tunen

Music + Memory for better focus

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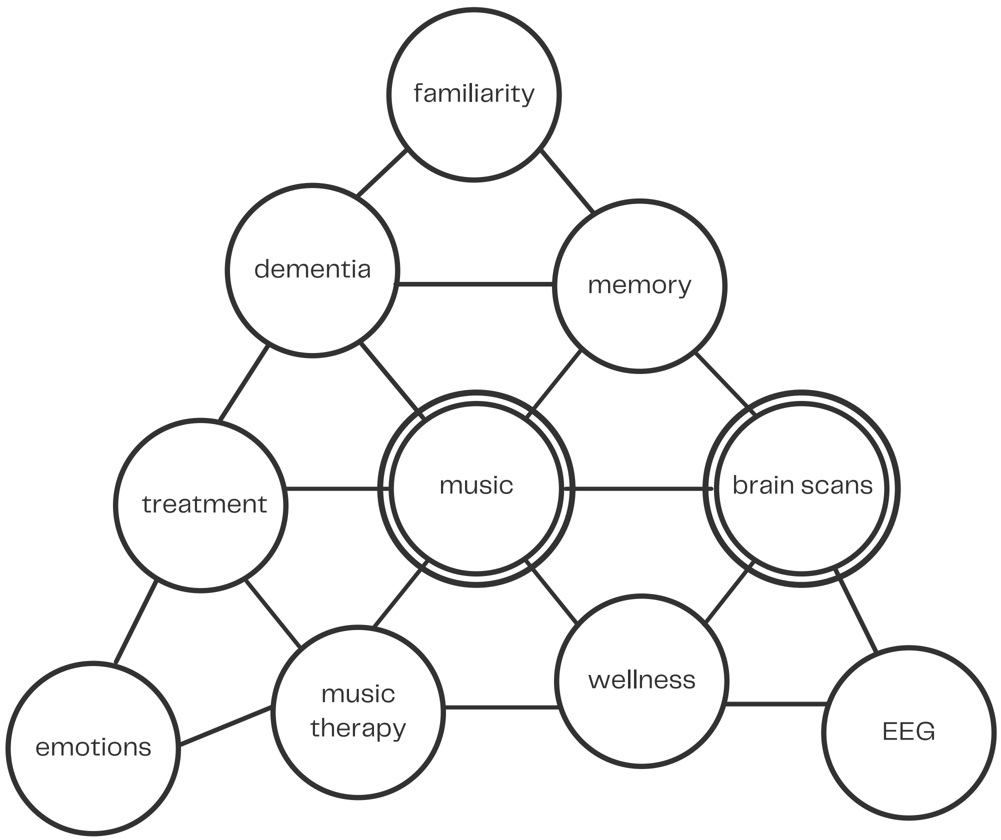
Research

This project is in collaboration with a team of engineering students for their senior capstone project. The object involved researching and developing a concept for a wearable device combining music & EEG tracking while the engineers plan and develop a mobile application combining EEG data, music & machine learning for personalized music listening. Next semester the engineers will test their application on a target audience using selected hardware.

My research focused on the relationship between memory functioning and music listening, investigating older adults with cognitive decline and dementia, as well as younger populations with normal brain functionality.

I used the following keywords to identify resources.



I referenced diagrams like this to determine appropriate electrode placement for an EEG headset that combines music. The prefrontal cortex and temporal lobe appeared to be the most common placement.

