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Appendix 1. Sennheiser portfolio and user group

Headphone character

- HD560s: these are considered an entry product, with good linear sound, for customers to immerse in the audiophile line.
- HD6xx: are a reference of neutral sound and a quality mark of audiophile headphones, with a technical design dating back to the 90s.
- HD8XX: futuristic design and neutral tone, with natural sound reproduction.
- HE X: are Sennheiser's showpiece, said to be "The best headphones in the world" by many users.

Target group

Along this line, the company's consumer target audience is the Cutting Edge Achiever:

Forward-looking, driven and motivated people in constant pursuit of the best, both in their lives and in the products they use which act as a reflection of their knowledge and discernment. Sound quality being of particular importance.

When looking into the current group, most audiophiles started their journey by listening to music, and eventually wishing for better and better sound quality.

"When you have a chance to listen to hi-end music players/headphones, there's no turning back"

Making music, entertainment and music listening are relevant hobbies that drove audiophile to become audiophile (Lienemann, 2022).

Sennheiser's research shows that headphone design is fairly important to Audiophiles as well, after sound. 29% rating it 1 out of 5, very important, and 41%, 2 out of 5.

There are three different user segments: Classical Audiophiles, Tactical Audiophiles and lastly our focus group, the New Generation Audiophiles (Headband briefing, 2022).

Age

18-25	35%
26-30	23%
31-35	23%
36-40	19%

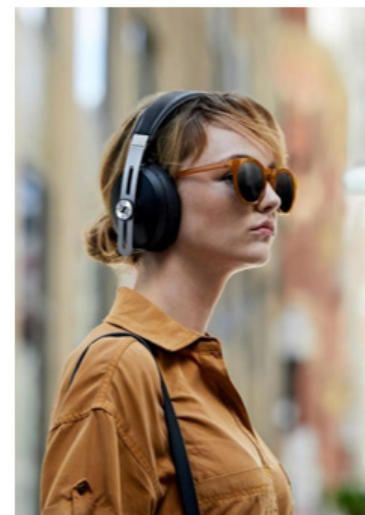
Gender

Male	70%
Female	30%

Criteria

1	Sound Quality
2	Comfort / Secure fit
3	Design / Look
4	Brand
5	Noise Cancellation

Sound quality is of particular importance to Cutting Edge Achievers. In fact, it's the #1 criteria they want satisfied.



Kantar TNS Sennheiser Consumer Segmentation Report, June 2018

Sennheiser proprietary customer insights

Appendix 2. Haptic moodboard





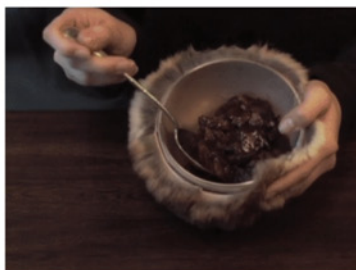
softness



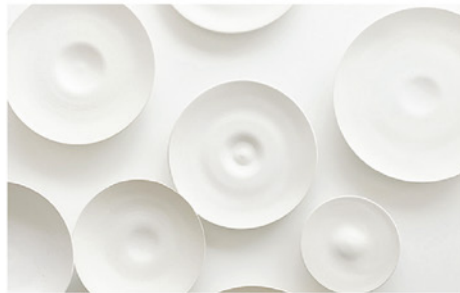
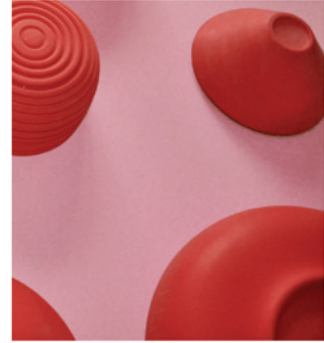
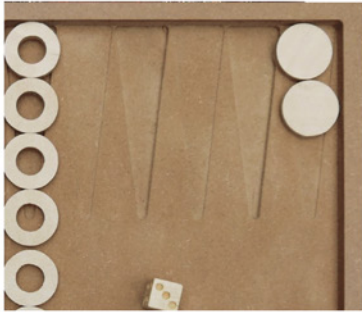
haptic interaction



natural textures



disconnected haptics



integrated haptics

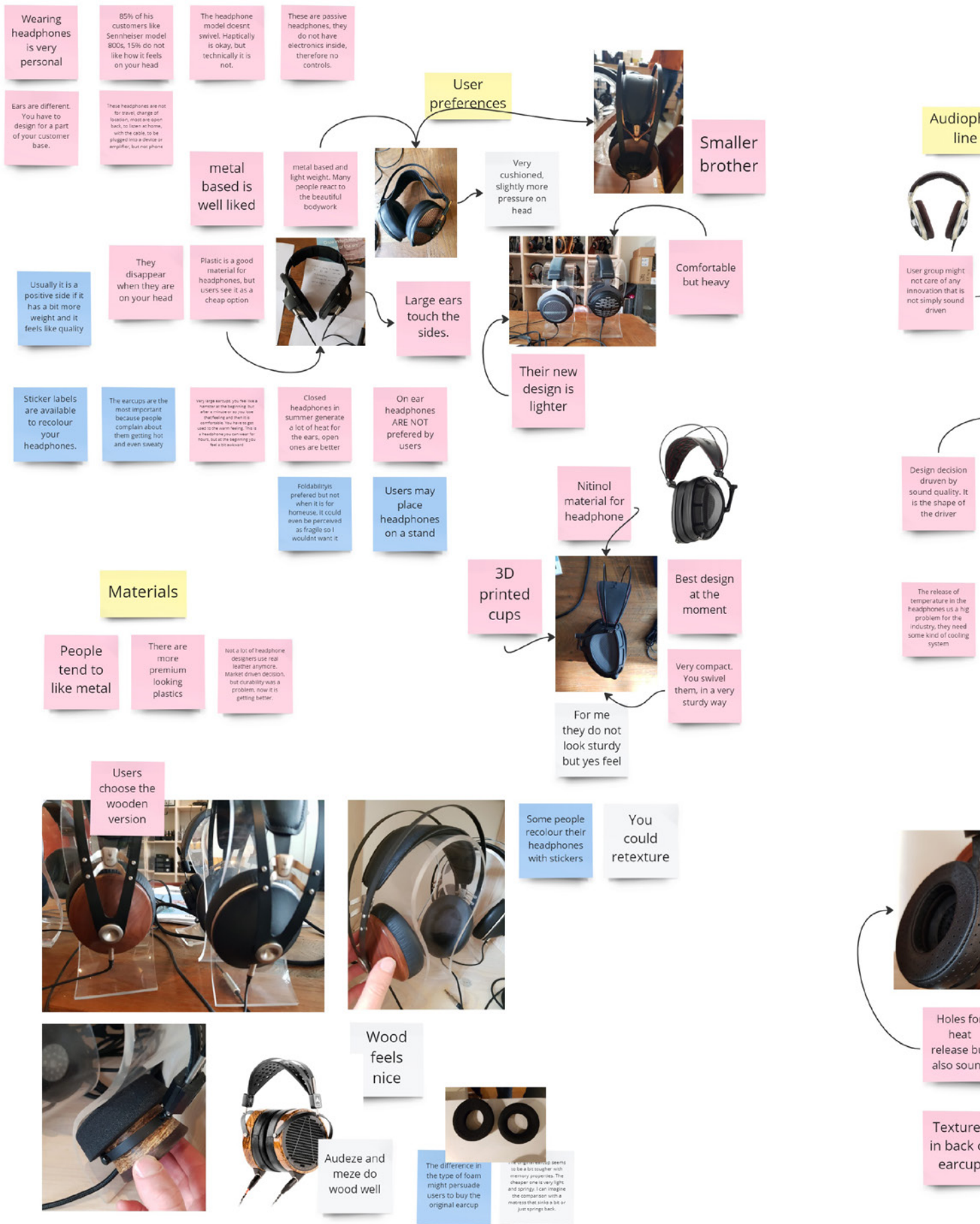


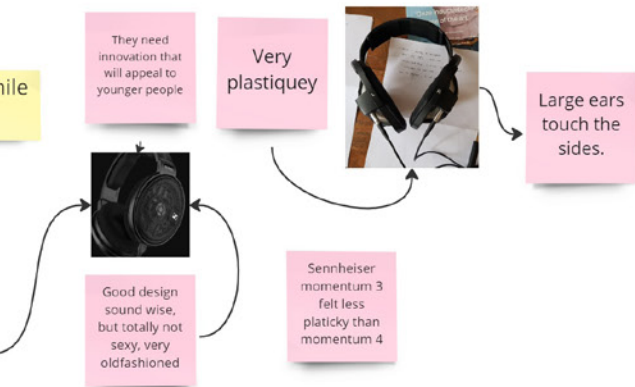
proximity objects



rethinking shape

Appendix 3. Insights from field research



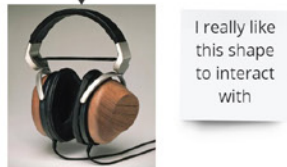


Ears unlimited

Audiohuis delft

Hi Fi Klubben den Haag

Industry



Review of more commercial headphones / premium line. Mostly bluetooth and NC

- They have to be light and wearable for a long time. If you have something that you can feel on your head you won't wear it for a long time.
- Momentum 3 and 4. They are very lightweight, you can have them on for longer periods of time.
- Too heavy and too clumpy x7x2. You can feel the headphones pushing too much

Plastic or carbon M4, M3 aluminium inside. M4 is the headphone that should compete with the sony.
Metal elements give it a more premium feeling.

- Wooden finish is not something that happens on active headphones. It probably has to do with the amplifiers, control wiring might cause overheating.
- Innovation is moving fast with bluetooth and nc. In technological aspects, not so much in design. You do notice that headphones have gotten a bit bigger.
- In terms of durability, some models no longer fold. This is because of the fragility of the hinges. Customers do not generally ask for it.
- Control there are some touch controls, it doesn't work all the time. Some people like regeneration, want to be able to press buttons.

Mostly fake leather earcups

Adjustability mechanism is generally the same

You need a case otherwise you need very expensive resistant materials.

Components



Hinge, sturdy hinge

Headphones around neck, does not occur with high end headphones, it is not representative of the market, you don't want to ruin them

Headband is incontact with neck

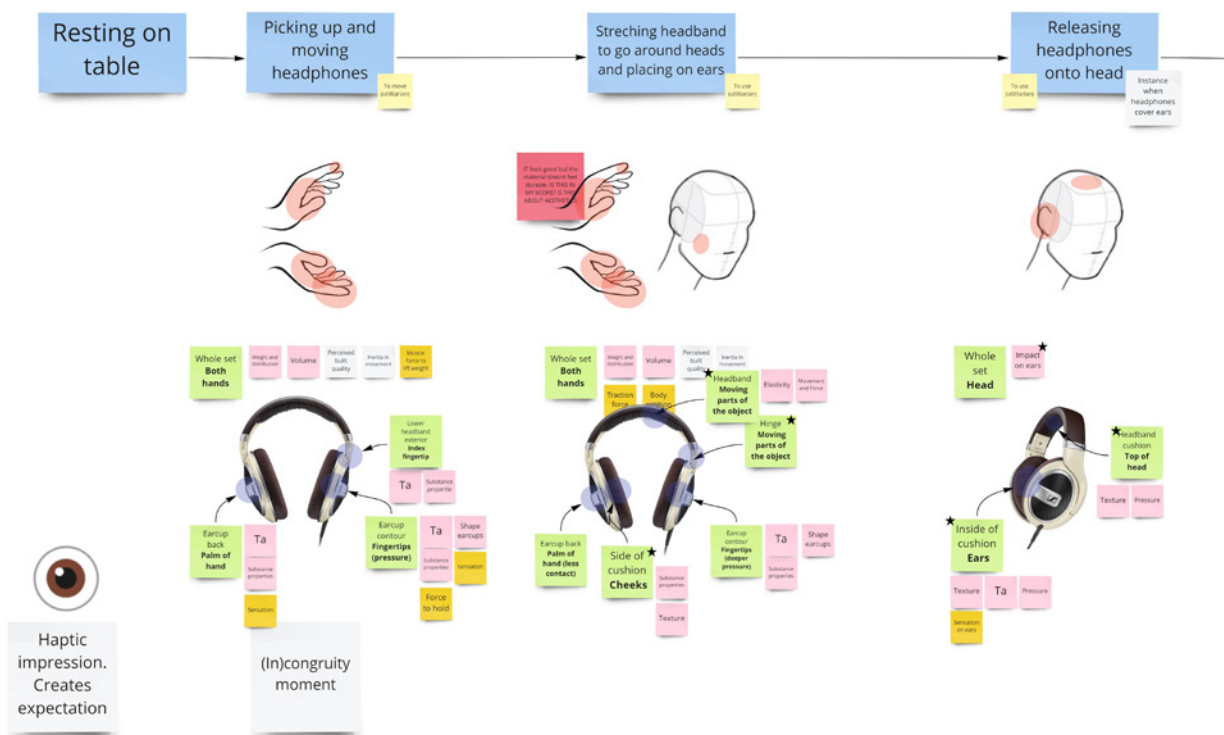
A double headband design is more comfortable than a single headband. The double headband design allows you to adjust the pressure on your head with your head only by using the double headband. The single headband design requires you to adjust the pressure on your head by using the headband. The double headband design is more comfortable than the single headband design.

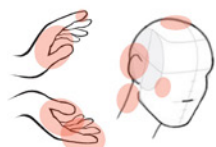
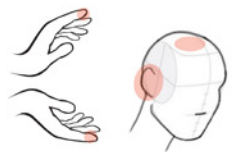


He didnt mention any earcushion material that was preferred.

Appendix 4. User journey and implications for haptics

The following shows the full analysed user journey, including which areas of the body are involved and what sensations arise at each instant.





Appendix 5. Sensitising material

The following images show the described collection. Each row of materials/probes embodies the essence of a group of properties, described in this page. Within each row, these materials also range and highlight other properties.



