 156 Open fingertips of the created inner glove

fourchettes of thin fabric was difficult and resulted in a low quality finish (Figure 156).The raw edges around the fingertip openings would not stay folded inside, even after they were glued down with textile glue.

The inner glove that was created in this way was the one that was used in the evaluation phase for testing. However an additional alteration on the inner glove pattern was made to create a well fitting glove without the need of the fourchettes.

This pattern without fourchettes (Figure 157) was created in four iterations (Figure 158) with the help of Linda. Because a hand is a complicated three dimensional shape the palm side and backside of the pattern are different. These pattern shapes have to conform to the hand shape accurately to prevent the resulting glove from sagging and creasing. This iteration step resulted in a better pattern which could be sewn easier and faster. Unfortunately there was no time to create an inner glove prototype with these patterns before the user testing in the evaluation phase.

Cutting the pattern
The pattern for the inner glove was drawn onto the fabric using a marker after which it was cut using sewing scissors (Figure 153).

The fabric for the outer glove was cut by laser (Figure 159). The first time the laser cut all the way through the fabric which caused the water resistant side to melt and harden at the cutting lines. Because these edges are turned inward at the seams this resulted in a glove with uncomfortable hard seams against the users skin. For the succeeding two models the seam edges were laser-etched after which the created etch lines were cut using scissors. This solved the issue and resulted in a more comfortable outer glove.


Figure 157 Iterated pattern inner glove, no fourchettes


Figure 158 Pattern iteration models in elastomer fabric


Figure 159 Laser cut outer glove pieces

Stitching

Different types of thread, stitches and fabric interact in various ways with each other. If you use an appropriate stitch type and thread your fabric will lay flat around the seams which improves the way it looks and feels.

A sample of test fabric was made, trying out an overlock-, babylock- and chainstitch (Figure 160). These stitches were made on specialized sewing machines at the Amsterdam Fashion Institute. For the prototype the chainstitch was selected. Unfortunately only ochre jeans thread, which is relatively thick and does not match in colour, was available on this machine (Figure 161).

For the pattern iterations models, mentioned on the previous page, Serafil thread was used with a 1 mm zigzag stitch on a domestic sewing machine.

The outer glove was stitched with a 1 mm zigzag stitch and Gütemann nachtblauw all-purpose thread on a domestic sewing machine.

Resistive wire

In the analysis phase Isotan® resistive wire was found that was used for the heated leather glove (page 41). From testing this prototype we found that this wire heats up sufficiently at a suitable length (73 cm, 7.3 ohm) and is flexible enough to allow for finger movement. Therefore this same wire is used in the final prototype.

The first idea was to attach the wire with several stitches to one side of the seam and use iron-on adhesive to seal the seam flat. Because of the small seam this proved to be too difficult. Instead the resistive wire was placed in between the two sides of the seam after which the sides were hand sewn shut using a running stitch (Figure 164). Afterwards the excess seam allowance was trimmed (Figure 165) and the seams were glued flat to one side using Bison textile glue.

Figure 160 Effect of different stitches on fabric flatness

Figure 161 Ochre jeans thread chainstitch on the inner glove prototype

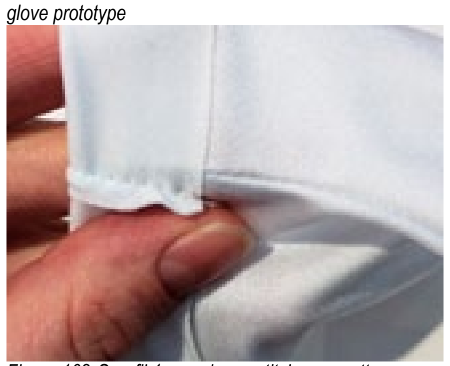


Figure 162 Serafil 1 mm zigzag stitch on a pattern iteration model

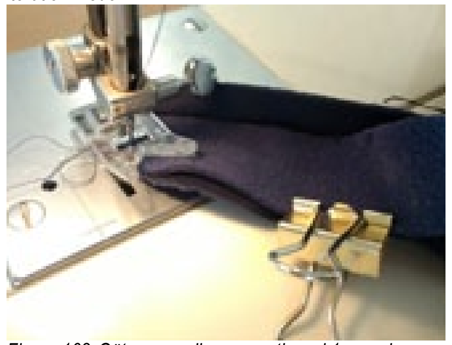


Figure 163 Gütemann all-purpose thread 1 mm zigzag stitch on outer glove prototype

Figure 164 Running stitch seals the resistive wire into the gloves seam

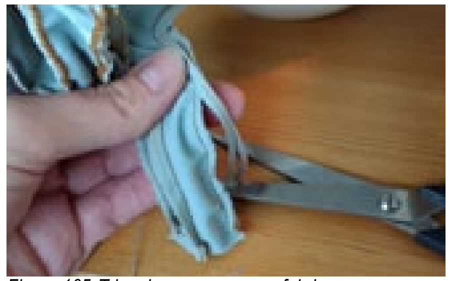


Figure 165 Trimming excess seam fabric

Figure 166 Sewing the resistive wire at the index finger with an all-purpose thread straight stitch

Figure 167 Resistive wires after being bent

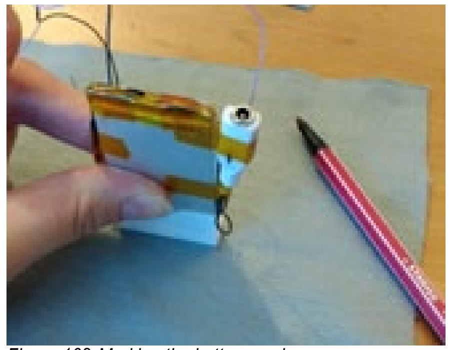


Figure 168 Marking the battery pack

Figure 169 Buttonhole stitch with all-purpose thread

Because there was no seam present at the outer side of the index finger the wire was sealed in the fabric using a all-purpose thread straight stitch and a zipper foot on a domestic sewing machine (Figure 166). Using this method for the entire glove would not be a good solution because a straight stitch is not flexible, like a zigzag- or chainstitch, and reduces the gloves stretchability.

The first heat wire, which was sewn to the left glove, was attached to the seams at the palm side (Figure 170). After completing the inner glove and wearing it, it became clear that the wire wants to remain slightly curved after bending the fingers (Figure 167). This results in slight bulging of the resistive wire which wrinkles the fabric. It was therefore decided to sew the resistive wire in the seams of the backside for the second glove (Figure 171).

Gauntlet

The gauntlets were made from blue-green ribbing material and thin elastic band. The ribbing had to be folded to cover the battery pack from both sides. This way the user is protected from the battery pack and it is hidden out of sight. In between these layers of ribbing the elastic is sewn to prevent the gauntlet from sagging and to hold the battery into place.

Two pieces of ribbing were cut, with a width to encircle the wrist and a length twice the length of the battery pack. The gauntlet needs openings to allow the battery to slide in and to enable the user to reach the charging connector. These openings were marked (Figure 168) and the edges of these openings were sewn with all-purpose thread and a buttonhole stitch (Figure 169). They were then opened with scissors.

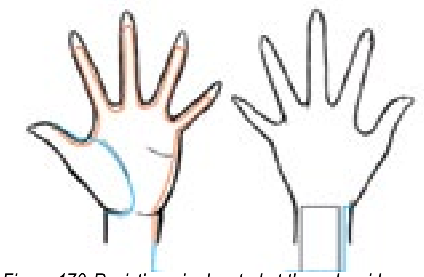


Figure 170 Resistive wire located at the palm side

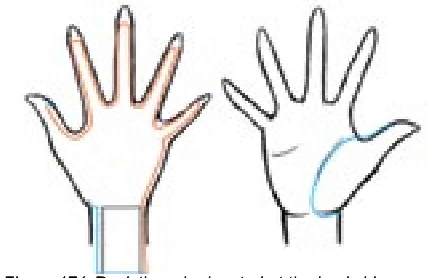


Figure 171 Resistive wire located at the backside

Then the elastic band was sewn to the ribbing. At the first attempt the elastic band was secured using a top stitch, which resulted in an unappealing cuff that emphasized the place of the battery (Figure 172). Therefore these stitches were removed and an iteration was made where the elastic was sewn only to the side of the ribbing touching the wrist (Figure 173).

The gauntlets were sewn into their circular shape (Figure 174). Because the protruding elastic band caused discomfort to the skin an iteration was made. The raw edges of the ribbing and elastic were folded inward before sewing to create a smoother seam (Figure 175).

Because the gauntlet could not fit over the smallest part of the sewing machine it was attached to the glove as shown in Figure 175. Because of this difficult sewing angle the gauntlet was not attached completely horizontally.

From testing we learnt that the battery often comes out of the gauntlet when the glove is taken off by the user. This was fixed by hand sewing the battery in place (Figure 177).


Figure 172 First attempt at stitching the elastic band inside


Figure 173 Iterated elastic band attachment


Figure 174 Gauntlet sewn into circular shape


Figure 175 Bottom: iterated gauntlet seam


Figure 176 Attaching the gauntlet to the glove


Figure 177 Handstitching the batterypack into place

Conclusion

During this phase a pair of inner gloves (Figure 178) and a pair of outer gloves were created (Figure 179). They form the main part of the prototype that is used for testing in the evaluation phase.

In each part of the construction, fabric choice, cutout patten, sewing pattern, stitches and gauntlet, the design was iterated.


Figure 178 Resulting inner glove


Figure 179 Resulting outer glove

20 Constructing batterypacks

On switches, LEDs and charging

The battery pack that can be seen on the previous page (Figure 173) had to be designed and constructed. From the program of requirements (page 47) we know that the user should be able to turn the heat on and off in a comfortable and easy to understand manner and that the product should communicate to the user whether the heat is turned on or off. It should also use no electricity when the glove is turned off.

Circuit

A circuit was designed (Figure 180) which could connect the resistive wire to the battery via a switch and simultaneously activate a control LED. It was deliberately kept simple to avoid complex assembly and high component costs. This circuit includes the battery, an on/off switch, an LED, resistor and resistive wire. A charging connector was also connected in parallel to the battery, which is not included in this diagram.

It would not be convenient to attach the switch, LED and resistor directly to the gloves fabric. This fabric moves around, which could weaken the connections between the components, and the components are hard, which might feel uncomfortable to the user. Therefore it was decided to mount these components on the battery, crating a "battery pack" (Figure 181).

The switch and LED need to be accessible by the user, even when the outer glove is worn. Therefore the choice was made to locate them at the short end of the battery pack, facing the user (Figure 182).

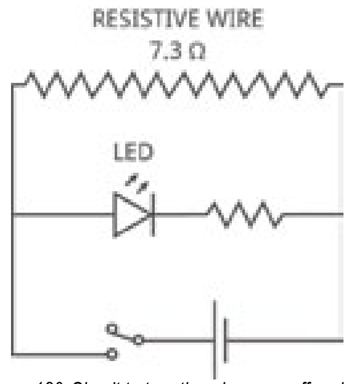


Figure 180 Circuit to turn the wire on or off and give feedback via LED

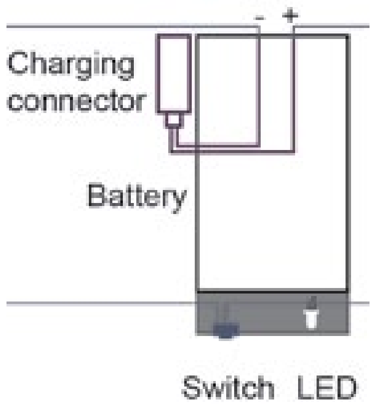


Figure 181 Physical layout of the components of the batterypack


Figure 182 Switch and LED facing the user at the short end of the battery pack

Switch

The choice for an on/off switch heavily depends on the size. The first on/off switch that was selected was a push button (Figure 186). Relative to the battery it proved quite large (12 x 12 x 5 mm) and a firm push was needed in order to switch. An iteration was made by choosing for a micro sliding switch. It is small in size (7 x 3 x 3 mm) and can be operated with a fingertip or fingernail.

During the construction of the second battery pack difficulties with the micro switch arose. Because the leads were small they broke during the process (Figure 183). A second and third attempt achieved the same result. Therefore an iteration was made to a more robust single channel dip switch for this battery pack (9.9 x 3.7 x 5.4 mm) (Figure 184) (Appendix 8).

LED

LEDs come in different sizes and brightnesses. For our application we need a small LED that is bright enough to be noticeable. A 3 mm white LED was chosen with a brightness of 1800 mcd. This brightness can be described as being fairly bright, like a keychain flashlight, to bright (Cooper, 2017).

LEDs need the correct voltage and current in order to light up. Connecting a suitable resistor can help achieve this. This LED has a forward voltage of 3.1 V, which means that it can emit 1800 mcd when 3.1 V is applied and can be dimmed by reducing this voltage. By temporarily connecting this LED, the battery and different resistors the brightness at different resistor values was evaluated. A 470 ohm resistor was selected.

Charging connector

Because the battery also had to be chargeable a low voltage connector was attached, in parallel to the other components, to the battery (Figure 189). These low voltage connectors were taken from the heated USB gloves (page 26). Their rounded shape was a bit larger than the


Figure 186 On/off push button switch


Figure 187 On/off micro sliding switch

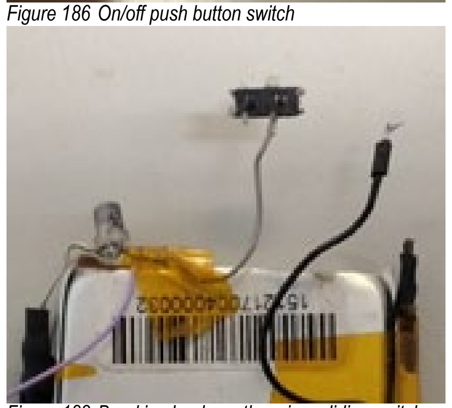


Figure 183 Breaking leads on the micro sliding switch


Figure 184 Iterated switch choice, 1 channel dipswitch

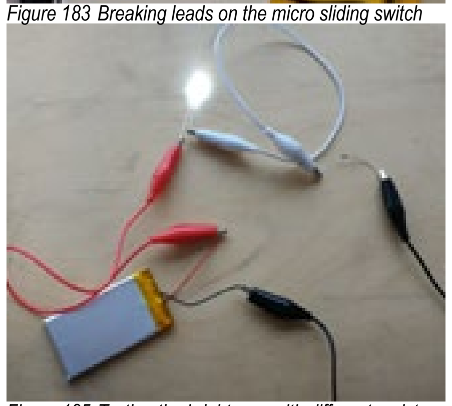


Figure 185 Testing the brightness with different resistors


Figure 188 LED dimmed by the 420 ohm resistor

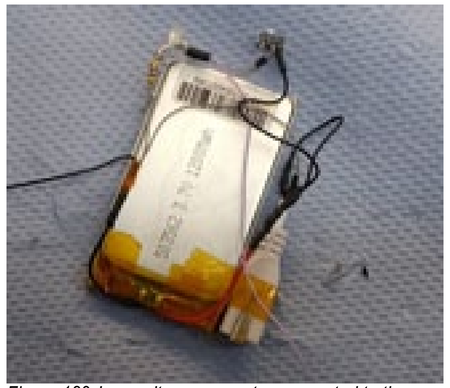


Figure 189 Low voltage connector connected to the other components in parallel


Figure 190 Low voltage connector sanded down to match the battery thickness

thickness of the battery, therefore they were sanded down (Figure 190). They were connected to the battery and stabilized using tape.

Cover

To make the switch and control light attach well and look good a cover (Figure 191) was designed to fit over these components and fix them to the short end of the battery. These components were 3D printed in PLA.

At first separate sliders were designed that were meant to transmit their movement to the slider of the micro switch (Figure 192). After three iterations this idea still did not work, because the printed sliders and slider of the micro switch did not attach well. Therefore it was decided to discard the idea of separate sliders and use the switches sliders directly for interacting with the prototype (Figure 195) and (Figure 196).

The LED and micro switch were soldered to wires that connected to the battery after which the cover would be glued on. To glue the cover to the battery it needed an extended plastic lip to create more contact area with the battery. For the second battery pack the lip broke off. Therefore a circular piece of 3D print material was used as a lip, gluing it to both battery and cover (Figure 195).

Connecting wires

The constructed battery packs then had to be connect to the resistive wire that was sewn into the inner glove prototype. They were soldered together (Figure 197) and the battery packs were placed inside the openings in the cuffs.

The gloves were then turned on to test whether they would heat up (Figure 198), which they did successfully.


Figure 191 Cover with LED and micro switch inside

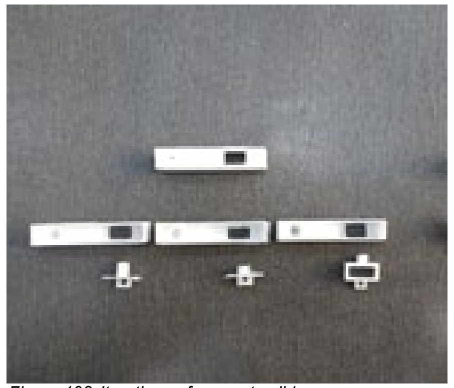


Figure 192 Iterations of separate sliders


Figure 193 Connected resistor, LED and micro switch


Figure 194 Gluing the cover on battery pack 1


Figure 195 Gluing the cover on battery pack 2


Figure 196 Battery pack 1 with cover


Figure 197 Soldering the battery pack to the prototype


Figure 198 Testing whether the prototypes would heat

Charger

Lithium polymer batteries need the appropriate circuit in order to charge safely. A charger was made (Figure 199) using the advised charging chips ("Proper charging", n.d.). Each chip is meant to only charge one battery, so two of them were needed. They get their power from a USB and charge through a JST connector.

The USBs of both chips were connected to a USB hub (Figure 199 and Figure 200) This way the hub could feed both chips with only one USB cable connected to the computer (Figure 201). The JSTs were soldered to the low voltage connector cables from the heated USB glove. The connectors on the cable can plug into the low voltage connectors of the battery packs. The charger was then tested by connecting the low voltage connectors of charger and battery packs. The indication lights on the charging chips showed that the charger was indeed able to charge the batteries.

A PLA case was 3D-printed to hold the USB hub and the two chips. Because the chips have indication lights, letting the user know when the batteries are charging and when they are done, the lid of the case was designed to let the light through. A small wall thickness shaped like a sun symbol was 3D-printed in the lid. The idea was that it would light up to a greater extend than the surrounding lid. The print did not bond well so a simple flat lid was printed instead.

Figure 199 Charger case with USB hub

Figure 200 Charger case with USB hub and chips

Figure 201 Prototype charger in use, connected to the inner glove prototypes

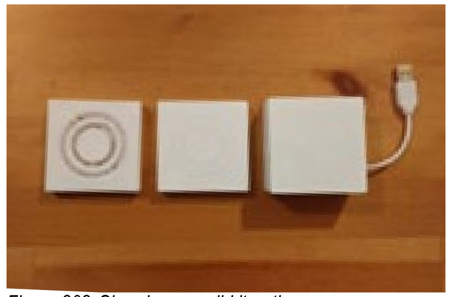


Figure 202 Charging case lid iterations

Conclusion

Battery packs were created and connected to the inner glove prototypes in this phase. The battery packs include simple on/off sliding switches, indication LED's, resistors and charging connectors. The creation and connection of these packs was successful, as the inner glove prototypes were able to heat up as a result. A successful charger was also created, which was able to charge both batteries via one USB port. It could do so while the heat of the gloves was on.

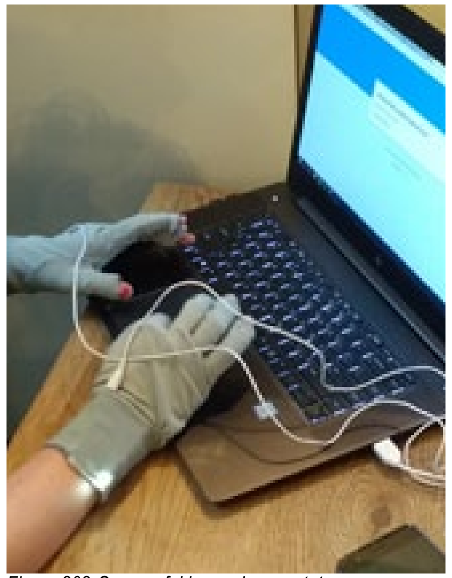


Figure 203 Successful inner glove prototype

21 Conclusion

In this phase a working prototype, which models the concept from the ideation phase, was constructed.