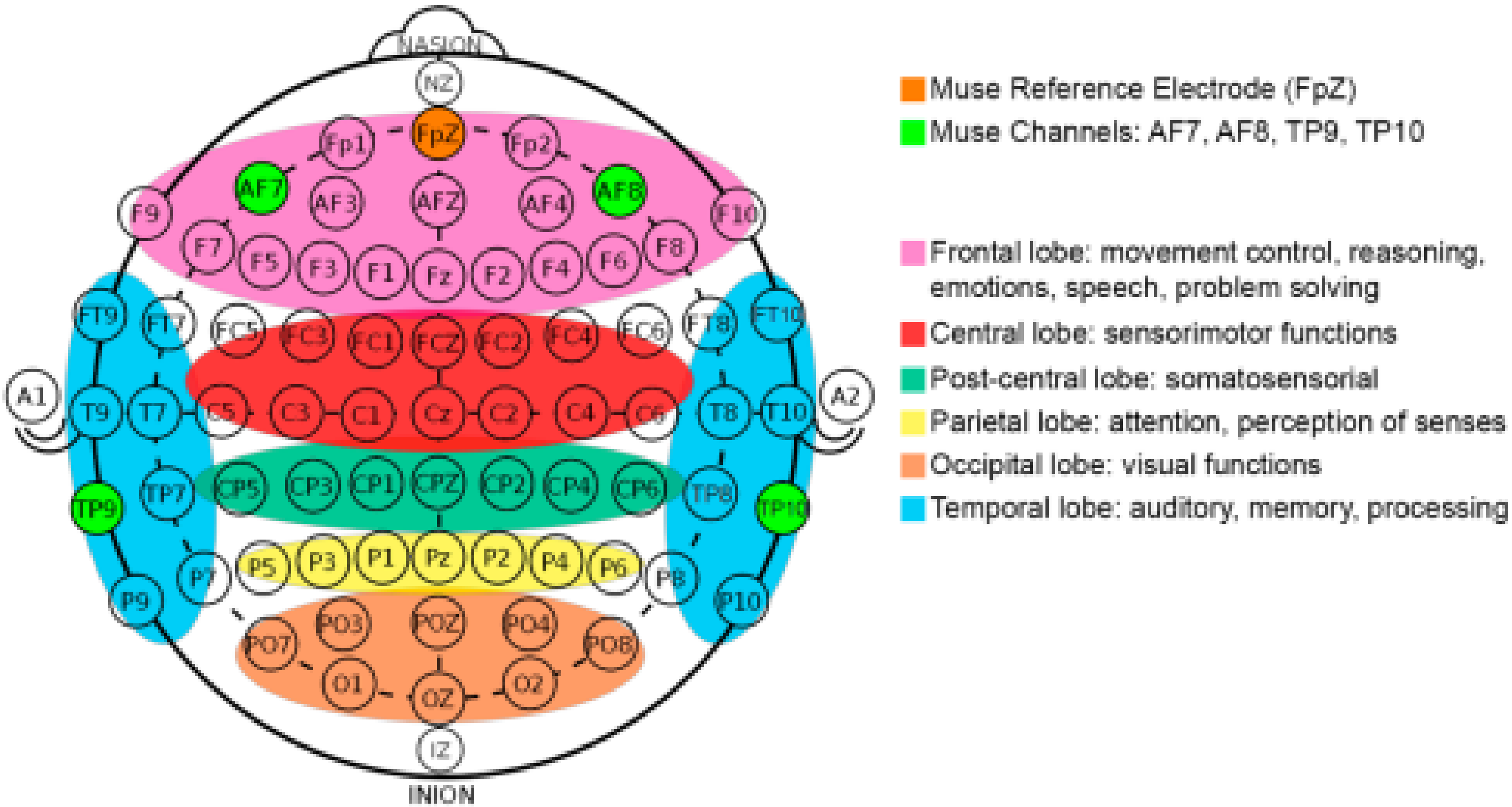


Figure 5. Muse electrodes position and brain functions.

Garcia-Moreno FM, Bermudez-Edo M, Garrido JL, Rodríguez-Fórtiz MJ. Reducing Response Time in Motor Imagery Using A Headband and Deep Learning. Sensors. 2020; 20(23):6730. https://doi.org/10.3390/s20236730

Literature Review

Music and Emotions in the Brain: Familiarity Matters (Carlos 2011)

The Right Music at the Right Time: Adaptive Personalized Playlists Based on Sequence Modeling (Liebman 2019)

Are the new mobile wireless EEG headsets reliable for the evaluation of musical pleasure? (Chabin 2020)

The Age of Music Streaming: The Use of Music Metadata to Inform Music Therapy Clinical Decisions (Filipcic 2021)

Train the brain with music (TBM): Brain plasticity and cognitive benefits induced by musical training in elderly people in Germany and Switzerland (James 2020)

Music Playlists for People with Dementia: Trialing A Guide for Caregivers (Garrido 2020)

Music & Memory' and Improved Swallowing in Advanced Dementia (Cohen 2020)

Effects of transcranial direct current stimulation combined with listening to preferred music on memory in older adults (Chow 2021)

EEG Analysis of the Contribution of Music Therapy and Virtual Reality to the Improvement of Cognition in Alzheimer's Disease (Byrns 2020)

Positive physical and mental outcomes for residents in nursing facilities using music (Mileski 2019)

Brain Melody Informatics: Analysing Effects of Music on Brainwave Patterns (Rahman 2020)

Similarity of individual functional brain connectivity patterns formed by music listening quantified with a data-driven approach (Karmonik 2020)

Music training is associated with cortical synchronization reflected in EEG coherence during verbal memory encoding (Cheung 2017)

Music-Based Intervention Connects Auditory and Reward Systems (Quinci 2021)

Major Takeaways

“Benefits of music listening were shown in autobiographical memory recall, working memory, semantic fluency, semantic memory, and episodic memory.”

Chow, Ricky & Noly-Gandon (2021). Effects of transcranial direct current stimulation combined with listening to preferred music on memory in older adults.

“Background music is effective in enhancing recall capacity and can be used as a useful measure to build interest and focus among students in their academic performance.”

Pohekar, Savita, et al. “Effectiveness of Listening to Background Music on Recall Ability Among High School Students.