1. Soft, rough, elastic

Highlights:

- Light
- Dense

- Bumpy, irregular

2. Warm, soft

Highlights:

- Light and elastic
- Dense

3. Soft, multilayered

Highlights:

- Sticky
- Warm



4. Dense, elastic



- Bumpy, regular
- Indented, irregular

12. Coarse, meshes

Highlights:

Highlights:

- Plain and smooth
- Bumpy

6. Fine, smooth, light

Highlights:

- Plain
- Indented, regular

7. Fine, smooth, dense

Highlights:

- Plain
- Indented, irregular

8. Animal fabrics, soft

Highlights:

- Smooth, dense, plain



- Plain, smooth
- Indented, irregular, smooth
- Coarse, elastic

13. Hard, cold

Highlights:

- Plain, smooth

- Light, irregular, coarse

9. Coarse

Highlights:

- Ridged, light
- Bumpy, rough

11. Slippery, plastic

Highlights:

- Plain, smooth



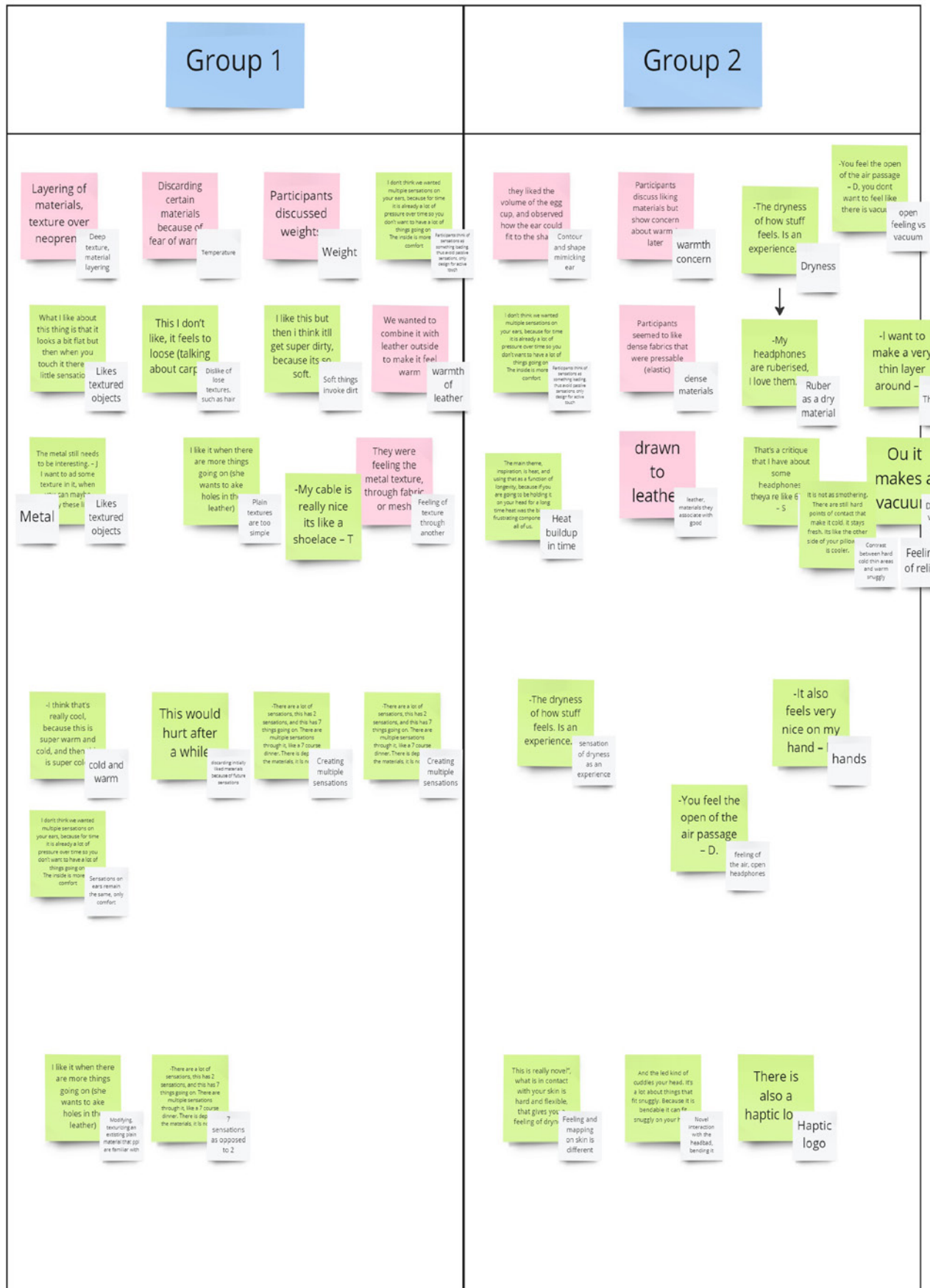
- Light
- Dense

5. Hard, warm

Highlights:



Appendix 6. Qualitative analysis exploratory session



Are there any new elements in the user journey?

Change in interaction

What mechanics do they use to build hapticity?

Techniques to build haptics

Mental model of how to build haptics

Other

prototype

I don't think we wanted multiple sensations on your ears, because for time it's already a lot of pressure over time so you don't want to have a lot of things going on. The inside is more comfort. They encourage active touch, if you explore the object, but not passive.

There are a lot of sensations, this has 2 sensations, and this has 7 things going on. There are multiple sensations through it, like a 7 course dinner. There is deep materials, it's firm. Creating multiple sensations.

I like it when there are more things going on (she wants to take holes in the leather). Misting, sensing an exciting pain material that got a bit familiar with.

Discarding certain materials because of fear of warmth. I don't know if I would like to touch it all the time but it is interesting - T - it doesn't feel nice to your fingers but liking feeling but covering with other texture.

What I like about this thing is that it looks a bit flat but then when you touch it there's little sensatio. Contrast between observed texture and feel.

I think that's really cool, because this is super warm and cold, and then is super cool. Thinking of contrasting and combining sensations.

It can be like patina. Making the material with your hands and wash your use. Maybe temperature?

They copied and interaction from existing model and enhanced it with the right materials that accompany the feeling. Matching material to feeling/sensation of interaction.

The building of the structure was independent of the haptics, but just a carrier - a skeleton for the materials. Participants still tried to make colour matching prototypes. Thinking about matching fabric colour. visual focus remains.

They first choose materials that they like to interact with and then think of where they want that, in which materials and textures take priority.

I don't think we wanted multiple sensations on your ears, because for time it's already a lot of pressure over time so you don't want to have a lot of things going on. The inside is more comfort. Thinking of where to create sensations and where not to.

It feels less premium - T (thin paper plastic). Material associations with premium, quality etc.

The main theme, inspiration, is heat, and using that as a function of longevity, because if you are going to be holding it on your head for a long time heat will be the frustrating component all of us. Heat buildup in time.

And at the start of the user experience you fold the headband onto your head. You have the cosiness without smothering. Different initial interaction.

Participants seemed concerned for the ergonomic aspects, the difference between ear sizes and the fit, return to this topic. Ergonomics concern.

I don't like it when the form factor and the weight don't match - A. Form factor and weight match.

-So the soft stuff touches your ear and the wood your head. Material deciding for which area.

Participants looked at layering materials. layering materials.

Participant thought about what sensation he liked from the material itself, and then where precisely in the outside of the. Sensation, then material, then area.

I don't believe in the stone in the ear, also, how thin can you cut stone? It becomes big very quick. materials related to their volume.

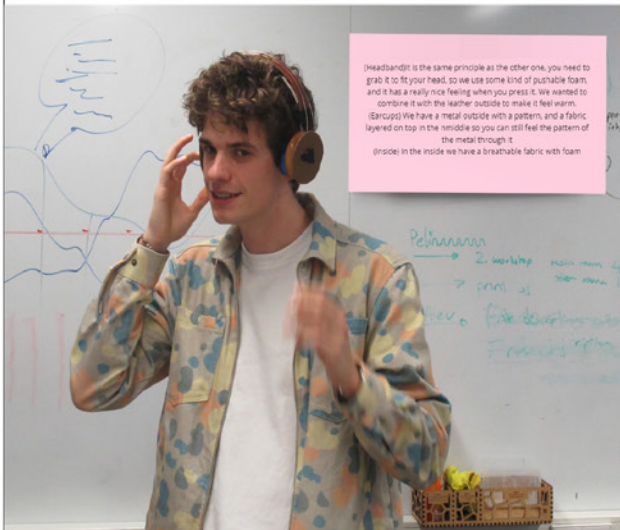
I don't like it when the form factor and the weight don't match - A. Form factor and weight match. Form factor and weight match.

-Decisions were made as they built and felt the prototype in between stages. exploration through building.

Led band at the top, which gives it the heavy exclusive feeling on the top, its sitting there. Weight somewhere else for premium feel but not loading.

-Glasses unfriendly is a concern for both team. Glasses functionality concern.

Around the ear, meaning over-ear. Nice sentence.



(Headband) is the same principle as the other one, you need to grab it to fit your head, so we use some kind of pushable foam, and it has a really nice feeling when you press it. We wanted to combine it with the leather outside to make it feel warm. (Ears) We have a metal outside with a pattern, and a fabric layered on top in the rim so you can still feel the pattern of the metal through it. (inside) in the inside we have a breathable fabric with foam.



The main theme, inspiration, is heat, and using that as a function of longevity, because if you are going to be holding it on your head for a long time heat was the biggest frustrating component for all of us. Led band at the top, which gives it the heavy exclusive feeling on the top, its just sitting there. The headpiece is a foam ring and on the inside there is another smaller ring of wood (imagine it thinner), it is the last point of contact with your head, its thin, so it touches your skull, and the actual foam bits touch your ear, so by the time it gets to your skull there's not much pressure.

Group 1

Group 2

What has been used to achieve the haptic aesthetic feel

Preferred object properties

What sensations are present in using the prototype?

Sensations

How has novelty been created

Haptic novelty

Are there any new elements in the user journey?

Change in interaction

-Participants try layering up to 3 materials and then interacting with it
Layering materials

The thing is I don't want something that slips
Dislike of slippery

It feels better than it looks (silicone)
like of silicon feel

Quality and softness of some headphones is contradictory
Softness not perceived as quality

I like the consistency of one with the surface of the other speaking of thin paper plastic covering thin foams
Layering materials

Like here, you can feel different densities
Densities within one material

-What I like about this is that it's bendable, and that you don't need to worry about breaking it
Likes sturdy feeling with flexibility

-If there is some weight that you feel is sitting on your head
weight as feeling of safety

I do like weight but not clamping
Weight is liked, clamping not

I do really like this
wooden block

They sued memory foam on the inside
memory foam

I do love the added security it gives you
Weight as feeling of safety

Participants try different materials on their ears, face, hand, top of the head, squashing against body parts
Trying materials against body parts

I really like the massaging when you put it on and off, especially your head, it feels really good, it gives that kind of experience when you're on and off.
on and off motions are sensational

When I wear them for hours, I feel some much pain here (points at top of the head) the pressure is, I agree
Sensations in time

This is cool but if you do this for 8 hours it would end up wet (referring to dense black foam)
Sensations in time

How about support from the bottom part - it makes it more stable and supports your head
feeling of support

Also, stopping work with a feeling of relief.
Relief

The rope is meant to give structure in some way
Adding elements to add sensations

For me it is on the point that it gives me a headache (the weight)
Weight gets heavier in time

Weight on the top, the sides are very light
different weight distribution

Participants discuss the feeling of one material or other. They seem to relate non rigid plastic as interesting
Non rigid plastic as novel

And it's the texture on the outside of this is also for novelty, I don't know how it feels but it gives feedback that you are touching the headphones and it gives some resistance and the feeling is more
Novelty related to disliking (as it's not what you expect)

this is surprising referring to plastic bumpy material
surprising texture

Novelty related to disliking (as it's not what you expect)

flexibility + rigidity of led

It's very interesting but I absolutely hate it, it feels crunchy
Novelty related to dislike

I love the idea of making it structurally bizarre - haptic wise
Structurally bizarre

The whole novelty of the headphones is that you have different textures, so you feel that L and R
Asymmetrical textures

we have strange type of plastic which is novel because usually it is hard plastic
Soft plastic is novel

-You can make it something that you can tie
tying

With this on the inside and then you can just tighten it
tightening

When you're using the earphone you can twist it instead of taking it off
twisting

I really like the massaging when you put it on and off, especially your head, it feels really good, it gives that kind of experience when you're on and off.
on and off motions are sensational

And we like the massaging headband, this band gives you the sensation, it can be either at the back of your neck and front where has been for you. There are different feelings in adjusting the headband
Adjusting/positioning the headband

They really like memory foam
memory foam

I think this is pretty cool (white bumpy plastic). If you want to touch the outside of your headphones. When you want to you can swipe a
white bumpy plastic

I really like the feeling of the soft leather
soft leather

This is super nice, I like the squish
Neoprene

-What if the outside, the whole thing would feel fluffy, this is definitely different - T. E. also, I would really like that
softness

The leather gives it some structure and a fancy feel
structure

I also like that it feels like you're touching the skeleton of the object, because you feel the inside
hardness is quality, also inside softness

This is actually a really cool feeling (multi-layered cotton etc)
multilayer

I like the springy feeling
springy

-I think its nice if there is something hard inside, there is something hard inside anyway
Hard inside

For some reason it feels very premium that you have a soft volume that stops at a hard and becomes a part
Hard inside

-On the inside we have this soft luscious feeling, very soft, kind on the ears and comfortable
soft and luscious

-They interact with materials in different ways, squashing, pulling, squeezing etc.
Trying materials against body parts

I would like, when you want to put them on, you have a snappy feeling, and when you take them out and separate the headphones, like a release paper
sensation in each action

It is a bit ticklish in the ears but not disruptive
sensation in measure

What is the intended experience? Could it change during the way or based on the sound, if you listen to MIDI the headphones become rougher, better made, subtle texture
sensations change in time

the headband on top can become quite tiring in long sessions
pressure in time

Maybe, if this is heavy enough (earcups) you don't even need to have weight top
Different weight distribution

And because it's a band it has a very different haptic experience
different areas stimulated

Normally the outside of the headphones is hard but we want to do the opposite. The inside is hard where the electronics are and you can experience the electronics because outside is soft
switching sensations

-What if the outside, the whole thing would feel fluffy, this is definitely different - T. E. also, I would really like that
extreme softness as novel

This is interesting (foam with lumps)
different densities

-It's not on top of your head but on the sides and that changes the entire customer journey
change in customer journey

What if you have a little thing on your headphones, when you want to immerse yourself in the music you wrap yourself up the others hang off in the back
Extra wrapping action

When you lift it up you can just stretch and tie
stretch and tie

And because it's a band it has a very different haptic experience
stretch and tie

If you want to get rid of your music you can take one headphone off, or slide it back
sliding

Appendix 7. Ideation

The following shows the developed How-Tos and a mind-map conducted to come up with concepts during the ideation.



organic,
natural,
increasing
curves like i
echo

Cushion
patches
in fabric

Be really soft
in one
direction with
directional
fabric

Articulated
headband
(mimicking
led)

Make layers of
materials,
different
sensation in
depth

Felt

Use a
breathable
sexy fabric

switch to
another
part of the
ear cushion

ush cushion
against ear,
so on sides

Texturise star
element.
Driver?Weaving

Give a reaction
to the
element. i.e.m
a click with
long travel.

Recess a
part, make
a gap

Give the haptic
a meaning. i.e.
L and R,
Senheiser logo

The right ear
responds more to
speech and logic
while the left ear is
more tuned in to
music, emotion
and intuition

the texture
changes as
you stretch
it out

Pins that
you can
push in



concentric
Textures
that align or
misalign

Playing with
structures/materials
that compress
and decompress
slowly back

Push pins in and
out for
increased/decreas
ed tactility (using
springs i.e.)

You can insert
different textures
into earcushion
from above, to
increase or decrease
sponginess

The pressure
increases/decreas
es when you tilt
your head,
depending on the
angle

You can
compress or
expand the
earcup
footprint

Interact with the listening element in a more **kinaesthetic and haptically rich** manner?

wrap it around your head

squeeze it

move elements on it

turn it around at put it on the other side

Tap to adapt/adjust something

rotate something in the earcups

son
u
c

Intergrate a **sensation** into the user journey that **overtakes the experience** in active or pasive touch, and in hand, head and ears?

Make the earcushions extremely squishy so they sink into everything

very loud, clear clicks

High elastic tension, you stretch it over your head,

Slight tickling sensation, fabric on neck

Very cold sensation on the outside. Little metal inserts

Your whole head is wrapped

Create the sensation of **depth** in hands, ears, or head with **active and passive touch** when using the headphones?

With a surface/fabric in tension that you can push

In one positio or settings the headphones are static, in another they sink

Making the interaction feel longer, have a longer travel, i.e. you have to pull earcup which is folded upwards and place onto ears

Grooves

If there is something inside the (empty) earcup, a hard or moving element that you feel

With layers, like the princess and the pea

Ma
ea
you
dep
be
sm

Create a feeling of **openness** in the ears and head?