With many iterations a pair of heated inner gloves was created that could be switched on and off by the user, give feedback via LEDs and allows the user to charge the battery via USB. The sewing pattern and fabrics were iterated to create a close and comfortable fit around the users hand and the cuffs were improved to hold the battery packs in place.

A pair of outer gloves was created as well. The iterations on the sewing pattern and laser cutout pattern improved the design to form an aesthetically pleasing model.

With these created prototypes we can test the design on performance and fit with the users needs and wishes in the coming project phase.

IV. EVALUATION PHASE

22 Introduction

The evaluation phase addresses the testing of the proposed design. A prototype was created which simulates the functionality and appearance of the design concept. It will be used in the coming chapters to test its performance and learn more about possible improvements via user testing.

The main function of the design is to heat the users fingers. Therefore the performance of the inner glove prototype is tested on temperature and heating duration in a temperature controlled environment.

Then a user test is conducted with ten women without Raynaud's syndrome. Their opinions on the products user interaction, comfort, dexterity and aesthetics are valuable indicators of the prototypes qualities and areas of improvement.

The last chapter of the evaluation phase focuses on the results of thorough user interviews with five women who suffer from Raynaud's. Because they are the intended target group their opinions and insights are crucial for design improvements in the future.

23 Heat performance test

A temperature measurement of the final prototype

To measure the heat performance of the created prototype a test was conducted. This test measured the temperature increase the glove was able to produce in a cold environment. The results were plotted to reveal the temperature progress over time.

Materials and methods
For this experiment the following materials were used:

- The left inner glove prototype created in the embodiment phase, battery fully charged
- A SquirrelSQ800 data logger
- Four K-Type thermocouple sensors
- A laptop running the SquirrelView software
- A silicone sheet, thickness 1.6 mm
- Needle and thread
- Masking tape

First a model representing a hand was created. It was created by cutting and hand sewing a silicone sheet to form cylinders that approximated the size of a hand, index-, middle- and ring finger (Figure 204 and Figure 205). This model was placed inside the glove to simulate the shape of a hand.

Silicone was chosen because its thermal conductivity constant is close to that of the human skin. The thermal conductivity constant of human skin is 0.293 - 0.322 W/(m*K) (Holmes, Ryan & Chen, 1983) and that of silicone is 0.15 - 0.32 W/(m*K) ("Thermal Conductivity of common Materials and Gases", 2017).

The temperature test was conducted in a refrigerated storage with an average temperature of 5.1 degrees Celsius. The hand model was placed inside the final prototype and the thermocouple probes were attached with tape in the following locations (Figure 206):

- C1 was attached at the index finger directly underneath the resistive wire
- C2 was attached at the middle finger underneath the fabric but not underneath the resistive wire
- C3 was placed on the back of the hand model where there is no resistive wire
- C4 was used to measure the environment temperature in the cold storage

The K-Type thermocouple probes were connected to a SquirrelSQ800 data logger (Figure 208) which took a measurement at all four channels every 10 seconds, resulting in 1247 data points. These data points were then downloaded and corrected for the deviations in environment temperature measured by C4. Then the results were plotted in a graph (Figure 207).


Figure 204 Cylinders sewn from silicone sheet


Figure 205 Created hand model


Figure 206 Placement of hand model and thermometer probes C1, C2, C3 and C4.

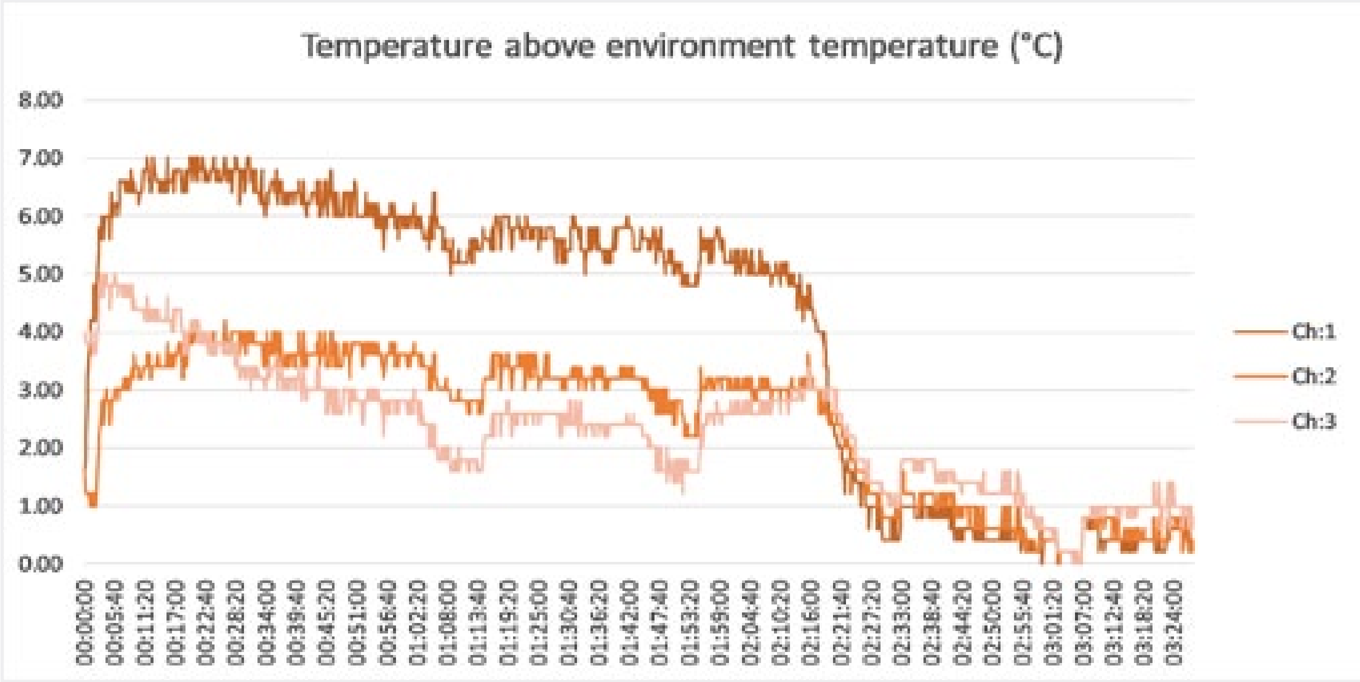


Figure 207 Measurement results of the heat performance test of the final prototype

Results
The maximum achieved temperature was 7 degrees Celsius above the environment temperature. This maximum temperature was measured at probe C1, which was located directly underneath the heat actuator. At the middle finger the maximum recorded temperature was 4.2 degrees Celsius above the environment temperature. At the back of the hand it was 5 degrees Celsius above the environment temperature.

After 2 hours 18 minutes and 30 seconds the battery was depleted and stopped heating the glove. This can be seen in the graph as a drop in temperature at that moment in time (Figure 207). Before this drop it can be seen that the temperature slowly decreases as time progresses.


Figure 208 Test setup. Laptop, SquirrelSQ800 with K-Type thermocouples and inner glove prototype.

Conclusion

The glove was able to heat the glove with a maximum of 7 degrees Celsius above the ambient temperature. This measurement was done directly under the heat actuator at the index finger.

It was able to heat for 2 hours 18 minutes and 30 seconds in an environment with an average temperature of 5.1 degrees Celsius.

Within this time frame the measured temperature at the index finger slowly declined to around 5 degrees Celsius above the ambient temperature. This is probably due to the slight voltage decrease that occurs when batteries get discharged.

A real hand differs from this model in that it is heated from within. When the gloves would be worn by a person the temperature above ambient temperature could therefore be higher.

Whether the heat produced by the glove is sufficient according to our target group will be tested in Chapter 25, target group interviews.

24 User testing

Prototype evaluation by women without Raynaud's

In order to evaluate the prototype a test was conducted with 10 participants. Opinions were collected on the gloves comfort, appearance and heat performance. These were participants without Raynaud's syndrome.

Method
The 10 participants were female and between the ages of 19 and 23. This test was conducted in a cooled storage with an average temperature of 7 degrees Celsius. This testing environment was chosen in order to get results about the gloves heating performance that were not influenced by warm or highly fluctuating environment temperatures. Permission was granted to use the participants questionnaire results, pictures and video material in the context of this project.

First participants were asked to put on and turn on one of the prototyped inner gloves. The two gloves differ slightly, therefore half of the group got the left glove and the other half got the right glove (Figure 214). The outer gloves were also placed on the table where the participants could interact with them if they chose to (Figure 215).

The left glove has its resistive wires sewn on the palm side of the finger seams (Figure 209) and has a slightly bigger on/off dip switch with a red casing and the word "on" printed on it (Figure 211). The right glove has the resistive wires sewn on the backside of the finger seams (Figure 210) and has the smaller micro sliding on/off switch (Figure 212). Other than that the construction of left- and right inner glove are identical.

Left inner glove prototype

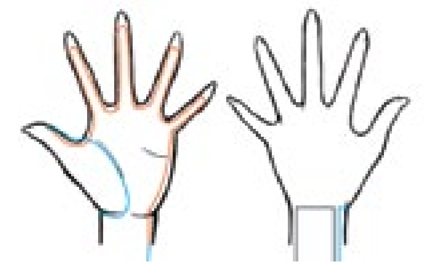


Figure 209 Left glove, resistive wire at the palm

Right inner glove prototype

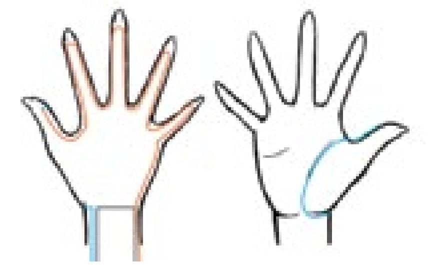


Figure 210 Right glove, resistive wire at the back

Figure 211 Left glove, dip switch, red casing

Figure 212 Right glove, micro sliding switch

Were you able to turn the glove on?

No, I was not able to do it	1	2	3	4	5	6	7	8	9	10	Yes, I was able to manage it easily

Do you think the glove feels comfortable?

No, it does not	1	2	3	4	5	6	7	8	9	10	Yes, it is very comfortable

Do you fingers have enough freedom to do and feel things?

No, my fingers are completely restricted	1	2	3	4	5	6	7	8	9	10	Yes, my fingers are free

Do you think the glove you are wearing looks good?

No, I don't think it looks good	1	2	3	4	5	6	7	8	9	10	Yes, I think it looks good

Do you think the outer glove looks good?

No, I don't think it looks good	1	2	3	4	5	6	7	8	9	10	Yes, I think it looks good

Do you think the glove heats up sufficiently?

No, I do not feel anything	1	2	3	4	5	6	7	8	9	10	Yes, it heats up well

Figure 213 Results of the product ratings with average score displayed in dark blue and score range in light blue

Then the participants were asked to fill in a questionnaire which asked them to rate certain aspects of the glove on a scale from 1 to 10 and, for some questions, explain their score. They were also asked how they would improve the design of the glove. The full list of questions can be found in Appendix 9.

Results
The results of the product ratings are displayed in Figure 213. The dark blue colour displays the average score and the light blue colour the score range.

Turning the prototype on
First the questionnaire asked whether the participants were able to turn the prototype on. No additional instruction was given. All participants succeeded in turning it on, rating it on average a 9.5 with scores ranging from 8 to 10. Interestingly all participants wearing the left glove rated this question with a 10, while only one participant wearing the right glove did so. This indicates that the switch on the left glove (Figure 211) might be slightly easier to operate.

Comfort
The gloves scored on average a 6.5 on comfort, with a wide range from 3 to 9. The participant rating it at 3 said the seams at the fingertips felt rough and uncomfortable. Discomfort at the fingertips and rough seams were mentioned by three other participants as well. The fabrics softness or stretchiness were mentioned as positive features by three participants.

Dexterity
On finger freedom the gloves scored an average of 7.1 with scores ranging from 4 to 10. Participants were not asked to explain their score.

Visual aesthetics inner glove
The inner gloves scored an average of 6.2 on appearance, scores ranging from 3 to 9. Six participants said that the finishing and seams were reasons to dislike the appearance. Three participants did not like the colour and one participant did not like the fabric in general. Oppositely one participant said she liked the colour and one other participant said she liked the fabric.

Visual aesthetics outer glove
The outer gloves scored higher in appearance and within a smaller range. An average of 8.4 with scores ranging from 7 to 9. Four participants said that the finishing could be improved. Four participants said they liked the colour of the outer glove and two participants the fabric. Three participants commented positively on the laser cutout pattern.

Heating performance
The heating performance got a score of 7.7 with a range from 5 to 9. There was no apparent difference between the left and the right glove.

Improvements
The following improvements were suggested by the participants:

- The seams could be sewn more neatly
- The colour of the inner gloves could be different
- Different sizes, s/m/l
- The inner glove could fit better to the shape of the hand
- The fingers could be less tight to allow more free finger movement
- The bulk of the battery could be hidden better
- The battery could be smaller
- The fingertips could be heated instead of open
- The heat could be higher
- The glove could have different heating settings

Conclusion

On average the prototyped gloves were graded positively. The test also provided valuable insights on possible design improvements.

The dip switch of the left inner glove seems to be slightly more easy to operate This could be due to the size or colour.

The area of improvement that was mentioned most often was that of the seams and finishes. The thick thread stitches and untidy finishes negatively impacted users rating of comfort and of visual appearance.

The ratings of the gloves dexterity also have a wide range. The untidy seams and stiffer outer glove might have influenced these results.

Both fabric were mentioned in positive ways. The inner gloves fabric was called soft and stretchy and the outer gloves colour was appreciated. The colour of the inner glove fabric could be improved.

No apparent difference was found between the heating performance of left and right glove.

Other mentioned improvements were offering different sizes (s/m/l), better fit around the hand, hide the battery better, smaller battery, heated fingertips, higher heat and different heat settings.

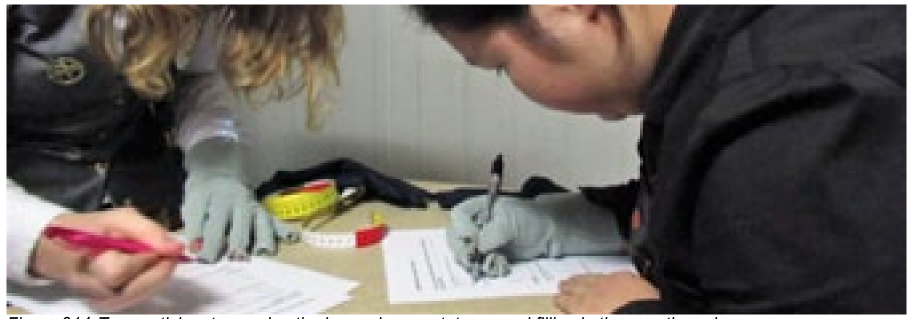


Figure 214 Two participants wearing the inner glove prototypes and filling in the questionnaire

Figure 215 Two participants wearing the inner- and outer glove prototypes and filling in the questionnaire

25 Target group interviews

Prototype evaluation by women with Raynaud's

Next to the collected opinions on the prototype we need to verify our assumptions and search for improvements with the input from the actual target group. For this purpose women with Raynaud's were asked to test the prototype gloves and were interviewed. The interview questions and results can be found in Appendix 10. Two interviews were transcribed completely.

Method

The test was conducted with 5 women with Raynaud's, Dorien (31), Kelly (26), Joyce (24), Marja (71) and Rosanna (54). They were asked to wear the prototypes, inner- and outer glove, turn them on and walk outside for 10 minutes. Then they were asked to fill in a form on the laptop wearing the inner gloves while they were connected to the charger. This form asked participants name and age and permission for video-, photo- and audio recording, which all participants gave. By performing these tasks the users tested the prototype both outdoors and indoors behind the computer while charging.

After performing the tasks the participants were interviewed. First the participants were asked about their experiences with Raynaud's and what situations in their daily life they would like to change. Then they were asked questions concerning the prototype.

Results

Raynaud's

First the women who participated in the interviews were asked to talk about their Raynaud's and how it effects their daily life. This was done in order to aim the conversation towards the problems the design is intended to solve and also in order to check whether there were no important facts about the disease we did not consider before.

The descriptions of their Raynaud's related problems fit with "Raynaud's Syndrome" on page 12. They include white, blue, numb and painful fingers which restrict them from performing everyday tasks like handling money or keys. Three of the participants also said that their Raynaud's makes it difficult to drive a car.

Heating performance

After trying the gloves three participants said that they should heat more. Kelly said that the gloves heated sufficiently.

The other four participants would actually prefer gloves with heated fingertips, because their Raynaud's attack usually starts at the fingertips. After seeing that the inner gloves can be used indoors they did also see advantages in the fingerless design. Because they had more trouble from their Raynaud's in outdoor situations they still preferred gloves with fingertips.

Two participants said that different heat settings would be beneficial, one for mild and one for cold weather. Three participants said they did not think different heat settings were necessary.

Even though the resistive wire was located differently in the two gloves (page 86) none of the women felt a difference in heating performance between the two. Marja said she liked that the thumb was not heated because she experienced no Raynaud's there.

"I am not really convinced about the heat. I think they won't be warm enough in colder weather"
Joyce

"My fingertips get cold first, so for me, I would want closed fingertips"
Marja

"Well my first idea would be to use them outside, but, when I think about it I do often have cold hands behind the computer. So it would actually be very useful."
Dorien

"When I get to work now, it takes about fifteen minutes before I can use my hands again. But these (inner gloves) I could keep wearing for a while and unzip my coat, open my e-mail and start the day. "
Rosanna

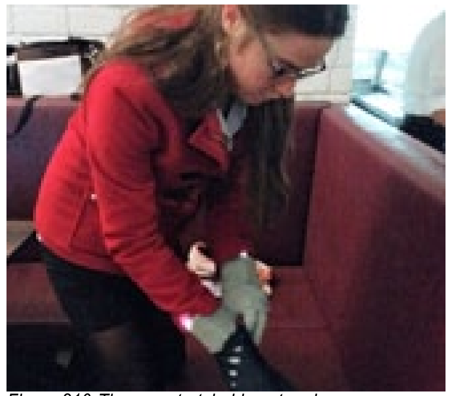


Figure 216 The non-stretchable outer glove

"In a normal product the battery would be properly fixed of course."
Rosanna

"I would only need them for one hour if I go to the supermarket."
Marja

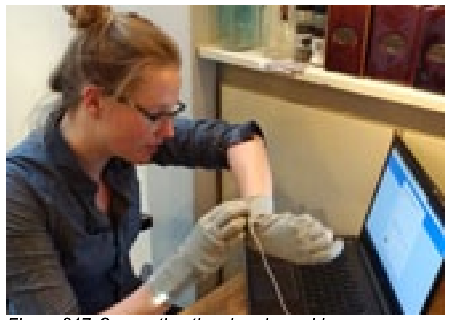


Figure 217 Connecting the charging cable

Figure 218 Cables running over the keyboard

Figure 219 Marja's heated gloves

Figure 220 Peacock fueled hand heater

Finger dexterity

The three participants who were asked said that if the gloves were to be fingerless the fingertips should end in between the first and second phalanx.

Three participants said that they liked the dexterity that the inner glove allowed. Kelly said she liked that she could type and use her phone and Marja said that these gloves would be good for driving a car and picking up small things. For three participants the outer glove did not fit well (Figure 216). The no stretch fabric was restrictive.

User control and feedback

Three participants said that the button could be easier to operate if it were to be larger. Two participants noted that it was good that the switch did not stick out, this way the user would not accidentally switch the glove on or off.

From observing the participants it became clear that it is hard to turn the heat of the inner glove on when the outer gloves are already worn.

Marja, who already owned heated gloves, said that the indication LED on her gloves gave information about the battery levels. Blinking green when the battery was full and red when the battery was empty.

Batteries and charging

None of the participants found the battery on the wrist uncomfortable. However two participants were concerned about its stability.

Dorien said that two hours of heating time would not be very long. But all participants said that it would be long enough for them in most cases. Rosanna suggested to also offer a pair of bigger batteries for long walks or bicycle rides.