- **Music activates primarily the auditory cortex and prefrontal areas of the brain**
- **Personalized music listening increases positive emotions such as valence and relaxation**
- **Relaxing music pieces can be determined by the gamma rates produced while listening to a song**
- **Song metadata can be utilized to improve personalized playlists based on factors like tempo, length, and mode**

Design Scope

User Group:

High school & University students

Opportunity:

EEG-equipped headphones & paired mobile application to help students measure focus and memory functioning through personalized music listening

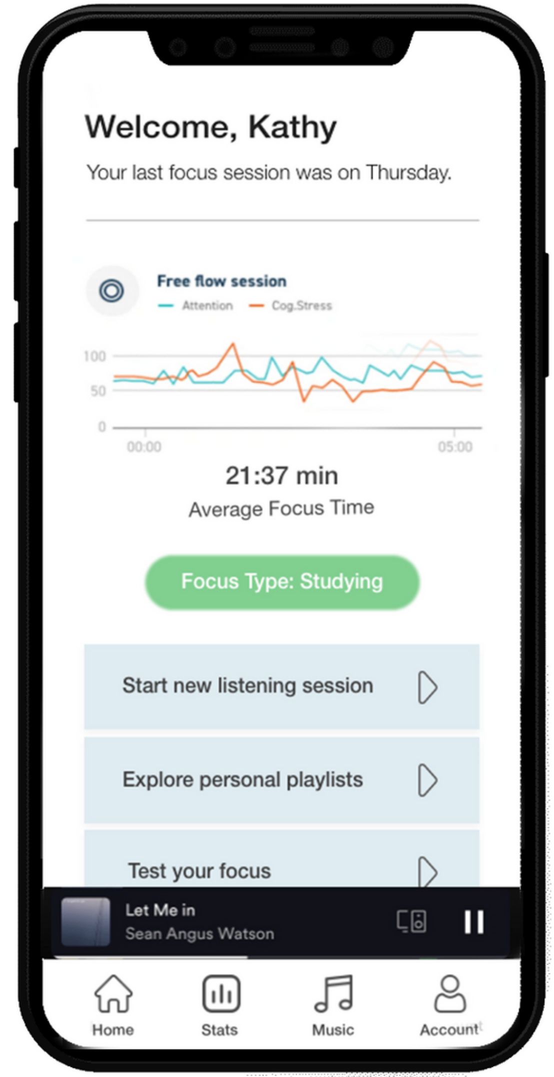
Based on my research and desire to create a consumer-geared product, I selected students as my target market. My research illustrated the positive impact of music on focus and recall, and a student audience simplifies the testing process for the engineers come spring.

tunen Application

Live EEG feed

Spotify integration

- Home page: Summary of full application features and navigation
- Statistics: Graphical feedback from recorded sessions & summarized data
- Music: Personalized music recommendations & playlists
- Account: Personal settings and initial calibration/setup

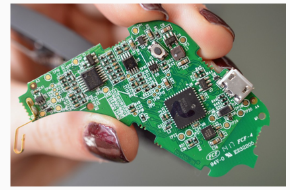


Although I myself will not develop the mobile application, I've included the game plan from the engineering team.
This mockup includes the basic application functionality determined in their design plan.

Competitive Analysis

I researched a plethora of existing EEG headsets including two around-the-ear style earbuds still in production. This analysis helped me validate possible form directions and investigate internal components. Notably, I referenced the Muse headset for several internal components and functionality choices.

Internal Components



Custom Circuit Board

Similar to board in the Muse to complement shape

Rechargeable Li-Ion Battery

3.7v 500mAh - Up to 6 hrs charge

Bluetooth module

RN42

EEG/EOG Dry Skin Sensors

1 cm silver chloride electrode sensors

Sources:

https://www.ifixit.com/Teardown/AirPods+Pro+Teardown/127551

https://learn.adafruit.com/muse-headset-teardown

Through competitve analysis, I indentified several internal components necessary for any wireless EEG headset. I also selected dry skin sensors to incorporate into my design as opposed to the hair sensors I saw in products intended for medical use. The remaining internal components will be determined by the engineering team in the next phase of this project.

