Health

Emilia Barakova

BREATHE - A - BEAR

Written By

Bente Elst - 1451189
Kira Jansen - 1699350
Siddharth Mahadevan - 1693670

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INTRODUCTION

Roughly 1 out of 100 [1] children have autism spectrum disorder (also referred to as ASD). Most people tend to have 125 [2] people in their social radius, which means that there's at least one person we all might know who has ASD. But what exactly is ASD? ASD is a neurodevelopmental disorder, which is characterized by deficiency in social communication as well as the presence of restricted interests and repetitive behaviour. The disorder is influenced by both genetic and environmental factors that are affecting the developing brain. There are some co-occurring conditions in ASD that include for example attention deficit/hyperactivity disorder (ADHD), obsessive compulsive disorder and mood disorders and anxiety. For children with ASD, the rate of anxiety disorder was found to be around 42% [3]. In general, children with ASD experience anxiety and stress much more intensely than children without ASD. As autistic children are very keen on their routine, small changes and disruptions might already cause a lot of stress. This also holds for unfamiliar or unpredictable situations. In addition, the deficit in social communication also makes it difficult for these children to understand other people's emotions, as well as communicating their own feelings [4].
They show stress through various behavioural characteristics. Examples are stimming, repetitive behaviour and resistance to changes in routine. Other ways stress can be recognized is by a lack of sleep, meltdowns/outbursts and withdrawn from social situations.

The Design Challenge

"Design a product that helps children with ASD from the age 4 to 8 to manage their stress and anxiety in a school setting."

[1] World Health Organisation

[2] Hill, R.A., Dunbar, R.I.M. Social network size in humans. Hum Nat 14, 53–72 (2003). https://doi.org/10.1007/s12110-003-1016-y

[3] Hodges H, Fealko C, Soares N. Autism spectrum disorder: definition, epidemiology, causes, and clinical evaluation. Transl Pediatr. 2020 Feb;9(Suppl 1):S55-S65. doi: 10.21037/tp.2019.09.09. PMID: 32206584; PMCID: PMC7082249.

[4] https://raisingchildren.net.au/autism/health-wellbeing/mental-health/anxiety-asd

Breathe-a-Bear

RESEARCH

Hence, more research was done on the topic. The group started with the question: how ASD as a diagnosis interacts with stress. According to raisingchildren.net.au [4], children with ASD experience stress and stressful situations much more intensely as compared to neurotypical children, or children displaying no atypical behaviours. Some experiences which may cause stress are disruptions in routine, unfamiliar or unpredictable social situations, and unfamiliar or unpleasant physical feelings or thoughts.

Corbett Blythe A., Muscatello Rachael A., Blain Scott D. (2016) [5] explores researches which explain how neurodivergent children tend to experience a significantly higher level of stress during peer-to-peer interactions, and builds on it through research into cortisol levels. Cortisol was related to higher sensory sensitivity, as well as more stress in different contexts. Children with ASD were shown to have higher physiological arousal, which correlates to cortisol levels, during play.

When it comes to de-escalating levels of stress in neurodivergent children, there are many ways that provide different levels of comfort to different children. For example, McCormack, G. L., & Holsinger, L. (2016) [6] found that, as compared to neurotypical children whose mothers reported physical touch more calming, those of neurodivergent children found that audio-visual stimuli were the most calming. However, it is to be noted that this does not apply to all neurodivergent children, and the paper makes a broad generalisation this group are “more difficult to calm”. This led to the mild doubt about the perspectives that researches view neurodivergence from, and how these perspectives generally tend to view neurodivergence as a handicap as compared to it being seen as a characteristic. Moreover, they do not acknowledge the fact that these affect different people differently, and how the child exhibits calmness does not necessarily denote calmness. It was also interesting to note that another category wherein neurodivergent children exhibited more calmness as a result of, was object.

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[5] Corbett Blythe A., Muscatello Rachael A., Blain Scott D. Impact of Sensory Sensitivity on Physiological Stress Response and Novel Peer Interaction in Children with and without Autism Spectrum Disorder Frontiers in Neuroscience Volume 10, 2016 10.3389/fnins.2016.00278 ISSN=1662-453X

[6] McCormack, G. L., & Holsinger, L. (2016). The Significance of Comforting Touch to Children with Autism: Sensory Processing Implications for Occupational Therapy. The Open Journal of Occupational Therapy, 4(2).

Another research looking into stress de-escalation was done by Burke A. (2014) [7], which conducted a longitudinal case study of 7 year old individual with ASD. A 5 point scale to indicate stress levels was created and used by the case study subject, before and after weekly 20-minute Zen Shiatsu sessions, which ran for 6 weeks. What was found was that this did, in fact, reduce stress levels. However, the sample size is immensely small, as therefore holds little ecological validity. Moreover, there is potential for confirmation bias and leading questions. Although, one interesting observation involves the sense of touch, as it claimed to be important to reduce stress. It quiets the sympathetic division of the nervous system that responds to fight or flight. By stimulating the parasympathetic nervous system, stress hormones decrease and the immune system is strengthened, and it is important for self-regulation. Touch between child and parent can also strengthen their bond. Although these claims are backed by the Centre for Spirituality and Healing wing of the University of Minnesota, there is little when it comes to scientific backing, and there are many account of it causing pain in many individuals. Although the point of touch is definitely an interesting point of note, the research overall is less than comfortable to use as a base for using a form of massage as a product.

de Moura IR, Teles AS, Endler M, Coutinho LR, da Silva e Silva FJ (2021) [8] conducted a research into a pattern recognition software to more appropriately understand behavioural changes, as a tool to support mental health professionals. The team found this to be an interesting approach when it comes to recognising behavioural changes in children, and recognising whether or not certain events led to behavioural changes which correlate to higher stress levels. This is a useful tool, and the group thought this to bring together parental bonds with the children, which was an avenue that was explored in ideation and idea development.
When researching for this project, it should also be mentioned that the base idea of stress management with an everyday object for children with ASD is not entirely the group's own ideation, as it is an adaptation from a previous project, Li, J., Barakova, E., Hu, J., Staal, W., van Dongen-Boomsma, M. (2022) [9], that was taken in a different direction and iterated upon. Whilst the original investigation designed a pen that, using sensors in place in the pen, detects levels of stress within the child using handholding pressure. Then, it gives feedback through vibration and lights, to alert either the user or their caretaker about this. Where the designers diverge is that the group put this control of when comfort is needed in the hands of the child, as they would know when they feel bad and need comfort best.

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[7] Burke A. Zen shiatsu: a longitudinal case study measuring stress reduction in a child with autism spectrum disorder. Int J Ther Massage Bodywork. 2014 Dec 2;7(4):23-8. PMID: 25452821; PMCID: PMC4240698.

[8] de Moura IR, Teles AS, Endler M, Coutinho LR, da Silva e Silva FJ. Recognizing Context-Aware Human Sociability Patterns Using Pervasive Monitoring for Supporting Mental Health Professionals. Sensors. 2021; 21(1):86. https://doi.org/10.3390/s21010086

[9] Li, J., Barakova, E., Hu, J., Staal, W., van Dongen-Boomsma, M. (2022). ApEn: A Stress-Aware Pen for Children with Autism Spectrum Disorder. In: Ferrández Vicente, J.M., Álvarez-Sánchez, J.R., de la Paz López, F., Adeli, H. (eds) Artificial Intelligence in Neuroscience: Affective Analysis and Health Applications. IWINAC 2022. Lecture Notes in Computer Science, vol 13258. Springer, Cham. https://doi.org/10.1007/978-3-031-06242-1_28

However, this notion of light and colour paved the path to research discussion the colour preferences amongst neurodivergent boys versus neurotypical boys. Grandgeorge M, Masataka N. (2016) [10] published a paper on exactly this, which demonstrated the fact that, overall, neurodivergent children held a preference towards more muted colours, like green and brown, and held an aversion to colours like yellow as they found it to be overstimulating. This was something the group kept in mind while designing our product.

A project that looked into a similar field as this project was the Final Bachelor Project done by Sem Jordaan: OWN IT. This, designed for teenagers, is a vest which helps with overstimulation by expanding a contracting to provide breathing exercises. While this is definitely interesting and one train of thought, the group also found this method to be a bit too restrictive for children, and can feel stuffy as it can take away control form their hands.

Hence, taking all of these research notions, the designers found breathing and touch to be the best ways to provide the comfort that group B3 wanted to provide, in a way that would not interfere with the context provided of the formative years at school. These proved effective in stress de-escalation, as well as be a source of comfort, by simulating breathing, whilst not including other features, to thereby help the child the best, whenever they want.

[10] Grandgeorge M, Masataka N. Atypical Color Preference in Children with Autism Spectrum Disorder. Front Psychol. 2016 Dec 23;7:1976. doi: 10.3389/fpsyg.2016.01976. PMID: 28066297; PMCID: PMC5179595.

