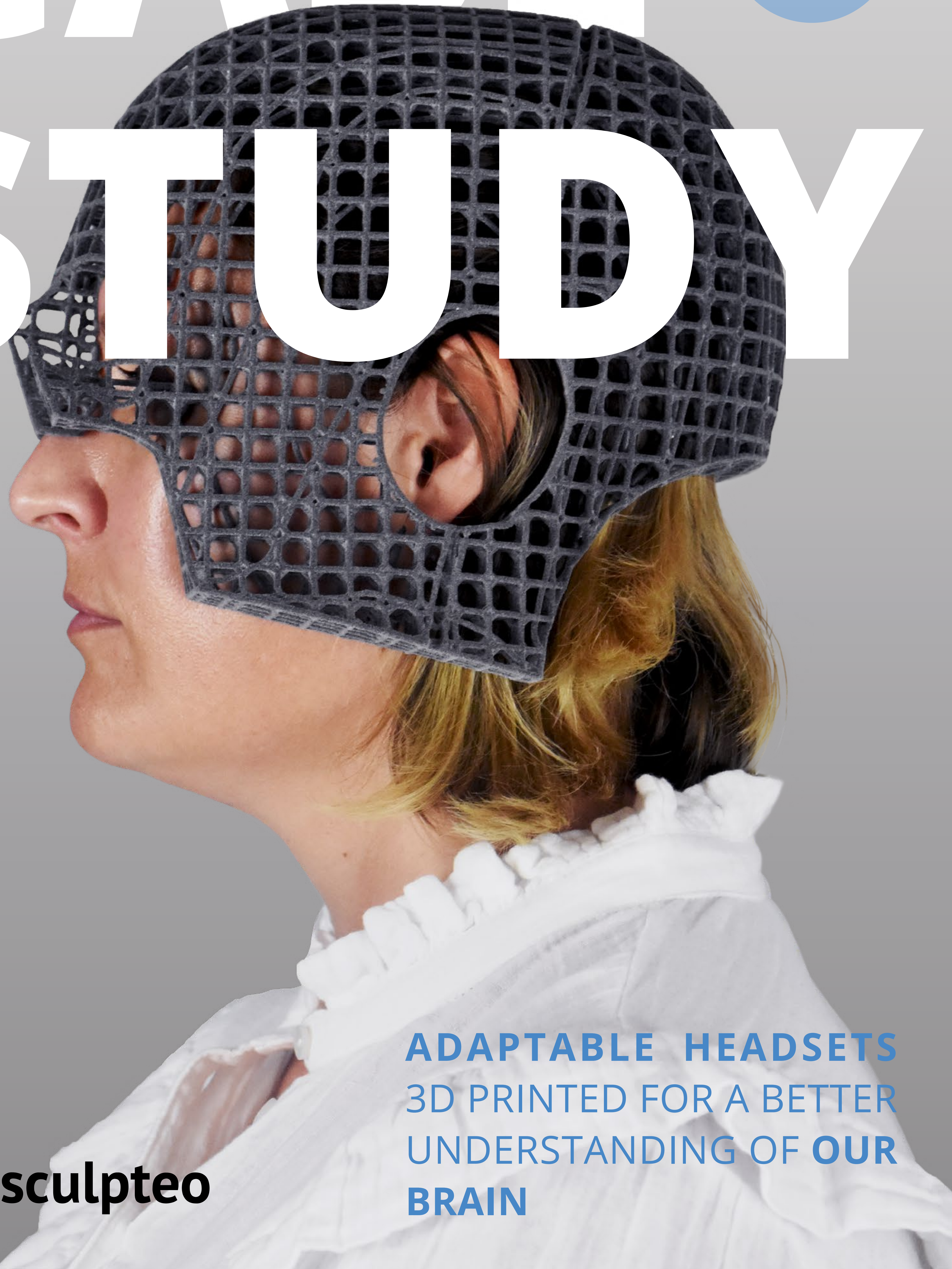
CASE STUDY



ADAPTABLE HEADSETS 3D PRINTED FOR A BETTER UNDERSTANDING OF **OUR BRAIN**

sculpteo

CHALLENGES

• 1

Optimizing an existing process to create headsets for their research project.

• 2

Finding a good prototyping technique providing accuracy and flexibility.

• 3

Choosing an adapted material for the comfort of the participant.

Main information

Company	Research laboratory
Industry	Research
Product	Headcast
Technology	Selective Laser Sintering
Material	Ultrasint® TPU01
Finishing options	None
Challenge	Creating an adaptable headset for research projects.