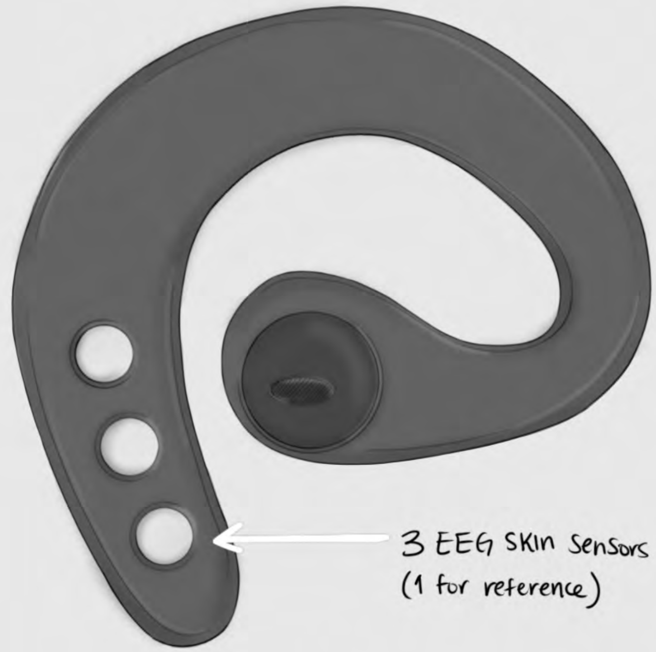
Ideation

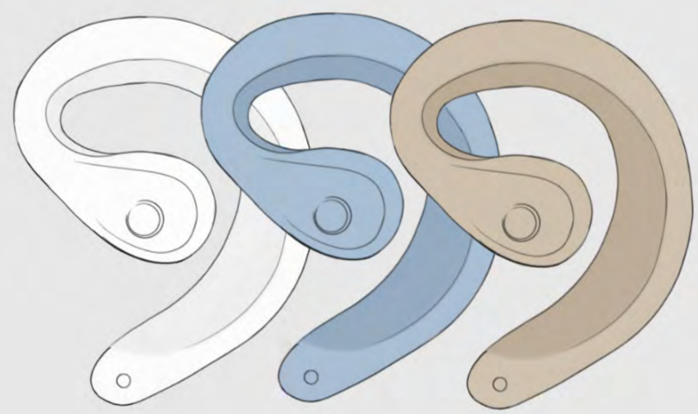
My initial ideation featured many concepts for over-the-ear headsets, though I was most interested in an ear bud form due to its recent emergence in the market.

EEG Equipped Headphones

In the second round of ideation, balancing a size that would be comfortable and leave enough room for internals was my biggest challenge. I also needed to consider room for internal components as I continued by research.

Tunen





Here is my final concept sketch. tunen is largely inspired by the bass clef, reflecting my background in music and the function of this product— tuning into your brainwaves and personalized tunes.

Models

I crafted several study models out of clay which helped me determine fit, comfort, weight and preferred appearance.

Anthropometric Data

Variable	Sex	n	Mean±SD	SE	P
Right ear length	Male	49	60.65±4.711	0.673	0.006*
	Female	107	58.69±3.92	0.379	
Right ear breadth	Male	49	31.47±2.77	0.396	0.003*
	Female	107	30.09±2.876	0.278	
Right ear length above tragus	Male	49	28.37±2.651	0.379	0.005*
	Female	107	27.06±2.781	0.269	
Right ear length below tragus	Male	49	19.16±3.46	0.494	NS
	Female	107	18.72±3.581	0.346	
Right ear tragus length	Male	49	13.06±2.096	0.299	NS
	Female	107	13.21±2.632	0.254	
Right ear concha length	Male	49	21.71±3.26	0.466	NS
	Female	107	21.02±3.311	0.32	
Right ear concha breadth	Male	49	15.86±3.028	0.433	NS
	Female	107	15.37±2.23	0.216	
Right ear lobule height	Male	49	11.39±2.532	0.362	NS
	Female	107	11.28±2.532	0.245	
Right ear lobule width	Male	49	19.69±3.33	0.476	NS
	Female	107	18.79±3.188	0.308	

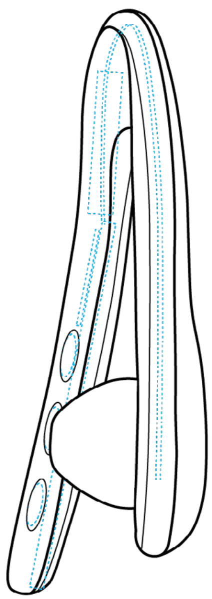
Variable	Sex	n	Mean±SD	SE	P
Left ear length	Male	49	60.53±4.574	0.653	0.002*
	Female	107	58.38±3.594	0.347	
Left ear breadth	Male	49	31.61±2.636	0.377	0.001*
	Female	107	30.16±2.741	0.265	
Left ear length above tragus	Male	49	28.39±2.907	0.415	0.027*
	Female	107	27.24±3.129	0.302	
Left ear length below tragus	Male	49	19.22±3.287	0.47	NS
	Female	107	18.56±3.291	0.318	
Left ear tragus length	Male	49	12.88±2.377	0.34	NS
	Female	107	13.06±2.464	0.238	
Left ear concha length	Male	49	22.06±3.654	0.522	NS
	Female	107	21.22±3.16	0.306	
Left ear concha breadth	Male	49	16.14±3.014	0.431	NS
	Female	107	15.62±2.452	0.237	
Left ear lobule height	Male	49	11.57±2.693	0.385	NS
	Female	107	11.27±2.583	0.25	
Left ear lobule width	Male	49	20.14±2.872	0.41	0.008*
	Female	107	18.86±3.223	0.312	

Japatti, Sharanbasappa R et al. “Anthropometric Assessment of the Normal Adult Human Ear.” Annals of maxillofacial surgery vol. 8,1 (2018): 42-50. doi:10.4103/ams.ams_183_17

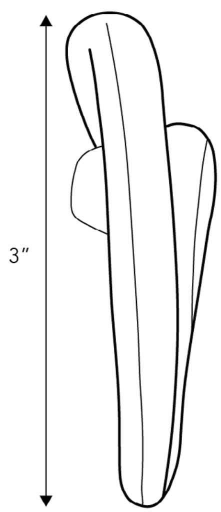
I referenced anthropometric data taken from individuals aged 18-30 to better determine an appropriate size for my technical drawings.