MARKET RESEARCH

Looking at what currently exists on the market, we find that there are a lot of products which claim to provide comfort, with varying levels of credibility. The first was a form of watch which claims to reduce stress by providing micro-vibrations at the push of a button [11]. This targets a different market than the one our product is aimed at. This evidently would not be appropriate for children, as generally, children might not want something that is always attached to them to provide comfort. Another product is like the one done by the aforementioned Sem Jordaan, which is a vest which you can fill with air to allegedly provide comfort [14]. This, for the reason mentioned above, would not work. There are options such as weighted blankets [12] and fidget toys, but as we are placing in the context of a school in the formative years of education, these would not work as direct competitors. However, what might work as indirect competitors would be products like the Boostiv Pulse [13], which is a device which pulses, which claims to help with falling asleep, chronic pain, stress, depression, etc. Another indirect competitor would be something like books which help manage stress, or even mood tracking apps. However, in a school setting, we found that a soft cuddly toy was the best option.

Fig 1-4: Clockwise:
- Watch with miicro-vibrations
- Weighted blanket
- Boostiv Pulse
- Inflatable vest

[11] https://thetouchpointsolution.com/products/touchpoints-for-calm

[12] https://www.latonablanket.nl/verzwaringsdeken-enkel.html?id=266081539&source=googlebase&gclid=CjwKCAiA2fmdBhBpEiwA4CcHzdjQZhkYhGRfKLmgnDvnI316xg0f8xIHuUg1uaBSedd0-q71vEQiVRoC9CgQAvD_BwE

[13] https://www.boostiv-brand.nl/products/boostiv-pulse-slaaptrainer

[14] https://www.squeasewear.com/shop/pressure-vest/

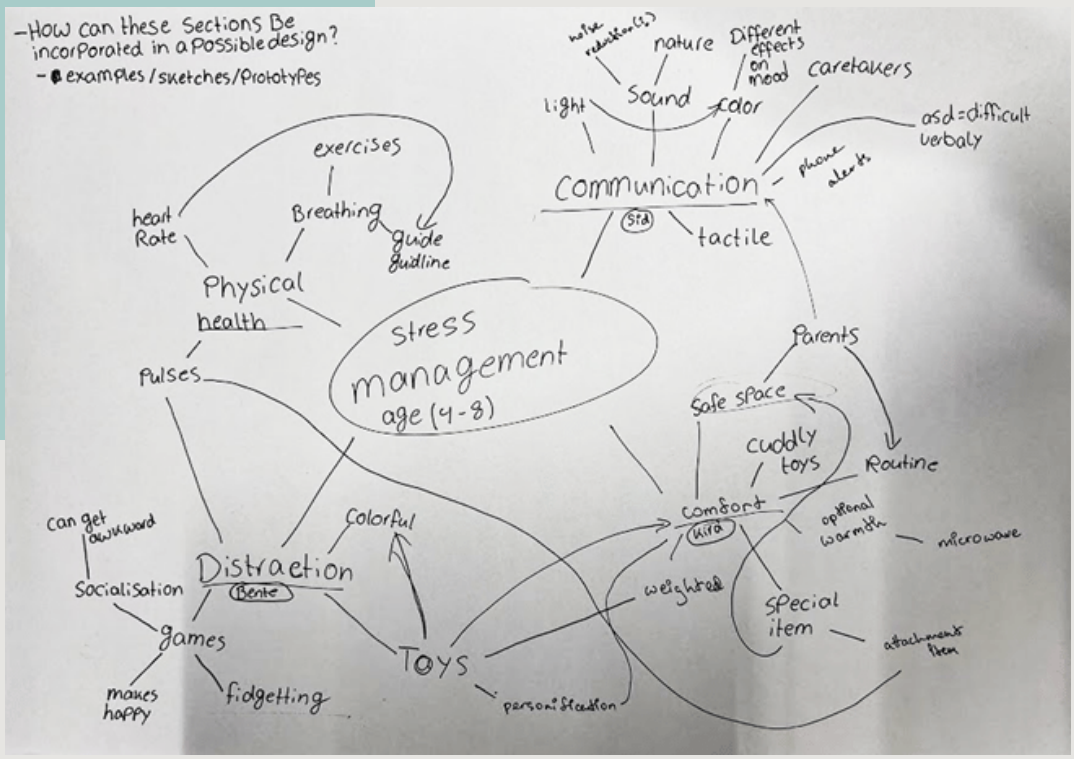


Figure 5 mindmap stress management

During multiple brainstorm sessions, various different concepts were created. The starting point was stress management in children with autism in a school setting. Then, multiple categories and contexts were discussed. The main ones are physical management (think about breathing exercises and heart rate), communication of stress, distraction from the stress and comforting when stressed.

As school is the context in which the product will be used, which is why distraction is the least applicable for the purpose of this product. You do not want to distract the children from their work, rather you want to make them feel more comforted within those stressed situations.

Communication could also be a useful area for the product, but again in a school context this is not ideal. It might distract the other children and it might make the child with ASD uncomfortable as it draws more attention to the child with ASD. Communication might be a good area to focus on when the children are not yet in a stressful situation, because this is already a skill that is very difficult for children with autism. This way it communicating is not unconsciously 'linked' to a stressful situation such as school.

Physical types of managing such as breathing exercises or guides are also not affective, since the age group is 4-8 and those ages are not fully capable of controlling their own breathing patterns and adapting this to a different pattern.

All this considered, the product will be focused on comfort. When thinking of comfort, a lot of aspects could be considered. Examples are routine, physical aspects such as warmth, weight, textures and personal aspects such as a special item and your parents. See figure 6.

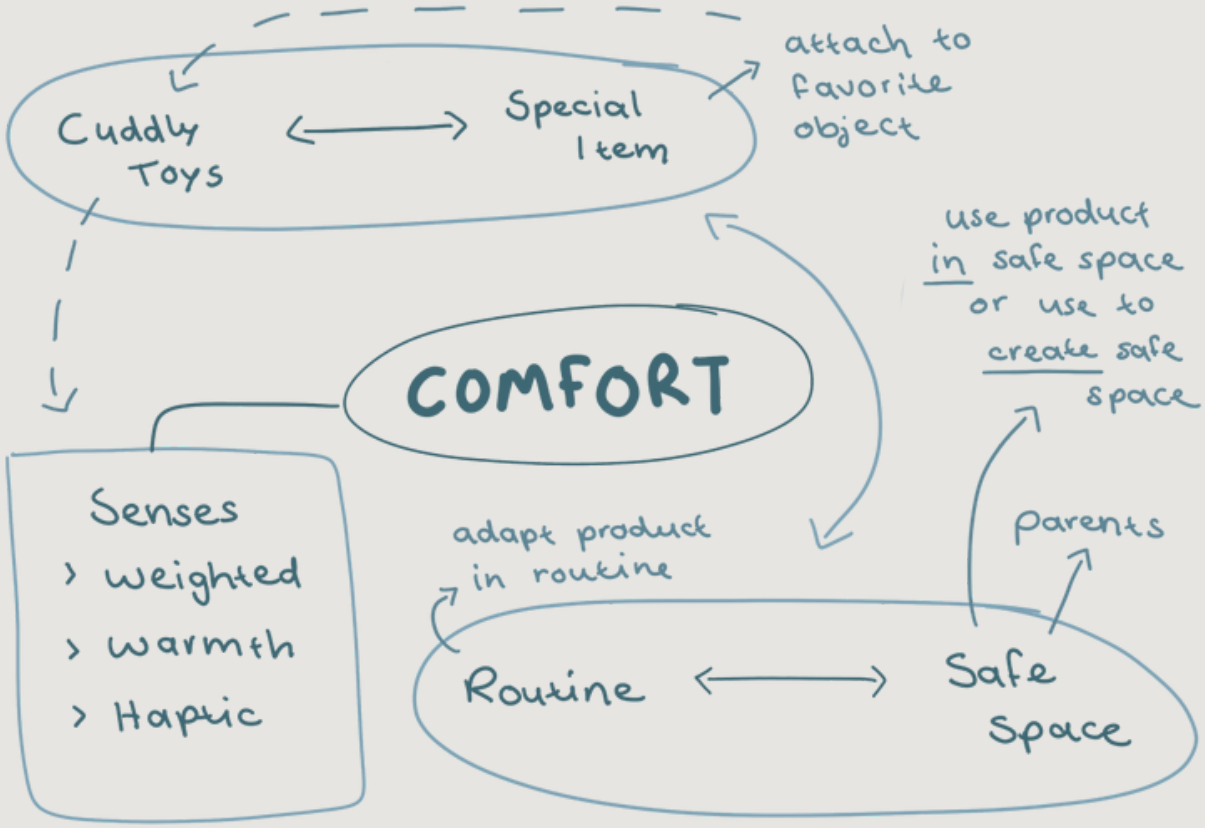
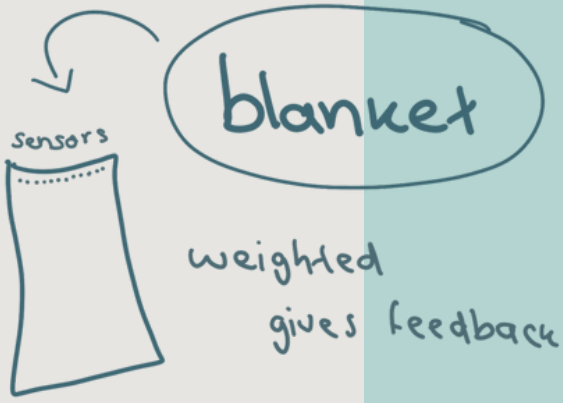