All participants thought that the USB charging was a good solution. Kelly and Dorien said that the charger connectors could be improved by orienting them to the sides or the back. That way they would be easier to connect (Figure 217) and the charging cables would not run over the keyboard while typing (Figure 218).

Aesthetics

Two participants said the prototype looked OK, but still very much like a prototype. Two participants were positive about the colours but, like three participants of the previous user test (page 86), Marja did not like the colour of the inner glove.

Two participants were enthusiastic about the cutout pattern and the fact that you could see the inner glove beneath. Kelly suggested it could also be combined with a brightly coloured inner glove.

Four participants liked the feel of the inner glove fabric, which was described as soft and comfortable.

Competitors

Marja was the only participants who owned a pair of heated gloves (Figure 219). Her opinion on these gloves confirmed some of the results from the analysis phase. She thought they were very bulky and could not use them in the grocery store, handling money or to pick things up. She also had a Peacock hand warmer, it runs on fuel and can stay warm the whole day. She was very happy with it and she uses it a lot (Figure 220).

I showed the participants a list of competing gloves (Appendix 10). Two of the participants said that the Thermogloves do not look like you could wear them in another pair of gloves. The Uniqknits were not very convincing, two participants said that they looked like cheap knitted gloves and Rosanna said she lost trust in claims about insulating fabrics from her disappointing experience with Thinsulate gloves.

Dorien said that the competitors looked more professional because they had labels and finishing. Joyce thought the competitors did not look very fashionable.

Pricing

Marja, Dorien and Rosanna said that a reasonable price for heated gloves would be €80. Kelly thought that it would be difficult to sell gloves for under €50 and cover the costs for production. Joyce found it difficult to estimate a price because she did not look into heated glove prices before.

Marja explained that it is difficult to know whether a product is good before you buy it. She bought a pair of heated socks before that were really disappointing. If she would be convinced that the product would work well and heat nicely she would pay over €100.

Product dimensions
Two other interesting things participants mentioned were about the dimensions of the gloves.

Rosanna liked the dimensions of the cuff, because they could fit in the sleeve of her jacket (Figure 221). The mittens her doctor recommended her to wear cannot do this, which is why she doesn't wear them much.

Joyce said she wore ski gloves whenever the weather dropped between 18 degrees Celsius. What she disliked about them is that they were too bulky to fit into her jacket pockets and she thought that the inner glove prototype might be able to solve that problem.

Wire connections
During the test phase some connections between the wires and resistive wires broke. These connections were soldered and secured with some heat shrink which proved to be too fragile.

Interest
Three participants would be interested in a product like this. Joyce would be interested depending on the products price and Marja would be interested if the gloves were to have heated fingertips.

Figure 221 Cuffs fitting in jacket sleeves

Conclusion

Four out of five participants said that he heat should be increased or that a warmer heating setting would be beneficial. This could be done by shortening the resistive wire to lower its resistance. This would shorten the time frame in which the battery can heat because it will dissipate its energy faster. The right balance between battery size and heating time should therefore be further investigated.

A preference for heated fingertips was found, because a Raynaud's attack often starts in the fingertips. The women also seemed to see the benefits of a fingerless design for indoor use but still preffered a pair with fingertips for outside. A possible solution could be to offer two type of glove designs. One version for outside use, with heated fingertips, and one version for typing on keyboards and driving cars, without fingertips for more finger sensitivity. One other possible option is to have inner gloves that only have an open fingertip at the thumb, which was a suggestion by Marja.

The women felt no difference in between the heating performance of the two gloves, even though the resistive wires were located slightly differently. Therefore we can conclude that for the heating performance it does not matter in which seam the wires are placed.

According to three participants a fingerless glove should end its fabric in between the first and second phalanx.

The dexterity the inner glove allows was judged positively. The outer glove can be improved in this area, by using a fabric that is more stretchable.

It might be good to have slightly larger switches especially for older users, as Rosanna pointed out. However they should not be easily turned on or off by accident.

Indication LEDs that could also tell the user about the status of the battery would be useful. Whether this can be achieved in a simple and inexpensive way is something that still needs more investigation.

The placing of the battery pack was judged to be comfortable but unstable. A way of securing it would be necessary for a market ready product.

Two hours of heating time were said to be enough, yet the option for larger batteries in a store might be beneficial.

The participants liked the USB charging but the placement of the charging connectors could be better. This way the chords do not obstruct the keyboard.

The fabric of the inner glove feel good and the appearance is OK. It could be improved by better finishes and inner glove colour.

A price of around €80 would be acceptable to these participants. However it is important to convince potential customers that they are not purchasing an ill designed product.

The dimensions of the cuff were good according to Rosanna because they could fit in her jacket sleeves. Joyce would like to be able to put the gloves into her pockets. The product should allow this by keeping its small cuff design and making the wires and connections strong enough to survive being put into a pocket.

The connections of the prototype appeared to be insufficiently durable. These tests show that the gloves need to withstand quite some tension repeatedly through its use. The connections should therefore be quite secure. The durability of the thin Isotan® resistive wire should also be tested in the future before a suitable consumer product can be made.

After design improvements all participants said that they would be interested in a real product like this.

26 Conclusion

During this evaluation phase the prototype was tested and useful results were acquired.

The prototype was tested on its heat production and duration in a controlled environment of 5.1 degrees Celsius. There it was able to heat with a maximum of 7 degrees Celsius above the ambient temperature and the capacity of the battery allowed the prototype to heat for 2 hours 18 minutes and 30 seconds.

From the two user evaluations, the user test and the interviews with women from the target group, we gained valuable insights on how the design could be improved and in what direction the future design should be headed.

Design improvements

The inner gloves should heat more strongly. This will have consequences for either the battery size or the heating duration, which should be further investigated to find the right balance.

There is a preference for gloves with closed fingertips among the women with Raynaud's and there is also some interest in the fingerless design for indoor use. Therefore it can be advised to develop both models, while focusing more actively on the design with closed fingertips.

Placing the resistive wire on the palm or the backside of the hand does not seem to influence the user experience. This means that it can be placed in a location along the fingers that is convenient for construction.

The fabric of the inner glove could be iterated in colour, the fabric of the outer glove could be iterated in stretchability.

The sewing pattern, seams and finishes of the inner glove prototype are not sufficient and should be iterated, improving both the comfort and the visual appearance. A start at this was already made in the embodiment phase with the improved inner glove sewing pattern (page 74).

The user control and interaction could be improved by using a larger switch and investigating possibilities of user feedback about the battery status. The wire connections should also be made more securely.

The placement and size of the battery were sufficiently comfortable but the battery should be secured more properly. Two hours of heating time and USB charging were considered to be appropriate. The charging connectors on the battery pack could be improved by changing their orientation, to allow easier connection and move the wires out of the way.

A consumer price of €80 would be a reasonable price. It is thereby important to win the consumers trust, because there are a lot of badly designed competitors on the market.

After design improvements all the interviewees from the target group would be interested in a real version of product like this. This means that the created design has potential to be further improved and developed to become a successful consumer product.

V. BUSINESS PLAN

27 Introduction

This part of the report addresses the business related subjects that have not been addressed in the preceding phases. These previous phases were all focused on the product design, but because this project is intended to help the startup Smart Innovation Development B.V. business related insights are valuable as well.

In marketing theory there is a model called the Marketing Mix, which is a tool used for effective marketing for decades (Londhe, 2014). These models contain multiple marketing decision variables (Gatignon, 1993), like the often used 4Ps: Product, Promotion, Place and Price.

Up until this point the product has been the main focus of this report and therefore this chapter, Business Plan, is included. It contains insights and advice on promotion, place (distribution) and pricing. First we will look at the promotional strategy looking at grabbing attention, timing, differentiating from the competition and convincing potential customers. Then we look at how to distribute the product to the target group we identified in the analysis phase. In the last chapter we look at pricing. We examine the costs that were made creating the prototype in the embodiment phase and generate advice on how to lower the costs for eventual production.

28 Promotion

Promoting our product to the target group

From the questionnaire we learnt that 92% of the participants do not own or regularly use heated gloves even though 70% of them would be interested in them (“Questionnaire” on page 14).

The main reason for participants not to try heated gloves was the costs, which we will discuss in “Price” on page 98. The second reason that was given was that participants did not know that heated gloves existed. This means that there is a lot to be gained from a good promotional strategy and execution.

Attention

To inform the target group of the products existence it has to be brought to their attention. Here three ideas are discussed on how to achieve this.

The women who responded to the questionnaire are active on facebook. Social media has the benefit that it can be used for advertisement by small companies at very low cost (Barnes, 2013). Therefore we could profit from reaching the target group this way.

A facebook page could be made which would feature convincing video’s, pictures and status updates. By asking people to share these posts, a lot of potential customers could be reached.

From the competitor analysis (page 20) we learnt that some of our competitors like the Thermoglove and Uniqknits are featured on the website of the Raynaud’s association. This website is aimed directly at our target group and therefore it could be beneficial to have our product featured there as well.

There are also more active ways to receive attention. One way might be to sponsor or co-organize a Raynaud’s event. The Hartstichting in the Netherlands regularly organizes events and awareness campaigns for people with vascular diseases. An event or awareness campaign, with video documentation, could show the brands legitimate concern for Raynaud’s disease and simultaneously create brand awareness.

Timing

It is important that the advertisements are published at the right moment in time.

If the target group gets notified of the products existence far before it is ready to be sold it could lead to customers who are disappointed with the long wait.

When the target group knows about the product too late there is a chance that competitors with a similar product design get to the customers faster than we do.

Differentiation

We can stand out from the competition, not only in product but also in advertisement. We looked at examples of advertisement from competing brands to learn from their qualities and avoid their mistakes.

First we will look at some advertisement for the Powerlet Atomic Skin Glove Liners from the brand RevZilla (Figure 222). Their advertisement shows male models, dark masculine colour schemes and make visual connections to other motorcycle related items. On their website the women’s clothing is actually a separate section (Figure 223). This brands advertisement is clearly targeting male motorcyclists.

Part of what an advertisement does is help the user imagine herself wearing this product. Featuring models and contexts that correspond to the user shows that the product is actually relevant and designed for them.

Most advertisements for heated glove liners, including those for the Thermoglove, have a far lower visual quality than the pictures from RevZilla. A reoccurring theme is the glove liner surrounded by a red glow (Figure 224 and Figure 225). These pictures share a similar red/black colour contrast, show no users or relevant context at all (Figure 227) and sometimes even cut a portion out of their own picture with their frame (Figure 224 and Figure 226).

The pictures of RevZilla are more attractive and professional looking. Partly through their coherent colours scheme, featuring of users and relevant context, symmetry and attractive framing. They are just aimed at a different consumer segment than we are.

Figure 222 RevZilla advertisement for the Powerlet Atomic Skin Glove Liners

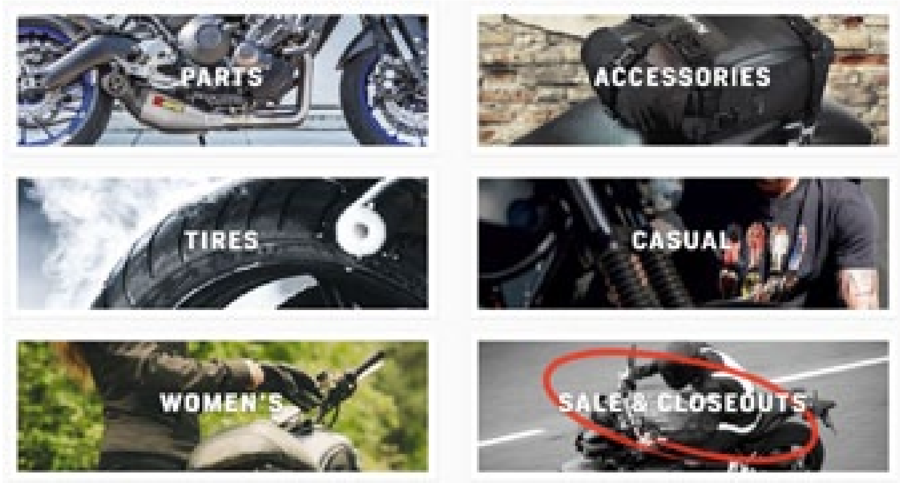


Figure 223 Categories in the RevZilla webshop

Figure 224 Thermoglove advertisement. Orange-red glow is cut by the frame at the top and left side

Figure 225 Glovii advertisement

Figure 226 Alpenheat advertisement. Product is cut by the frame on the right side.

Figure 227 Activheat advertisement. Showing battery packs but no user or product environment

Convincing

It is not enough to let the target group know the product exists. They have to want to buy the product as well.

Trust
From the competitor analysis (page 20) and user interviews we learnt that there are badly designed products on the market. It is very difficult for potential customers to judge whether a product is actually worth the investment (page 88).

One way to prove the products worth is to gather user testimonials, like the TU Delft startup Somnox is doing for their product (Figure 228).

Product benefits
Because of our Analysis phase we know a lot about the target groups needs and wishes. Showing them that the product respects these wishes and can solve their specific problems would help convince them of the products worth. An advertisement could for instance talk about the freedom of hand movement the product provides and its thin, elegant, affordable design.

Attraction
Next to convincing the target group on a cognitive level it is also important to convince them on an emotional level. Creating advertisements that express the empowerment that these gloves could represent for women with Raynaud's could help increase product desire.

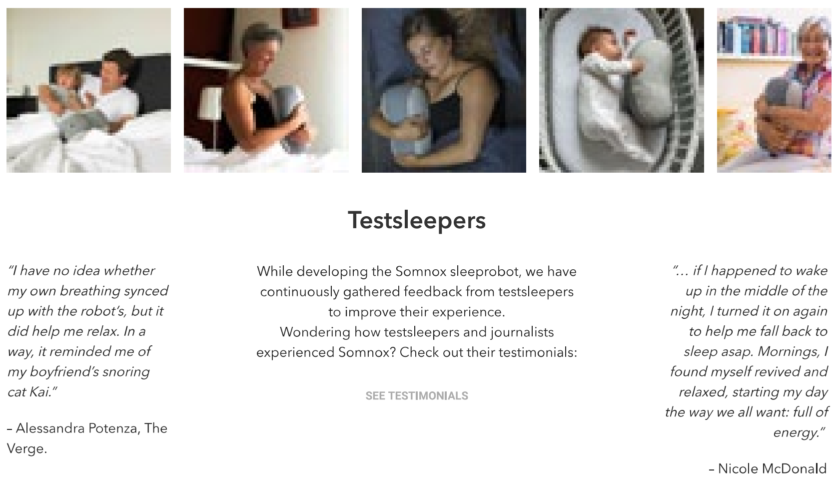


Figure 228 Testimoninals on the Somnox sleep robot webiste

Conclusion

Because we know that part of our target group is active on facebook they might be reachable for promotion through this channel. Quality content like video's, images and posts might be shared trough facebook users which would increase the reach of our advertisement on a low cost.

Some promotion could also occur through collaborations with associations who are already in contact with our target group. The Raynaud's Association might be interested in featuring our product on their website and the Hartstichting might be interested in sponsoring or co-organisation of one of their events.

The right timing to launch an advertisement campaign is important. Too early could lead to disappointed customers and too late creates a risk of competing brands to step in.

The visual language of the advertisement should be addressed to our target group directly. This can be done by using female models, feminine colour schemes and showing the product in environments in which these women will likely be or want to be.

The advertisement, for the consumer who has never seen the product before, is a representative of the product. Low quality advertisement will therefore likely be associated with a low quality product. Higher quality advertisement can partly be achieved through good visuals with coherent colour schemes, featuring of users and relevant context, symmetry and attractive framing.

Convincing the target market that our product is valuable to them can be done in several ways. Creating trust with user testimonials, showing knowledge and compassion for their condition by explaining how the product solves their problems and creating product desire with emotionally driven advertisement content.

29 Place

Distributing the product to the target group

When someone from the target group knows about the product, is convinced about its potential benefits and wants to buy it she needs to be able to do this in a convenient way. This chapter discusses the "Place" or distribution of the product.

From the questionnaire we learnt that many participants never tried heated gloves before because they did not know where to buy them. It is therefore important that the advertisement communicates clearly where and how potential customers could purchase the product.

An important demographic factor is the target groups location. From the questionnaire we got a broad range of countries. Most participants were from the United States. Based on this information it is advisable to create marketing and selling channels that are able to reach people and ship products all around the world. An online store would be suitable for this purpose.

From the competitor analysis we also know that high shipping costs can be disappointing to some potential customers (page 20). Therefore these should be kept reasonably low.

Products can be sold from a website owned by the company, direct distribution, or be distributed via other retailers, indirect distribution. Selling via retailers will lower the profit per product but it will also make it more widely available to customers. Especially when a certain retailer already has a trusting customer base this could increase the total sales. A downside of this strategy is that possible mistakes by this distribution partner, like badly designed advertisement or poorly handled customer service, might reflect poorly on the brand as a whole.

Selling through physical stores might not be a very logical option for this product. Finding a partner who would want to add the product to their shelves would be difficult, as it falls right in between the categories of garments and consumer electronics. Maybe outdoor gear stores might be interested, but for them heated ski gloves would fit better to their intended target market.

Conclusion

In order for our potential customers to purchase a product they have to know where to buy it. The promotional material should therefore help customers by providing this information, for instance in the form of links to the companies online store.

This online store is a good way to make purchases from all around the world possible. Shipping channels have to be arranged which can properly deliver these products on time while the customers shipping costs should be kept reasonably low.

Direct and indirect distribution both have their benefits. With direct distribution the company keeps more control over the advertisement, customer service and income stream. However it can be a big investment to set up a new distribution network. Working with a partner who already has this in place and also has a trusting customer base could be beneficial.

30 Price

Estimation of cost- and selling price

In this chapter we make an estimation for the cost price. These estimations are made to create insight into the costs per pair and to evaluate where these costs might be reduced to be able to offer a reasonably priced product.

We base this pricing estimation on the costs that were made for the creation of the final prototype (Figure 229) and the current prices of components and labour costs. We then evaluate these costs against the opinions gathered from the interviews with the target on what a reasonable price would be (“Target group interviews” on page 88).

This chapter will estimate the prices for both a small production series, 100 pairs, and a larger production series, 10 000 pairs. The estimations are collected in an overview table (Figure 230 on page 100). The estimated prices are rounded at half euro’s.

Labour

For the creation of the prototype the labour was virtually free of charge. The time that was put in creating each of the gloves was around 1 hours per outer glove (2 hours per pair) and around 8 hours for the inner glove pair. This is an estimation of the net working hours without counting the time that was needed to iterate and adjust the design. Skilled tailors and electrical assemblers could probably bring this time down to 5 hours per complete product and in a large automated process to 2 hours per complete product.

A tailor from the Netherlands makes around €30 per hour (“Salaris en tarief van een Naaister”, 2017) and a assemblyworker around €11 per hour (“Salaris en tarief van een Assemblagemedewerker”, 2017). If around half of the hours are spent on sewing and half on assembly the labour per pair would cost around a €100 for the smaller series and about €40 for the larger series.

Fabrics

The Bartotex should be changed to a more stretchable fabric but we will assume that this new fabric would have a comparable price. Bartotex blue costs €11.95 per meter (width 1.44 m) from which you can cut about 9 outer glove patterns. This brings the fabric costs to around €2.65 per pair. The costs for the fabrics of the inner glove can be calculated at €6.60 plus €2.90 for threads and elastics. In a small series this would add up to about €13 fabric costs per pair. When the fabric can be bought in larger quantities for the large series the price could be lower. In this example we make the assumption the price can be halved.

Resistive wire

The Isotan® resistive wires worked well in the prototye but its long term reliability has not been proven yet. In this cost estimation we assume that this or a similar wire will be used for both the small and the larger series. The costs per wire are estimated at €1 for the small and €0.50 for the larger series.

Batteries and charging

When looking at the prototype costs (Figure 229) it becomes clear that the battery and charging chip are, by far, the most expensive parts of this prototype. This might be due to the fact that they were purchased at Kiwi-electronics, a company that sells electronic components in small quantities to hobbyists.