tunen Headphones Technical Drawings

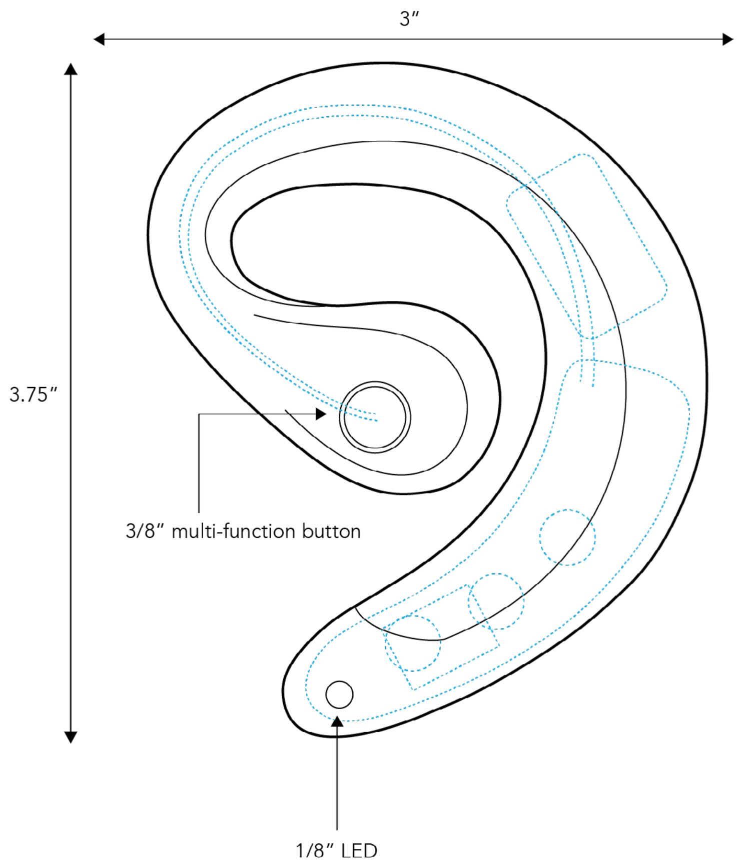
Front View



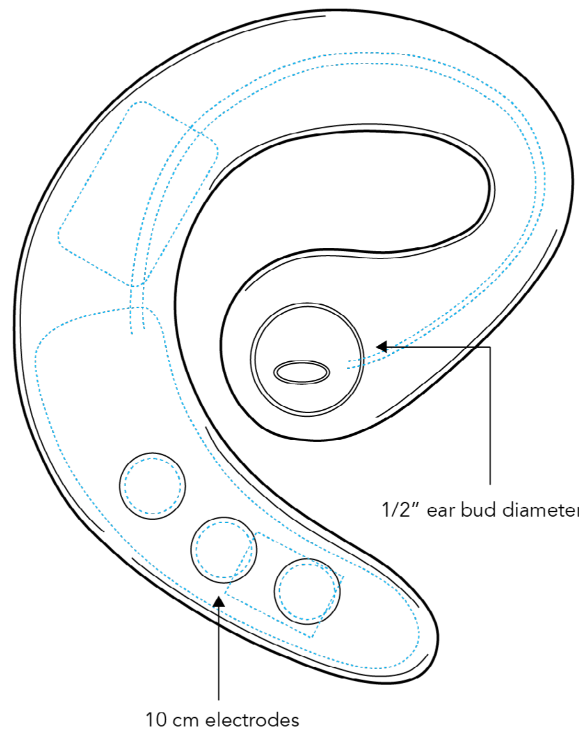
Top View



Right View



Left View



Battery Dimensions: 1″ x 0.5″ x 0.25″

Bluetooth Module Dimensions: 0.75″ x 0.375″ x .09″

Circuit Board Dimensions: 2.25″ x 1″ x .13″

Olivia Wilczek	Nov 3, 2021
EEG-Equipped Headphones	Grad Studio I
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Renders

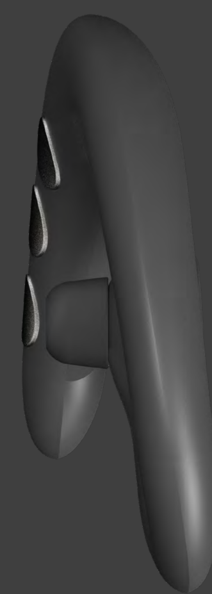
Using the measurements in my technical drawings, I modeled tunen using Solidworks. In addition to the 3 skin sensors placed behind the ear, my concept for tunen features a rubber overmold to improve comfort, an LED indicator light which turns on when the sensors are activated, and a multifunction button used to control the device during music listening.