Figure 6 mindmap comfort for children with ASD

CONCEPTS

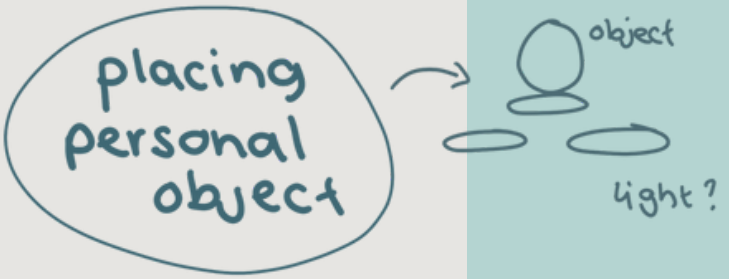
One of the initial concepts included a soft toy that would help bring comfort to the children. The soft toy could include aspects like warmth, weight and fidget toys.

Another concept was a stress cube that would also include fidgeting aspects. The communication part could also be included in this concept. Each side of the cube could also for example include different types of comfort (think about textures, warmth, light).



This concept is inspired by a weighted blanket. This concept could be expanded to a blanket that includes things like calming vibrations, warmth, light or fidgeting aspects.

This concept is a chair that is specifically designed for children with autism. It would be a soft chair, with calming textures.



This concept is not focused on comforting, but on communicating. The child could place a specific object on a smiley (ranging from very sad to very happy). This way the teacher could see how the child is feeling and if this feeling is bad, they could provide help.

The soft toy was chosen to be the starting point of the product. This, because it is already an existing, normal everyday object so the children would not feel abnormal. In addition, it is also a normal object to bring to school (instead of for example a blanket) and a cuddly toy in itself is already comforting.

Figure 7 exploration every day objects at school

ITERATIONS

The soft toy was chosen to be the starting point of the product. This, because it is already an existing, normal everyday object so the children would not feel abnormal. In addition, it is also a normal object to bring to school (instead of for example a blanket) and a cuddly toy in itself is already comforting.

Some iterations were made after defining the starting point.
The first iteration was adding fidget parts in the paws and feet of the plush toy. This could make them feel more comforted as they can shift their mindset towards the fidgets on the toy.

The second iteration completely focuses on comforting aspects. This would be a plush toy that heats up and is heavy.

The third iteration includes adding a breathing movement. As discussed in the research part, breathing movements are very calming for children with autism. The product could mimic this breathing movement. This concept could also include other comforting aspects such as weight and warmth. After some discussions, the third iteration was chosen, because it showed the most potential. It was decided not to focus on fidget toys, as this brings back the distraction aspect, which was already considered to be not efficient. In addition, only focussing on weight or warmth might be difficult for children to focus on. When you add movements (in this case a breathing movement) it might become more easy for the children to focus on this, as it easier to focus on movements rather than something that stays consistent such as weight.

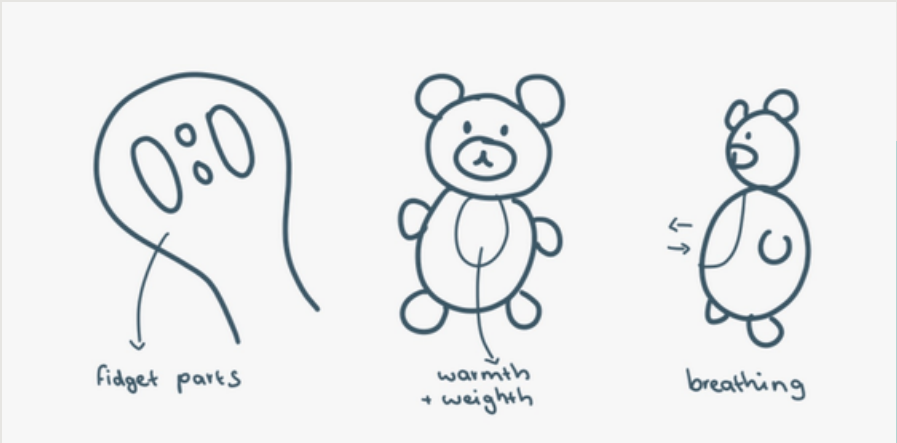


Figure 8 Iterations plush toy concept

CLIENT MEETING

This design project is based on a design brief from the clinic, Karakter.
Karakter is child-psychiatry clinic based in the Netherlands. The clinic focuses on helping children age 0 to 18 with Autism, ADHD, Depression, Anxiety, and other mental issues (Over Ons, n.d.) [15]. This means that Karakter has an expert knowledge on the targeted user group of the design.
Ten weeks into the project, a meeting was set up to discuss the design concept. This meeting was held with Wouter Staal (Wouter Staal, n.d.) [17] and Martine van Dongen-Boomsma (Onze Behandelaren, n.d.) [18]. One of the topics discussed, is the simplicity of the product, since simplicity is important in designing for a sensitive group like children with ASD. Another topic brought to the table was, the interaction with the product. This is important for the same reason simplicity is important, Autism spectrum disorder often causes oversensitivity to how things feel, interact or look (Tomchek et al., 2014) [16].
All questions and answers are shown in table 1 below.

Question	Answer
Is it best to only implement a breathing motion, or is it better to ad things in like a heartbeat and/or heating element?	I would just focus on the most basic, so like a breathing motion or heartbeat, and then just use one element, otherwise it may be to many stimuli. I like the idea of a breathing simulation more the other possible elements.
If the breathing motion is implemented, we have to use servo motors, these can be a bit noisy, will this be a problem for our target group?	I would try to make it as silent as possible, it depends on the individual child how much this will impact them.
We are considering three different options to turn the breathing mechanism on; a button in the nose, squeezing the toy or making it automated. What would you say is the best option?	I would not make it automated, this will take away the control of the kids, controlling what happens and when can act like an extra safety blanket.

Is 4 to 8 years old a relevant age group for our product?	I would possibly drop it to 2 or 3 years old, or make 4 to 8 more of a lose guideline.
How important is the texture and feel of the fabric in this product?	Textures are very important, some people with autism can be very sensitive to all types of stimuli and others can be very insensitive. So maybe you can look into making it personalized, where you can choose out of some fabric options.
Do you have any other comments on our design concept?	Maybe make it from a sustainability perspective, like making it washable. Look in to co-regulation with parents, maybe this is another angle you can take in your design.

Table 1 questions and answers client meeting

15] Over ons. (n.d.). Karakter. https://www.karakter.com/over-ons
[16] Tomchek, S. D., Huebner, R. A., & Dunn, W. (2014). Patterns of sensory processing in children with an autism spectrum disorder. Research in Autism Spectrum Disorders, 8(9), 1221. https://doi.org/10.1016/j.rasd.2014.06.006
[17] Wouter Staal. (n.d.). Karakter. https://www.karakter.com/opleiding-onderzoek/onderzoekers-en-opleiders/wouter-staal
[18] Onze behandelaren. (n.d.). Karakter. https://www.karakter.com/behandelaren/p4#dongen-boomsma-martine-van

EXPERT MEETINGS

Frank Delbressine

Delbressine has a background in engineering, mechanical design and manufacturing, and has authored or co-authored around 40 papers about precision engineering and mechanical design (Frank Delbressine, n.d.) [20].
A meeting with Frank Delbressine was set-up to discuss the technicalities of the breathing mechanism, since there was a little trouble with actualising the idea of the mechanism. During this meeting, a prototype of a moving 3D-printed ribcage was shown by Delbressine to use as inspiration. Another big part of this meeting existed out of discussing the motors to use for the mechanism. Due to the client meeting, the amount of sound the mechanism produces has become a big part of the design.
After this meeting, a sketch was drawn (Figure 9), inspired from the ribcage example, which acted as the starting point for the other mechanical concepts, including the final concept implemented in the prototype (Figure12).

Overall this meeting has been a big help in the brainstorm session to come up with a suitable mechanism.