Making a very structural headphone

Being able to feel the driver

Not much padding

Bring the user interaction **physically closer** to the purpose of the headphones.

You need to hold the earcups while listening

The cable connector has a way bigger interaction, a big surface to push on

Can you actually amplify the base or something by acting on the headphone

To put them on, you move your head and ear into the headset

Enhance/accompany the **experience of using headphones** with haptics?

It adapts to the activity you are doing. Are you in chill mode? or in active mode. The sides of the earcups could expand

You have different types of headbands depending on the interaction. You just switch them up

You can bend back one earcup to stop listening in one ear

If you stretch it and deform it and it slowly clamps/forms back to your head

Enhance/accompany the **listening experience** with haptics?

Inertia of headphones accompany the movements of your head. Tapping against sides if you move sideways. Could be held by a magnet

Adapting to the kind of music with deformed/flat surface

Cable is dancing with your hands

Membrane touches your ear whenever you shake it

PAR of the headphones is dangleing as you shake your head

The membrane is connected to a mechanical part, it transmits certain frequencies to that part. You can adjust it also through the amplifier.

Diff
of
diffe
it p
w

Create sturdy feeling **swivel and hinge** movements?

Swivling feels like a dance

A bit like a top kitchen cabinet, you fold the earcup from above and place over the ears

The earcups rotate 360 in y, z, x?? axis, using one pivot soing or more.

Slide something up and down

Move headband forwards and backwards, hinge adapts

Tap it in the right place so you feel it somewhere else

Deform the cushion yourself so it fits your ear

Bring the softness from the outside to the inside by squeezing an air cushion

Hinge in the middle of the headband. Fold over head

Click in the middle of headband, like a cable

Slide one part into the other, one half into the other

You can create more tension in the headphones by twisting the headband and making knots in it

You move your head/ears down/sideways to your earcups

Slide them onto your head from the front

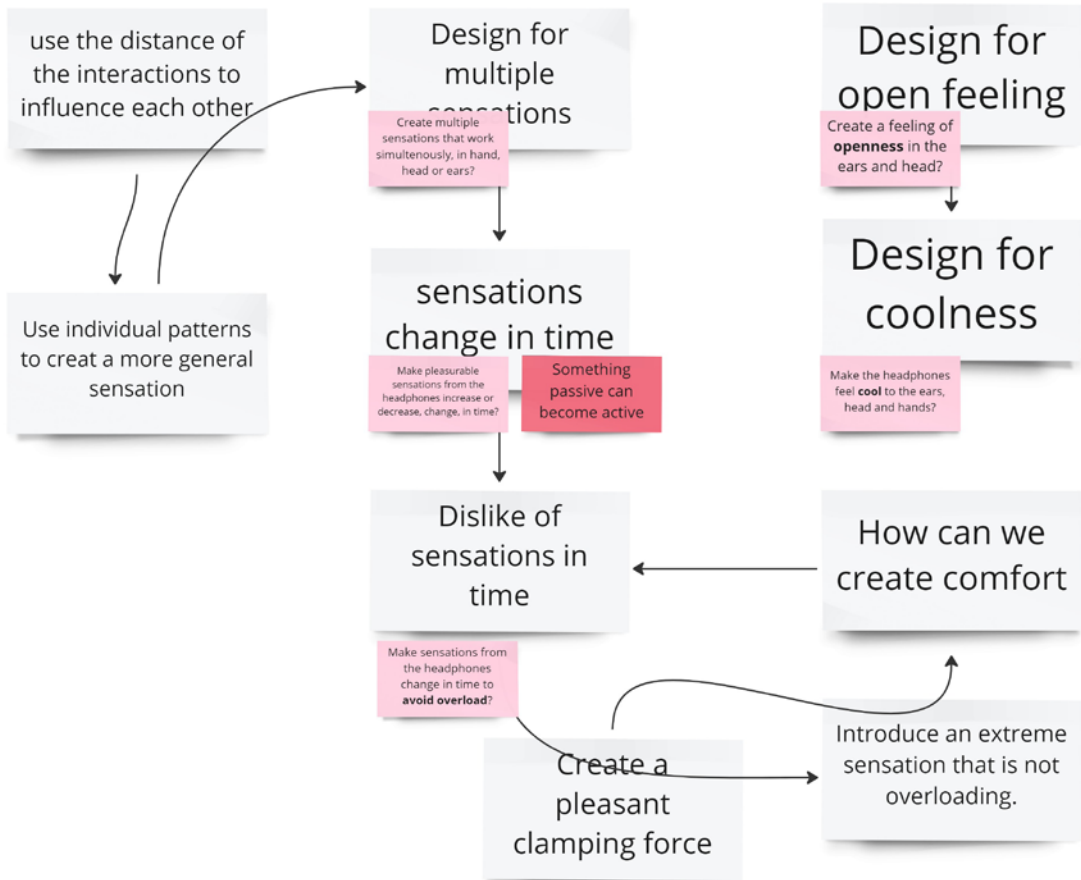
Making a large earcup cavity, if ears feel the depth, they can be squeezed to smaller volume

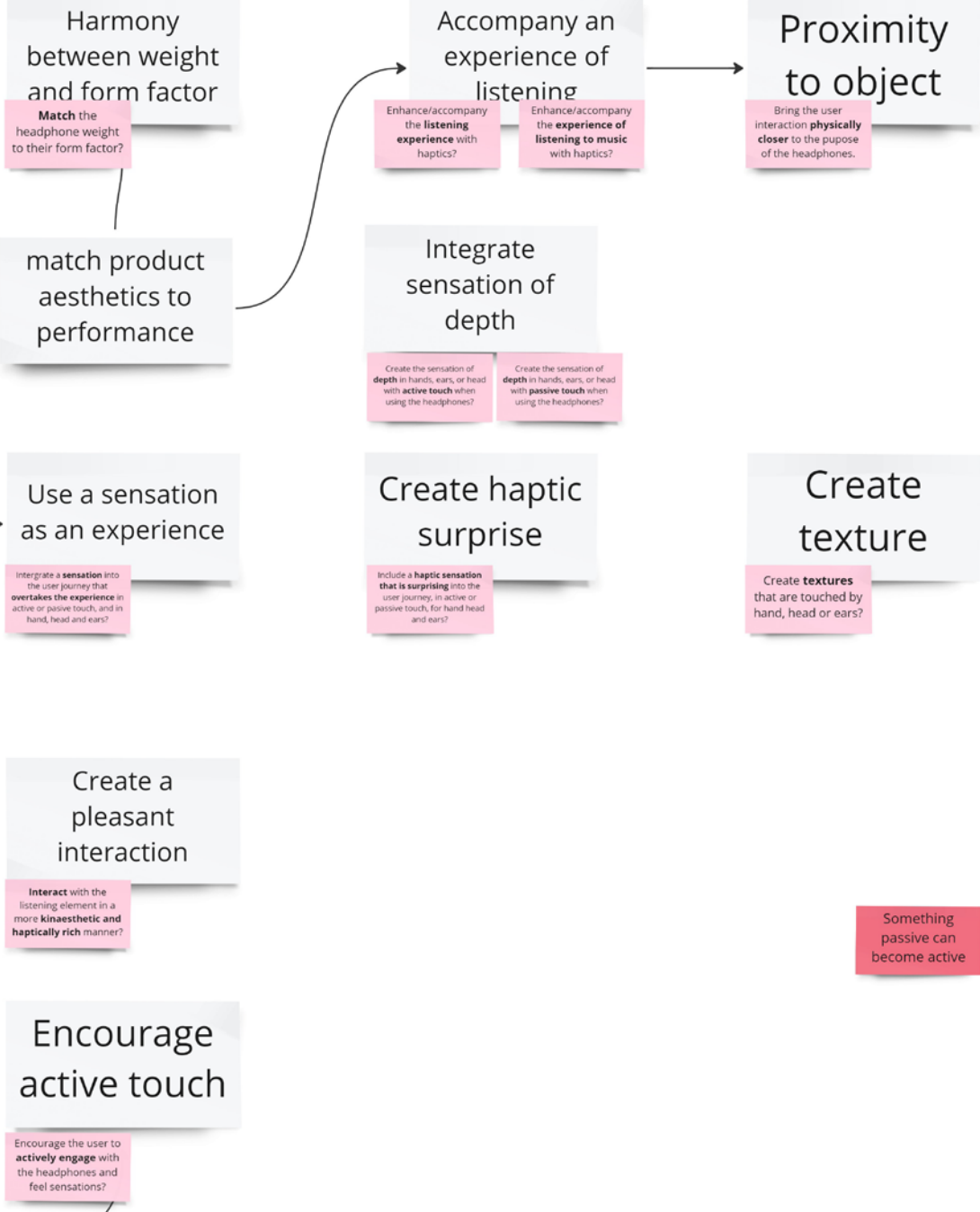
It covers deeper into your body. i.e., your neck

Different lengths of cable have different textures, progresses as if playing a song

Stereo haptics

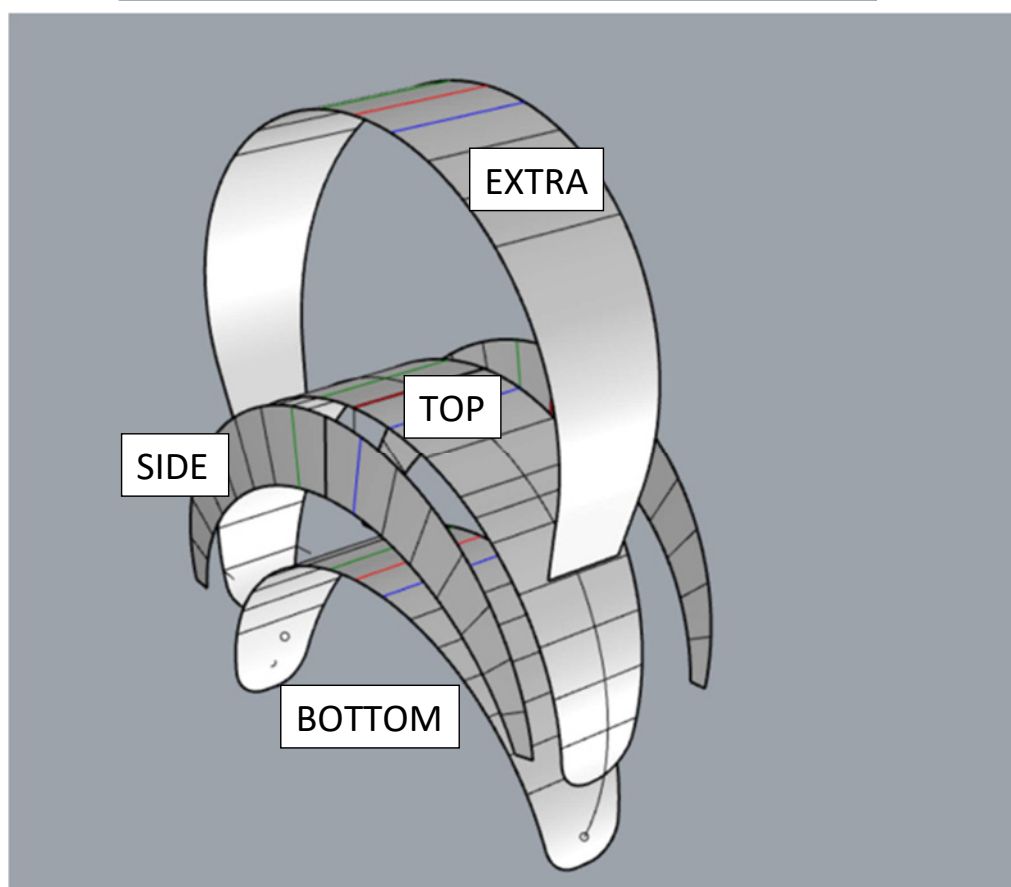
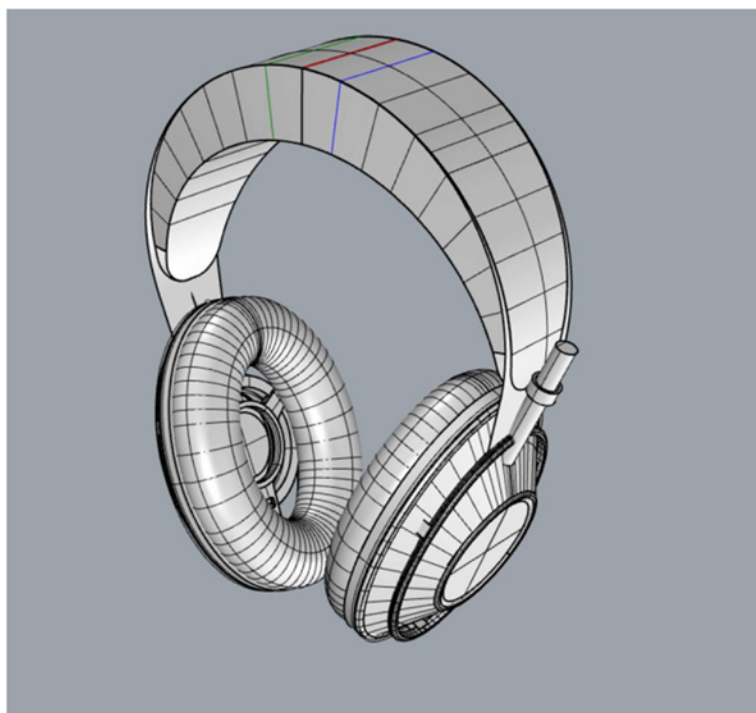
HMW

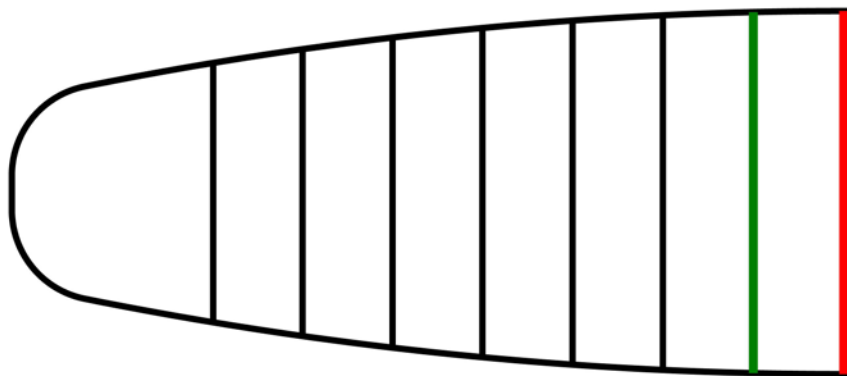
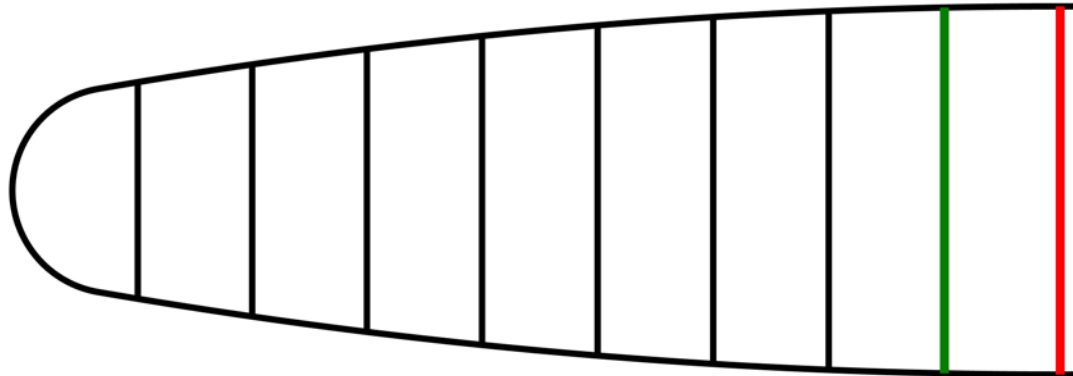
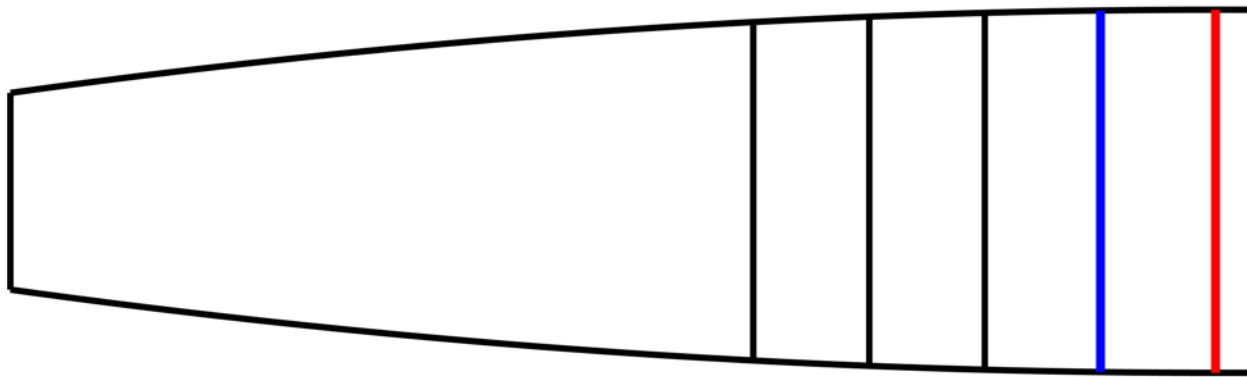