The battery (Appendix 4) worked well for the prototype and probably this or a similar type would be used in the product. When ordering one hundred pieces it would make economical sense to order these components from China. Websites like Alibaba.com offer these batteries for around €0.85 to €2.55 a piece when you buy them in quantities of a hundred (“3.7v 1200mah Lipo Battery”, 2017). When you buy them in quantities of 5000 you can get them for around €0.85 to €1.70 (“Rechargeable Lithium Polymer 1200mah 3.7v Battery”, 2017). That would be about €3.40 per pair for the production of 100 and €2.60 per pair for the production of 10 000 products.

The charging system that is now created for the prototype is not suitable for consumers yet. But a better charger, which can safely charge both batteries simultaneously from a USB port, might be available already on the market.

Description	Source	Quantity	Price
Bartotex blauw fabric	Textielstad, Tilburg	30x60 cm	€ 2.65
Blue-green fabric, 2% nylon 18% polyurethane elastomer	A Boeken, Amsterdam	25 cm	€ 3.00
Blue-green ribbing, 95% cotton 5% lycra	A Boeken, Amsterdam	20 cm	€ 3.60
Elastic band	Jan de grote Kleinvakman	20 cm	€ 2.75
Thread			€ 0.15
Gütemann nachtblauw all-purpose thread	Textielstad, Tilburg	10 m	€ 0.15
Isotan® resistive wire, 10 ohm/m, 5 m	Conrad	2 m	€ 0.92
Lithium Ion Polymer Battery, 3.7 V 1.2 Ah	Kiwi-electronics	2	€ 23.90
Charging chip for LiPo Battery	Kiwi-electronics	2	€ 29.90
Low voltage USB connectors	Heated USB gloves (“Benchmarking” on page 26)	2	€ -
USB hub	Conrad	1	€ 6.99
Micro USB cables	Owned by me	1	€ -
Single dip switch	Opencircuit	2	€ 0.60
LED, white round 3 mm 1800 mcd 60 ° 20 mA 3.1 V	Conrad	2	€ 0.84
470 ohm resistor	TU Delft	2	€ -
Wires, diameter 0.6 mm	TU Delft	1 meter	€ -
Heat shrink	TU Delft	10 cm	€ -
Polyimide isolation tape	Conrad	20 cm	€ 1.60
PLA filament for 3D printing	TU Delft	50 cm	€ -
Bison two-component adhesive	TU Delft	10 ml	€ -
Bison textile glue	Gamma	10 ml	€ 1.25
Total			€ 78.30

Figure 229 Overview of prototyping costs for the final prototype

The Thermoglove for instance uses a charger that charges both their battery packs from a wall socket. At this time we could not find such a charger on websites like Alibaba.com but we estimate that it would cost about €5.00 for the small series and €2.00 for the larger series.

Switches and LED’s

If we assume that the product would use a similar switch and indication LED they would amount to around €1.00 for the small and perhaps €0.50 for the larger series.

Battery pack covers

The 3D printed battery pack covers need an iteration before they are suitable for a consumer product. For the small series it would be easy to keep 3D printing the cover, perhaps on 3D printers that can produce parts with higher accuracy than the Ultimaker 2.

It is beneficial that the parts are small, which means that many of them can fit on a printing bed and that they do not require a lot of printing time or filament per part. A series of 10 000 parts might not be worth the investment of an injection mould and it would take a lot of time to print all of them. Outsourcing the prints to many 3D printers might be a solution. The costs per 3D printed part is estimated at €1.00

Connections

During the tests in the evaluation phase the connections between the wires and resistive wires broke (Chapter 25 ‘’Target group interviews’’ on page 88). Therefore better connections need to be made and tested before the product can be sold. The wires, solder, clamps, tape and heat shrink is estimated at €2.00 per pair for the small series and €1.00 per pair for the larger series.

	One pair	100 pairs (€/pair)	10 000 pairs (€/pair)
Labour (NL)	€ 0	€ 100	€ 40
Fabrics and the like	€13	€13	€ 6.50
Resistive wire	€ 1	€ 1	€ 0.50
Batteries	€ 24	€ 3.50	€ 2.50
Charger	€ 37	€ 5.00	€ 2.00
Switches and LEDs	€ 2	€ 1	€ 0.50
Battery/switchcovers	€ 0	€ 1	€ 1
Connections	€ 3	€ 2	€ 1
Total	€ 80	€ 126.50	€ 54

Figure 230 Cost estimations for one pair, 100 pairs and 10 000 pairs

From the evaluation with users we learnt that the target group says that €80 is a reasonable price for a pair of electrically heated gloves. When the first series of 100 pairs would be sold for this price there is no profit to be made if the total cost price is indeed around €130.

If we look at Figure 230 we see that over 70% of the costs for producing gloves is for labour. If production costs need to be reduced this is probably the segment where we can save most money.

The first strategy of reducing labour costs is to automate the assembly process, which might only be beneficial for larger production series. Approaching glove manufacturing companies and negotiating about the price per product might lead to a lower cost price.

The second strategy is by moving the labour to a low-wage country. It is possible to purchase fabric gloves at the HEMA for €8 (Figure 231) (“dameshandschoenen”, 2017).
As HEMA is a for-profit company their cost price for these gloves is probably significantly lower. If Smart Innovation Development B.V. were to purchase semi manufactured gloves, to their specifications, from a low-wage source a lot of labour costs would be saved.

Assembling the battery pack, attaching the resistive wire and connecting all the components could also be outsourced to a low-wage country. However these assembly steps are more specialized than sewing gloves. There are far more unheated gloves on the market than heated ones and therefore we there are probably less companies who are able to deliver the whole product according to our specifications. If this process is outsourced to a low wage country it is more difficult to protect the end products quality and to adjust the manufacturing process when necessary. Therefore it might be better to have the assembly line closer to home.

We advise to order a semi manufactured glove from a low-wage source and investigate possibilities for the final assembly line closer to home. This way the largest production expense, the labour costs, can be lowered while more complicated assembly steps are relatively easy to adjust when necessary.

Figure 231 €8 fabric women’s gloves from HEMA

31 Conclusion

After focusing extensively on the product this business plan looked into the three other elements of the marketing mix: the promotion, place or distribution and the price.

Because a large part of the target group does not know heated gloves exist there is a huge benefit to be gained from good promotion with the right timing.

First we have to grab the target groups attention, three ideas on how to do this were proposed. Promoting high quality content via facebook, having our product featured on the Raynaud’s association website or by sponsoring or co-organizing a Raynaud’s event with the hart stichting.

In order to create high quality promotional content it should be addressed to the target group directly, have good visuals and have a convincing message.

Then the advertisement has to tell the consumer where and how to buy the product. Online stores, owned by the company or by distributing partners, would make the product available for our target group all around the world.

When producing the product the largest component in the cost price is the labour. In order to sell the product for the reasonable €80 some of these costs have to be outsourced to countries with lower wages. It is advisable to purchase partly manufactured gloves from overseas and do the electrical assembly closer to home. This way adjustments to the assembly can be made quicker and in a more controlled manner.

Conclusion

This project consisted of five different phases, each of which contributed in its own way to the project.

The analysis phase generated insights on the problem, the target group and their needs and wishes, the competitors and the needed technical components. It resulted in a program of requirements and a problem definition.

The ideation phase then took these insights into the problem and generated and combined partial solutions into a concept.

The embodiment phase then took this concept and created a physical model representing it in the form of a working prototype.

This prototype was tested in the evaluation phase on its heating capacity and evaluated on its quality by users from within and outside of the target group. This resulted in valuable insights that will help steer the product design and development in the future.

The business plan was the final stage of the project, addressing promotion, placement and pricing. Business advice based on the insights from this project was given.

Each of these phases contributed to the goal of proving the start-up of Smart Innovation Development B.V. with insights and a substantiated product design.

For this start-up company this project is only the beginning. The design and the business itself still have many developmental steps ahead before a product will be successfully sold to many people. However the insights generated and the design created will form a good foundation for all the steps to come.

All the enthusiasm that was encountered during this project gives a strong indication that this product and, therefore this start-up, have enormous potential. I hope that my work will help Smart Innovation Development B.V. improve the lives of many women with Raynaud's in the future.

Recommendations

This is the last chapter of this design project but the project of Smart Innovation Development B.V. will certainly continue. Therefore this chapter bundles the conclusions from the evaluation phase and the business plan into strategic advice to help guide future developments.

Product recommendations

The area in which the design should be improved is in its heating abilities. Women with Raynaud's would prefer the product to heat more strongly and to heat the fingertips as well. This means that the design should be adjusted to fit these needs. A design without fingertips might be an interesting second product to develop.

New fabrics for the outer glove and new colours for the inner glove should be investigated and the iterations on the sewing pattern should be continued. This would create a product with a better fit, dexterity and aesthetic.

Then the electronic components could be improved by investigating better switches and user controls, improving the design of the charger and performing durability tests on the wires and batteries. The way of securing the battery pack and resistive wires could also be improved. Working towards a stable battery placement and towards simplifying the process of integrating all of the components into the glove.

The issue of safety has not been addressed in the prototype or user testing yet. However protecting the user from excessive heat and danger from electrical shortages is vital for creating a safe consumer product. These safety related issues should therefore be investigated and properly tested.

Business recommendations

Next to improving the products design there is also the challenge of setting up a business. Three business related areas, promotion, place and price, were explored and the results can be summarised in the following advice.

There is a lot to be gained from good promotion. Therefore high quality promotional content should be generated that addresses the target group and their needs directly.

Product distribution might present a challenge but to reach the target group an online store might be a good starting point.

The production price of current design is too high to make a profit. Outsourcing the production of the gloves and simplifying the assembly of the electrical components might be ways of lowering this price to reach the reasonable consumer price of €80.

Resources

All About Batteries. (2017). Learn.adafruit.com.
Retrieved 16 October 2017, from https://learn.adafruit.com/all-about-batteries/how-batteries-are-measured?view=all

Barnes, L. (2013). Fashion marketing. Textile Progress, 45(2-3), 182-207. http://dx.doi.org/10.1080/00405167.2013.868677

Basic color schemes. (2017). Tigercolor.com.
Retrieved 17 November 2017, from http://www.tigercolor.com/color-lab/color-theory/color-theory-intro.htm

Close, E. (1950). How to make Gloves. Couturestuff.com. Retrieved 9 August 2017, from http://www.couturestuff.com/vintage-sewing-books/how-to-make-gloves-by-eunice-close/

Cooper, T. (2017). All About LEDs. Learn.adafruit.com. Retrieved 18 November 2017, from https://learn.adafruit.com/all-about-leds/what-are-leds-used-for?view=all

Dameshandschoenen. (2017). HEMA.nl.
Retrieved 10 December 2017, from https://www.hema.nl/winkel/dames/dames-accessoires/dames-handschoenen-mutsen/dameshandschoenen-(16460060)?variant=16460062

Featured products. (2017). Raynauds.org.
Retrieved 5 December 2017, from http://www.raynauds.org/featured-products/

Gatignon, H. (1993). Handbooks in Operations Research and Management Science (5th ed., p. 697). Philadelphia: University of Pennsylvania.

Gayraud, M. (2007). Raynaud's phenomenon. Joint Bone Spine, 74(1), e1-e8. http://dx.doi.org/10.1016/j.jbspin.2006.07.002

Gilleo, K. (1996). Polymer thick film (p. 140). New York: Van Nostrand Reinhold.

Hanania, J., Stenhouse, K., & Donev, J. Energy density of storage devices. Energyeducation.ca.
Retrieved 3 January 2018, from http://energyeducation.ca/encyclopedia/Energy_density_of_storage_devices

Herrick, A. (2012). The pathogenesis, diagnosis and treatment of Raynaud phenomenon. Nature Reviews Rheumatology, 8(8), 469-479. http://dx.doi.org/10.1038/nrrheum.2012.96

Holmes, K., Ryan, W., & Chen, M. (1983). Thermal conductivity and H2O content in rabbit kidney cortex and medulla. Journal Of Thermal Biology, 8(4), 311-313. http://dx.doi.org/10.1016/0306-4565(83)90014-1

How to make gloves. Sew-ing.com.
Retrieved 18 November 2017, from http://sew-ing.com/make/gloves.html

How to Solder (Stainless Steel) Conductive Thread. (2017). Instructables.com.
Retrieved 27 October 2017, from http://www.instructables.com/id/How-to-Solder-Stainless-Steel-Conductive-Thread/

Keillor, B. (2007). Marketing in the 21st century (p. 10). Westport, Conn.: Praeger.

Levitin, D. (2016). The organized mind. [United States]: Joosr Ltd.

Liao, H., Yeh, S., & Shimojo, S. (2011). Novelty vs. Familiarity Principles in Preference Decisions: Task-Context of Past Experience Matters. Frontiers In Psychology, 2. http://dx.doi.org/10.3389/fpsyg.2011.00043

Londhe, B. (2014). Marketing Mix for Next Generation Marketing.
Procedia Economics And Finance, 11, 335-340. http://dx.doi.org/10.1016/s2212-5671(14)00201-9

MacGillivray, M., Koch, K., & Domina, T. (1998). Fashion opinion leadership among working and non-working women. Journal Of Consumer Studies And Home Economics, 22(4), 199-207. http://dx.doi.org/10.1111/j.1470-6431.1998.tb00730.x

Nikolov, A. (2017). Design principle: Aesthetics. uxdesign.cc.
Retrieved 1 November 2017, from https://uxdesign.cc/design-principle-aesthetics-af926f8f86fe

Pizzorni, C., Sulli, A., Smith, V., Ruaro, B., Trombetta, A., Cutolo, M., & Paolino, S. (2016). Primary Raynaud's phenomenon and nailfold videocapillaroscopy: age-related changes in capillary morphology. Clinical Rheumatology, 36(7), 1637-1642. http://dx.doi.org/10.1007/s10067-016-3442-3

Pookulangara, S., & Shephard, A. (2013). Slow fashion movement: Understanding consumer perceptions—An exploratory study. Journal Of Retailing And Consumer Services, 20(2), 200-206. http://dx.doi.org/10.1016/j.jretconser.2012.12.002

Power and Energy. (2017). Learnabout-electronics.org. Retrieved 3 October 2017, from http://www.learnabout-electronics.org/Resistors/resistors_15.php

Proper charging. Learn.adafruit.com.
Retrieved 10 January 2018, from https://learn.adafruit.com/li-ion-and-lipoly-batteries

Rechargeable Lithium Polymer 1200mah 3.7v Battery. (2017). www.alibaba.com.
Retrieved 10 December 2017, from https://www.alibaba.com/product-detail/Rechargeable-lithium-polymer-1200mAh-3-7V_60682585501.html?spm=a2700.7724838.2017115.184.313e59b554BCVG

Salaris en tarief van een Assemblagemedewerker. (2017). Mijnzzp.
Retrieved 10 December 2017, from https://www.mijnzzp.nl/Beroep/1330-Assemblagemedewerker/Salaris-en-tarief

Salaris en tarief van een Naaister. (2017). Mijnzzp.
Retrieved 10 December 2017, from https://www.mijnzzp.nl/Beroep/347-Naaister/Salaris-en-tarief

Satomi, M., & Perner-Wilson, H. (2009). HOW TO GET WHAT YOU WANT. Kobakant.at.
Retrieved 6 December 2017, from http://www.kobakant.at/DIY/?p=379

Sessions, D. (2016). Vintage Gloves. VintageDancer.com.
Retrieved 18 December 2017, from https://vintagedancer.com/vintage/vintage-gloves-styles-1900-to-1960s/

Silva, I., Teixeira, G., Bertão, M., Almeida, R., Mansilha, A., & Vasconcelos, C. (2016). Raynaud phenomenon. Reviews In Vascular Medicine, 4-5, 9-16. http://dx.doi.org/10.1016/j.rvm.2016.03.001

Stankovski, K. Gloves. LoveToKnow.
Retrieved 18 December 2017, from http://fashion-history.lovetoknow.com/clothing-types-styles/gloves

Stern, B. Connecting components, Conductive Thread. Learn.adafruit.com.
Retrieved 13 December 2017, from https://learn.adafruit.com/conductive-thread/connecting-components

The basics of USB battery charging. (2017). Maxim Integrated. Retrieved 16 October 2017, from http://maximintegrated.com

Thermal Conductivity of common Materials and Gases. (2017). Engineeringtoolbox.com.
Retrieved 9 December 2017, from https://www.engineeringtoolbox.com/thermal-conductivity-d_429.html

ThermoGloves. (2017). Verseo. Retrieved 6 December 2017, from https://www.verseo.com/cold-weather/heated-apparel/thermogloves-rechargeable-heated-gloves.html

Valdovinos, S., & Landry, G. (2014). Raynaud Syndrome. Techniques In Vascular And Interventional Radiology, 17(4), 241-246. http://dx.doi.org/10.1053/j.tvir.2014.11.004

What is thermal conductivity?. (2017). Khan Academy. Retrieved 5 November 2017, from https://www.khanacademy.org/science/physics/thermodynamics/specific-heat-and-heat-transfer/a/what-is-thermal-conductivity

Ziekte of syndroom van Raynaud. (2017). Patient1.nl.
Retrieved 29 September 2017, from https://www.patient1.nl/encyclopedie/raynaudfenomeen

3.7v 1200mah Lipo Battery. (2017). www.alibaba.com.
Retrieved 7 December 2017, from https://www.alibaba.com/product-detail/503562-3-7v-1200mah-lipo-battery_60582924304.html?spm=a2700.7724838.2017115.65.45b94101mi46z7

Heated Gloves
Appendices

Master thesis by
Doenja Maris

January 2018

Index

Appendix 1 Questionnaire

Design for Raynaud's

Thank you for participating in this short Questionnaire. Filling it in should take around 2 minutes. The results of this test will help me design a product for Raynaud's patients that will be better than products that are available now. My name is Doenja Maris and I am a student of Industrial Design Engineering at the TU Delft. The product I am designing is for Smart Innovation Development. This questionnaire will be open until September 1st. If you would like to contact me you can find me on facebook at Smart Heated Gloves Project (https://www.facebook.com/groups/463709020679052/).

1. **Where do you experience most problems from your Raynaud's?**
Mark only one oval per row.

	Never	Not often	Often	Very often
My fingers	◯	◯	◯	◯
My entire hands	◯	◯	◯	◯
My toes	◯	◯	◯	◯
My entire feet	◯	◯	◯	◯
My ears	◯	◯	◯	◯

2. **Other:**

____

3. **Which products do you own and regularly use for your Raynaud's?**
Tick all that apply.

- [ ] Thick gloves
- [ ] Thick socks/insoles/shoes
- [ ] Thick hats/scarfs
- [ ] Electrically heated gloves
- [ ] Electrically heated socks/insoles/shoes
- [ ] Electrically heated hats/scarfs
- [ ] Other: ____________________

4. **Which products would you be interested?**
Tick all that apply.

- [ ] Thick gloves
- [ ] Thick socks/insoles/shoes
- [ ] Thick hats/scarfs
- [ ] Well designed electrically heated gloves
- [ ] Well designed electrically heated socks/insoles/shoes
- [ ] Well designed electrically heated hats/scarfs
- [ ] Other: ____________________

5. **Did you ever try heated gloves?**
Mark only one oval.

◯ Yes, I liked them
◯ Yes, but I did not like them
◯ No

6. **Could you tell me why?**

____

7. **In which situations do you regularly wear gloves?**
Tick all that apply.

- [ ] Outside the house in warm weather
- [ ] Outside the house in mild weather
- [ ] Inside the house
- [ ] In the car
- [ ] Behind the computer
- [ ] At work
- [ ] Other: ____________________

Which of these glove materials do you prefer for everyday use?

8. *Mark only one oval.*

◯ Cotton
◯ Leather
◯ Suede
◯ Wool
◯ Softshell
◯ Other: ____________________

Demographics

9. **Sex**
Mark only one oval.

- Male
- Female
- Other

10. **Age**

11. **Country**

Thank you for filling in the questionnaire.

Are you interested in this project and could I contact you in the future?

If not, you do not have to fill the next question and can press submit on the bottom of the form. If you are, please tell me the email adress or the facebook link where I can contact you.