Right

Left

Front

Top

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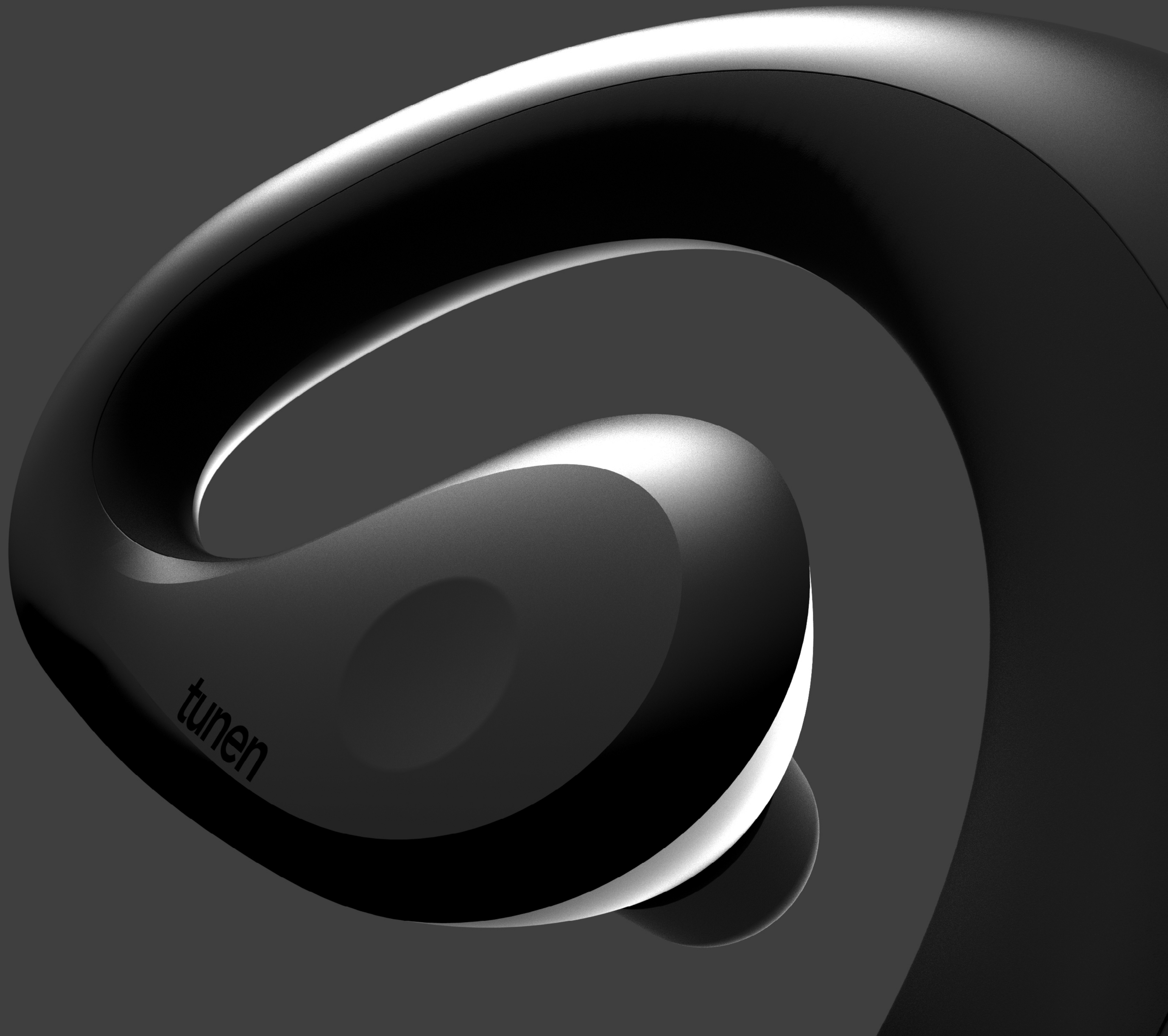
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