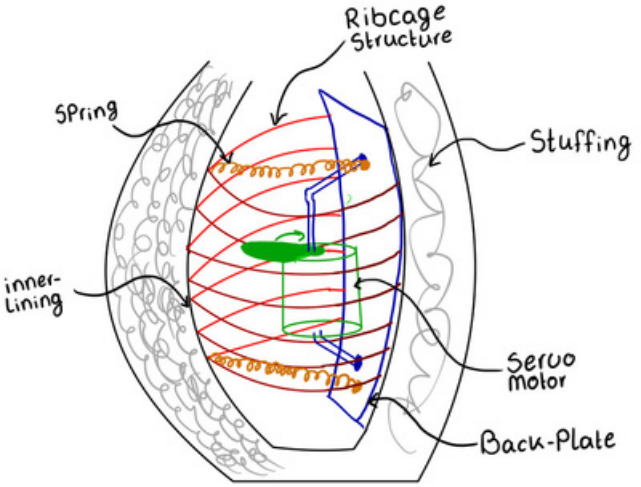


Figure 9 sketch ribcage mechanism

Loe Feijs

Feijs, Full Professor Industrial Design of Embedded Systems, focuses on creating novel demonstrators using mathematics, mechanics, machine learning, connectivity, programming, and electronics. He has extensive experience in telecommunication, formal design methods, embedded systems and software testing (Loe Feijs, n.d.) [21].

On the same day as the meeting with Delbressine, another meeting was held with Loe Feijs, after. This meeting focused more on the material construction of the teddy bear itself, as well as the testing of the mechanism.

Feijs has given the advice to maybe do some testing on different texturized fabrics, for example by asking people to assign different emotions to different types of fabric. In the end there was not the time to do some testing on the fabric texture side of the design, but this would have been implemented, was there more time.

The topic of testing the mechanism was spend the most time on. Since there are already researches in existence that prove the positive effects of a breathing motion on stress, we discussed the necessity of user testing the design concept. The outcome of this discussion is that it may be better to do testing on the mechanism than the effects of the mechanism. From there on out we dove a bit deeper into the idea of testing the mechanism. Feijs came up with the idea of testing the loudness among different motors, material surfaces and stuffings, to see which combination will work best in the design. Lastly we shortly talked about the idea of testing different material qualities like bendability and testing different mechanical structures like the ribcage idea in Figure 10 a balloon that is inflatable and deflatable, a subwoofer that expands when exerting a certain sound, and the structure shown in Feijs's sketch in figure 10 below.

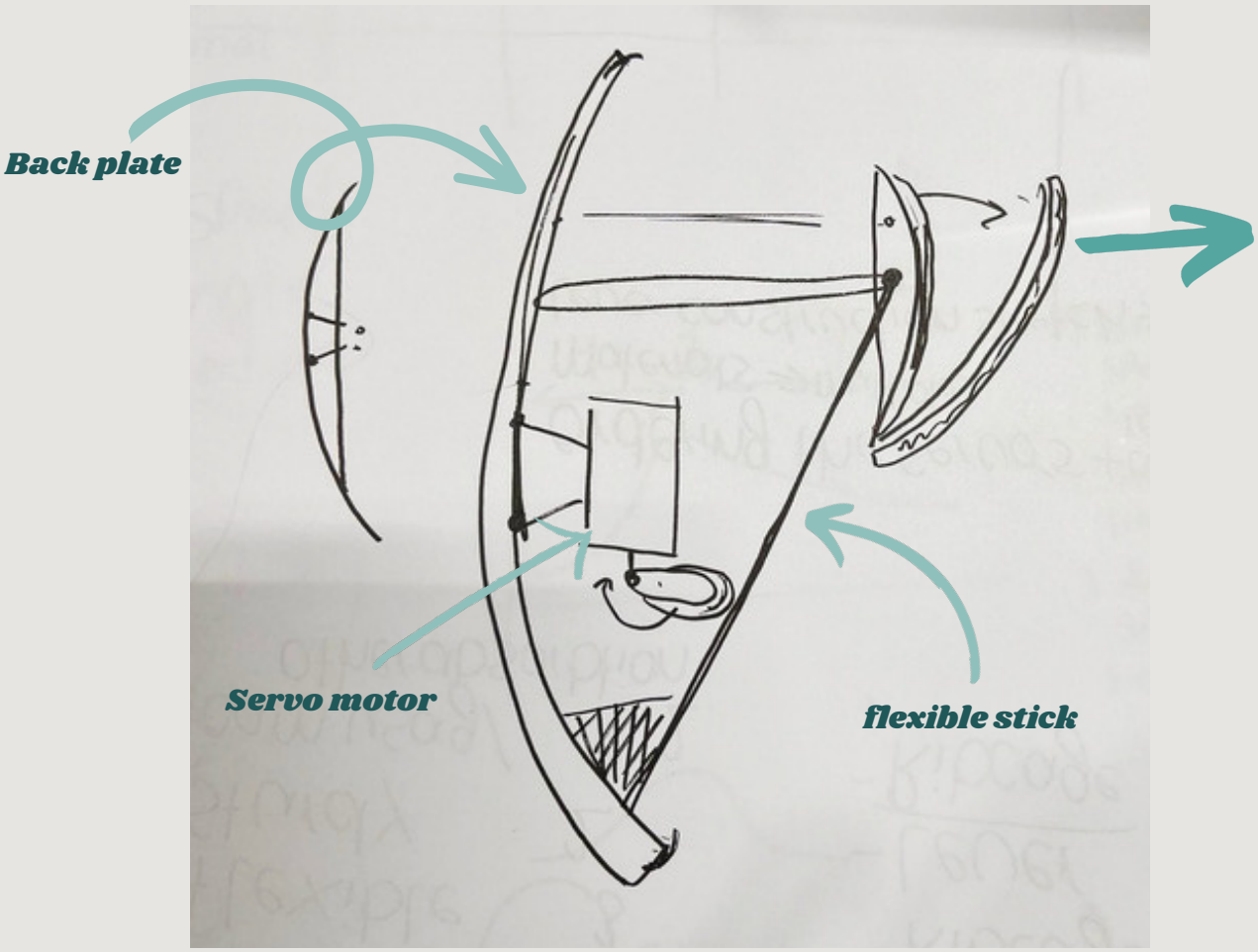


Figure 10 flexible stick with servo mechanism

Eventually this type of testing has not been done due to time and money constraints. However, discussing these different types of testing gave a wider insight into multiple aspects of the mechanism. This insight has helped greatly with the brainstorm of the mechanics design.

FINAL ITERATIONS

Based on the client meeting and expert meetings, final iterations were made.

Ability of implementing product in own cuddly toy

The first final iteration was the implementation of making the product customizable. This will allow for a much greater market and would also suit the target group better. A lot of children with ASD have a favorite soft toy, so making it possible to implement the breathing mechanism into their own toys would increase the effectiveness of the product.

Only focus on breathing

The client advised to only focus on the breathing part of the product, which is why this will be the focus point of the product. Other aspects like heat and weight and fidget parts will not be included.

Including separate pocket for electronics

The last iteration is focused on safety and durability. It includes a pocket that is separately made for the electronics. This creates another layer of protection as kids can be quite careless. The pocket can be taken out through a zipper, which makes the product washable, and therefore more durable. The pocket can be closed with Velcro. This pocket will also make sure that no stuffing will get into the mechanism.

FINAL CONCEPT

The product focuses on stress management with an everyday object for children with ASD. It is a plush toy, which is soft and comfortable to hold and simulates the breathing movement of an adult. The feel of this breathing will comfort children, as it reminds them of the breathing of their parents. The product will be activated through pressure sensors that are placed in both paws of the plush toy. When activated the toy will breathe for a few minutes after which it will automatically turn off. This activation will feel intuitive for the children and gives them control over the product. This is done because each child has unique needs at different points in time.
The product is washable, since the electronics can be taken out through the use of a zipper and a pocket for the electronics. This makes the product more sustainable. This also provides more safety as the stuffing won't get into the mechanism.
Our product could be implemented in any plush toy. So, it could also be integrated in the user's own favorite stuffed toy.

Storyboard

Below in figure 11 a storyboard is shown to clarify our product and the context in which it will be used.