12. **E-mail or facebook link**

Powered by Google Forms

Appendix 2 Severe Raynaud's Interviews

Quotes from youtube video's SRUK

Diane

''It is really quite severe, my hands go completely white. And during that period you really can't feel anything, you can't pick money up, you can't touch things. And then they go into what I call my Halloween Hands, which is a blueish grey color. And then the most painful thing is when the circulation comes back. And that is bright red and that is my frying eggs stage where it's so hot and painful it is like being stabbed with knives. And you can have so many attacks during the day, it is truly debilitating.''

''The actual condition of the Raynaud's, people really underestimate it. They think it is just for cold weather. Raynaud's attacks happen from one room to the next, it is the change in temperature. I have gloves in every room, in my car. When I worked I had them at work.''

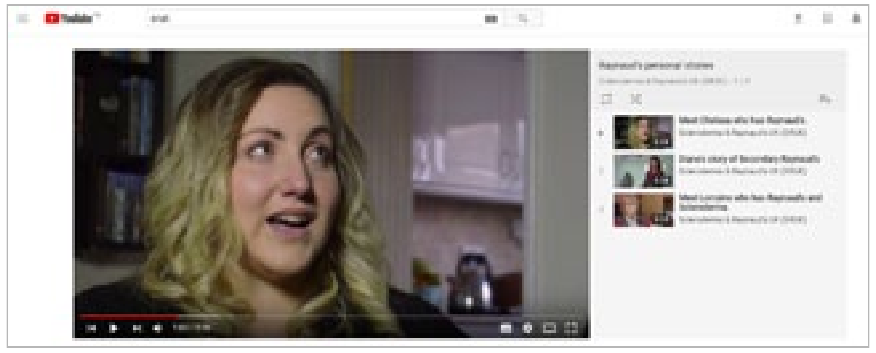
''Because when you are at that stage where you can't feel your hands, you can't use them. So it really affected the way I could actually work''

''Advice that I could give to anybody with Raynaud's, whether that is primary Raynaud's or secondary as I have, is really have some warm gloves.''

''I have to have mittens now because my hands, I can't fit in the gloves. And because when you have Raynaud's your fingers do swell an awful lot when it's at that stage, so just be wary of that.''

(Diane's story of Secondary Raynaud's, 2017)

Chelsea



''We have tried a range of medications. Some of which I was allergic to, some of which that gave me such bad side effects that I couldn't cope with them and some that just didn't work. So at the moment I am on six types of medication which is normal for me now. At one point I was at seventeen tablets a day which obviously is quite a lot.''

''And also the mental health side of things really. Having a condition that nobody really knows about and nobody really sees, it can get you really down. It can make you quite depressed.''

''For me, an attack from Raynaud's just basically means my fingers are going blue straight away. A lot of people their fingers go white first of all but mine skip that stage entirely these days.''

''Anything can bring them on for me. A temperature change, going into the fridge or the freezer, just opening the backdoor to get something from the garden or just a very slight temperature change. Washing my hands, getting out of the bath or shower. They will bring an attack on.''

''I do have quite a few attacks when I am at work just because of the stress.''

(Meet Chelsea who has Raynaud's., 2017)

Lorraine

‘’I’ve had Raynaud’s for quite some time. I could live with it it didn’t really bother me that much. And then in 2010, work was very stressful, and then things just rapidly declined.’’

‘’Picking out the washing is difficult. Going from one room to another can set me off.’’

‘’I have hand-warmers and gloves everywhere.’’

‘’Every handbag has got a pair of gloves, lipsol, handcream, there is no room for money.’’
‘’I still got difficulty sometimes getting change out of my purse. Using pay-meters is a nightmare. Putting coins in the payslots. Because I drop everything. My dexterity is not that good.’’

‘’It is difficult to drive, not only because of the scleroderma but because of the Raynaud’s. Just holding the wheel can cut off your circulation.’’

‘’I struggle every day but people don’t see that. And they don’t want to see that.’’

(Meet Lorraine who has Raynaud's and Scleroderma., 2017)

Resources

Diane's story of Secondary Raynaud's. (2017). [video] United Kingdom: Scleroderma & Raynaud's UK (SRUK).

Meet Chelsea who has Raynaud's. (2017). [video] United Kingdom: Scleroderma & Raynaud's UK (SRUK).

Meet Lorraine who has Raynaud’s and Scleroderma. (2017). [video] United Kingdom: Scleroderma & Raynaud's UK (SRUK).

Appendix 3 Average price of glove liners

“Questionnaire” on page 14 indicated that most participants never tried heated gloves before because of the high price. Unfortunately we cannot know what the exact price was that they were referring to.

We can however look at the price of products with which our product competes directly. In “Competitor Analysis” on page 20 we discovered that heated glove liners are the current product on the market that match the wishes of our target group the best.

Method
For this calculation we took a sample of 10 glove liners from different brands. Glove liners that were not battery heated and worked only on motorcycles were excluded.

Each of these brand websites was visited and the description and indicated prices were added to Figure 232. The prices are rounded to whole dollars.

Result
The overview of 10 glove liner brands can be seen in Figure 232. It is interesting that the Thermoglove is the least expensive product of the sample.

Conclusion

The prices of this sample of glove liners ranges from $120 to $290, with an average of approximately $180.

The Thermoglove is the least expensive product in this sample. This indicates that it is relatively low priced for a glove liner, making the brand an even bigger competitor.

Brand & product name or description	Price	Picture
ActionHeat 5V Heated Glove Liners - Women’s	$160	
Venture Heat Battery Heated Glove Liners	$170	
Hestra Battery Heated Liner Gloves	$290	
Gerbing Battery Heated Glove Liner - 7V Battery	$150	
Volt resistance 7V Heated Glove Liners	$130	
Glovii Battery Heated Glove Liners	$160	
Venture heat Battery heated glove liners	$180	
Verseo Thermoglove	$120	
ActiVHeat Touchscreen Cordless Heated Glove Liners w/ Rechargeable Battery	$140	
AlpenHeat Fire-Gloveliner	$280	
Average price	$178	

Figure 232 Price comparison glove liners from different brands

Appendix 4 Battery datasheet

Polymer Lithium-ion battery Product Specification	Doc. No.	Q/WAPL503562-1011
	Edition No.	1.0
		2/10

1、 Scope

This product specification describes polymer lithium-ion battery. Please using the test methods that recommend in this specification. If you have any opinions or advices about the test items and methods, please contact us. Please read the cautions recommended in the specifications first, take the credibility measure of the cell's using.

If the cells should be using at the environment that not preferred in this document, please connect with our first and get our authorization. For the reason of stable performance and better safety, battery pack with more than 2 cells connected in serial way should be charged with a balance charger.

It is claimed that we should have no any responsibility with the contingency and loss due to the cells' wrong usage (not preferred in the product specification).

2、 Product Type, Model and Dimension

2.1 Type：Polymer lithium-ion battery

2.2 Model：503562(Cell adding Ni Tabs)

2.3 Cell Dimension(Max, Thickness×Width×Length，mm^3)：5.0×35×62

Pack Dimension(Max, Thickness×Width×Length，mm^3)：5.2*35.5*62.5(with pcm)

3、 Specification

Item		Specifications	Remark
Nominal Capacity		1200mAh	$0.2C_5A$ discharge，25℃
Nominal Voltage		3.75V	Average Voltage at $0.2C_5A$ discharge
Standard Charge Current		$0.2\ C_5A$	Working temperature：0～40℃
Max Charge Current		$1C_5A$	Working temperature：0～40℃
Charge cut-off Voltage		4.2V	CC/CV
Standard Discharge Current		$0.5C_5A$	Working temperature：25℃
Discharge cut-off Voltage		2.75V	
Cell Voltage		3.7-3.9V	When leave factory
Impedance		≤50mΩ	AC 1KHz after 50% charge,25℃
Weight		Approx:22g	
Storage temperature	≤1month	-10～45℃	Best 20±5℃ for long-time storage
	≤3month	0～30℃	
	≤6month	20±5℃	
Storage humidity		65±20% RH	

4. General Performance

Definition of Standard charging method：At 20±5℃，charging the cell initially with constant current $0.2C_5A$ till voltage 4.2V, then with constant voltage4.2 till current declines to $0.05C_5A$.

Appendix 5 Datasheet Isotan resistive wire

A. The Electrical Resistance and its Temperature Coefficient

Resistivity

In accordance with the equation

$$R_t = \frac{\rho_t \cdot l}{q}$$

the electrical resistance of a conductor at temperature t is proportional to its length and inversely proportional to its cross-sectional area on the condition that there is a constant cross-section over the whole test length.

R_t = Resistance in Ω at Temperature t
l = Length in m
q = Cross-Sectional area in mm²
ρ_t = Resistivity in Ω · mm²· m^{-1} at temperature t

In order to calculate

$$\rho_t = R_t \cdot \frac{q}{l}$$

R_t, q and l are determined. If

q = 1 mm² and
l = 1 m

are given, one calculates the resistivity in Ω · mm² · m^{-1}, i.e. the resistance of a conductor of 1m length and 1 mm² cross-sectional area.

The resistivity can also be defined as to be the electrical resistance of a cube with 1cm edge length; then it is expressed in units of Ω · cm. Since for base metals and alloys the resistance of such a cube is very low, the resistance values are expressed in µΩ · cm, i. e. in millionths of an Ω · cm.

The values for e.g. ISOTAN® would then be either

0.49 Ω · mm² · m^{-1}

or

49 µΩ · cm.

The practical determination of the resistivity can be difficult, since determination of the cross-sectional area of e.g. wires with non-circular cross-section or very thin wires is difficult. In such cases, the cross-sectional area is determined on the basis of weight and length.

The resistivity of a wire can then be determined in accordance with the equation:

$$\rho_t = \frac{R_t \cdot g}{\gamma} \cdot \frac{1}{l^2}$$

R_t = Resistance in Ω at Temperature t
ρ_t = Resistivity in Ω · mm²· m^{-1} at temperature t
g = Weight in g
γ = Density in γ /cm³
l = Length in m

For countries using a different system of meaurement the resistivity is expressed in units which must be converted when changing over from one system to another (see Annex "Conversion Values"):

Resistance per Meter

The resistance per meter of a conductor is determined by the quotient of its resistivity and cross-sectional values.

The Temperature Coefficient (α) of Resistivity

Metals and their alloys exhibit a dependence of the resistivity on temperature. In general the resistivity increases with temperature dependence of resistivity can be expressed by the equotion:

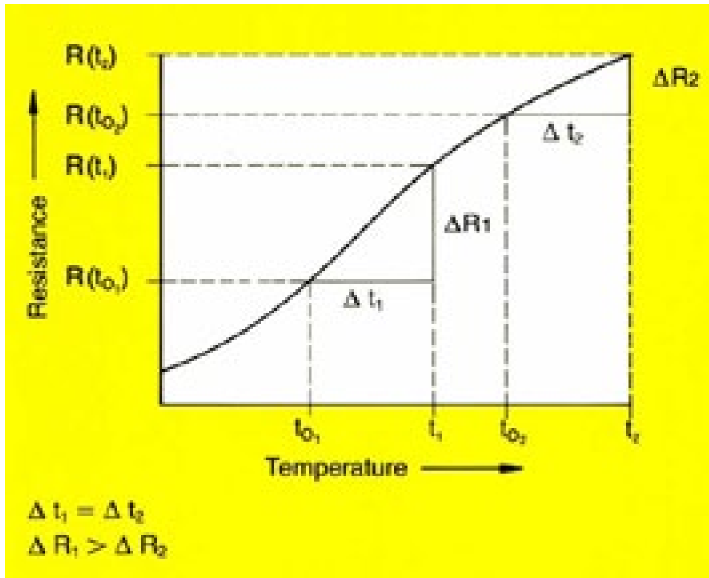
$$R_t = R_o\,[1 + \alpha\,(t - t_o)]$$

This equation applies only if resistance and temperature expose a linear relationship in the test temperature expose a linear relationship in the test temperature range from t_o to t. For most alloys and metals this is not the case, especially as regards large temperature intervals. In order to deliver an exact description of the temperature dependence of the resistivity, complicated equations are required.

In spite of this temperature coefficient is defined from the equation above as being:

$$\alpha = \frac{R_t - R_o}{R_o(t - t_o)}\left[K^{-1}\right]$$

$$\text{Resistance per Meter} = \frac{\text{Resistivity } (\Omega \cdot mm^2 \cdot m^{-1})}{\text{Cross-sectional area } (mm^2)} = \Omega \cdot m^{-1}$$



page 2

It thus indicates the average variation of the resistivity per degree Kelvin in the temperature range from t_o to t, referred to the resistance value R at t_o.

When experimentally determining the temperature coefficient as well as during communication between supplier and customer two points must be observed:

1. As already mentioned, the temperature dependence of the resistivity in general does not show a linear, but a curved form. This applies particularly to certain resistance alloys and is the reason why differing temperature coefficients result from the calculations, because they depend on the part of the curve which corresponds to a certain Δ t (see the figure on page 2).
2. Due to the fact that the temperature dependent resistance variation is referred to the resistance value R_o when defining the temperature coefficient values result for different values of R_o, even if the temperature intervals chosen are of equal width.

This means that together with the value of the temperature coefficient the temperature interval from °C to °C must always be quoted. Comparison of test results is possible only if the test conditions are the same.

In some alloys the temperature coefficient can be controlled by combining certain alloy components. It can then achieve negative values or values around 0 between room temperature and appr. 100°C.

Dependence of Resistivity in $\Omega \cdot mm^2 \cdot m^{-1}$ on Temperature for Various Alloys

Alloy	20°C	100°C	200°C	300°C	400°C	500°C	600°C	700°C	800°C	900°C	1000°C	1100°C	1200°C
ISACHM	1,32	1,32	1,32	—	—	—	—	—	—	—	—	—	—
ISA-CHROM 60	1,13[1]	1,14	1,16	1,18	1,20	1,22	1,21	1,21	1,22	1,23	1,24	1,26	1,28
	(1,11)[2]	(1,12)	(1,14)	(1,16)	(1,18)	(1,22)	—	—	—	—	—	—	—
ISA-CHROM 80	1,12[1]	1,13	1,13	1,14	1,15	1,16	1,15	1,14	1,14	1,14	1,15	1,16	1,17
	(1,08)[2]	(1,09)	(1,10)	(1,12)	(1,14)	(1,16)	—	—	—	—	—	—	—
ISA-CHROM 30	1,04	1,07	1,11	1,14	1,17	1,20	1,22	1,24	1,26	1,28	1,30	1,32	—
ISOTAN	0,49	0,49	0,49	0,49	0,49	0,49	—	—	—	—	—	—	—
ISA-NICKEL	0,45	0,48	0,49	0,51	0,52	0,53	0,55	0,56	—	—	—	—	—
MANGANIN	0,43	0,43	—	—	—	—	—	—	—	—	—	—	—
NICKELIN W	0,40	0,404	0,41	0,417	0,424	0,432	—	—	—	—	—	—	—
RESISTHERM	0,33	0,41	0,52	0,64	0,76	0,89	1,02	—	—	—	—	—	—
ISAZIN	0,30	0,304	0,31	0,315	0,321	0,326	—	—	—	—	—	—	—
ZERANIN 30	0,29	0,29	—	—	—	—	—	—	—	—	—	—	—
Alloy 127	0,21	0,215	0,221	0,228	0,234	—	—	—	—	—	—	—	—
Alloy 90	0,15	0,156	0,162	0,169	0,175	—	—	—	—	—	—	—	—
ISA 13	0,125	0,129	0,133	—	—	—	—	—	—	—	—	—	—
Alloy 60	0,10	0,107	0,114	0,123	—	—	—	—	—	—	—	—	—
Pure Nickel	0,09	0,13	0,19	0,25	0,32	0,38	0,41	—	—	—	—	—	—
Special Nickel	0,077	0,11	0,17	—	—	—	—	—	—	—	—	—	—
Alloy 30	0,05	0,057	0,064	—	—	—	—	—	—	—	—	—	—
A-Copper	0,025	0,031	0,039	—	—	—	—	—	—	—	—	—	—
Pure-Copper	0,0172	0,023	0,031	—	—	—	—	—	—	—	—	—	—

1) These values apply to a state of equilibrium.
2) These values apply to a state after rapid cooling; see also **B. "Special Characteristics of Nickel-Chromium-Alloys".**

Appendix 6 Lilypad Code

```
const int pressureFeed=3;
const int pressurePin=A5;
const int tiltFeed=9;
const int tiltPin=2;
const int ledPin=11;
const int switchPin=10;
int pressureValue;
int threshold=50;
int tiltValue;

void setup() {
Serial.begin(9600);
pinMode(pressurePin, INPUT);
pinMode(pressureFeed, OUTPUT);
pinMode(tiltPin,INPUT);
pinMode(tiltFeed,OUTPUT);
pinMode(ledPin, OUTPUT);
pinMode(switchPin, OUTPUT);
digitalWrite(pressureFeed, HIGH);
digitalWrite(tiltFeed, HIGH);
digitalWrite(switchPin, LOW);
}

void loop() {
pressureValue=analogRead(pressurePin);
tiltValue= digitalRead(tiltPin);

if (pressureValue>threshold && tiltValue==0){
 // Serial.println(pressureValue);
 // Serial.println(tiltValue);
  digitalWrite(ledPin, LOW);
  digitalWrite(switchPin, LOW);
}
else if (pressureValue>threshold && tiltValue==1){
 // Serial.println(pressureValue);
 // Serial.println(tiltValue);
  digitalWrite(ledPin, HIGH);
  digitalWrite(switchPin, HIGH);
}
}
```

Appendix 7 Symbols of warmth

In order to find a suitable pattern to laser into the outer glove, symbols that are associated with warmth were explored. Icons associated with warmth were searched and described on this page.

Warmth of a fire

Symbols of fire could induce associations with warming your hands by a cozy fireplace.

Negative associations are also possible when fire is interpreted as danger. In a consumer electronics it might be inappropriate to reference to fire directly.

Warm bath or shower

Associations with warm baths and hot showers to make the user think of warmth and comfort.

However symbols involving water (for instance a water drop pattern) are usually associated with opposites feelings involving cold. This makes it not suitable for our application.

Warm meal or cup of coffee

Warming your hands on a cup of soup or coffee is an interaction that can evoke positive emotions.

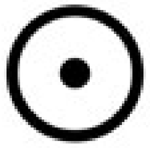
One idea to amplify the emotion associated with this interaction would be to use heat reactive paint on the palms of the glove.

Warmth and things

Thermometers represent the measurement of temperature. High temperatures are a symbol of warmth but in an objective way.

Warmth from the sun

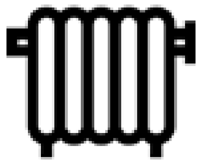
Associations of warmth and positivity. The warmth of this product slowly increases like a sunrise.



The second icon is more abstract. It is a symbol of the sun from alchemy. Circular patterns can be abstract representations of the sun and could be used for elegant patterns.

Warmth of home

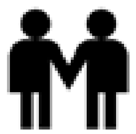
The cozy and safe feelings of home can also be associated with warmth.



Using fabrics that one would normally wear around the house, like soft jogging or jersey knits, could perhaps evoke this association. It could also help communicate that the inner gloves are meant for indoor use.

Warmth from people

Welcomes, handshakes, people and friendships can all be described as "warm" in our language. Meaning that we can associate social interaction with warmth. Because the product provides warmth to the hands and hands are associated with social interaction there might be symbols possible that capture both aspects. However our product or its interactions are not especially social in nature.



Conclusion

The symbolic representation for warmth that was chosen was the sun. Not only does the sun provide us with an association of positivity and warmth, the sun is also something that rises from the dark. Symbolizing the overcoming of difficult situations, which fits well with the empowering character our product could potentially have.

Appendix 8 Datasheet single channel dip switch

TRU COMPONENTS

Distributed by Conrad Electronic SE • Klaus-Conrad-Str. 1 • D-92240 Hirschau

Datasheet

Item no. 704809/ 704824/ 704837/ 704850/ 704862/ 704876/ 704889/ 704902/ 704916/ 704932/ 704963

V1_0717_01_en

Dip Switches

Product Overview

- Using excellent heat and chemical resistance engineering plastic.
- Using standard gold- plated contact points ensure reliability and longer life of the switch.
- Have the advantage of self- cleaning when the switch in ON- OFF state.
- Using widely in manual programproducts, like data processing, communications, remote controls and burglar alarmsystem.