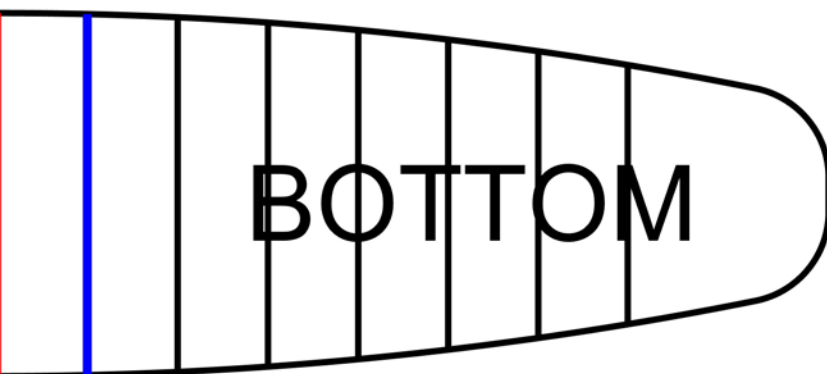
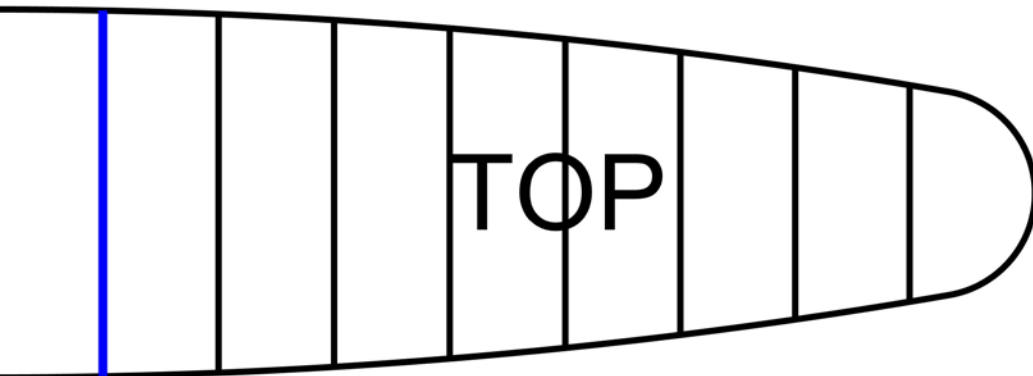
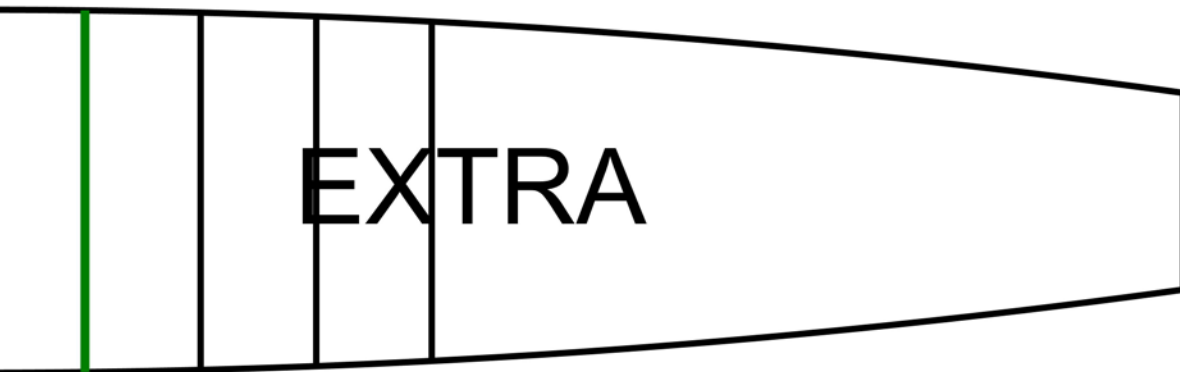


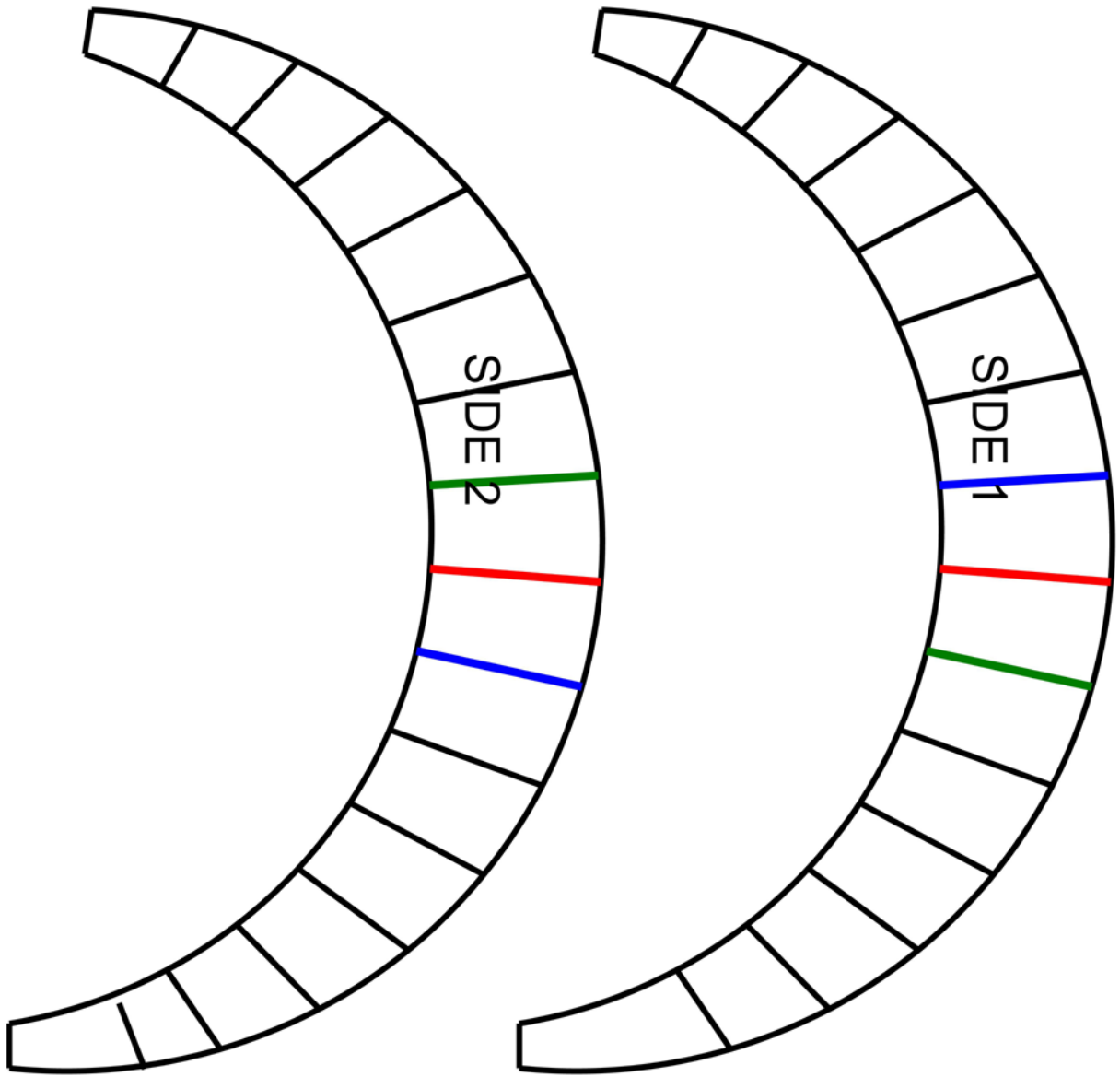
Appendix 8. Sleeve pattern

The following patterns were developed in Rhino3D to create a sleeve for the final prototype.









Appendix 9. SPSS calculations

For the empirical tests, many statistical models and values were calculated using SPSS. The following shows the results obtained in the software.

A. Means of each stimuli: A, B, C and deviations

Descriptive Statistics			
	Mean	Std. Deviation	N
AestheticA	5.4091	1.43623	22
UnityA	5.6818	1.12911	22
VarietyA	4.7273	1.20245	22
AestheticB	5.0000	1.87718	22
UnityB	4.2273	1.63100	22
VarietyB	6.1364	.88884	22
AestheticC	4.5000	1.47196	22
UnityC	4.9091	1.50899	22
VarietyC	4.3182	1.39340	22

B. Pearson correlations, partial correlations

UA Correlations

		Unity	Aesthetic
Unity	Pearson Correlation	1	.208*
	Sig. (1-tailed)		.047
	N	66	66
Aesthetic	Pearson Correlation	.208*	1
	Sig. (1-tailed)	.047	
	N	66	66

*. Correlation is significant at the 0.05 level (1-tailed).

VA Correlations

		Aesthetic	Variety
Aesthetic	Pearson Correlation	1	.223*
	Sig. (1-tailed)		.036
	N	66	66
Variety	Pearson Correlation	.223*	1
	Sig. (1-tailed)	.036	
	N	66	66

*. Correlation is significant at the 0.05 level (1-tailed).

UV Correlations

		Variety	Unity
Variety	Pearson Correlation	1	-.441**
	Sig. (1-tailed)		.000
	N	66	66
Unity	Pearson Correlation	-.441**	1
	Sig. (1-tailed)	.000	

N	66	66
---	----	----

** . Correlation is significant at the 0.01 level (1-tailed).

UA - v Correlations

Control Variables		Unity	Aesthetic	
Variety	Unity	Correlation	1.000	.351
		Significance (1-tailed)	.	.002
		df	0	63
	Aesthetic	Correlation	.351	1.000
		Significance (1-tailed)	.002	.
		df	63	0

VA – u Correlations

Control Variables		Aesthetic	Variety	
Unity	Aesthetic	Correlation	1.000	.359
		Significance (1-tailed)	.	.002
		df	0	63
	Variety	Correlation	.359	1.000
		Significance (1-tailed)	.002	.
		df	63	0

Correlation table for all variables

		Aesthetic	Unity	Variety	ID	Typicality	Novelty
Pearson Correlation	Aesthetic	1.000	.208	.223	-.052	-.065	.396
	Unity	.208	1.000	-.441	.153	.357	-.316
	Variety	.223	-.441	1.000	-.161	-.281	.538
	ID	-.052	.153	-.161	1.000	.183	-.010
	Typicality	-.065	.357	-.281	.183	1.000	-.420
	Novelty	.396	-.316	.538	-.010	-.420	1.000
Sig. (1-tailed)	Aesthetic	.	.047	.036	.340	.301	.000
	Unity	.047	.	.000	.109	.002	.005
	Variety	.036	.000	.	.098	.011	.000
	ID	.340	.109	.098	.	.071	.470
	Typicality	.301	.002	.011	.071	.	.000
	Novelty	.000	.005	.000	.470	.000	.
N	Aesthetic	66	66	66	66	66	66
	Unity	66	66	66	66	66	66
	Variety	66	66	66	66	66	66
	ID	66	66	66	66	66	66

Typicality	66	66	66	66	66	66
Novelty	66	66	66	66	66	66

C. ICC

Means of intra individual correlations. Assessing interrater reliability. ICC is used to assess the consistency of measurements made by multiple observes measuring the same quantity.

- ICC (2,202)

Unity Intraclass Correlation Coefficient

	Intraclass Correlation ^b	95% Confidence Interval		F Test with True Value 0			Sig
		Lower Bound	Upper Bound	Value	df1	df2	
Single Measures	.467 ^a	.192	.927	21.763	3	63	.000
Average Measures	.951	.840	.996	21.763	3	63	.000

Variety Intraclass Correlation Coefficient

	Intraclass Correlation ^b	95% Confidence Interval		F Test with True Value 0			Sig
		Lower Bound	Upper Bound	Value	df1	df2	
Single Measures	.473 ^a	.194	.929	19.610	3	63	.000
Average Measures	.952	.841	.997	19.610	3	63	.000

D. Repeated measures ANOVA

Repeated measures ANOVA: to determine whether or not there is a statistically significant difference between the means of three or more groups with the same subjects in each group.