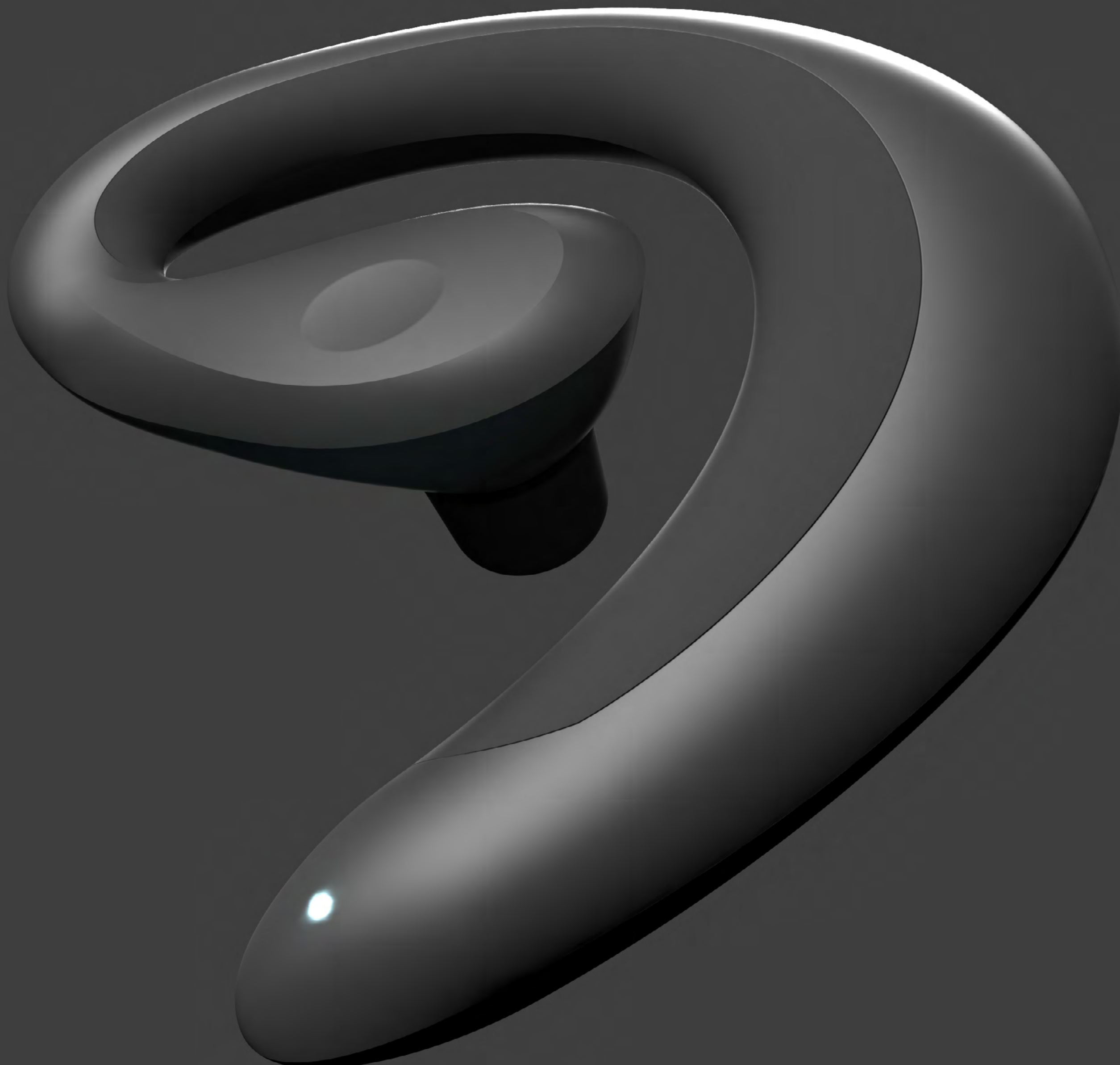
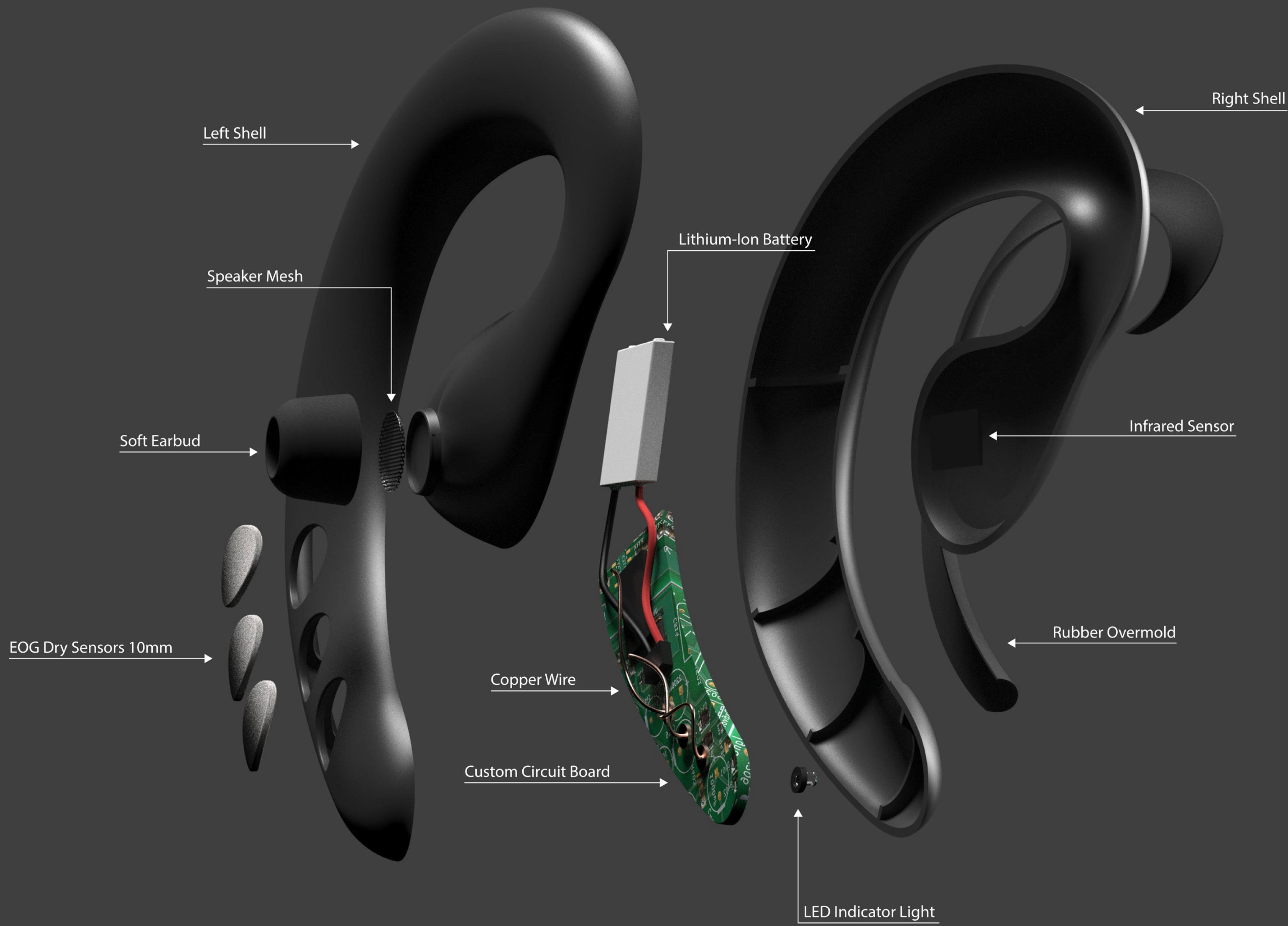
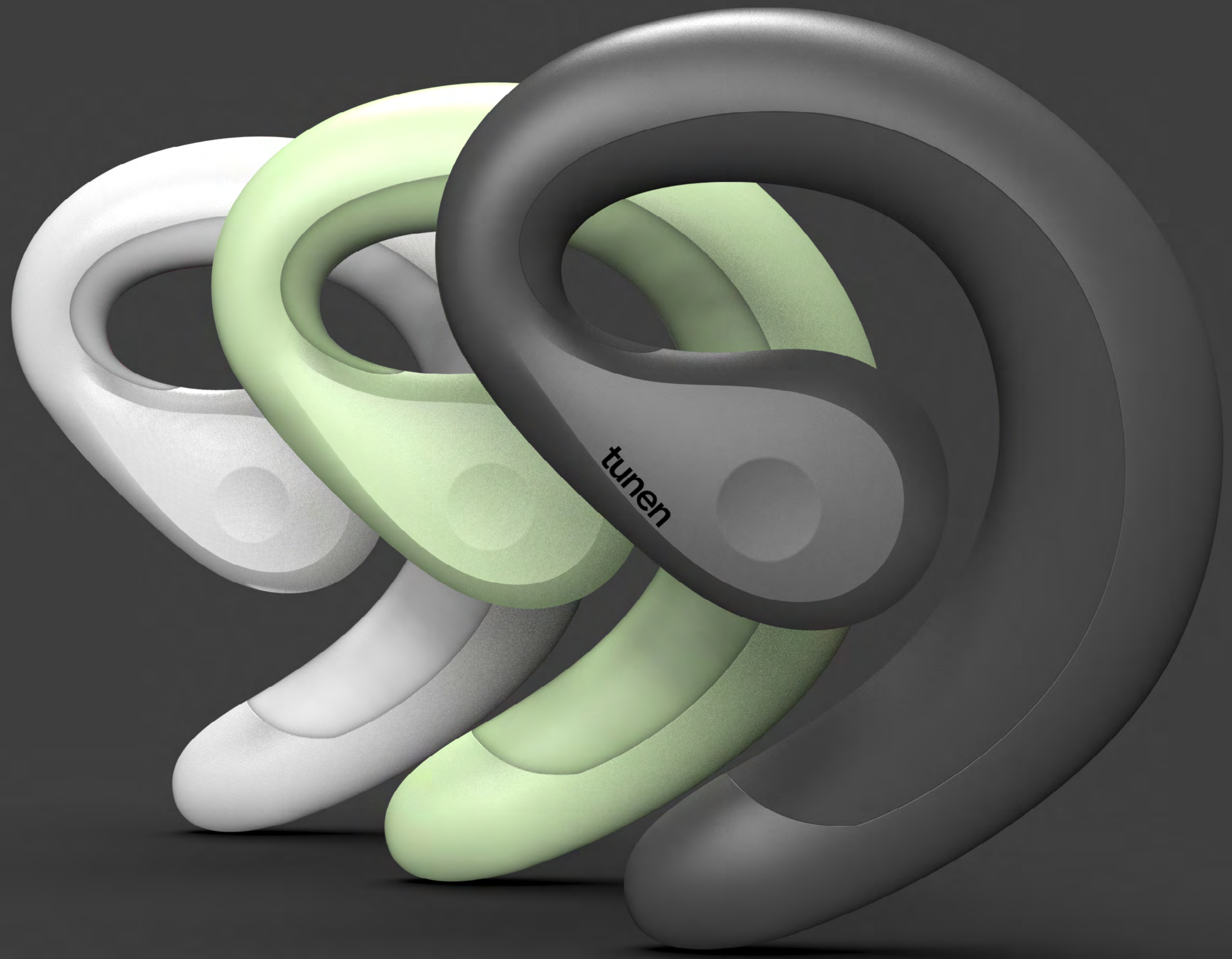



Left Shell
Speaker Mesh
Soft Earbud
EOG Dry Sensors 10mm
Lithium-Ion Battery
Copper Wire
Custom Circuit Board
LED Indicator Light
Right Shell
Infrared Sensor
Rubber Overmold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