Figure 11 storyboard product

REALISATION

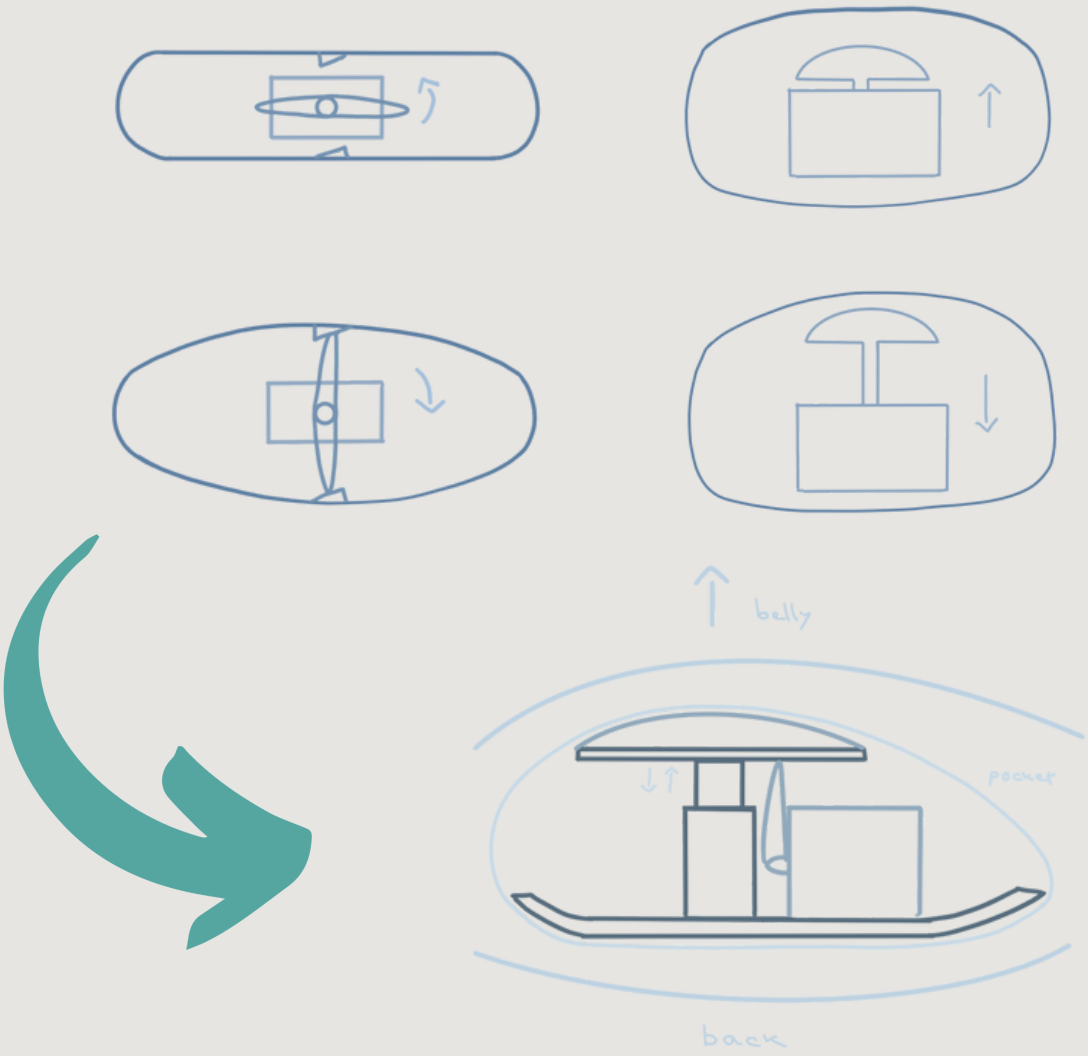


Figure 12 final breathing mechanism

After multiple discussions regarding the breathing mechanism, it was decided to go with the mechanism shown in figure 12 The main reason for this was that it was the easiest to realize in the given amount of time. It is also a very strong mechanism, so it was most reliable. Suggestions by Frank Delbressine were also considered, but this design was more time-efficient, and also a bit more strudy. The figure only shows one pole, the end product has 3.

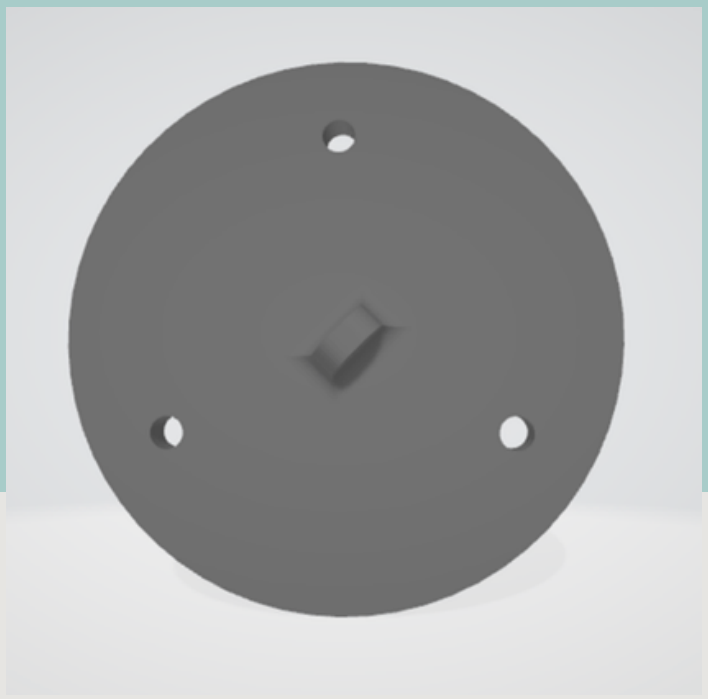


Figure 13 top part breathing mechanism top viewt

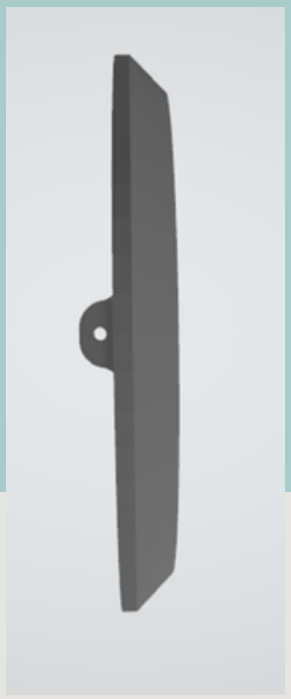


Figure 14 top part mechanism side view

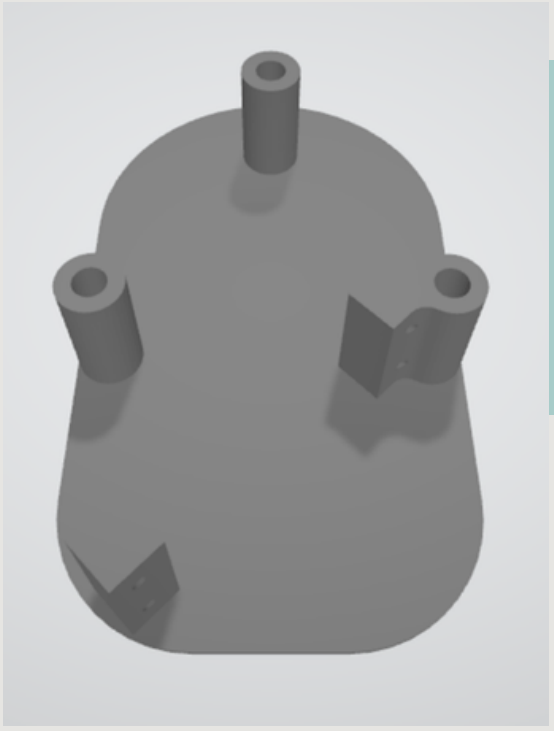


Figure 15 base part mechanism top view

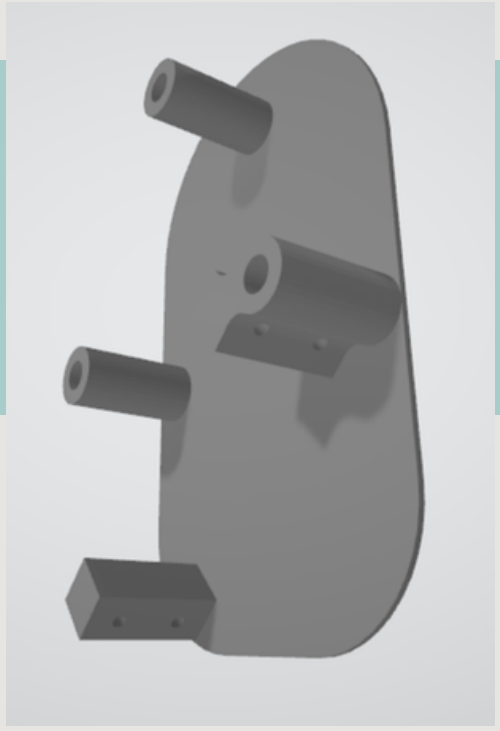
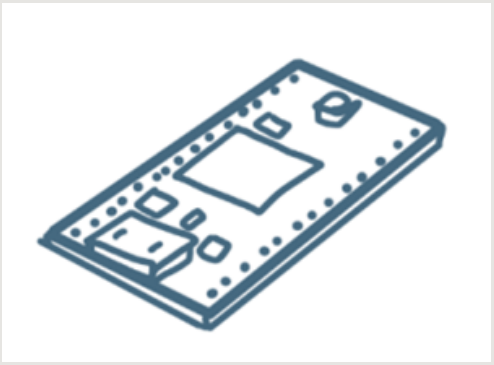


Figure 16 base part mechanism side view

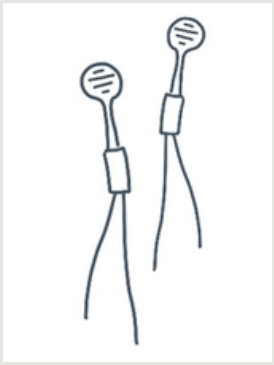
Above you can see the 3d models that were made of the breathing mechanism. Figures 13 and 14 show the top part of the mechanism, which is the part that is being pushed up and down. Figures 15 and 16 show the base plate of the mechanism, which contain the servomotor on the top, as well as the teensy (that will contain the code for the mechanism) that will be placed at the back. In addition, to let the mechanism work, there are three poles connected to the top part (through the three holes), which will slide into the three pillars in the base part. These three poles will be made out of metal, as this material is smooth, making the movement smoother as well.