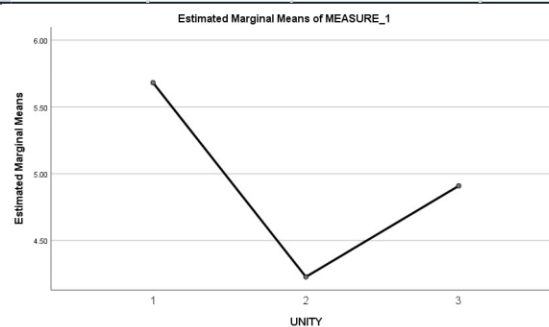
Unity

UNITY	Dependent Variable
1	UnityA
2	UnityB
3	UnityC

Multivariate Tests^a

Effect		Value	F	Hypothesis df	Error df	Sig.
UNITY	Pillai's Trace	.376	6.014 ^b	2.000	20.000	.009
	Wilks' Lambda	.624	6.014 ^b	2.000	20.000	.009
	Hotelling's Trace	.601	6.014 ^b	2.000	20.000	.009
	Roy's Largest Root	.601	6.014 ^b	2.000	20.000	.009

UNITY	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	5.682	.241	5.181	6.182
2	4.227	.348	3.504	4.950
3	4.909	.322	4.240	5.578



Variety

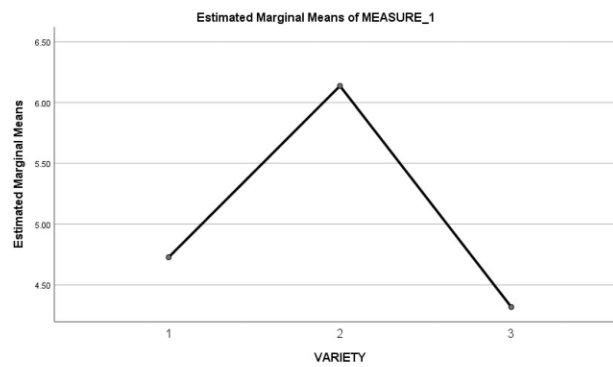
VARIETY	Dependent Variable
1	VarietyA
2	VarietyB
3	VarietyC

Multivariate Tests^a

Effect		Value	F	Hypothesis df	Error df	Sig.
VARIETY	Pillai's Trace	.625	16.676 ^b	2.000	20.000	.000

Wilks' Lambda	.375	16.676 ^b	2.000	20.000	.000
Hotelling's Trace	1.668	16.676 ^b	2.000	20.000	.000
Roy's Largest Root	1.668	16.676 ^b	2.000	20.000	.000

VARIETY	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	4.727	.256	4.194	5.260
2	6.136	.190	5.742	6.530
3	4.318	.297	3.700	4.936



Aesthetic pleasure

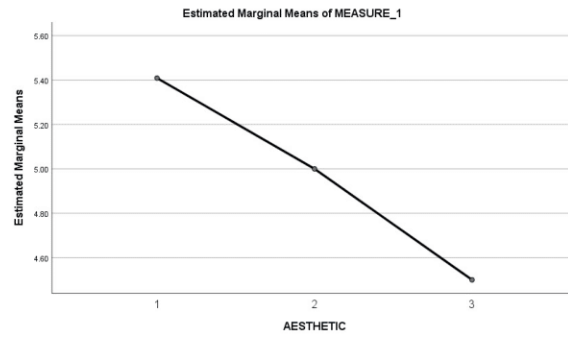
AESTHETIC	Dependent Variable
1	AestheticA
2	AestheticB
3	AestheticC

Multivariate Tests^a

Effect		Value	F	Hypothesis df	Error df	Sig.
AESTHETIC	Pillai's Trace	.233	3.041 ^b	2.000	20.000	.070
	Wilks' Lambda	.767	3.041 ^b	2.000	20.000	.070
	Hotelling's Trace	.304	3.041 ^b	2.000	20.000	.070
	Roy's Largest Root	.304	3.041 ^b	2.000	20.000	.070

AESTHETIC	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	5.409	.306	4.772	6.046

2	5.000	.400	4.168	5.832
3	4.500	.314	3.847	5.153



E. Linear regression

Descriptive Statistics

	Mean	Std. Deviation	N
Aesthetic	4.9697	1.62641	66
Stimuli	2.00	.823	66
Unity	4.9394	1.53802	66
Variety	5.0606	1.40196	66

Correlations

		Aesthetic	Stimuli	Unity	Variety
Pearson Correlation	Aesthetic	1.000	-.230	.208	.223
	Stimuli	-.230	1.000	-.207	-.120
	Unity	.208	-.207	1.000	-.441
	Variety	.223	-.120	-.441	1.000
Sig. (1-tailed)	Aesthetic	.	.032	.047	.036
	Stimuli	.032	.	.048	.169
	Unity	.047	.048	.	.000
	Variety	.036	.169	.000	.
N	Aesthetic	66	66	66	66
	Stimuli	66	66	66	66
	Unity	66	66	66	66
	Variety	66	66	66	66

Model Summary^b

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	Change Statistics			Sig. F Change
						F Change	df1	df2	
1	.423 ^a	.179	.139	1.50907	.179	4.501	3	62	.006

a. Predictors: (Constant), Variety, Stimuli, Unity

b. Dependent Variable: Aesthetic

ANOVA^a

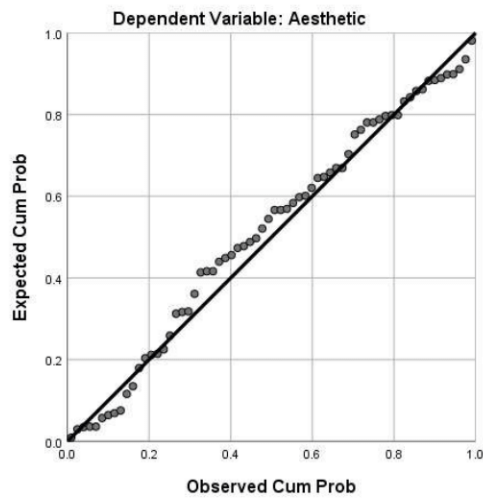
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	30.747	3	10.249	4.501	.006 ^b
	Residual	141.192	62	2.277		
	Total	171.939	65			

Coefficients^a

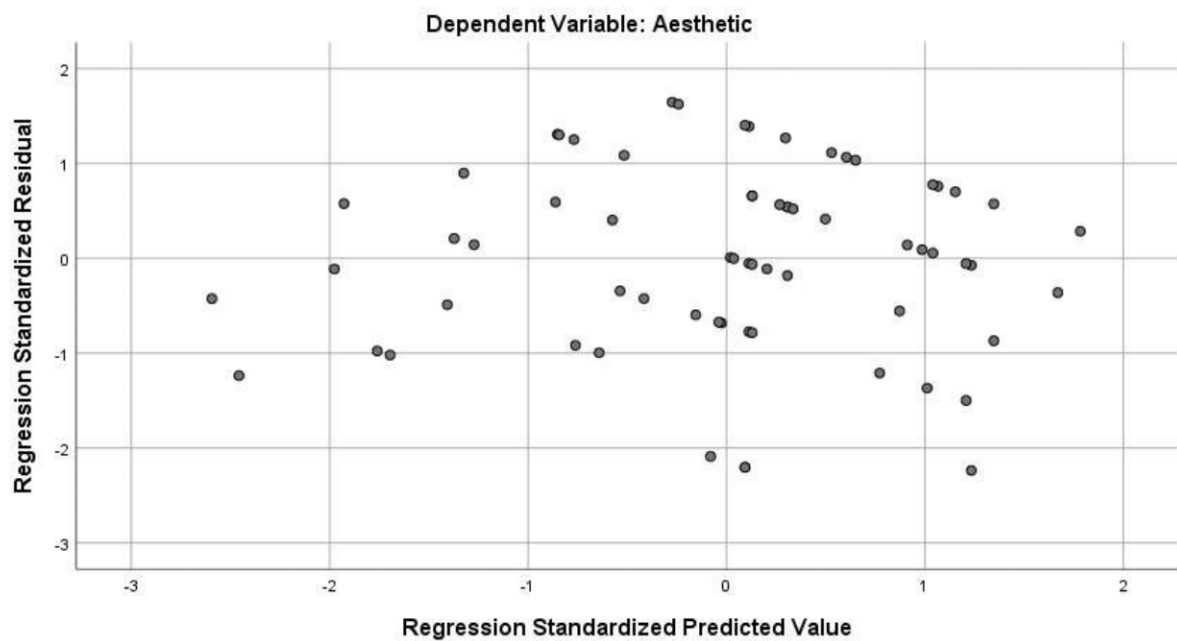
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Correlations		
		B	Std. Error	Beta			Zero-order	Partial	Part
1	(Constant)	1.513	1.500		1.009	.317			
	Stimuli	-.229	.240	-.116	-.954	.344	-.230	-.120	-.110
	Unity	.363	.142	.344	2.563	.013	.208	.310	.295
	Variety	.419	.153	.361	2.733	.008	.223	.328	.315

a. Dependent Variable: Aesthetic

Normal P-P Plot of Regression Standardized Residual



Scatterplot



F. Hierarchical linear regression, controlling for novelty and typicality.

Model Summary^c

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.393 ^a	.154	.141	1.50717
2	.563 ^b	.318	.273	1.38698

a. Predictors: (Constant), Novelty

b. Predictors: (Constant), Novelty, Stimuli, Unity, Variety

c. Dependent Variable: Aesthetic

ANOVA^a

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	26.559	1	26.559	11.692	.001 ^b
	Residual	145.380	64	2.272		
	Total	171.939	65			
2	Regression	54.593	4	13.648	7.095	.000 ^c
	Residual	117.346	61	1.924		
	Total	171.939	65			

a. Dependent Variable: Aesthetic

b. Predictors: (Constant), Novelty

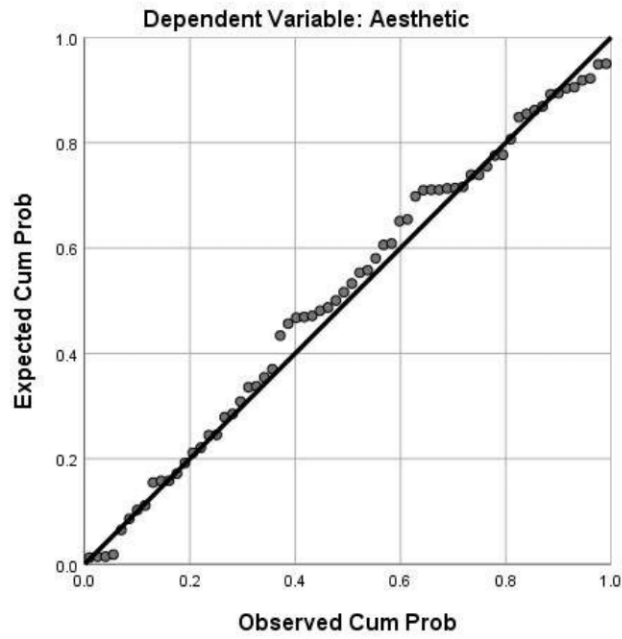
c. Predictors: (Constant), Novelty, Stimuli, Unity, Variety

Coefficients^a

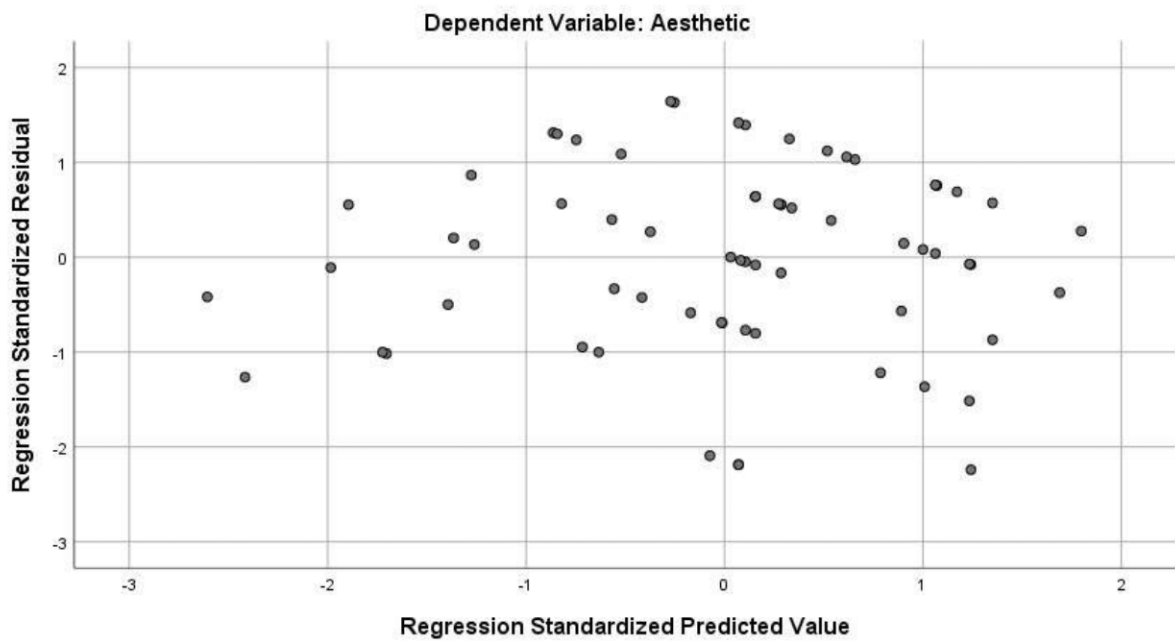
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.286	.806		2.835	.006
	Novelty	.505	.148	.393	3.419	.001
2	(Constant)	-.375	1.479		-.254	.801
	Novelty	.574	.163	.447	3.521	.001
	Stimuli	-.264	.220	-.134	-1.198	.236
	Unity	.410	.131	.388	3.132	.003
	Variety	.157	.159	.135	.985	.328

a. Dependent Variable: Aesthetic

Normal P-P Plot of Regression Standardized Residual



Scatterplot



G. Hierarchical linear regression, controlling for unity and variety

Model Summary^b

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.460 ^a	.212	.174	1.47822

a. Predictors: (Constant), Stimuli, Novelty, Typicality

b. Dependent Variable: Aesthetic

ANOVA^a

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	36.461	3	12.154	5.562	.002 ^b
	Residual	135.478	62	2.185		
	Total	171.939	65			

a. Dependent Variable: Aesthetic

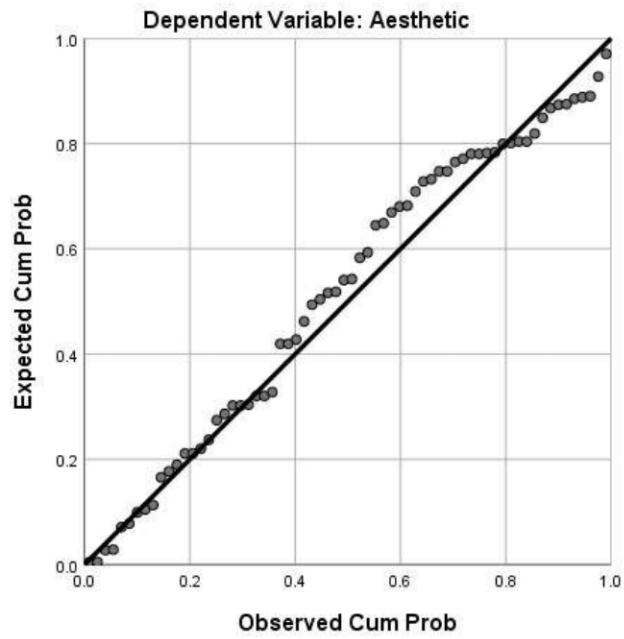
b. Predictors: (Constant), Stimuli, Novelty, Typicality