Soldering Information

- Soldering iron under 30Wand under 350℃ for 3 seconds max or 270℃ for 5 seconds max.
- Wave crest soldering:
  240℃ within 20seconds max, .Keep all actuators in "off" position during soldering and cleaning process.

Specifications

- Contact capacity
  OFF: 25mA,24VDC
  ON: 100mA,50VDC
- Contact resistance
  Initial: 50mΩ 24VDC /100mA
  After life test: 100mΩ typical, 24VDC /100mA
  Insulation resistance: ≥100MΩ ,500VDC
  Dielectr ic strength: 500VDC RMS min.
  Operating force: 1000g Max
  Operation Life expectancy
- Mechanical: 3000 operations
  Electrical: 2000 operations
  Temperature range operating/storage: - 25℃~70℃

-1-

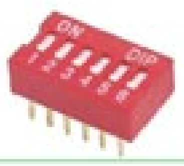
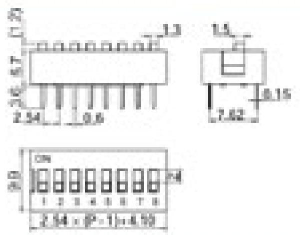
Distributed by Conrad Electronic SE • Klaus-Conrad-Str. 1 • D-92240 Hirschau

Datasheet

Item no. 704809/ 704824/ 704837/ 704850/ 704862/ 704876/ 704889/ 704902/ 704916/ 704932/ 704963

V1_0717_01_en

Dip Switches

	Slide Type
Hiding Type	
Shape % Dimensions	

Note: The above P≥ 2 ; If the P=1 the length is 3.75mm

704809 : Slide-type, Hiding Type, Off/On, 1 Position, measured weight 0.2 g, measured dimension: 9.9 x 3.7 x 5.4 mm

704824 : Slide-type, Hiding Type, Off/On, 2 Position, measured weight 0.5 g, measured dimension 9.9 x 6.7 x 5.4 mm

704837 : Slide-type, Hiding Type, Off/On, 3 Position, measured weight 0.55 g, measured dimension 9.2 x 9.9 x 5.4 mm

704850 : Slide-type, Hiding Type, Off/On, 4 Position, measured weight 0.7 g, measured dimension 11.8 x 9.9 x 5.5 mm

704862 : Slide-type, Hiding Type, Off/On, 5 position, measured weight 0.9 g, measured dimension 14.4 x 9.9 x 5.4 mm

704876 : Slide-type, Hiding Type, Off/On, 6 position, measured weight 1 g, measured dimension 16.9 x 10 x 5.4 mm

704889 : Slide-type, Hiding Type, Off/On, 7 position, measured weight: 1.2 g, measured dimension: 19.4 x 9.9 x 5.5 mm

704902 : Slide-type, Hiding Type, Off/On, 8 position, measured weight: 1.35 g, measured dimension: 22 x 9.9 x 5.5 mm

704916 : Slide-type, Hiding Type, Off/On, 9 position, measured weight: 1.5 g, measured dimension: 24.5 x 9.9 x 5.5 mm

704932 : Slide-type, Hiding Type, Off/On, 10 position, measured weight: 1.7 g, measured dimension: 27 x 9.9 x 5.5 mm

704963 : Slide-type, Hiding Type, Off/On, 12 position, measured weight: 2 g, measured dimension: 32 x 9.9 x 5.5 mm

HUIYUAN ELECTRONIC CO.,LTD.

TECHNOLOGY DATA SHEET & SPECIFICATIONS

MODEL：3034W2D-ESA-B

Features

- High efficiency
- Low Power consumption
- General purpose leads
- Selected minimum intensities
- Available on tape and reel
- Pb free

Descriptions

- The series is specially designed for applications requiring higher brightness
- The LED lamps are available with different colors, intensities, epoxy colors, etc
- Superior performance in outdoor environment

Usage Notes:

- When using LED, it must use a protective resistor in series with DC current about 20mA

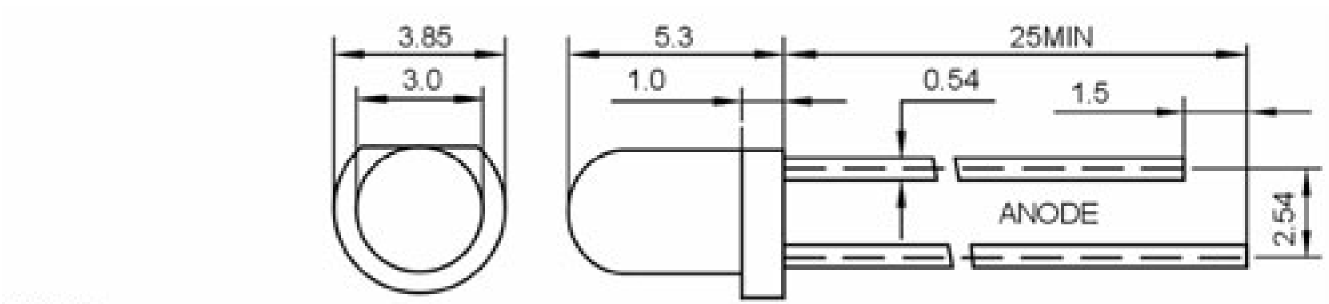
Applications

- Status indicators
- Commercial use
- Advertising Signs
- Back lighting

Device Selection Guide

LED Part No.	Chip		Lens Color
	Material	Emitted Color	
3034W2D-ESA-B	InGaN	White	Color Diffused

Package Dimensions



UNIT:mm

Notes:

- Other dimensions are in millimeters, tolerance is 0.25mm except being specified.
- Protruded resin under flange is 1.5mm Max LED.
- Bare copper alloy is exposed at tie-bar portion after cutting.

HUIYUAN ELECTRONIC CO.,LTD.

TECHNOLOGY DATA SHEET & SPECIFICATIONS

MODEL：3034W2D-ESA-B

Absolute Maximum Rating (T_a=25℃)

Parameter	Symbol	Absolute Maximum Rating	Unit
Forward Pulse Current	I_{FPM}	70	mA
Forward Current	I_{FM}	30	mA
Reverse Voltage	V_R	5	V
Power Dissipation	P_D	140	mW
Operating Temperature	Topr	-40～+80	℃
Storage Temperature	Tstg	-40～+100	℃
Soldering Heat (5s)	Tsol	260	℃

Electro-Optical Characteristics (T_a=25℃)

Parameter	Symbol	Min.	Typ.	Max.	Unit	Test Condition
Luminous Intensity	I_V	1000	---	2500	mcd	IF=20mA(Note 1)
Viewing Angle	$2\theta_{1/2}$	---	60	---	Deg	(Note 2)
Peak Emission Wavelength	λp	---	---	---	nm	IF=20mA
Spectral Line Half-Width	△λ	25	30	35	nm	IF=20mA
Forward Voltage	V_F	2.9	---	3.3	V	IF=20mA
Reverse Current	I_R	---	---	10	μA	VR=5V

Note:

1. Luminous intensity is measured with a light sensor and filter combination that approximates the CIE eye-response curve.

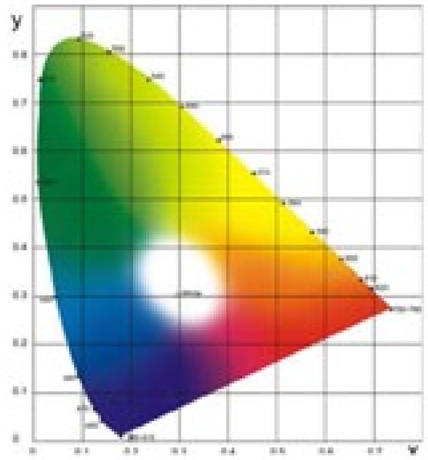
2. $\theta_{1/2}$ is the off-axis angle at which the luminous intensity is half the axial luminous intensity.

HUIYUAN ELECTRONIC CO.,LTD.

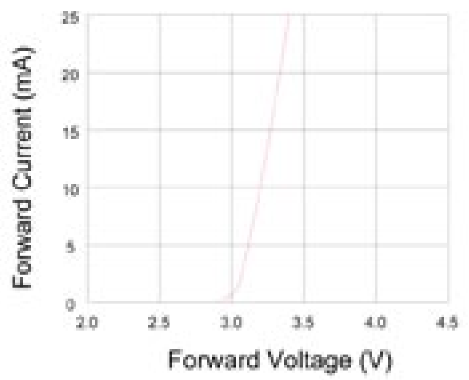
TECHNOLOGY DATA SHEET & SPECIFICATIONS

MODEL：3034W2D-ESA-B

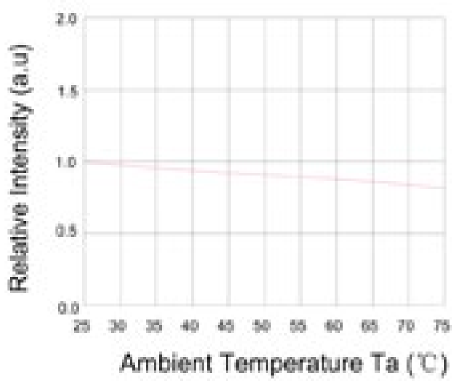
Typical Electro-Optical Characteristics Curves



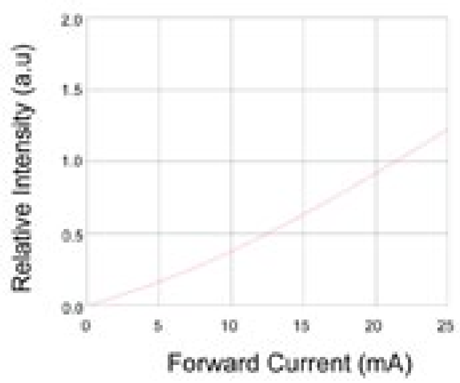
Forward Current VS.Forward Voltage



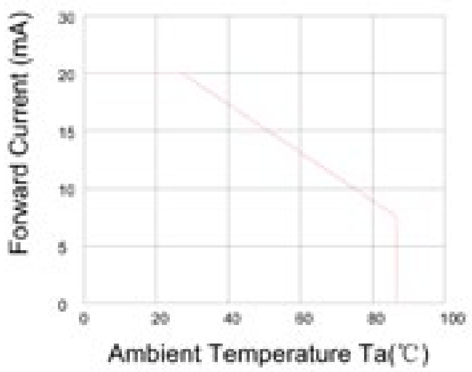
Relative Intensity VS. Ambient Temp



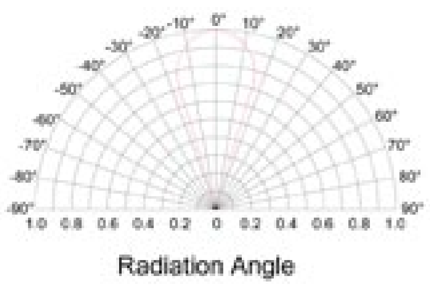
Forward Current VS.Relative Intensity



Forward Current VS.Ambient Temp.



Radiation Characteristics



HUIYUAN ELECTRONIC CO.,LTD.

TECHNOLOGY DATA SHEET & SPECIFICATIONS

MODEL：3034W2D-ESA-B

Notes

1. Above specification may be changed without notice. HYLED will reserve authority on material change for above specification.
2. When using this product, please observe the absolute maximum ratings and the instructions for using outlined in these specification sheets. HYLED assumes no responsibility for any damage resulting from use of the product which does not comply with the absolute maximum ratings and the instructions included in these specification sheets.
3. These specification sheets include materials protected under copyright of HYLED corporation. Please don't reproduce or cause anyone to reproduce them without HYLED's consent.

Appendix 9 User test questions

Verwarmde handschoen test

Ik zou je graag willen vragen de handschoen aan te trekken en aan te zetten.

1. **Heb je een linker of een rechter handschoen aan?**
Mark only one oval.
   - Links
   - Rechts

2. **Is het gelukt de handschoen aan te zetten?**
Mark only one oval.

	1	2	3	4	5	6	7	8	9	10	
Nee, het lukt niet											Ja, het aanzetten lukt makkelijk

Comfort

3. **Vind je dat de handschoen lekker zit?**
Mark only one oval.

	1	2	3	4	5	6	7	8	9	10	
Nee, hij zit niet lekker											Ja, hij zit heel lekker

4. **Kun je beschrijven waarom?**

5. **Hebben je vingers genoeg vrijheid om dingen te doen en te voelen?**
Mark only one oval.

	1	2	3	4	5	6	7	8	9	10	
Nee, mijn vingers zijn volledig beperkt											Ja, mijn vingers zijn vrij

Uiterlijk

6. **Vind je dat de handschoen die je aan hebt er goed uit ziet?**
Mark only one oval.

	1	2	3	4	5	6	7	8	9	10	
Nee, ik vind hem niet mooi											Ja, ik vind hem mooi

7. **Kun je beschrijven waarom?**

8. **Over deze handschoen komt nog een buitenhandschoen. Vind je dat deze buitenhandschoen er goed uit ziet?**
Mark only one oval.

	1	2	3	4	5	6	7	8	9	10	
Nee, ik vind hem niet mooi											Ja, ik vind hem mooi

9. **Kun je beschrijven waarom?**

Warmte

10. **Vind je dat de handschoen warm genoeg wordt?**
Mark only one oval.

	1	2	3	4	5	6	7	8	9	10	
Nee, ik voel niks	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	Ja, hij warmt goed op

Verbeteringen

11. **Wat zou ik volgens jou kunnen verbeteren aan dit ontwerp?**

____

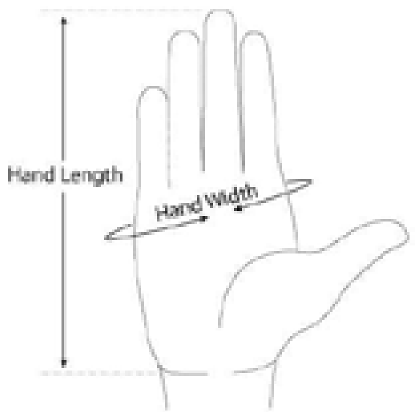
____

____

____

____

Bedankt, ik wil je vragen de handschoen uit te trekken en je hand voor me op te meten.



12. **Handlengte in cm**

____

13. **Handbreedte in cm**

____

14. **Polsomtrek, smalste deel**

____

15. **Wat is je leeftijd?**

____

Heel erg bedankt voor het meedoen aan deze test!

Appendix 10 Target group interviews

This appendix shows the results of five interviews that were conducted with the target group. The observations and answers on the interview questions are compactly described in the form of bullet points.

Questions

The following questions were used as a guideline. The interview diverged from them according to the situation

Intro

Bedankt voor het meedoen aan deze test. Dit project gaat over het ontwerpen en ontwikkelen van slimme verwarmde handschoenen voor vrouwen voor Smart Innovation Development. We testen hierbij het product, niet jou, je kunt tijdens deze test daarom geen foute antwoorden geven. Dit is een prototype, dus ze kunnen nog een beetje fragiel zijn. Het is nog geen eindproduct.
Ik wil je graag vragen deze handschoenen aan te trekken. Dan gaan we even kort naar buiten, dan kun je ze daar even ervaren. Verder wil je vragen een kort formuliertje in te vullen op mijn laptop, dan kun je ervaren hoe ze zijn in gebruik achter de computer en heb ik direct wat algemene gegevens van je. Daarna zou ik je graag wat vragen willen stellen over wat je van de handschoenen vind en hoe ik ze zou kunnen verbeteren.

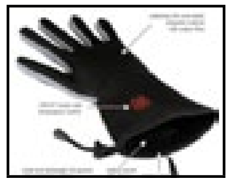
General
- Zou je mij iets kunnen vertellen over jouw ervaringen met Raynaud's?
- Heb je ooit eerder verwarmde handschoenen geprobeerd?
- Wat vond je van deze handschoenen?
- Wat heb je voor deze betaald?
- Was dit product het geld waard?

Heat performance
- Warmden de handschoenen voldoende op?
- Warmden de handschoenen snel genoeg op?
- Voel je verschil tussen de handschoenen?
- Warmden de handschoenen op op de juiste plaatsen op de hand?
- Zijn er andere plekken die je graag zou willen verwarmen?
- Zou je de hoeveelheid warmte graag willen instellen?
- Indien ja, hoe zou je het liefst de warmte van de handschoenen instellen?
- Hoe vind je dat de handschoenen zitten?
- Kun je je vingers goed bewegen? Zitten ze overal goed?
- Wat vind je van de lengte van de vingertoppen?
- Zou je liever een dikke handschoen met een dunne batterij of een dunne handschoen met een dikke batterij hebben?
- Wat vind je van het aan en uit schakelen van de handschoenen?

Batteries
- Vind je de batterijen comfortabel zitten?
- Wat vind je van de capaciteit van de batterij? Deze batterij zou theoretisch 2 uur lang kunnen verwarmen.
- Hoe lang vind je dat batterijen minimaal moeten kunnen verwarmen voordat ze opgeladen moeten worden?
- Wat vind je van het opladen van de batterijen?

Material
- Hoe vind je dat de handschoenen er uit zien?
- Wat vind je van de kleur?
- Welke (andere) kleuren vind jij mooi voor handschoenen?
- Wat vind je van het materiaal van de handschoenen?
- Wat voor andere materialen vind je prettig? Denk bijvoorbeeld aan katoen, wol, leer, softshell.

General
- Zou je interesse hebben in dit soort handschoenen?
- In welke situaties zou je deze handschoenen dragen?
- In welke seizoenen?
- Bij welke activiteiten?
- Welke dingen zou ik kunnen verbeteren aan deze handschoenen?
- Ik heb hier een paar afbeeldingen van bestaande handschoenen. Wat vind je van deze?



Thermoglove heated glove liner €78

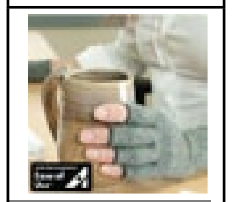
Alpenheat fire glove liner €230

Warmawear glove liner €45

Gerbing motor cycle glove €180

Altrite 30Seven Ski glove €170

Primrose heated fleece gloves €30



Imak Arthritis compression gloves €24

Uniqknits snowflake knitted gloves €80

- Wat vind je van de prijs die ze voor deze handschoenen vragen?
- Heb je nog vragen of suggesties voor mij?

Conclusion

Heel erg bedankt voor het meedoen met deze test. De resultaten zullen zeker nuttig zijn in het verdere ontwerp- en ontwikkelproces.

Results

Interview 1 - Dorien

Observations
- She was already wearing the gloves but was still able to put her coat on over them.

Raynaud's
- Her Raynaud's is decreasing
- Washing her hands can cause an attack
- She also has Raynaud's problems in the car, her hands can get so cold she can hardly hold the steering wheel
- She doesn't heat her hands with warm water because it is painful
- She has attacks when she goes outside
- For skiing she uses double gloves

Heating performance
- She did not have cold hands but she also did not think the gloves got very warm
- Different heat settings for inside and outside use might be good
- She especially felt the heat at her thumb
- In colder weather they might not be warm enough
- She preferred if the heat was the highest at the fingertips

Finger dexterity
- She thinks gloves without fingertips might be useful. Now that she saw these gloves she realized she does get cold hands while typing
- For fingerless gloves the seam should fall in between the first and second phlanx
- The outer gloves have long fingertips which limits dexterity
- She likes that the inner glove fits fairly well around her hand
- When you put on the outer gloves the fingers of the inner glove move down a bit

User control & feedback
- When you are wearing the outer gloves you cannot use the on/off switch
- If you have an attack your fingers get numb, so this switch might be difficult to operate
- The switch does not stick out which means you won't turn it on or off accidentally

Batteries and charging
- The battery fits comfortably, she did not feel wearing the gloves
- She does not think 2 hours of heating time is very long
- For most situations it would be long enough for her
- Charging them via USB is good
- The charging cables get in the way while you are typing. Maybe if the connectors pointed to the sides it would be better.