Electronical components

Servo Motor 180 degrees



Teensy 3.2



ARD SEN pressure sensor

Material

At first, a soft, flexible material was considered, because the stuffed animal was desired to remain as soft as possible.
However, as the model contains separate parts that need to move against/in each other, flexible material is not ideal as this could block the movement a lot easier. It is also more difficult to connect the hardware such as the servo motor to the baseplate. It is for these reasons that the material that is used in the final product is hard plastic, PLA. As said, this is a very sturdy and firm material. This is why the thickness of the parts as shown in the figures on the previous page are as thin as possible, to leave enough space for the stuffing. This will allow for the stuffed animal to remain soft.

Printing

Figure 17 Flexible material (TPE) experimentation side view

Figure 18 Flexible material (TPE) experimentation top view

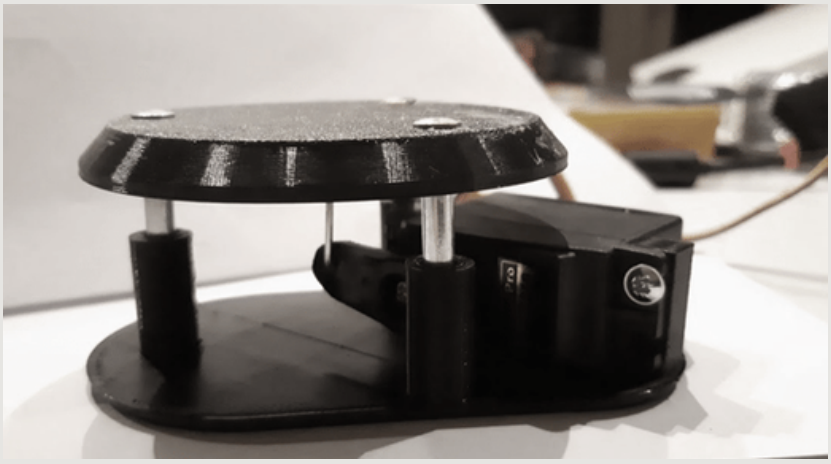


Figure 19 Printed breathing mechanism, including servo motor

Coding

For the coding part of the product, two separate parts of coding were made which were eventually have been combined into one.

The first part includes the movement of the servo motor. The servo motor that is used is a 180 degrees servo. This allowed for the movement to go up and to go down the same path. The pace of the breathing is set to be around 14 breaths per minute as this is the average adult breathing pace.

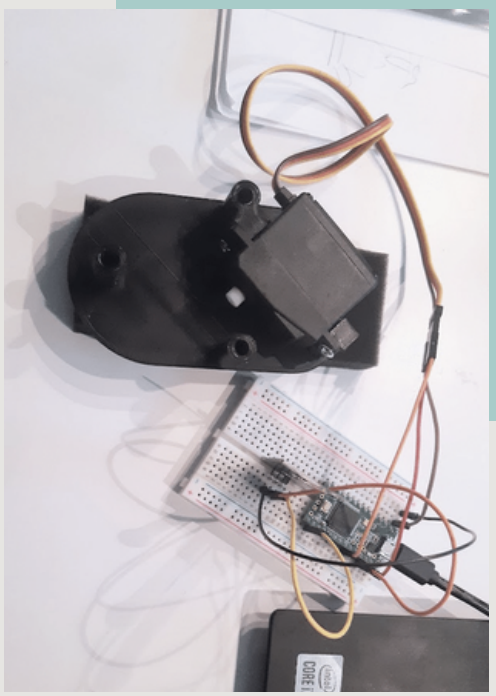


Figure 20 Coding servo motor

The second part includes the pressure sensor. This part senses whether the pressure exercised on the pressure sensor is higher than the threshold.
After defining those two parts of the code, they were combined. In the final version, the pressure sensor is being used as an activator of the servo motor. When the sensor exceeds the threshold, the servo starts making the breathing movements for a certain amount of time. After this it will automatically turn off and it needs to be activated with the pressure sensor again.

See the Appendix 1 for the full code.

Soft Materials

Teddy Bear

As discussed in the research section, it is clear that children with ASD are sensitive to textures. Which is why this part of the realization process is very important.
The product is made using an existing soft animal, as this is already a product the children are familiar with. The textures are all soft and do not contain any hard parts.
If there was more time and money, the teddy bear would be made from scratch to be able to use the most effective textures. As our concept aims for a customization option, it would be ideal if the children or parents could communicate their favorite colors / textures so these can also be implemented in the product. However, if they already have the 'perfect' plush toy, our mechanism can just be implemented in that toy.

Zipper and Pocket

To make the product washable, a zipper is needed to be able to take the electronics out. The zipper is the same color as the fur of the bear and is invisible from the outside. However, you are able to feel it, so in the future a different option of closing the bear could be considered. In addition, the electronics will be placed in an individual pocket to make the product more user friendly and to provide an extra layer of protection. This pocket is made of cotton.

Patches

Finally, patches were added on the paws of the bear (see figure ...), indicating the placement of the pressure sensor. It is meant to make the activation of the breathing more intuitive and more recognizable for the children.

IMPLEMENTATION

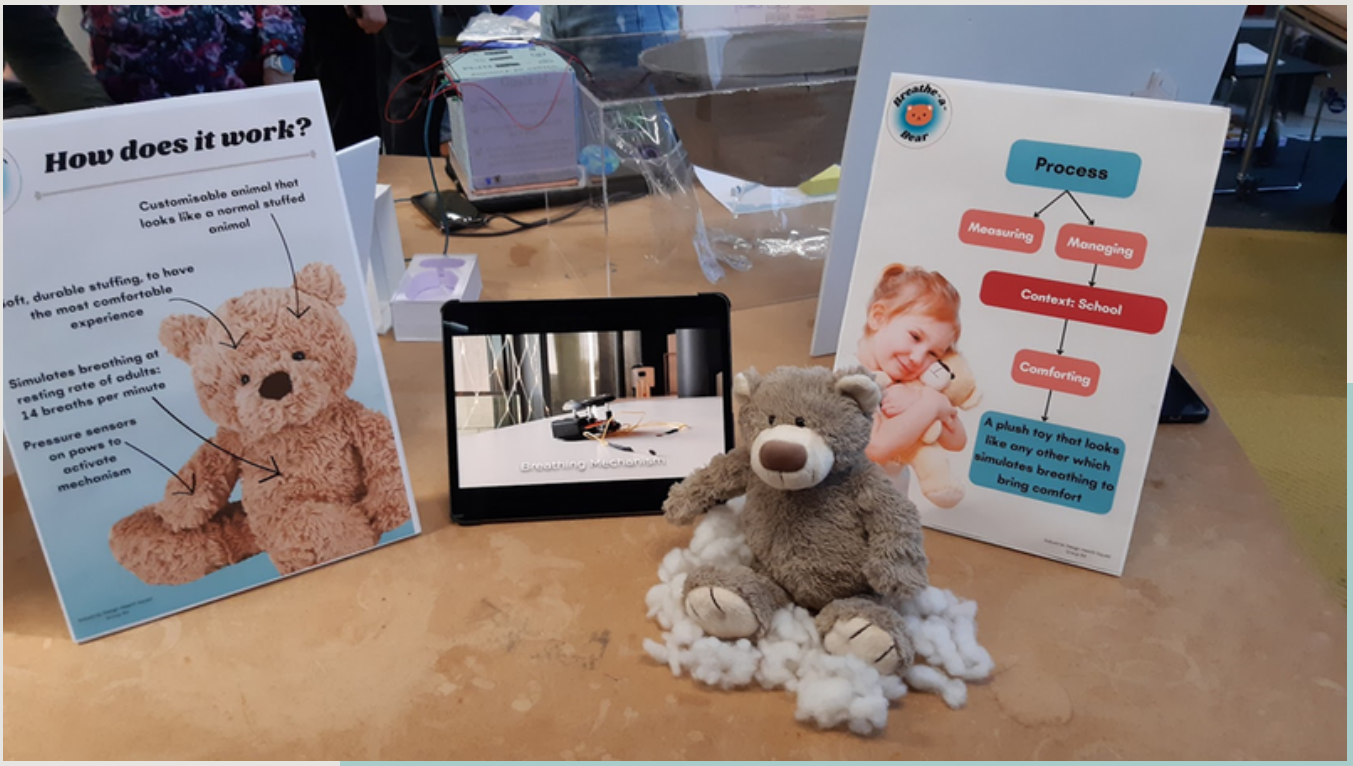
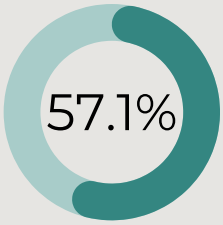