Coefficients^a

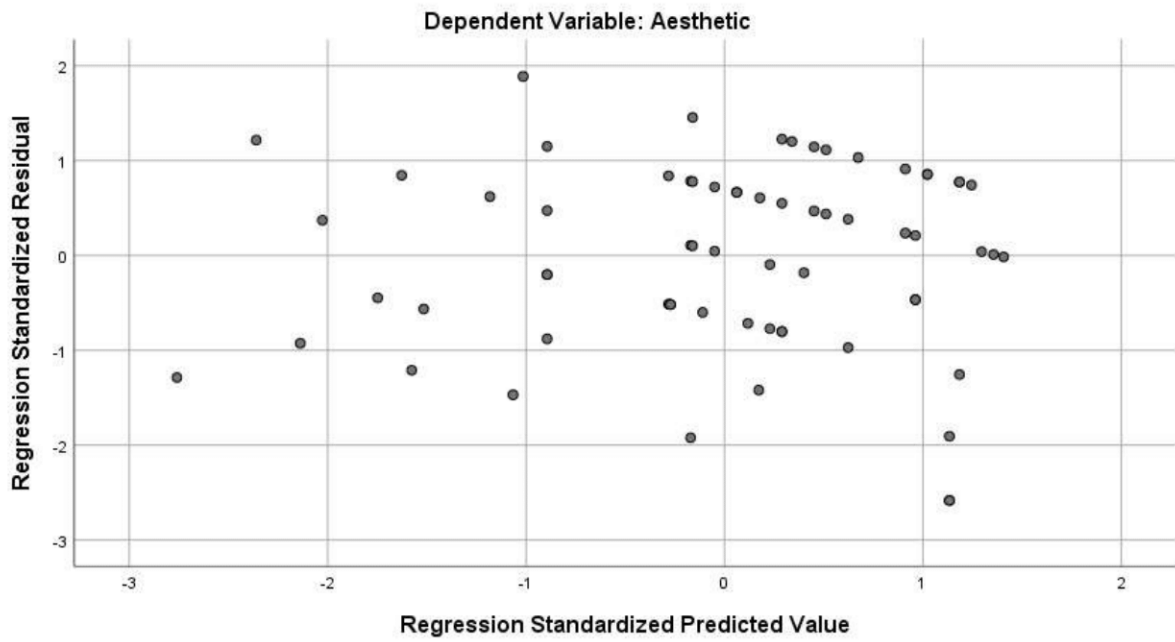
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.566	1.375		1.867	.067
	Typicality	.083	.137	.079	.609	.544
	Novelty	.549	.162	.428	3.387	.001
	Stimuli	-.420	.230	-.213	-1.830	.072

a. Dependent Variable: Aesthetic

Normal P-P Plot of Regression Standardized Residual



Scatterplot



Appendix 10. Codes for unity in variety user test

User	Comment scope	Code	Category	Core category
1	This feels too empty	The shape feels empty, boring (Uv)	Lack of stimulation is boring	A
1	Also are more interesting to touch	The rhomboid and its angles, variety, are interesting to touch (uV)	Pleasing to have a playful interaction	A
2	What I like about this one is that it has these two circles on each side, which you can interact with	Pleasing to have more elements to interact with	Pleasing to have a playful interaction	A
2	The circles also feel more like they are representative to headphones because the speaker circle	Circular shape is related to the speaker archetype	Circular shape is related to the speaker archetype, thus connected to function of making music and feels representative of headphones	B
2	The circles also feel more like they are representative to headphones because the speaker circle	Circular shape is related to the speaker archetype	Novelty – typicality in headphone	B Novelty
2	Which I think you could add functionality to and they are distinctively different in size and depth	Intention to add functionality	Intention to add functionality to interaction	A
2	The round circles in the different height feel like it's organized	Repeating shape feels unified (UV)	Unity found in variety	C
2	because you could add features or gestures to them	Intention to add functionality	Intention to add functionality to interaction	A
2	I would say that it feels like a pair of headphones	While wearing them, the headphones feel like a typical pair of headphones	Typicality found in the passive touch of the headphone	B
2	I don't really interacting with this product because for me it's very confusing. A lot of stuff going on	A lot of information feels confusing/distracting (uV)	Too much stimulation is unpleasant	A

User	Comment scope	Code	Category	Core category
2	So there's like a learning curve here. So it feels very innovative	As it is complex and innovative there is a learning curve (uV)	Learning / liking curve	E
2	have two different shapes round and sharp	Combination of rounded and sharp does not feel unified (uV)	Unity not found in variety	C
2	it conveys a lot of variety in height and depth and shape	Variety in height and depth (UV)	Relevant / perceived product features	C
2	So it's pleasing to play with the insert	Pleasing to have a playful interaction	Pleasing to have a playful interaction	A
2	the round shape feels familiar	Circular shape is representative of headphones	Circular shape is related to the speaker archetype, thus connected to function of making music and feels representative of headphones	B
2	different openings and a big circle opening in the middle. So you have all these different shapes	Repeated openings make it feel varied, yet unified and ordered (Uv)	Unity found in variety	C
3	They're very comfortable	The headphones are comfortable	Ergonomic headphones	D
3	lightweight.	The headphones are lightweight	Ergonomic headphones	D
3	Yeah. I like the shape. I like this. The funkiness. Oh, it's more interesting than the round.	The rhomboid and its angles, variety, are interesting to touch (uV)	Pleasing to have a playful interaction	A
3	Yeah. I like the shape. I like this. The funkiness. Oh, it's more interesting than the round.	"I like the funkiness"	Funky	B
3	I also like the size of the pieces here because kind of suspends over the years and I feel like it's quite organic over the	The length of the rhomboid matches that of the ears, feels organic (uV)	Feels organic, pleasing	E Haptic aesthetics

User	Comment scope	Code	Category	Core category
3	I mean, it's kind of like the opposite of this, right? So I guess, is it two?	Novelty and Typicality assessed as opposites	Seeing categories as opposites	Misunderstanding of statements and ratings
3	With the slots in here	Feeling the slots of Uv affects judgement	Unintended perception of stimulus	Misunderstanding of statements and ratings
3	With the slots in here	Feeling the slots of Uv affects judgement	Support structure is relevant	E
3	The circle protrudes quite a bit	The middle ring feels protruding because of lack of second layer (Uv)	Unintended perception of stimulus	Misunderstanding of statements and ratings
3	The circle protrudes quite a bit	The middle ring feels protruding because of lack of second layer (Uv)	Bulky is unpleasant	E
3	Does feel a bit new-ish, but not super new	While wearing them, the headphones feel like a typical pair of headphones	Typicality found in the passive touch of the headphone	B
3	Not big fan of the noches though.	Feeling the support of second ring in UV affects judgement	Support structure is relevant	E
3	This looks very different than I thought	Surprise when viewing stimuli	Visual aesthetics are relevant	F
3	I didn't realize the inner bit was exactly the same as the other one	Surprise when viewing stimuli	Visual aesthetics are relevant	F
3	I like the look of the diamond.	Rhomboid is visually aesthetic too (uV)	Visual aesthetics are relevant	F
3	I think the weight's really good	The headphones are lightweight	Ergonomic headphones	D Holistic evaluation
4	It's very delicate with this thin edges and then thin	The headphones feel delicate and thin	The headphones feel fragile	D
4	This feels more natural because it's round in instead of the, the other one was more rectangular.	Circular shapes feels more natural, more organic	Feels organic, pleasing	E Haptic aesthetics

User	Comment scope	Code	Category	Core category
4	with this straight line it felt a bit less organic	The rhomboid / straight edges feel less organic (uV)	Feels organic, pleasing	E Haptic aesthetics
4	So a bit more odd to interact with than the other two, but also a bit more interesting	Interaction with rhomboid is more interesting, and odd (uV)	Pleasing to have a playful interaction	A
4	It feels like this shape here It's a bit too big	The shape feels too big, bulky (uV)	Bulky is unpleasant	E
4	And then it took me a while to get that there's something in there	Difficult to feel the differences between stimuli	Participant perception differs	G
4	there should have been a bigger height difference between these	Height difference between the rings is relevant	Space and geometry allow for interaction, affordances	E, A
5	Yes, because it's difficult to feel the difference	Difficult to feel the differences between stimuli	Participant perception differs	G
5	because they're quite light	The headphones are lightweight	Ergonomic headphones	D Holistic evaluation
5	I was thinking about this kind of design more like the form that follow the function	Circular shape is connected to function of making music	Circular shape is related to the speaker archetype, thus connected to function of making music and feels representative of headphones	B
5	but I like the way it's different from the others, like the structure	The soft fabric outside that lets you feel the structure is novel	Novelty and typicality found in the headphone	B
5	like the structure, the way that you try to save the weight, with this kind of structure	The headphones are lightweight	Ergonomic headphones	D Holistic evaluation
5	A different shape	Combining different shapes feels varied (uV)	Unity found in variety	C
5	some contrast on this side. Yeah. But adjust the volume	Intention to add functionality	Intention to add functionality to an interaction	A

User	Comment scope	Code	Category	Core category
5	Because however, they very similar	Difficult to feel the differences between stimuli	Participant perception differs	G
5	but it reminds me how you know the game. Ah, video and they are very sometimes very strange, big with different shapes	Rhomboid shape associated with gaming headphones (uV)	Novelty and typicality found in the headphone	B
5	it would be nice to interact with them to adjust the sound or maybe pair with to connect with the phone.	Intention to add functionality	Intention to add functionality to an interaction	A
6	I like the feeling of the headband, the squishiness of it.	The fabric give in the headband feels pleasant	Pliability is pleasant	E Haptic aesthetics
6	It almost feels like I shouldn't be touching	It feels fragile to engage with the earcup	Emotions	E Haptic aesthetics
6	Okay, so the speaker will be in here. Yeah. So you actually touching,	Thinks of product's function	Closer to core of headphone	D Holistic evaluation
6	it fragile? Is it okay to touch? That's a, it's scary,	It feels scary to engage with the earcup	Emotions	E Haptic aesthetics
6	This feels a bit more secure compared to the previous one	It feels more secure to engage with the earcup as the fabric is more supported (uV, UV)	Emotions	E Haptic aesthetics
6	I kind of like the squarish though. These are very neutral cause it's so round. It's round this oval. Of course. Little edges. I like this too.	Circular shapes feels very neutral (Uv)	Feels organic, pleasing	E Haptic aesthetics
6	it still just feels a bit fragile	It feels fragile to engage with the earcup	Emotions	E Haptic aesthetics
6	It's interesting because of the sharp corners, the contrast stuff, the diamondy pattern. it also feels quite irregular.	The rhomboid and its angles, are interesting to touch (uV)	Pleasing to have a playful interaction	A

User	Comment scope	Code	Category	Core category
6	I agree with it, but it's still a bit funky to feel it this way because it's a bit unusual	Interaction with rhomboid is more interesting, and odd (uV)	Pleasing to have a playful interaction	A
6	I agree with it, but it's still a bit funky to feel it this way because it's a bit unusual	"Funky to feel"	Novelty – typicality in headphone	B Novelty
6	It feels quite coherent with different parts.	Combining different shapes feels varied (uV)	Variety achieved with low unity manipulation	C
6	I think they all feel quite well if I just wear them, they feel all feel quite typical	While wearing them, the headphones feel like a typical pair of headphones	Typicality found in the passive touch of the headphone	B
6	On the outside, I think they would all feel all quite non-typical	Engaging with the soft fabric outside that lets you feel the structure is atypical	Novelty found in the active touch of the headphone	B
6	And I would say this one is slightly above because it's square	The rhomboid earcup is less typical	Novelty – typicality in headphone	B Novelty
6	This feels a bit more conventional, which is also very nice because you kind of just <laugh> put your finger on and just go around	Pleasing to have a playful interaction, following the circle with the hand	Pleasing to have a playful interaction	A
6	the ring feels a bit too high to be honest. So it's a bit like you have this step and this is very small	Layer height feels imbalanced	Height difference between the rings is relevant	E Haptic aesthetics
6	But it still kind of gets back to the archetype of being the speakers are around.	Circular shape is related to the speaker archetype feels representative of headphones	Circular shape is related to the speaker archetype, thus connected to function of making music and feels representative of headphones	B
6	Yeah. And that's why I give it lower. Yeah. But I say it's more unified. Say it's more unified in the shapes. Cause in the other	Height difference between the rings is relevant	Height difference between the rings is relevant	E Haptic aesthetics

User	Comment scope	Code	Category	Core category
	one, this is square and this round. So that's more contrast in on that sense.			
6	But then the other one, because it kind of points out there's more space for your fingers.	The shape causes your fingers to be squeezed inbetween, unpleasant interaction (UV)	Restricting interaction	A
6	That's also what I noticed is the more you kind of play with them, they you learn them a bit. That does change how you think about 'em.	There is a familiarising time / liking curve that changes your impression	Learning / liking curve	E
6	So it just feels a bit weird you that it's touchy	The soft fabric outside that lets you feel the structure is novel	Novelty found in the active touch of the headphone	B
6	It just feels very basic	The shape feels empty, boring (Uv)	Lack of stimulation is boring	A
6	It's definitely something I haven't had before	The soft fabric outside that lets you feel the structure is novel	Novelty found in the active touch of the headphone	B
6	But now you have round and then goes to this kind of oval ish shape.	The lack of the inbetween element makes it feel not unified, disconnected (Uv)	Discontinuity feels not unified	C
7	because it has less elements, it feels more like it all belongs together.	Less elements make it feel more unified (Uv)	Less elements (low variety) feels more unified	C
7	I think typical would be more smooth and this something's standing out of it, so I think that's atypical	The protrusion feels atypical (Uv)	Novelty – typicality in headphone	B Novelty
7	because I think I feel like if it has more parts, yes, less of a unified product	and variety mistaken for oneanother	Misunderstanding of statements and ratings	Misunderstanding of statements and ratings
7	But the difference is clear	The difference between the stimuli is clear	Participant perception differs	G

User	Comment scope	Code	Category	Core category
7	I think it's close to normal headphones because it also has a round shape	Circular shape feels representative of headphones	Circular shape is related to the speaker archetype, thus connected to function of making music and feels representative of headphones	B
7	I think this feels more coherent because it all has the same round shape instead of different	Repeating shape feels unified (UV)	Unity found in variety	C
8	Because I'm a bit distracted by the square thing	A lot of information feels confusing/distracting (uV)	Too much stimulation is unpleasant	A
8	It's more round shaped and then think if you listen to music, you might want to stroke and circle movements around your ear a	Pleasing to have a playful interaction, following the circle with the hand	Pleasing to have a playful interaction	A
8	It's more round shaped and then think if you listen to music, you might want to stroke and circle movements around your ear and then you can do the better on these headphones.	Intention to add functionality	Intention to add functionality to interaction	A
8	I'm just not familiar with fabric cover over the headphones	The soft fabric outside that lets you feel the structure is novel	Novelty found in the active touch of the headphone	B
8	There's more gaps	Other parts are more accessible and influence appreciation (Uv)	Attention focus is different across participants	G
8	It's the thing that's in the middle of the circle points out too much.	The middle ring feels protruding because of lack of second layer (Uv)	Unintended perception of stimulus	Misunderstanding of statements and ratings
9	Feel like it's wearing panty hose	Association to an intimate garment	Emotions	E Haptic aesthetics
9	Well soft but fragile	It feels fragile to engage with the earcup	Emotions	E Haptic aesthetics

User	Comment scope	Code	Category	Core category
9	It's very hard to really have a difference	Difficult to feel the differences between stimuli	Participant perception differs	G
9	it is made of different parts. I would give it high, but it doesn't really convey variety because the same form of parts is why I would not call it	Unity and variety mistaken for oneanother	Misunderstanding of statements and ratings	Misunderstanding of statements and ratings
9	Yeah, because it has a more bulky, this part sticks out	The middle ring feels protruding because of lack of second layer (Uv)	Unintended perception of stimulus	Misunderstanding of statements and ratings
9	it's less interesting than the other one because it has less parts	The shape feels empty, boring (Uv)	Lack of stimulation is boring	A
9	Because it kind of reminds me of a typical headphone shape	While wearing them, the headphones feel like a typical pair of headphones, with archetype shape	Typicality found in the passive touch of the headphone	B
9	Because there's more contrast between the shapes, more things happening or something going from circle to what is it? Square	The rhomboid and its angles, variety, are interesting to touch (uV)	Pleasing to have a playful interaction	A
9	But if you would go from the looking perspective and just using them, the other ones with the circles, ovals might be just more nice or straightforward.	The circular shapes are more visual aesthetic, while the rhomboid is more haptic aesthetic	Visual aesthetics are relevant	F
10	The tissue around it. It feels weird.	It feels weird to interact with the fabric (too novel?)	Too novel	B
10	haven't so far all of the headphones ever quite sturdy outside, but solid on the outside. This one feels a little bit with different.	The soft fabric outside that lets you feel the structure is novel	Novelty found in the active touch of the headphone	B