Aesthetics
- They look ok
- She says that the colour does not matter to her

Comfort
- The soft ribbing fabric feels good
- She likes the fabric of the inner glove, she has a pair of gloves like that herself

Competitors
- She never tried heated gloves before
- She did try heat packs but they did not work that well
- The thermoglove does not look like you should wear an outer glove
- The Uniqknits look like cheap gloves from Kruidvat, they would not be her first choice
- She thinks that they look more professional because they have a brand

Interest
- She would be interested in these gloves
- She would like to use them primarily outside
- Behind the computer would also be an option

Pricing
- € 230 is very expensive
- €80 is reasonable for heated gloves
- €50 is reasonable for unheated gloves

Interview 2 - Kelly

Observations
- She needs a few tries before she can connect the charger

Raynaud's
- She has an injured wrist and problems occur when the weather is cold
- She has problem with her joints and knees
- She always feels quite warm but she has to wear gloves for her wrist
- Therefore she likes fingerless gloves

Heating performance
- The gloves heated sufficiently for her
- She noticed the heat increase immediately
- Because there is an outer glove she would not need more than one heat setting
- She did not notice a difference between the two gloves or a certain hot area

Finger dexterity
- The fingertips should end in between the first and second phalanx
- She likes that she can type and use her phone

User control & feedback
- Bigger on/off switches might be switched by accident
- The LED is useful

Batteries and charging
- The batteries stiffness is actually an advantage for her, because it stabilizes her wrist
- The battery is placed well on the top, that is better than the sides or underside
- She thinks 2 hours of heating time would be enough

- Two separate charging cables might be better so that the wires are not in the way during typing
- One long cable that can travel around the computer might also be a solution
- The charger could be easier to connect if the battery packs connector would be facing the user
- Or the connector on the battery pack could face to the side
- Because the battery pack is not fixed to the fabric she was afraid to push it out with the charging cable

Aesthetics
- She thinks they look cool
- The cutout pattern looks good
- Different colour combinations would be cool
- She likes this colour combination
- A bright colour for the inner glove would also be good
- She does not mind black gloves, but she would not want bright pink ones

Comfort
- She thinks the glove are comfortable
- She likes that the fabric in between the fingers stays in place and does not move up
- The fabric feels very good because it is warm but not sweaty
- Knitted gloves are sweaty and not watertight

Competitors
- She tried gloves before with copper particles, they are a kind of acupuncture
- The Thermoglove does not look like it would fit under another glove. It looks more like a ski-glove
- For her, gloves that connect to her motorcycle battery would be interesting
- Uniqknits do not seem comfortable to her, they would be sweaty and itchy
- The Imak gloves look more comfortable to her
- She would not like the Warmawear gloves because they look like they would fit very loosely
- She does not like gloves with touch pad fingertips that much

Interest
- She thinks she would be interested in a real version of this prototype
- She would like to wear them on her motorcycle

Pricing
- She paid a few euros for the copper gloves
- You will probably need to charge a minimum of 50 euros to make it profitable

Interview 3 - Joyce

Raynaud's
- She almost always wears gloves, always when the weather is below 18 degrees Celsius. They do not always warm enough.
- Her hands turn white and people sometimes notice that
- It hurts and she cannot feel her hands
- It is difficult to get her bike unlocked because she cannot feel her keys in her pocket

Heating performance
- First she tested the gloves without outer gloves, she was not convinced they were heating well
- She felt the wind through the inner gloves
- She tested again with the outer glove but was still not convinced of the heating
- The gloves should heat more
- She did not feel a difference in heat in between the gloves
- She did not notice a place where they heated more
- She did not feel where the warmth was located
- She would prefer gloves to heat her fingertips. Usually these get cold first
- One heat setting might be enough
- For inside use finger less could also be useful

Finger dexterity
- If the gloves would be finger less she would like the fabric to end in between the first and second phalanx
- The outer gloves limit her finger dexterity because they do not stretch very well
- The inner gloves do not limit her finger dexterity

User control & feedback
- Turning the gloves on/off could be easier with a push button, because it is difficult to turn them on when you are already wearing an outer glove

Batteries and charging
- She does feel the battery, which is not ideal but also not a problem
- The battery sticks out a bit
- Two hours of heating would in most cases be enough for her
- She can also think of situations where it would not be enough, like skiing or long motorcycle journeys where people might want to wear these gloves
- The charging was OK, it gave no problems
- If you were to use them inside it would be useful to charge them on the computer

Aesthetics
- The inner glove still looks a lot like a prototype
- The colour is OK
- The fabric is OK
- The outer glove looks more finished

Comfort
- For her the outer gloves fit a bit tightly, especially in the fingers

Competitors
- She never tried heated gloves before but she does know they exist
- Today she is wearing ski gloves outside (8 to 1 degrees Celsius)
- Her parents gave her these ski gloves for Christmas
- She thinks the cheap polyester mix gloves (page 24) with smart phone operable fingertips are comfortable but a often too thin. She likes the stretchiness, opposed to the no stretch of the Bartotex outer gloves
- She thinks the competing products (page 132) look OK but not really fashionable
- One of the biggest downside of wearing ski gloves is that they do not fit in the pockets of your jacket. If they could be smaller that would be a benefit for her.
- She would consider trying the IMAK gloves, they only cost €24
- The Uniqknits look like normal gloves for €80, they are not really convincing
- Uniqknits do look less heavy and like they fit into your pocket

Interest
- She might be interested in these gloves depending on the price

Pricing
- More than €50 to €60 are expensive gloves for her
- She got her gloves from her parents for Christmas so she says she does not really know how expensive gloves are
- She thinks the Thermogloves are a bit expensive, but it might be a normal price.
- She never bought heated gloves before and that it is difficult to estimate a reasonable price for something you never bought before

Interview 4 - Marja

Raynaud's
- If she doesn't have her heated gloves or heat packs her hands get really cold and numb
- Driving a car almost gets impossible. She still does it, but it is difficult
- In summertime she almost has no problems from her Raynaud's
- She also experiences from her Raynaud's indoors
- Water, even warm water, can cause problems
- Grocery shopping, ATM machines, laundry, water, cycling.
- She also has Raynaud's in her nose and her toes

Heating performance
- She would prefer closed fingertips for the heat because they are the first place to get cold
- She doesn't think it needs different heat settings
- She likes that the prototype does not heat the thumb because she has no Raynaud's there
- She thinks they get nicely warm
- She thinks the gloves could be warmer

Finger dexterity
- She likes the dexterity the prototype allows
- She thinks they would be nice for driving a car or picking things up
- Closed fingertips with only an open thumb might be a good option according to her
- Fingerless might have advantages, like at the ATM machine. But she is not sure whether that would weigh up against colder fingertips.
- She likes that the prototype could be used indoors, she never uses her heated gloves indoors
- For using them behind the computer it would be good if they were finger less

User control & feedback
- The heated gloves she owns notify the user when the battery is full (green light) or depleted (red light)
- She likes that there is an LED
- She had gloves with different settings but with her cold hands it was difficult to switch them in those settings
- The switch is OK, it could be bigger but it should not make it more bulky

Batteries and charging
- The batteries of her own heated gloves deteriorate and heat shorter over time
- When they can only heat for an hour she buys new ones
- Two hours of heating time is quite a lot when considering that they are less heavy than her heated motor gloves
- Two hours would be enough to do grocery shopping
- She says you could have multiple batteries that you can swap quickly
- The battery feels good
- USB charging is OK

Aesthetics
- The prototype looks much smaller than her heated gloves
- She does not like the colour of the inner glove

Comfort
- The outer gloves do not fit very well. She would probably wear mittens over the inner gloves and not wear those in the store
- She likes how the fabric feels

Competitors
- As regular gloves she likes fleece, always carries a pair
- She owns a pair of heated motor gloves
- The batteries do not heat that long, she cannot use them for a few hours of playing golf
- She likes that she can take these heated gloves with her on the plane
- She cannot use them in the grocery store, she cannot handle money wearing those
- She thinks they are very bulky
- She can wear them in the car but if she has to pick something up she has to take off these gloves
- She uses them on her bike
- Her heated gloves broke one time, she got a new pair of the supplier
- She used to attach them to her golf cart because she is afraid to loose them
- She uses peacock hand warmers in many situations like going grocery shopping
- These work on fuel and can stay warm for 8 hours
- They are really warm, they have a fabric cover She says these are ideal and she always carries them outside in winter
- She has two, one for every pocket
- She has lost those before because numb hands do not feel where they are located
- Because of the fuel in the heater she cannot take it into a plane

- She has heated socks with a battery at the ankle. They were not ideal, the battery detaches easily when walking
- Chemical heat packs that just heat for an hour are not worth it

Interest
- She might be interested in these gloves if they had heated fingertips

Pricing
- For her own heated gloves she paid more than €100. She thinks she paid €130
- Her husband thinks they paid €250
- She doesn't know exactly but knows they are expensive
- She thinks the batteries are also expensive. She thinks they had cost her €60
- Around €80 is a good price
- Before you buy them you do not know for sure whether they work. She did not like the heated socks she bought but she did pay a lot of money for them
- If she would know for sure that a product works well she would pay more than €100

Interview 5 - Rosanna

Observations
- She needs to take off her watch before putting on the gloves. She says that it is not very important, she would just put her watch back on when she'd take off the gloves
- When she is wearing the outer gloves she cannot operate the switch
- Attaching it to the charger was a little difficult in the beginning

Raynaud's
- She has Raynaud's on a few fingers but not all of them
- Her doctor recommended using mittens so that the fingers warm each other
- Gloves do not warm her fingers enough
- She does not like wearing mittens because their cuffs do not fit in the sleeves of her coat
- When she gets indoors and her hands are cold it can take up to 15 minutes before she can fully use her hands
- She avoids cycling, even though she likes it, because of Raynaud's attacks
- She wears mittens that are too warm for the weather, that is uncomfortable for her hand but better than painful fingers
- She has trouble driving a car

Heating performance
- She felt a difference between the left and the right because her fingertips were more covered in the right inner glove. The more covered fingertips were warmer
- She did not notice other differences between the gloves
- She would like different heat settings, one for temperatures that day (7-0 degrees Celsius) and one for very cold weather
- A autumn and winter setting
- Heating up took a while, then the heat felt stable
- She likes the heat
- She would prefer gloves with fingertips for outdoors

Finger dexterity
- She likes that with the open fingertips you could keep wearing the gloves for a while when you get to work.
- She can move her hands well
- She likes the flexible fabric

User control & feedback
- She needed to get used to finding the button, she says that it is like having a new phone where you also need to get used to the product first. She does not think that is a problem.
- She would switch the gloves on before she would leave the house
- She thinks that for older women that the switch would be too small
- She likes the red colour of the left inner gloves switch

Batteries and charging
- She did not feel the battery when it was on
- She thinks she would not need to warm for three hours if she went grocery shopping, two hours would be ok
- For longer walks a bigger battery might be good
- She likes the size of the battery because it fits in her sleeve
- She says that in a real product the battery pack should be fixed properly

Aesthetics
- She says they look good
- She says the outer glove looks stylish
- She likes the colour
- She likes that you can see the inner glove through the cutouts

Comfort
- She says that putting them on is something you need to learn the first time
- The material feels good
- They are comfortable
- There should be sizes, s/m/l

Competitors
- She had Thinsulate gloves but she feels like the insulating quality did not work so well after a few washing cycles
- She would prefer the prototype over the Thermoglove
- She doesn't trust Uniqknits due to experience with Thinsulate

Interest
- She would be interested in these gloves if they were on the market
- She would wear it to work
- She would also be interested in a pair of sporty looking outer gloves for walking the dog

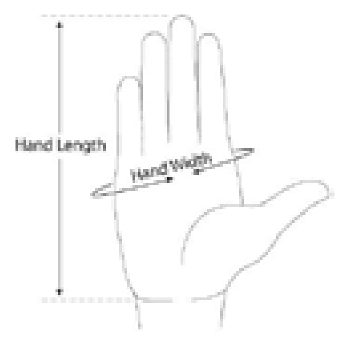
Pricing
- €80 is a good price

Verwarmde Handschoenen Test

TU Delft

Naam: Dorien	Leeftijd: 31	♀

✓ Toestemming foto	✓ Toestemming video recording	✓ Toestemming audio recording

	Hand lengte: 18 Hand breedte: 18.5

Eerst werd dorien gevraagd de handschoenen aan te trekken en aan te zetten. Vervolgens loopt ze buiten een rondje van 5 minuten. De buitentemperatuur is 10 graden celcius.

''Oh even mn jas aan''
''Heb het nu al warm in ieder geval''

Jas kan over de handschoenen heen
Knopje aanzetten gaat lastig met de over-handschoenen aan. ''Beetje lastig, maar het lukt wel.''

Dorien wordt gevraagd een formulier in te vullen op mijn computer terwijl ze nog steeds de handschoenen draagt. Dit formulier vraagt om haar naam, leeftijd en toestemming voor foto, video en audio recording.

Zou je mij iets kunnen vertellen over jouw ervaringen met Raynaud's?

Ja. Ik heb er niet hele erge last van. Wel erg veel last van koude handen maar het wordt steeds minder dat ik echt hele blauwe en witte vingers krijg. Maar dan worden ze ook gewoon vrij gevoelloos en dan is het lastig om er dingen mee te doen. Ik heb nu meestal gewoon hele koude handen, en dat kan zijn als ik mijn handen was met koud water ofzo dat ik echt al hele koude handen krijg. Maar ook gewoon zo eigenlijk.

Nu heb ik hele warme handen.

Nou waar ik nu bijvoorbeeld vaak hele koude handen heb is in de auto. Omdat het stuur dan heel koud is. En dan kan ik eigenlijk nauwelijks het stuur vastpakken omdat dan gelijk al koude vingers krijg.

Verder is het vooral vaak lastig dat als je zo hele koude handen hebt dat het dan ook niet lekker is om ze onder de warme kraan te stoppen omdat dat dan echt zeer doet. Dus dan is het lastig om ze op te warmen, want ja je eigen handen zijn koud.

En gewoon buiten. Dan heb ik heel snel koude handen. En dan bijvoorbeeld met skiën heb ik altijd koude handen. Ook al heb ik onderhandschoentjes en handschoenen er overheen. Dan heb ik nog koude handen. Dus dan zou het heel handig zijn denk ik.

Heb je ooit eerder verwarmde handschoenen geprobeerd?

Nee. Ik heb dus wel dubbele handschoenen. Maar geen elektrische handschoenen. Wel van die zakjes met spul erin dat dan warm wordt als je het kneedt. En dat dan in je handschoen doet, of in je schoen, om dan een beetje warme handen of voeten te krijgen.

Ze werken op zich wel maar dan krijg ik nog steeds koude handen. Op een gegeven moment moet ik dan gewoon mijn vingers bij elkaar doen zeg maar, en dan op dat dingetje, en dan kunnen ze wel weer een beetje warm worden.

Warmden de handschoenen voldoende op?

Ik vond ze niet heel warm aanvoelen, maar ik had absoluut geen koude handen. En ik had net hele warme handen. Dus ja. Het is ook niet heel koud buiten dus ik weet niet.

Ik vond vooral hierzo (wijst plaats aan op de duim) warmte.

Ik had niet in ieder geval het idee dat het te warm was ofzo. Ik vond ze voor nu prima. Maar ik kan moeilijk zeggen of als het echt kouder is of dat dan ook zo is.

Op welke plek zou je willen dat de handschoenen het warmst zijn?

Bij de vingertoppen. Tenminste, die worden bij mij altijd het snelst koud. Juist de toppen die hier nu niet verwarmd zijn.

Zou je liever handschoenen hebben met vingertoppen waarmee je iets minder goed kan typen?
Ja dat hangt denk ik een beetje af van wat je doel is inderdaad. Als je ze echt achter de computer wil gebruiken dan snap ik wel dat het handiger is om geen vingertoppen te hebben. Voor buiten zou ik eerder liever wel juist warme vingertoppen hebben.

Zou je interesse hebben in handschoenen voor achter de computer of eerder in handschoenen voor buiten?

Ja mijn eerste gedachte zou zijn voor buiten, maar op zich, als ik er over nadenk heb ik wel vaak koude handen achter de computer, dus zou het eigenlijk wel heel handig zijn.

Zou je het handig vinden om de warmte te kunnen instellen?

Ja op zich wel. Ik denk zeker dat als je ze voor binnen en buiten gebruikt dat, nou ja, binnen is het vaak toch wat warmer dan buiten dus dan heb je misschien wat minder extra warmte nodig dan buiten.

Nou heb je natuurlijk buiten wel die extra handschoentjes nog eroverheen dus is het misschien sowieso al warmer. Maar ja, ik denk wel.

Hoe vind je dat ze zitten? Kun je je vingers goed bewegen en dingen doen?

Ja. Die over-handschoenen waren eigenlijk voor mij een beetje groot. Beetje te lange vingers waardoor je dan niet zo veel gevoel meer hebt om iets te kunnen doen ermee. Maar verder wel prima.

De vingertoppen zijn nu van verschillende lengten. Heb je een lengte die je prettig vind?

Dorien trekt de handschoenen opnieuw aan om te kijken. Ze drukt met haar vingertoppen op de tafel om de randjes van de handschoen te testen.

Deze is te lang. Omdat het randje dan, dat is natuurlijk wat dikker door het stiksel ook, en dan zit ie daar op eigenlijk, in plaats van op je vinger.

Zo is het wel prima eigenlijk ***wijst naar ringvinger***. Eigenlijk een beetje meer richting ***wijst plaats aan tussen eerste en tweede vingerkootje van de ringvinger.***

Ik zag dat je net een beetje moeite had met de handschoen aanzetten.

Ja het is makkelijker als je hem aanzet als je deze alleen aan hebt denk ik, natuurlijk. Want dan heb je je vingertoppen vrij.

Wat wel zo is dat als je echt hele koude handen hebt dan zijn ze ook een beetje gevoelloos. Dan is zo'n kleine dat is moeilijk dat is om dat dan daar iets mee te doen. ***Gebruikt het knopje om de handschoen aan en uit te zetten.*** Qua knopje dan zeg maar.

Zou je dan een grote knopje willen? Of iets anders?

Ik denk vooral ook dat, dit knopje zit er best wel in, hij steekt niet echt uit. Dat is aan de ene kant wel handig want dan kan je hem niet per ongeluk aan en uit zetten. Maar daardoor is het wel weer moeilijker om erbij te komen.

Zit de batterij ok? Wat vind je van het comfort?

Ja die voelde ik eigenlijk niet echt zitten.

Deze batterij zou in theorie 2 uur warmte kunnen geven. Wat vind je daarvan?

Het is niet heel lang denk ik. Maar voor mij zou het in de meeste gevallen wel lang genoeg zijn.

Zou je liever een dunne handschoen met een dikke batterij hebben of een dikke handschoen met een dunnere batterij?

Ik denk eerder een kleinere batterij ten opzichte van een grotere batterij. Omdat het anders ook gewoon zwaarder wordt en dat je het meer voelt zitten.

Vind je het handig dat ze opladen aan de computer? Zou je dit misschien anders willen doen?

Zeker als je ze gebruikt voor je computer lijkt dat me wel handig. En, ja, ik neem aan dat je op zich kun je dit natuurlijk ook gewoon op een stekkertje aansluiten. Dan kun je hem ook gewoon aan het stopcontact aansluiten.
Wat vind je van hoe ze er uit zien?

Op zich prima.

De kleur bijvoorbeeld?

Nee het maakt mij überhaupt niet zo heel veel uit nee.

En de stof, wat vind je daarvan?

Het is wel lekker dat het hier, zeg maar, wat zacht is ***wijst naar de ribbing stof die rond de pols zit.*** En het voelde prima.

Heb je nog andere stoffen die je zelf fijn vind? Je hebt bijvoorbeeld gebreid van katoen of je hebt leren handschoenen.

Ik heb nu zelf ook onderhandschoentjes van deze stof-achtig. En die vind ik wel fijn zitten. Ook omdat ze redelijk goed om je hand past zeg maar.

Zou je interesse hebben in dit soort handschoenen?

Ja op zich wel.

Voor wat voor situaties zou je graag dit soort handschoenen gebruiken?

Ja vooral voor buiten zou ik in de eerste instantie zeggen. Maar ja, wellicht ook wel voor achter de computer.

Heb je voor mij nog dingen die ik kan verbeteren?

Nouja, dat knopje dan dus.

Ja als je ze oplaad achter je computer dan zitten de draadjes wel een beetje in de weg als je typt. Hoe dat beter zou kunnen weet niet.

Het stekkertje zou ook nog naar een andere kant kunnen misschien?