Figure 21 deliverables demoday

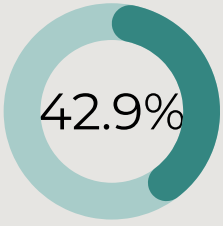
USER TESTING

The user testing, which ideally would have been conducted on children with autism between the ages 4 to 8, was conducted on university students in the second year of industrial design instead. This was because acquiring the permission to conduct the test with the original vulnerable group was difficult to conduct with the allotted time due to the proceedings necessary with relation to the Ethical Review Board of the TU/e. (The ERB-form is findable in Appendix 4). Therefore, the latter target audience was chosen. This was because it was mutually agreed that this target audience experiences a high level of stress as well and would therefore be a good candidate in testing the stress de-escalation. An overt observational study and semi-structured interview was conducted.

The user testing was conducted with 7 participants who read through and signed the informed consent form (Appendix 2). The consent form was deliberately left a little vague about the product itself, in order to reduce the potential confirmation bias that might arise from knowing the point of the product beforehand. It should be noted that they were informed in entirety after and were asked whether their consent changed as a result. The participants were then instructed to interact with the teddy bear however they wanted, in order to test the convenience of the switch to turn the mechanism on. In case they were unable to find the mechanism, this was then noted for future developments and improvements. In the interview, they were asked about the interaction with the mechanism, the comfort levels before and after using the product, as well as extraneous variables such as the sound levels generated by the mechanism (Appendix 3)



People who found the mechanism to be realistic



People who thought the mechanism needed some improvement

In the analysis, the group found that the user testing was a net positive, as it was generally agreed amongst participants that it helped de-escalate stress levels. The mechanism to turn it on was fairly intuitive. However, it did not always lead to the intended results due to mild mechanical issues wherein the pressure sensors were too small to work reliably with every attempt. 100% of the participants found the pace comfortable. 57.1% of the people thought the amount it expands to be perfect and realistic, while the remaining 42.9% claimed to prefer more expansion or a larger surface area for the breathing mechanism. The participants also suggested the aforementioned improvements, which were noted down for to further improve the product in the future.

The data was collected on a Microsoft Word document located on TU/e servers only accessible to the researchers. One person handled conducting the interview, asking questions, and providing information about the product, while the other person noted down answers from the participant(s). This was then collated and read thoroughly and analysed by means of putting similar ideas together. Although we do acknowledge the sample size to be quite small, we believe that it helped get a better idea of how our product feels like to interact with from a third-person perspective, as well as whether it helps alleviate stress at all.

Comforting

"Bit too mechanical, if it were smoother, it would be calming"

"I actually did, I felt really calm"

"It was soothing"

Mechanism

Comfortable expansion for size of bear

"Good, I like that it pushes against me"

Would prefer mechanism in belly, as paws feel unnatural

CONCLUSION

At the end of the project, both low and high fidelity prototypes have been made to be used as research as well as communication. A user test has been done to create a more in depth knowledge of the effects breath-a-bear has on users and the designs usability. Different stakeholders, like experts and clients, have been involved in the process to bring knowledge in the field of the target audience, mechanics and testing.

Multiple iterations have taken place to create the final breath-a-bear design. These iterations have shown good and bad aspects of our designs and changes have been made accordingly. This played a crucial and big part in bettering multiple aspects of the previous designs, to in the end present a visually, mechanically and mentally well rounded concept.

The prototype does not represent the end vision, but clearly shows the intention of the design concept and works well when using in a user test.

Breath-a-bear is not overly complicated, it achieves the goal the designers wanted to achieve, reducing stress and anxiety by means of comforting.

DISCUSSION

When designing for anxiety and stress it is important to keep in mind that everyone reacts differently to different stimuli. Especially for Autistic children this is the case, some are very sensitive to stimuli while others are very insensitive (Tomchek et al., 2014) [16]. Besides, children with ASD are very specific in what they like and do not like (Wouter Staal, n.d.) [17]. While it is proven that a breathing motion can help with stress and anxiety (Haynes et al., 2022) [21], this will not be the case for everyone. Therefore this design might not work as well for all potential users.

To optimise the design, more testing has to be done. While the effects of the design on stress and anxiety have been tested. The mechanics implemented are not yet tested. There are possibly better mechanisms to use for the concept, so there is more testing in this field needed to make sure the breathing motion is optimised.

While the effects of the design on stress and anxiety have been tested, this was only tested on university students. The target audience for this design concept is children with ASD age 4 to 8. Testing the concept with the actual target audience may result in different insights, so to optimise its effects user testing will have to be Carried doubt with the target audience. For now it is important to realise that this testing has not been done yet, so this may effect its effects.

It is also to be considered that, regarding the way user testing has been collected, no data was collected through sensors, so there is no quantitative data as such, and the qualitative data form the interviews. This data might even be subject to biases, such as conformation bias, framing bias, as social-desirability bias. All of these could sway the results of the experiment greatly, but the group tried their best to negate these and frame all of the questions as neutral as possible, without much information being given before the testing to the participants, so that their feedback is as objective as possible.

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APPENDICES

Appendix 1:
Arduino Code

```
#include <PWMServo.h>

#define DATA_PIN 5 // Output Pin to Data Line on Strip
#define ENABLE_PIN 7

PWMServo myservo;  // create servo object to control a servo

#define BREATHE_IN 14 //8
#define BREATHE_OUT 10 //6
float count = 0;
int breathe_time = 0;
boolean up = true;
boolean stopped = false;

void setup()
{
  pinMode(ENABLE_PIN, INPUT_PULLUP);

    myservo.attach(21);  // attaches the servo on pin 9 to the servo object
    Serial.begin(9600);
 //myservo.attach(21, 1000, 2000); // some motors need min/max setting
}


void loop(){
 int value1 = analogRead(A6);
 int value2 = analogRead(A5);
 if ((value2<13) or (value1<13)){
   breathe_time =4000;
   }

 if (breathe_time>0){
   if (up) {
     float step = (1.0/50.0)/BREATHE_IN;
     count += step;
     if (count >= 1.0){
       up = false;
       count = 1.0;
     }
   }
   else {
     float step = (1.0/50.0)/BREATHE_OUT;
     count -= step;
     if (count <= 0.0){
       up = true;
       count = 0.0;
       if (digitalRead(ENABLE_PIN)== 0){
         stopped = true;
```

```
      }
    }
  }
  myservo.write(0 + count*50);
  breathe_time -= 1;
 }
 Serial.println(breathe_time);

 delay(5);
}
```

Appendix 2:
consent form user test

P2 User Test 2 - Informed Consent form

Introduction:

We are Bente Elst, Kira Jansen, and Siddharth Mahadevan, and we are currently doing a project which explores the effect of breathing movements on the stress levels of the user. The goal of this user test is to evaluate the usability, effectiveness, and enjoyability of the interaction with the developed product. The products includes a plush toy that mimics a calming breathing movement and is designed to decrease stress levels.

Before participating in this test, we ask you to carefully read this information sheet and give us your explicit informed consent to use and store your data, according to the ethical standards for scientific research.

Objective of the research project:

This research project will be led by Bente Elst, Kira Jansen, and Siddharth Mahadevan, and will be supervised by Emilia Barakova. The objective of this user test is to evaluate the usability and comforting element of the breathing plush toy.

The legal ground on which we process your data is consent and we ask you to give us your explicit consent to process your personal data at the bottom of this document.

Procedure:

In general

In the user test, data will be gathered using both observations as a semi-structured interview. The user test can be divided into 2 parts:

- The evaluation of the usability of the action performed by activating the breathing mechanism
- The evaluation of the effectiveness of the experience of the breathing mechanism.

For every part, participants are provided with one concept and will be observed while interacting with the product. If needed, we will provide guidance. Subsequently, the participants are asked to evaluate the different aspects of the product and how they felt during the experience.

UX design

The users will be given the product after which they can try different actions that feel intuitive to them. They will be guided through the basic actions if needed. After they have experienced the product, they will be asked a few questions through a semi-structured interview.