User	Comment scope	Code	Category	Core category
10	It feels too much softness or too much. It feels not, how do you say that? Stable enough from the outside?	The lack of the inbetween element makes it feel not supported (Uv)	Emotions	E Haptic aesthetics
10	I give it a two. It feels a bit like you have just something flat and you put like this on it.	The middle ring feels protruding because of lack of second layer (Uv)	Unintended perception of stimulus	Misunderstanding of statements and ratings
10	I thought that the third ones would be my favorite, but now I kind of like this	There is a familiarising time / liking curve that changes your impression	The headphone perception changes after engaging for some time	E
11	it feels also a bit fragile	It feels fragile to engage with the earcup	Emotions	E Haptic aesthetics
11	the middle is flat so I can have the trampoline effect	Likes the stretching / trampoline of the fabric	Pleasing to have a playful interaction	A
11	the middle is flat so I can have the trampoline effect	Likes the stretching / trampoline of the fabric	Pleasing to have a playful interaction	E
11	It's more like angular and the fabric feels different on that part	The fabric feels different across the headphone	The fabric feels different across the headphone	D
11	it feels a bit higher quality because the shape which is underneath the fabric,	Discovering the shape through the fabric feels high quality	Associations	E
11	It reminds me of metal tubing, which has finding machines holes,	Association to industrial product	Associations	E
11	just clashes with what I'm used to. Especially cause there's a circle in middle again and the fabric has less stretched because of the shape but it's interesting to have these sharp corners	The rhomboid / straight edges feel less organic (uV)	Feels organic, pleasing	E Haptic aesthetics

User	Comment scope	Code	Category	Core category
11	It feels slightly larger compared to the first one	The middle ring feels protruding, and bulkier, because of lack of second layer (Uv)	Unintended perception of stimulus	Misunderstanding of statements and ratings
11	So it feels less sophisticated	The simplicity makes it feel less sophisticated	Associations	E
11	I like the cylinder in the middle. I can hold it with my hands, I can put my fingers around the cylinder	Likes holding the ring in the middle	Pleasing to have a playful interaction	A
11	you can still feel the fabric stretch as well	Likes the stretching / trampoline of the fabric	Pleasing to have a playful interaction	A
11	the diamond shape is unusual on the outset of headphones always round or awful shaped or something.	The rhomboid earcup is less typical	Novelty found in the shape	B
11	because the fabric stretches, which is not usual on the outside, it is it more common on the inside maybe	The soft fabric outside that lets you feel the structure is novel	Novelty found in the active touch of the headphone	B
11	if it's too unified, it's a bit boring	The shape feels empty, boring (Uv)	Lack of stimulation is boring	A
11	And it also makes me a bit worried that the fabric will break	It feels fragile to engage with the fabric	Emotions	E
12	Okay. Because I don't know, I can grab it in many different ways. It feels like you can play around with it quite nicely.	Interaction with rhomboid is more interesting, and odd (uV)	Pleasing to have a playful interaction	A
12	Because it does feel unified and coherent, but it's not orderly	Contradictions within unity	Misunderstanding of statements and ratings	Misunderstanding of statements and ratings

User	Comment scope	Code	Category	Core category
12	it does make sense because it's all kind of longish	The length of the rhomboid matches that of the ears, feels organic (uV)	Feels organic, pleasing	E Haptic aesthetics
12	there's no variety in it. So for me it's like you get to know it rather quickly and if it, there's more different parts	As it is not varied there is no learning curve (Uv)	Learning / liking curve	E
12	I'm just very visual, so I'm imagining how it should look	Visual aesthetics are considered	Visual aesthetics are considered	F
12	the more I wear them, the more comfort I into feel	There is a familiarising time / liking curve that changes your impression	Learning / liking curve	E
13	It's funny how you immediately have an image of how it looks.	Visual aesthetics are considered	Visual aesthetics are relevant	F
13	It pictures the mesh that you have in backpacks when you want the backpack to be comfy	Association to garment	Associations / Emotions	E
13	I guess if you like the trampoline, it's nice.	Likes the stretching / trampoline of the fabric	Pleasing to have a playful interaction	A
13	I don't know anyone that has triangles.	Rhomboid feels atypical	Novelty found in the shape	B
13	all this minimalist jewelry and stuff where they want to stuff angular	Association to minimalist jewelry (feminine)	Associations	E
13	it's not typical cause none of them have the mesh,	Engaging with the soft fabric outside that lets you feel the structure is atypical	Novelty found in the active touch of the headphone	B
13	This one. Is it new? Is this typical? It's the opposite of new	Novelty and Typicality assessed as opposites	Misunderstanding of statements and ratings	Misunderstanding of statements and ratings
14	They feel kind of light	The headphones are lightweight	Ergonomic headphones	D

User	Comment scope	Code	Category	Core category
14	Wait, am I allowed to do this	Surprised by the interaction with the mesh	Surprised	E
14	Feels kind of like common headphones	While wearing them, the headphones feel like a typical pair of headphones	Typicality found in the passive touch of the headphone	B
14	this maybe feels more unified because I think the circular stuff fits	Circular shape is related to the speaker archetype, thus connected to function of making music and feels representative of headphones	Circular shape is related to the speaker archetype, thus connected to function of making music and feels representative of headphones	B
14	here I feel like I'm kind of feeling the mechanics of the what's happening inside of them or something.	Feeling connected to the core of the headphone	Headphone assesment	D
14	I feel more connected to what's happening inside	Feeling connected to the core of the headphone	Headphone assesment	D
14	but it also feels a bit fragile	It feels fragile to engage with the earcup (Uv)	Emotions	E Haptic aesthetics
14	So I feel maybe that I can feel more of the stuff happening inside, but then it feels maybe a bit more like, is it stable enough	It feels less secure to engage with the earcup as the fabric is less supported (Uv)	Emotions	E Haptic aesthetics
14	you can take my thumb too and take them off	Intention to add functionality	Intention to add functionality to interaction	A
14	but the other ones maybe when I felt the round stuff, I was like, is this, am I touching the microphone	Circular shape is related to the speaker archetype	Circular shape is related to the speaker archetype, thus connected to function of making music and feels representative of headphones	B
14	triangle, I feel like it's definitely a support because	Interaction with rhomboid is more interesting (uV)	Pleasing to have a playful interaction	A

User	Comment scope	Code	Category	Core category
14	this one maybe feels the most fragile	It feels fragile to engage with the earcup (Uv)	Emotions	e
14	it does feel like a typical headphones when I'm wearing it	While wearing them, the headphones feel like a typical pair of headphones	Typicality found in the passive touch of the headphone	B
14	This round part feels a bit more separated from the headphones than in the other two	The middle ring feels protruding because of lack of second layer (Uv)	Unintended perception of stimulus	Misunderstanding of statements and ratings
14	but this makes it a bit interesting	The rhomboid and its angles, variety, are interesting to touch (uV)	Pleasing to have a playful interaction	A
14	maybe I change my own definition of uni unified	Inconsistent ratings	Misunderstanding of statements and ratings	Misunderstanding of statements and ratings
14	n, it's still kind of new to me that you can feel this part. Maybe that's more novelty.	The soft fabric outside that lets you feel the structure, the inside, is novel	Novelty found in the active touch of the headphone	B
14	when I do this, if it reminds me of my headset or something.	The two circular layers, give structure, and remind of a headset	Typicality found in more structure	B
14	think when I look at them, I like the circle. But then that feeling of this interest,	The circular shapes are more visual aesthetic, while the rhomboid is more haptic aesthetic	Visual aesthetics are relevant	F
15	like it's less connected than the other one	The lack of the inbetween element makes it feel not unified, disconnected (Uv)	Unintended perception of stimulus	Misunderstanding of statements and ratings
15	No, the aesthetics better. So you think this one looks more aesthetic? I think so, yeah. Okay. With the roundness	The circular shapes are more visual aesthetic	Visual aesthetics are relevant	F
16	Its spikey and it's interesting. It has some holes somewhere and it's round and it's Quadratic.	The rhomboid and its angles, variety, are interesting to touch (uV)	Pleasing to have a playful interaction	A

User	Comment scope	Code	Category	Core category
17	Because it feels like the roundness. It's like cool. So it makes it touch it more and go around and then the other circle as well	Pleasing to have a playful interaction, following the circle with the hand	Pleasing to have a playful interaction	A
17	Maybe I would give it a three maybe because all the space is covered with circular elements and the shape of the area is more or less circular as well	Repeating patterns is not varied. Contradicting statements.	Misunderstanding of statements and ratings	Misunderstanding of statements and ratings
17	More or less fully covered with different shapes and the shapes are coherent with themselves	The inbetween element makes it more connected and unified (UV)	Discontinuity feels not unified	C
17	for some reason straight lines bother me or	The rhomboid / straight edges feel less organic (uV) and disturbing	Feels organic, pleasing	E Haptic aesthetics
17	I feel like there is a lot of space around and I feel like it's not completely necessary.	The shape feels empty, boring (Uv)	Lack of stimulation is boring	A
18	I have a panty over my headphones	Association to an intimate garment	Associations	E Haptic aesthetics
18	I want to say cheap, but so it misses a sturdyness	It feels cheap to engage with the fabric as it is not tense	Product assesment	E
18	Because the fabric feels sturdier.	It is pleasing to interact with the sturdier fabric	Emotion	E
18	because the overall feeling is just a headphone	While wearing them, the headphones feel like a typical pair of headphones	Typicality found in the passive touch of the headphone	B
18	your cards don't really focus on also how it makes me feel while wearing it	Emotions elicited by the product	Emotion	E
18	feel different elements and there are small borders and stuff, however although you	Feeling different elements, yet unified and ordered (UV)	Unity found in variety	C

User	Comment scope	Code	Category	Core category
	feel that it doesn't feel strange. So yeah, the coherency is nice in this one			
18	, it feels enough if yet it remains within an ordinary headphone shape	While wearing them, the headphones feel like a typical pair of headphones	Typicality found in the passive touch of the headphone	B
18	Yeah, this feels a bit oversized	The shape feels too big, bulky	Bulky is unpleasant	E
18	would offer a lot of interaction.	Intention to add functionality	Intention to add functionality to interaction	A
18	It follows also a bit of the shape of my face or especially the diamonds	The length of the rhomboid matches that of the ears, feels organic (uV)	Feels organic, pleasing	E Haptic aesthetics
18	but the subtleness makes that it blends in an ordinary headphone.	Subtleness gives it unified	Subtleness gives it unified	C
18	Oh yeah. I kept saying, oh, the higher one.	The middle ring feels protruding because of lack of second layer (Uv)	Unintended perception of stimulus	Misunderstanding of statements and ratings
19	the round shapes	Circular shapes feels more natural, more organic, thus more unified	Feels organic, pleasing	E Haptic aesthetics
19	Because also because of the round shapes, actually, yeah.	Circular shape is related to the speaker archetype, thus connected to function of making music and feels representative of headphones	Circular shape is related to the speaker archetype, thus connected to function of making music and feels representative of headphones	B
19	Because you have something to grab onto	Pleasing to have a playful interaction	Pleasing to have a playful interaction	A
19	The angles in this finger are nice.	The rhomboid and its angles, variety, are interesting to touch (uV)	Pleasing to have a playful interaction	A
19	it feels stronger	Emotion associated to unified. Misinterpretation of statement	Misunderstanding of statements and ratings	Misunderstanding of statements and ratings

User	Comment scope	Code	Category	Core category
19	if I would touch them too strong or pick 'em up wrong	It feels fragile to engage with the earcup	Emotions	E Haptic aesthetics
19	It feels like a difficult barrel over your headphones	The lack of the inbetween element makes it feel not unified, disconnected (Uv)	Unintended perception of stimulus	Misunderstanding of statements and ratings
19	I like the round ones the most to look at, but not to Feel	Circular is visual aesthetic, rhomboid is haptic aesthetic	Visual aesthetics are relevant	F
20	It does really feel like a normal set of headphones on my head, but it does feel different when you touch them.	While wearing them, the headphones feel like a typical pair of headphones	Typicality found in the passive touch of the headphone	B
20	Or at least I feel like you're supposed to touch your, I'm drawn to pick try. I wanted to pick them up or take them off by the rings	Pleasing to have a playful interaction	Pleasing to have a playful interaction / affordances	A
20	The fabric with the last one, you've got more that the fabric feel and because there are more parts in this which prevent you from feeling the fabric a bit more	The inbetween element makes it feel more supported (Uv)	Emotions	E Haptic aesthetics
20	usually some of them have this variation between round the round shape of your ion and then angular shape following	The transition from circular to angular feels more high end	Association	E
20	I don't particularly like the change in the contrast between the smaller entering and the bigger angular ring outside	Combination of rounded and sharp does not feel pleasing (uV)	Variety is not pleasing	C
20	I don't particularly like the change in the contrast between the smaller entering and the bigger angular ring outside	Combination of rounded and sharp does not feel pleasing (uV)	Variety is not pleasing	E

User	Comment scope	Code	Category	Core category
20	I gave it a four, but I, there's the separation between the inner ring and the outer ring. Just it's not quite there.	Layer height feels imbalanced	Height difference between the rings is relevant	E Haptic aesthetics
20	I gave it a four, but I, there's the separation between the inner ring and the outer ring. Just it's not quite there.	Layer height feels imbalanced	Imbalance in height, low unity	C
20	Because you get the feeling of the fabric	The soft fabric outside that lets you feel the structure, the inside, is novel	Novelty found in the active touch of the headphone	B
21	I feel it's pretty common for this kind of a design	While wearing them, the headphones feel like a typical pair of headphones	Typicality found in the passive touch of the headphone	B
21	it does have different parts for sure, but then it does feel like one whole thing, at least with the sides.	Unity and variety mistaken for oneanother	Misunderstanding of statements and ratings	Misunderstanding of statements and ratings
21	I see a different way of interacting with these	Novel interaction	Pleasing to have a playful interaction	A
21	what could happen with these kind of, yeah. Interactions.	Intention to add functionality	Intention to add functionality to interaction	A
21	, it's easy to find so and interact with, because it's a large piece	The length of the rhomboid makes it more pleasing to interact with	Affordances / Ergonomics of the interaction	A
21	Sony headphones, which had this knob so that it reminds me of this	Association to other headphones	Intention to add functionality to interaction	A
22	But yeah, this was really nice. I like the fabric.	Likes the soft outside	Softness of fabric	E
22	I feel like I'm touching something that doesn't fit with my head and or organic shape of my body or something	Rhomboid and pointy does not feel organic	Feels organic, pleasing	E Haptic aesthetics

User	Comment scope	Code	Category	Core category
22	s funky.	The rhomboid and its angles, variety, are interesting to touch (uV)	Pleasing to have a playful interaction	A
22	they fit more with music because, but that's also just because what form? Language wise	Circular shape is related to the speaker archetype, thus connected to function of making music and feels representative of headphones	Circular shape is related to the speaker archetype, thus connected to function of making music and feels representative of headphones	B
22	I feel like I want to turn up the volume.	Intention to add functionality	Intention to add functionality to interaction	A
22	think this is a bit more sticking outward	The middle ring feels protruding because of lack of second layer (Uv)	Unintended perception of stimulus	Misunderstanding of statements and ratings
22	and I feel like I have less options here. Also. I feel like I'm not intrigued to touch them.	The shape feels empty, boring (Uv), less intriguing to touch	Lack of stimulation is boring	A