Ja naar de zijkant, dat je dan aan beide kanten de draad hebt bijvoorbeeld. Dat hij er dan niet overheen loopt en niet in de weg zit.

Oh ja en wat ik merkte bij het aantrekken, dat als je deze aandoet en daarna die andere er overheen, dan kruipt dit zeg maar een beetje naar beneden. ***Wijst naar de randjes van de vingertoppen.***
Dus dan worden ze extra vingertoploos zeg maar. Dus dan heb je hier dan minder stof zitten en dan worden je vingertoppen dus minder verwarmd.

Je en ik kon dus niet zo heel veel met die overhandschoenen doen, maar dat kwam ook gewoon denk ik omdat ze te lang waren. Ja als je te grote handschoenen draagt dan kun je er sowieso niet zoveel mee doen denk ik. Ik denk dat als ze wel gewoon passen dat dat dan wel gewoon beter is.

Hand wordt opgemeten en resultaten genoteerd.

Pagina met bestaande producten wordt laten zien (Appendix 15, p. x-x).

Wat vind je van deze handschoenen?
Dorien bekijkt de handschoenen op de pagina.
Oh ja, die silver glove, daar heb ik wel eens van gehoord.

Ja, daar zit alleen geen zilver in.

Oh haha

Want hebben deze dan ook allemaal een binnenhandschoen? Of zijn dit gewoon handschoenen met verwarming er in? ***Wijst naar de Thermoglove***

Ze noemen deze handschoen zelf eigenlijk een binnenhandschoen.

Oh dus daar moet nog een handschoen overheen? Zo zien ze er niet uit.

Ja ze zien er wel wat professioneler uit dan dit zeg maar. Waar dat door komt, dat komt misschien ook omdat er een merk op zit.

Wat vind je van de prijzen?

Ik vind 230 euro wel heel duur.

Ik vind 80 euro nog wel een redelijke prijs. Voor een verwarmde handschoen. Tenminste, ja. Ik heb wel eens gekeken, dan zie je wel meer van dat soort prijzen. Op zich vind ik dat wel, want als je gewoon goede handschoenen koopt dan zijn die ook duur.

Hoeveel zou je voor niet-verwarmde handschoenen betalen?

Wel 50 euro ofzo.

Ze zijn ook allemaal zwart, zou dat jou iets uitmaken?

Nee.

En dit merk (Uniqknits) noemt zichzelf ook het fashionable alternatief.

Ja dat zie je. Ja zoals ze er uit zien lijkt het meer gewoon katoenen handschoentjes die je ook bij de Xenos koopt zeg maar. Zou niet mijn eerste keus zijn.

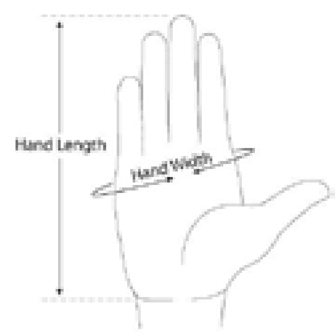
Heb je nog andere vragen of suggesties voor mij?

Niet echt eigenlijk. Wat is je doel zeg maar, met deze vragen en dit prototype hierna?

Verwarmde Handschoenen Test

Naam: Kelly	Leeftijd: 26	♀

✓ Toestemming foto	✓ Toestemming video recording	✓ Toestemming audio recording

	Hand lengte: 16 Hand breedte: 19 Pols: 14.5

Kun je me iets vertellen over jouw Raynaud's en op wat voor manieren dat lastig voor je is?

Ik zit een beetje gek in elkaar. Ik heb allerlei aandoeningen en blessures waaronder ook een polsblessure. En ik heb er sowieso heel snel last van als het koud weer wordt dat mijn gewrichten dan gewoon echt veel pijn gaan doen. Ze zijn in het ziekenhuis nu bezig met kijken bij een Reumatoloog of ik EDS heb, dat zou er mee te maken kunnen hebben maar ik merk het in ieder geval zelf wel.

Ik heb niet dat, hoe zei je dat het heette? Raynaud's? Als de auto? Ik heb geen Raynaud's maar wat ik wel heb zijn blessures en waarschijnlijk Ehlers-Danlos syndroom. Dat houd in dat ik met kou in ieder geval erg veel last krijg van mijn gewrichten, veel pijn-steken heb, en dan voornamelijk in mijn polsen en mijn knieen.

En ja, met handschoenen en armwarmers enzo, ik heb het zelf eigenlijk altijd warm, dus wat dat betreft ben ik, ja. Handschoenen die helemaal dicht zijn zijn nooit fijn. Maar ik heb ze wel nodig voor mijn polsen. En met deze merk ik dat juist omdat hij om je pols best wel strak zit dat dat best wel fijn aanvoelt. Dat geeft voor mij ook, in ieder geval het gevoel alsof het verstevigd. En dat plaatje er bovenop dat voelt voor mij eigenlijk alleen maar fijn omdat ik een polsblessure heb. En doordat het daar die warmte afgeeft, ja, dat helpt echt enorm. Daardoor heb ik een stuk minder last als ik buiten loop. En juist omdat die vingertoppen ook gewoon vrij zijn geeft dat ook wel weer genoeg afkoeling voor de rest van mijn handen.

Met typen werkt dat ook echt ideaal omdat je vingertoppen vrij zijn. Zo kun je natuurlijk ook nog gewoon op je telefoon zitten en dat soort dingen. Ja misschien zouden ze dan, ik heb niet zulke grote handen, voor mij iets korter mogen. Maar verder, echt, best wel goed ontwerp.

En heb je wel eens eerder verwarmde handschoenen geprobeerd?

Ja, alleen niet dan niet zo zeg maar. Alleen met die koperen deeltjes erin, dat het gewoon, zelf een beetje warm is. Een soort acupunctuur met magneetjes zeg maar. Dat is een beetje het idee waar ze het over hebben. Dus niet op deze manier nee.

Weet je hoe dat werkt?

Nee niet helemaal. Haha. Je hebt zeg maar wel met acupunctuur dan doen ze met van die kleine ronde pleistertjes met een naaldje en als je dan een paar keer op drukt gaat alles weer activeren daar. En dan gaat de bloedstroming wordt dan weer iets beter waardoor je handen warm kunnen worden. En dat hebben ze soms ook met van die kleine pleistertjes met magneetjes erin en dat werkt ook. En volgens mij zitten die magneetjes dan in die handschoenen waardoor, blijkbaar, dus weer iets betere doorstroming krijgt.

Wat had je toen voor die handschoenen betaald?

Een euro ofzo, die komen uit china, haha.

En vond je ze dat waard?

Ja ik dacht ik kan het altijd proberen.

Je had het prototype net aan, vond je dat ze voldoende opwarmden?

Ja, zeker.

Vond je het ook snel genoeg?

Ja je merkt het ook meteen. Tenminste ik deed hem aan en dan merk je al best wel snel dat het verwarmde. Het scheelt misschien ook wel dat er iets op je hand zit, natuurlijk, wat al warmer is. Maar ja, voor mijn gevoel werkte het snel.
Voelde je verschil tussen de twee handschoenen?

Nee, dat niet.

Had je een bepaalde plek waar je de warmte voelde?

Nee, niet zo over nagedacht.

Deze hebben nu maar één stand, ze kunnen aan of uit. Denk je dat het handig is om ze te kunnen instellen?

Mwah. Ik denk dat mensen voor binnen en buiten iets anders willen, maar daar heb je die extra handschoenen al voor. Dus ik denk eigenlijk niet dat dat nodig is. Wie weet.

Hoe vind je dat ze zitten?

Oh echt super chill. Ze zakken echt totaal niet af waar ik van die gewone handschoenen heb je normaal dat dit, tussen je vingers zeg maar, dat dat zo terugzakt omhoog. En bij deze blijft het gewoon goed zitten dus dat is echt super chill. Dus dat vind ik juist fijn.

Voor mij zijn ze misschien net iets te lang. Tenminste, voor mijn pink dan. Maar verder juist heel relaxed. Juist ook omdat je vingertoppen vrij zijn.

Dus je kan je vingers goed bewegen enzo?

Ja en juist fijn dat het een beetje elastisch materiaal is. Ze zitten wat strakker, blijven gewoon goed zitten.

De vingertoppen zijn nu nog een beetje verschillend. Waar zou jij graag willen dat die zou eindigen?

Denk ik hierzo. ***Wijst naar plaats onder eerste vingerkootje van de wijsvinger.*** Of net onder dat.
Ja, net er op of er onder.

De schakelaar is nu zo, vind je hem goed? Kun je er goed bij? Kun je hem goed aan en uit zetten?

Ja hoor. En het is, ja, ik denk dat als je hem iets groter maakt dat je hem dan heel gauw per ongeluk aan of uit zet. En nu is het gewoon van, ok, je zet hem aan, en het is prima. En je zet hem uit en het is ook prima.

En je zei net over de batterij dat die bij jou?

Ja voor mij is dat juist chill.

Dus het zit eigenlijk wel comfortabel?

Ja. Ja sowieso ik denk dat als je hem inderdaad er bovenop doet dat dat echt het meest relaxed is. Want aan de zijkant, ja, dat is voor de meeste mensen denk ik niet fijn. En aan de onderkant is vervelend als je gaat typen of iets wil doen. De bovenkant is echt perfect. En hij zit ook onder je scharnierpunt dus daar heb je ook geen last van. Dus ik denk dat hij helemaal goed zit daar.

Het is altijd een afweging hoeveel warmte je kan produceren en hoe groot je batterij is. Deze batterij kunnen ze in theorie ongeveer twee uur verwarmen. Denk je dat dat genoeg is?

Ja denk het wel. Want als je binnen zit dan kun je ze toch aan de lader gooien. Eventueel. In ieder geval wel als je aan het typen bent. Dan kun je ze beter gewoon aan de oplader laten.

Wat dan misschien wel handig is om twee aparte dingetjes te hebben dat je ze aan allebei de kanten van je computer kan laden. Anders zit je over je draadje heen te typen.

Dus hoe zou jij hem doen?

Dus zeg maar éëntje aan deze kant en éëntje aan de andere kant.

Dus die komt dan zo er achterlangs?

Oh dat kan ook nog. Ja of twee usb's.

Maar je kan inderdaad ook gewoon lang genoeg maken dat er eentje omheen kan. Net zoals oortjes, dat heb je ook wel eens. Dat er eentje langer is dan de ander en dat je hem dan achter je rug kan doen. Dat zou misschien een idee zijn. Dat ze je kan laden tijdens het typen in ieder geval.

Mocht je ze aan willen hebben tijdens het typen natuurlijk.

En hoe vind je dat ze er uit zien?

Ja ik vind ze best wel cool. Zeker ook met deze ***Pakt de buitenhandschoen.*** Met die gaatjes dat vind ik best wel vet eigenlijk.

Ja ik denk ook, zeker als je ander kleurtjes heb dat mensen vaak dingen gaan combineren. En dat je ook verschillende designs kan maken voor die overhandschoen. Dat mensen dat ook leuk kunnen combineren met andere kleurtjes. Denk dat dat wel cool is.

Wat voor kleuren zou jij leuk vinden?

Nou ik vind deze kleurencombinatie eigenlijk wel cool. Maar, je kan bijvoorbeeld ook een felle kleur aan de binnenkant doen. Zoals knaloranje. Dat is ook wel vet.

En wat vind je van de stof, van het materiaal?

Ja heel fijn.

En heb je zelf andere materialen die je fijn vind? Bijvoorbeeld gebreide dingen of leren dingen.

Ik vind deze eigenlijk wel fijn want warm maar het gaat niet meteen zo zweten. En met van die goedkope handschoentjes, die gebreide, dan heb je dat snel dat dat wel gaat zweten enzo.

En die zijn ook niet waterdicht. Nou weet ik niet of deze dat wel zijn. Geen idee.

De buitenhandschoenen zijn in theorie waterafstotend maar dat is nog niet getest.

Zou jij eventueel interesse hebben in dat soort handschoenen als het een echt product was?

Ja. Ja ik denk het wel.

Voor wat voor situaties zou je dat dan handig vinden?

Op een motor bijvoorbeeld. Ik ben nu veel aan het motorrijden. En ik merk gewoon dat dat met mijn handschoenen niet warm genoeg is. Zeker niet in de regen en alles. Dus als die er onder zouden kunnen dan zou dat wel ideaal zijn. En dan hoef je ook geen verwarmde handvatten aan te schaffen en te kloten aan je motor. Dan heb je gewoon twee handschoenen die werken. En meestal als je gaat rijden in echt koud weer dan doe je dat ook niet langer dan twee uur. Want dat doe je ook niet voor je plezier. Een beetje, haha, maar op een gegeven moment houdt het op. Desnoods maak je tussendoor een tussenstop want dat wil je sowieso als je twee uur in de regen zit. Dan ga je gewoon ergens een bakje koffie doen en je kan tegenwoordig overal je telefoon opladen dus waarom niet je handschoenen.

Ik ben natuurlijk heel erg op zoek naar hoe ik ze beter kan maken. Dus welke dingen zou jij eraan verbeteren?

Ik denk, ik zat net even te spelen met de oplader, en dat dat aan deze kant zit. Als je ze aan hebt is het moeilijk om hem er in te doen omdat je hem dan tegen moet houden. Dus ik zat een beetje zo, dat ging wel. Maar dat zou misschien makkelijker kunnen.

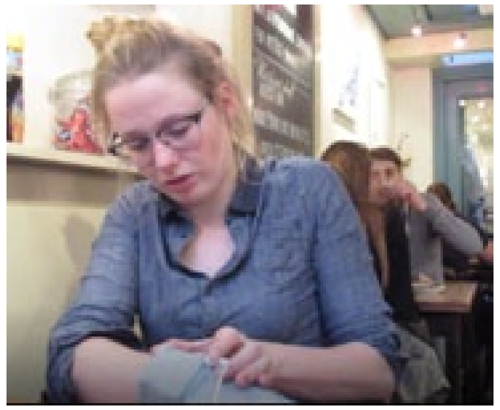
Ja ik ben bang om hier doorheen te drukken. Voor het geval dat ie er uit valt ofzo. En het zit natuurlijk niet vast aan de stof zelf. Dus dan ben je al gauw bang dat die zeg maar verder doordrukt.

Maar verder niet echt eigenlijk.

Zou je hem dan bijvoorbeeld onder een andere hoek doen, of?

Trekt binnenhandschoen opnieuw aan. Even kijken hoor.

Aan de onderkant is op zich wel makkelijker want dan kan je je vingers er op leggen en dan kan je er in duwen. Zoals nu is het lastig omdat je dan andersom zit met je handen. En dat is bij de onderkant vaak net iets makkelijker.



Ander doe ik zo, en dat is best wel lastig kracht zetten.

Anders kan je hem zo doen. En dan kan je iets makkelijker kracht zetten want dan kan je je duim hierop houden.

En zou dat nog steeds ok zijn met het typen?
Ja ik denk dat dat eigenlijk alleen maar relaxter is. Want dan zitten de draadjes niet hier in de weg, dan kom je niet in de war met typen. Dus het is eigenlijk misschien nog wel beter zo.

Of aan de zijkant, zou ook kunnen. Dan wel aan de buitenkant, niet aan de binnenkant. Binnenkant is wel makkelijker inprikken trouwens.

Of gewoon zo er op, nee, haha. Dat niet.

Nee ik denk dat de onderkant geen verkeerd idee is. Als dat kan. Je zit natuurlijk ook met je aan/uit knopje.

Ja op zich. Je kan het aan/uit knopje ook natuurlijk hier doen. Je moet wel zorgen dat je hem niet zelf aan/uit zet. ***Scharnier hand op en neer.*** Klik aan, klik uit.

En ook best wel handig dat dat lichtje er in zit. Want dan weet je gewoon wanneer ie aan staat en wanneer niet.

Vind je het lichtje niet te fel of opvallend?

Nee. Ja je kan er een rood lampje van maken dan is ie wat minder opvallend maar ik vind het niet storend in ieder geval.

Stel dat je er meer warmte uit zou willen halen. Dan kan je ervoor kiezen een grotere batterij te doen of om ze dikker te maken. Welk van die dingen zou jij beter vinden?

Ik denk, grotere batterij. Want die stof is nu best wel relaxed zeg maar. Ik denk dat dikkere handschoenen op zich het niet echt veel beter maken want anders hadden mensen dat nu ook al gedaan en dan waren ze niet op zoek zijn geweest naar verwarmde handschoenen. Dus ik denk dat dan de batterij iets groter moet.

Ik heb hier afbeeldingen van bestaande verwarmde handschoenen van andere merken.

Zo, groot prijsverschil. Holy moly.

Wat vind je van de prijs?

Ten eerste, ik had echt geen idee wat ik kon verwachten. Maar ik vind de tweede wel echt belachelijk duur. Is die eerste is dat per stuk of per paar?

Per paar.

Ja toch. Er staat er maar een op de foto, je weet het niet, haha. Ja het prijsverschil is zo groot. Ja jeetje, bizar.

Wat vind je een redelijke prijs?

Ja, je zal toch wel gauw in de buurt komen van die eerste prijs denk ik. Ik denk zeker wel dat je, dat 50 euro wel echt het minimum is denk ik.

Van, als je hem maakt bedoel je?

Stel dat je het echt gaat produceren dan denk ik niet dat je het voor minder dan 50 kan verkopen om de kosten er uit te halen.

Maar als je het bekijkt vanuit de persoon die het misschien wil kopen? Wat zou je er zelf voor willen betalen, even los van wat het kost.

Ja ok. Ja ik probeer altijd ook een beetje van de andere kant te kijken natuurlijk. Dus ik zou 50 euro sowieso geen probleem vinden om daar aan uit te geven. Als het me echt zou helpen inderdaad.

Met deze handschoen zeggen ze nog dat je daar nog een handschoen overheen zou kunnen doen (Thermoglove)

Oh zo ziet hij er niet uit. Het ziet er echt uit als zo'n wintersporthandschoen.

Hier heb je ook deze, die zijn voor op de motor. Dus die zijn misschien voor jou wel interessant. Die kan je aan je accu aansluiten.

Geniaal. Oh die ziet er ook uit alsof die er niet onder kunnen.

Deze zijn ook inderdaad over. Maar je hebt ook onder die dunner zijn.

Ja dat is dus zo fijn aan deze dat ze zo dun zijn.

Zoals je ziet zijn ze allemaal zwart, alleen deze is grijs. Zou dat voor jou iets uitmaken?

Nee. Zolang ze niet knalroze zijn.

Deze twee merken zijn er ook nog. Die zijn alletwee niet verwarmd. Maar die worden wel aangeraden voor Raynaud's en reuma. En deze zijn met druk, en deze zijn met, ze zeggen dat ze een soort van super isolerende laag hebben. Maar ze zegge niet echt hoe het werkt. Zij noemen zichzelf ook meer het fashionable alternatief. Wat vind je van dit soort handschoenen?

Nou die onderste is gebreid (Uniqknits) dat lijkt mij niet heel fijn. Dat gaat jeuken en dat gaat wel zweten. Tenminste, bij mij.

Die daarboven lijkt me iets chiller. Ik weet niet of ze echt gebreid zijn maar ze zien er in ieder geval een stuk relaxter uit. Ook omdat de vingertoppen vrij zijn.

Die lijken me helemaal niks, die grijze (Warmawear).

Waarom niet?

Nou ze zien eruit alsof ze heel los zitten en ik heb best wel kleine handjes dus voor mij zit al heel snel iets los. Dus dat lijkt me niet fijn. En voor binnen is het denk ik ook niks want dan heb je juist nodig dat hij strak zit zodat je dingen kan oppakken enzo en je hebt je vingertoppen gewoon nodig. Ik zie wel dat er zo'n touchpad op zit maar toch werkt dat nooit echt helemaal relaxed. Dus dat lijkt mij in ieder geval niks.

Ja en die daarboven zijn allemaal heel erg grote motorhandschoenen dat is voor binnen sowieso niet zo relaxed. Oh dat waren ze al.
Nee voor mij lijkt het binnen ook wel echt juist heel chill om ze te hebben. Ook om zeker met werk om wat dan ook. Ik merk gewoon dat als het echt koud is dat ik ook af en toe mijn vingers echt niet meer kan bewegen. Ook al zit ik binnen en doe ik even niks

19:04