The test will approximately take 10 minutes.

Confidentiality:

Confidentiality will be maintained throughout the entire study and data analyses. All data obtained in this user test will be anonymised. Data will only be presented in the aggregate and individual user comments will be anonymised when recorded. Only the researchers and the supervisor will have access to the data.

Data storage:

All data will be safely stored on SURFdrive, a password - protected server, and will be deleted after 2 months after finishing the course.

Potential risks and inconveniences

Your participation in this test does not involve any physical, mental, legal or economic risks. You do not need to do something or answer any questions you do not wish to. Your participation is completely voluntary. This means you may cancel your participation or skip a certain question at any moment you choose.

Questions or concerns:

If you have any questions or concerns related to this study, please contact Siddharth Mahadevan, s.mahadevan@student.tue.nl

****Scroll down for the consent form****

Consent form for participation by an adult

Through this consent form I agree with the following:

1. I am sufficiently informed about the research through a separate information sheet. I have read the information sheet and have had the opportunity to ask questions. These questions have been answered satisfactorily.
2. I take part in this research project voluntarily. It is clear to me that I can cancel my participation at any moment. I do not have to answer a question against my wish.
3. I give consent to the researchers to store the data collected from me and give them permission to use this information for further scientific reasons while complying with the ethical standards for scientific research.
4. I give permission to the researchers to quote my personal data in publications, while anonymity is maintained.

Do you agree with the terms above?

☐Yes

☐No

Name of participant: Click or tap here to enter text.

Signature: _____

Date: __/__/____

Name of researcher: Siddharth Mahadevan

Signature:

Date: 12/1/2023

Appendix 3:
User Test Raw Data

Notes user test 1

Interaction:

Feeling a lot

Hugging it

Trying to find comfortable position

When feeling breathing: that's cool!

Activation

Does the activation of the breathing mechanism feel natural?

> Is the pressure threshold high/low enough? (pressure sensor wasn't working)

> Is the placement of the pressure sensor comfortable for you?

I think so. You do need to know when it's there. I do not naturally interact with the hands. I would have it in the body itself.

Breathing mechanism

Is the pace of breathing comfortable?

>It was comfortable. 4 in, 4 hold, 4 out.

How do you feel about the amount it expands?

>That was good. It felt realistic.

Do you feel more comforted?

>I think so. If you would hold it for a little while, it would help like breathing exercises.

Do you feel less stressed?

>Not particularly. I was not super stressed before.

Do you have any things you think could enhance the experience/make the experience more comforting?

>I think it's good. Maybe make the inside more soft.

General: I think it would really help. It's like an intuitive breathing exercise. I would maybe use it for falling asleep.

Notes user test 2

Activation

Does the activation of the breathing mechanism feel natural?

> No, it was very hard to turn non, turns off very fast, would be harder for target group, maybe nose or something.

> Is the pressure threshold high/low enough?

> It is too high

> Is the placement of the pressure sensor comfortable for you?

> Not really, if you're hugging it, someplace where it is weird, paws still a good idea if you can make it work nicely

Breathing mechanism

Is the pace of breathing comfortable?

> Yes, it's good,

How do you feel about the amount it expands?

> Good, likes that it pushes against them

Do you feel more comforted?

> "I actually did, I felt really calm"

Do you feel less stressed?

> "When it expands, it makes these noises, it was the main focus, it was close to ear when hugging"

Do you have any things you think could enhance the experience/make the experience more comforting?

> Not being able to feel the mechanism so easily, it is hard if you hold it

> For a kid, it's a good size, visibility of breathing thing should be easy

> maybe would not like the texture of zipper

> Would use product, takes up a lot of space to be carry around

> something with a more sophisticated look for older audience, like breathing ball

Notes user test 3

Activation

Does the activation of the breathing mechanism feel natural?

> Not really

> Is the pressure threshold high/low enough?

> Just right

> Is the placement of the pressure sensor comfortable for you?

> No, can't find it, but in the paws in general, would prefer it in an area where you vcan recognise it appening

Breathing mechanism

Is the pace of breathing comfortable?

> Yes

How do you feel about the amount it expands?

> Yes

Is it too loud?

> Sounds like it is mechanised, more auditory interaction to the breathing, auditory recognition of change of breathing

Do you feel more comforted?

> Yes

Do you feel less stressed?

> Yes

Do you have any things you think could enhance the experience/make the experience more comforting?

> Would prefer a different form factor for uni students

> How would you deliver this as a final product (fpr the report, how to integrate into existing product, full cycle where does it go when it is no longer useful)

Would you buy it?

> Yes

Notes user test 4

Activation

Does the activation of the breathing mechanism feel natural?

> best way they can think of doing it, not exactly natural though, if the pressure sensor was in the abdomen, not exactly unnatural

> Is the pressure threshold high/low enough?

> Low

> Is the placement of the pressure sensor comfortable for you?

> Yes

Breathing mechanism

Is the pace of breathing comfortable?

> Yes it is

How do you feel about the amount it expands?

> Just right

Is it too loud?

> Bit too mechanical, if it was more consistent, it would be more calming

Do you feel more comforted?

> Yes, a bit

Do you feel less stressed?

> Yes

Do you have any things you think could enhance the experience/make the experience more comforting?

> The activation

> The sound

>

Would you buy it?

> Depends on the price, under 30, would consider

Notes user test 5, 6, 7

Activation

Does the activation of the breathing mechanism feel natural?

> The pressing of the paws was the first thing one, it's supposed to do something, logical places ot have the thing

> Feel squeaky toys in it, so you know where to feel it, feel a button you can press

Is the pressure threshold high/low enough?

> Doable outside the plush, when sticking out it's play

> a button or tactile reposnse would be nice

> it's fine, woul dbe good to hug to activate

Is the placement of the pressure sensor comfortable for you?

> Yeah, logical place

Breathing mechanism

Is the pace of breathing comfortable?

> Yes, they really like it

How do you feel about the amount it expands?

> it might be better to expand a bit more, larger surface area

> depends on the bear, if this bear expands more, it might be weird, bigger one expands more

Is it too loud

> Minimal, couldn't hear it well, not intrusive

Do you feel more comforted?

> Yes, searching for it to work

Do you feel less stressed?

> it is soothing, if they were stressed, this would help with it

Do you have any things you think could enhance the experience/make the experience more comforting?

> small bear

> bigger bear for bigger people

> more tactile response

> hugging activates mechanism

> feels fragile, feels like they don't want to hug it too tight, with the breathing, feels like a baby

Would you buy it?

> Wouldn't buy for themselves

Appendix 4:
ERB consent form

TU/e EINDHOVEN UNIVERSITY OF TECHNOLOGY

Ethical Review Form Education

(Version 17.07.2020)

This Ethical Review Form should be completed for every research study that involves human participants or personally identifiable data. The form should be submitted and approved by your supervisor before potential participants are approached to take part in the research study.

Part 1: General Study Information

1	Student name and email	Bente Elst (b.else@student.tue.nl), Kira Jansen (k.jansen@student.tue.nl), Siddharth Mahadevan (s.mahadevan@student.tue.nl)
2	Supervisor name and email	Emilia Barakova, e.i.barakova@tue.nl
3	Degree Program	Industrial Design
4	Bachelor/master	Bachelor
5	Bachelor/master end project?	Bachelor project
6	Course name and code	Project 2 DFP004
7	Project title	Name of your study
8	Research location	Eindhoven University of Technology
9	Research period (start/end date)	December 5, 2022 – December 22, 2022
10	[If Applicable] Proposal already approved by (external) Ethical Review Board: Add name, date of approval, and contact details of the ERB	Is your study part of a larger study that has been ethically reviewed before? Then describe the details of that ERB approval.
11	Research question	*How are students' stress levels affected by simulated breathing in a plush toy?: A Qualitative Analysis*
12	Description of the research method	Participating students will experience a tactile mechanism that represents a breathing pattern. This mechanism will be implemented in a plush toy. The experience consists of two parts: activating the breathing mechanism and getting comforted by the mechanism. They will be asked a few questions during the experience and the answers will be written down.
13	Description of the research population, in- and exclusion criteria	University students
14	Number of participants	10 students
15	Explain why the research is socially important.	The research is important for justifying the design that we developed. It will give insight in how stress relates to the exposure to breathing movements. As we initially designed for children with autism, this research might allow for useful innovations to make these stressed children less stressed and more comforted by breathing mechanisms.

TU/e EINDHOVEN UNIVERSITY OF TECHNOLOGY

Ethical Review Form

16	Describe the way participants will be recruited	Convenience sampling
17	Provide a brief statement of the risks you expect for the participants or others involved in the research and explain. Take into consideration any personal data you may gather and privacy issues.	We expect few risks for the participants from taking part in the user test. They don't have to perform complex tasks as they only have to share their thoughts on the effectiveness of the product.


Breathe-a-
Bear