Appendix 11. Codes final evaluation

Comment scope	Comment text	Category
Fidelio x3, feels on the exterior like your headphone because it also has a cloth around it.	Association to headphone	Associations
The ratio of the shape, how it feels in my hands is different than what I know, instead of just being on my head and then going into a blob	Novelty in the structure and its shape	Novelty / atypicality in the structure, height and edges
I would like it to be softer, there are some sharp edges in there and I would then like it to be, because its inviting because of the cloth to be like a cushion	The cloth invites to a whole soft shape	Desires from headphone / headphone evaluation
Feels like a typical: for sure the fact that there is a net all around it	The fabric makes it not typical	Novelty / Atypicality in the use of fabric and its texture
I know it from the air pod max from apple	Association to headphone	Associations
It does feel representative	The headphone feels representative	The headphone conveys the archetype feel
It is so friendly in character but at some point I would like to have more spice	HD650 is light and pleasant, it disappears and could be more interesting	HD650 is comfortable, ergonomic and lacking stimulation
the cloth would not reveal the shape of the thing bellow it, because cloth has this sense of softness pleasantness and the hard edges break for me, so if it would be uniformly the round shape it would feel more pleasant.	The structure breaks the pleasantness of the fabric	Desires from headphone / headphone evaluation
To a teddy bear	Associations	Associations
GRADO headphones, because this (the slider) is like Grado, it is the same design	Association to Grado headphone	Associations
5, it just feels different than what you normally wear. Its quite innovative because of the vibration, that's something you don't have a lot.	Novelty in the vibration	Novelty in the vibration

Comment scope	Comment text	Category
They feel more typical because the oval shape	Typicality in the oval shape	The headphone conveys the archetype feel
but the double level feels less typical. 4	Atypicality in the structure and its shape	Novelty / atypicality in the structure, height and edges
I like the vibrating,	The vibration is a pleasant interaction	Desires from headphone / headphone evaluation
you always have the time to try and feel stuff. You have more time to figure out with which songs the vibration is deeper, what is cool to really interact with etc.	Time is essential to understand / figure out the concept	Time is essential to understand / figure out the concept
I have the association to a videogame controller because of the vibration	Associations	Associations
I do like the frame of it, it feels very industrial	Association to industrial	Associations
, I like that. I don't know about the fabric, its not weird but it just feels like a quick solution,	Fabric gives the feeling of a quick solution	Desires from headphone / headphone evaluation
Is the cloth a part of it	Fabric feels detached form the headphone	Desires from headphone / headphone evaluation
because of the textur	Novelty in the texture of the fabric	Novelty / Atypicality in the use of fabric and its texture
to push the fabric feels very new	Novelty in the fabric tension / give	Novelty / Atypicality in the use of fabric and its texture
its always been these cups and a bad over the head, mainly the part where you can push in a little bit is very fun	Novelty on the outside of the headphone but not the inside	Novelty on the outside but not on the inside or overall feeling
its always been these cups and a bad over the head, mainly the part where you can push in a little bit is very fun.	The fabric push is fun	Playful interaction is pleasant

Comment scope	Comment text	Category
a lot of it is more rough around the edges	Atypicality in the structure and edges	Novelty / atypicality in the structure, height and edges
4, in general it does feel like a headphone, especially when it sits on ,my head and I don't touch it directly	Typicality in the inside of the headphone	The headphone conveys the archetype feel
This one as well because it feels kind of heavy, it is not the most comfortable, and it weighs compared to this one.	Ergonomic concerns	Desires from headphone / headphone evaluation
It reminds him of the Grado headphones.	Association to headphones	Association
It does feel very sturdy in a good way, like a very long lasting headphone, compared to the plastic	It feels robust	Desires from headphone / headphone evaluation
It looks like it felt on my head	No haptic- visual surprise	Visual sense
The one thing you are missing is actual sound pressure from the speakers connecting with your body, having more vibrations that you can actually feel would add that extra dimension	Feeling the vibration adds extra dimension that speakers have. The sound pressure of the speaker connecting with your body	Desires from headphone / headphone evaluation
the GRADO are the edges, Grado has a rough exterior as well, based on the feeling and the visual aesthetic, they look similar, the way to adjust the height.	Association to headphones	Association
I think it would be nice to have some texture on the outside.	Textured outside is pleasant	Stimulation is pleasant
Oh yes, the vibration is nice	The vibration is pleasant	Stimulation is pleasant
you can really immerse yourself, more experiencing the whole music	The vibration helps to immerse yourself, experiencing the whole music	Desires from headphone / headphone evaluation
Haptics on the outside is something I only feel when I grab it.	Active touch does not happen much in the user journey	Active touch does not happen in the user journey

Comment scope	Comment text	Category
I think of the outside of the headphone as adding to the headphone but not being the most important part of the headphone	The outside of the headphone is not what brings novelty to the headphone	Desires from headphone / headphone evaluation
I would say so, but this is something I would like to have in a headphone, I want to be able to use to and look nice etc. 4	Typicality is appreciated in the headphone	Typicality is appreciated in the headphone
but the overall feel is like a headphone should feel.	Typicality in the overall feeling of the headphone	The headphone conveys the archetype feel
perforated fabric, so a cap, its stretch	Association to a garment	Associations
I noticed the earcups were metal, you can feel it through the fabric.	The metal can be felt through the fabric	Desires from headphone / headphone evaluation
Recommendation, study of the fabric, to develop own fabric	Develop own fabric	Desires from headphone / headphone evaluation
The headband really adds to being lightweight, the support is over the full arch, your head finds its own pressure points. Without being too voluminous, a big construction like the soluble headband, like the others. The stretch is sufficient.	The headband construction is compact and has the benefits of the double headband, where the head finds its own pressure points	Desires from headphone / headphone evaluation

Appendix 12. Graduation brief

Aesthetic theory in haptics: optimising the feel of a set of headphones project title

Please state the title of your graduation project (above) and the start date and end date (below). Keep the title compact and simple. Do not use abbreviations. The remainder of this document allows you to define and clarify your graduation project.

start date 26 - 09 - 2022 03 - 03 - 2023 end date

INTRODUCTION **

Please describe, the context of your project, and address the main stakeholders (interests) within this context in a concise yet complete manner. Who are involved, what do they value and how do they currently operate within the given context? What are the main opportunities and limitations you are currently aware of (cultural- and social norms, resources (time, money,...), technology, ...).

Within Western society, vision has been prioritised as the predominant sense. The role of haptic emotions and aesthetics has been mostly disregarded in product design. This has thus had an undeniable effect in the way we experience consumer products. This thesis aims to bring the focus back to designing with the total feel of a product in mind, that is, including the haptic aesthetics and experience.

Therefore, the main parties involved are on one end, the users, and on the other designers and consumer product companies which are responsible of creating the products we experience on a daily basis.

In this case, Sennheiser (audio design and production company) is a main stakeholder, as a set of their headphones will be haptically aesthetically redesigned during the project. Thus, gaining insights and opportunities to delight the user's sense of touch through their designs.

For users, the sense of touch is one shared by all and the first to develop in a child. By promoting the haptic feel of a product, not only is another dimension of meaning and pleasure added, but a further inclusiveness of those users which are visually impaired.

In recent years there has been considerable research in the field of haptics, mostly focused on digital interphases and HCI. The field of Haptic Aesthetics is still largely unexplored. The current challenge within haptic aesthetic research is that most efforts have been directed to show the "importance" of the feel of a product. However, if and how aesthetic theories transfer to the haptic sphere, has not yet been fully addressed. On account of this, this thesis uses an aesthetic principle to guide the exploration of the aesthetics of touch.

As for the main barriers and limitations of this project, time and budget are definite constraints. In order to make the project more concrete I have chosen to use the redesign of an object as a medium for the research and exploration. Furthermore, as haptic aesthetics is a somewhat unexplored field, the project will have to rely on only a small pool of existing resources and research.

Lastly, a barrier that I might encounter during the redesign in itself is the relationship between the touch aesthetics and the ergonomics of the product, when does comfort relate to pleasure and when to ergonomics?

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introduction (continued): space for images



image / figure 1: Daily Haptics (Marie Rouillon)



image / figure 2: Haptic aesthetics in consumer products (Yamaha)

PROBLEM DEFINITION **

Limit and define the scope and solution space of your project to one that is manageable within one Master Graduation Project of 30 EC (= 20 full time weeks or 100 working days) and clearly indicate what issue(s) should be addressed in this project.

Aesthetic theories suggest that the hedonic value (pleasure) in perception will peak when there is an optimum level of psychological arousal. This can be interpreted as the aesthetic balance of information in a product (novelty and contrast), and its concinnity (order and sense). The goal of this project is to conduct research on whether this mechanism is also applicable to our aesthetic appreciation of tactile experiences, and in which way.

The project will follow the research through design method (RtD), using a set of headphones as the artifact of focus. It will commence with an investigation of which design factors are most relevant to the haptic aesthetic experience of the product.

These factors will be used to embody different levels of haptic "arousal" in the headphones (novelty and contrast vs order and sense). The designed object will be tested to inform the next design and the haptic aesthetic model. In this way, the arrangement of haptic design factors that create a pleasurable, holistic, haptic experience when using a pair of headphones could be identified.

Since the perception of haptic input affects both cognition and emotion and causes different reactions, the study must also consider the observer's motivational state. Finally, the interaction with the product while in use (while been worn) will be left in scope, yet whether and how it fulfills its function will be left out of scope.

ASSIGNMENT **

State in 2 or 3 sentences what you are going to research, design, create and / or generate, that will solve (part of) the issue(s) pointed out in "problem definition". Then illustrate this assignment by indicating what kind of solution you expect and / or aim to deliver, for instance: a product, a product-service combination, a strategy illustrated through product or product-service combination ideas, In case of a Specialisation and/or Annotation, make sure the assignment reflects this/these.

The research will focus on whether an aesthetic balance of novelty and contrast versus order and sense, are a source of hedonic value (pleasure) also for the haptic aesthetic realm.

The research outcome should be a set of headphones with an optimum arrangement of haptic design factors, that result in a pleasurable interaction with the object.

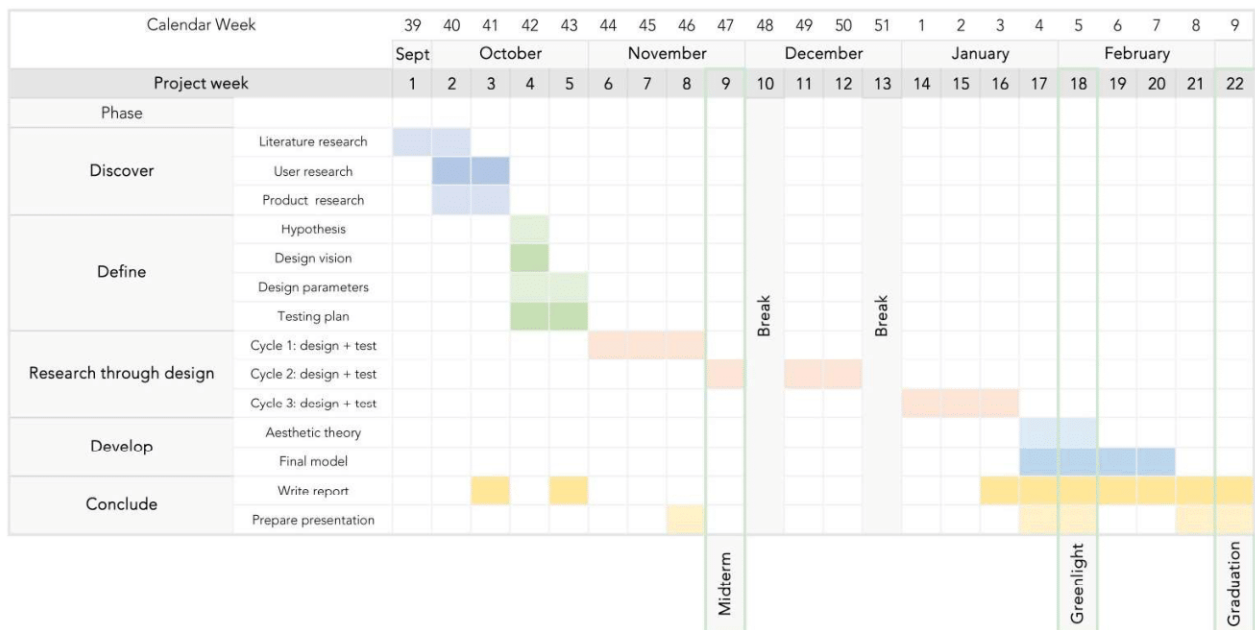
This thesis uses research through design (RtD) as a method of investigation. By using the aforementioned aesthetic theory to guide the design of the object, the artifact can expose the transferability of the model to the world of haptics.

PLANNING AND APPROACH **

Include a Gantt Chart (replace the example below - more examples can be found in Manual 2) that shows the different phases of your project, deliverables you have in mind, meetings, and how you plan to spend your time. Please note that all activities should fit within the given net time of 30 EC = 20 full time weeks or 100 working days, and your planning should include a kick-off meeting, mid-term meeting, green light meeting and graduation ceremony. Illustrate your Gantt Chart by, for instance, explaining your approach, and please indicate periods of part-time activities and/or periods of not spending time on your graduation project, if any, for instance because of holidays or parallel activities.

start date 26 - 9 - 2022

3 - 3 - 2023 end date



The project will commence with a Discover phase, where literature, user and product research will be conducted.

The Define phase will commence by laying out a vision for the haptic aesthetic headphones and a hypothesis for how the aesthetic theory transfers to haptics. Then the headphone design features to be manipulated in the redesign will be selected, and a precise redesign and testing plan for the next phase will be developed.

With this information the Research through Design phase will begin. For every cycle, one design feature will be manipulated following the outlined aesthetic theory. In each cycle, a set of models will be designed, prototyped and tested with a group of users. The learnings will help modify the aesthetic theory and inform the next cycle.

Finally, the gained knowledge will converge into a model of haptic aesthetic headphones and a refined haptic aesthetic theory.

MOTIVATION AND PERSONAL AMBITIONS

Explain why you set up this project, what competences you want to prove and learn. For example: acquired competences from your MSc programme, the elective semester, extra-curricular activities (etc.) and point out the competences you have yet developed. Optionally, describe which personal learning ambitions you explicitly want to address in this project, on top of the learning objectives of the Graduation Project, such as: in depth knowledge a on specific subject, broadening your competences or experimenting with a specific tool and/or methodology, Stick to no more than five ambitions.

During the masters in IPD I became exposed, and drawn, to the concept of product experience. In my own designs, this has led me to take special care of the interaction between user and product.

The field of Haptic Aesthetics adds another dimension to this interaction. By focusing my graduation on this topic, I am excited to delve deeper into how to design for full user satisfaction, with special focus on the sense of touch. The learning goals to achieve during my graduation are:

- To conduct the research I intend to make several models to embody the aesthetic theory. In this way I would like to develop my prototyping skills and take a more "hands on" approach to design.

- For the thesis I will be using Research through Design as a methodology (RtD). This approach has been often critiqued as not "scientific" enough. Despite this I aim to apply the methodology in a way that provides useful, grounded, results. I also would like to learn about it as it could prove useful in my future design efforts.

- Since this project seeks to generate a rich aesthetic experience for the user, user testing must be conducted. This is an opportunity for me to develop my skills in user testing, especially that of product experience.

- Finally, I would like to develop my sensitivity as to how to create a pleasurable haptic experience, potentially shifting my design perspective in future practice.

FINAL COMMENTS

In case your project brief needs final comments, please add any information you think is relevant.