ABOUT THE PROJECT:

Sculpteo was approached by a group of scientists working at a national neuroscience research institute in France. The laboratory, headed by researcher James Bonaiuto, is dedicated to the study of actions performed by the brain.

The team studies how the brain produces actions, including how it decides what actions to perform, how it prepares to perform an action, and how it updates its internal representations based on the outcome of the action. This project has received funding from the **European Research Council (ERC)** under the European Union's Horizon 2020 research and innovation programme (grant agreement N°864550).

ABOUT THEIR RESEARCH TOPIC:

The brain interacts with muscles through a complex system of neurons, known as the **motor system**. When the brain sends a signal to a muscle, it triggers a series of events that ultimately result in muscle contraction. This process is known as **neuromuscular activation**.

Generally speaking, understanding the interaction between the brain and muscle can help in preventing several diseases related to neuromuscular dysfunction, such as Parkinson's disease, muscular dystrophy, stroke and spinal cord injury.

ABOUT THEIR RESEARCH TOPIC:

This research project is focused on determining how neural activity in the motor cortex, at a particular frequency range of **13 – 30 Hz**, is involved in the preparation of naturalistic movements such as reaching and grasping, and how this activity is involved in changing our mind: **performing a different movement than the one you planned**.

THEIR CHALLENGE USING MEG:

Muscular activation is commonly measured using **electromyography (EMG)**, which involves placing small electrodes on the skin overlying the muscle of interest. These electrodes detect electrical activity generated by the muscle during contraction.

Similarly, **neural activity** can be measured by **electroencephalography (EEG)**, which involves placing electrodes on the scalp to detect the electrical activity generated by large numbers of neurons. The team at the institute uses **magnetoencephalography (MEG)**, which is similar to EEG, but measures the **magnetic fields** that are generated by the electrical activity of neurons in the brain.

MEG sensors rely on superconduction, so they have to be kept **very cold** and **cannot be placed directly** on the scalp. As a result, if the subjects move their heads while they are in the scanner, the quality of the data will be reduced. That is why the team needed to create a specific head-cast to **prevent** the head of the patient from **moving** in the scanner. 3D printing offered new opportunities to develop an adaptable and comfortable head-cast.

OUR COLLABORATION:

The research team needed the support and expertise of 3D printing professionals to understand how this technology could benefit their research. They collaborated with **Sculpteo's design studio** and 3D printing services, to develop a workable prototype for their research project.

OPTIMIZING THE PROCESS:

The first manufacturing method used by the research lab to maintain the position of the participant's head in the scanner involved polyurethane foam head-casts, individualized for each subject to restrict head movement and collect high-quality data. However, this solution was not ideal. Creating these head-casts was **labor-intensive** because they firstly had to 3D print a mold based on an MRI image of the subject's scalp and then physically pour the foam mixture into the mold.

That's the moment the team turned to Sculpteo, to see if they could design a 3D printed head-cast that could be directly created from a digital inprint of the subject's scalp. With this new 3D printing solution, they can skip some time-consuming steps: **no mold is needed**, the head-cast is 3D printed to fit the subject's head, which simplified the whole process and helped the team become more flexible, saving time, energy and resources.

ACCURACY AND FLEXIBILITY:

Using 3D printing for their project has saved a significant amount of manual labor in creating a head-cast for each subject. Traditional manufacturing techniques make customization expensive and time consuming.

Using 3D printing has significantly **reduced the cost**, time and effort required to create a head-cast for each subject. It is also providing a **more accurate fit** to the subject's scalp, making it possible to physically create each head-cast individually in a straightforward way. Thanks to additive manufacturing, these new head-casts will allow the team to collect **high-quality MEG data** more efficiently and accurately, while also providing greater comfort to the subjects.

MORE COMFORT THANKS TO ADAPTED MATERIAL:

Choosing the right material is also an essential part of using additive manufacturing. To print these head-casts, the researchers decided to use **Ultrasint® TPU01, a flexible but still robust material**, a perfect option for this kind of application. Design for Additive Manufacturing was a significant part of this endeavor, as it allows for the precise tuning of the product to the project's requirements.

In this instance, a **specific lattice design** has been made, to create a head-cast that is rigid enough to restrict head movement but soft enough to be comfortably worn, which means this design allows for the collection of high-quality MEG data, while also providing the subject with greater comfort!

LATTICE DESIGN:

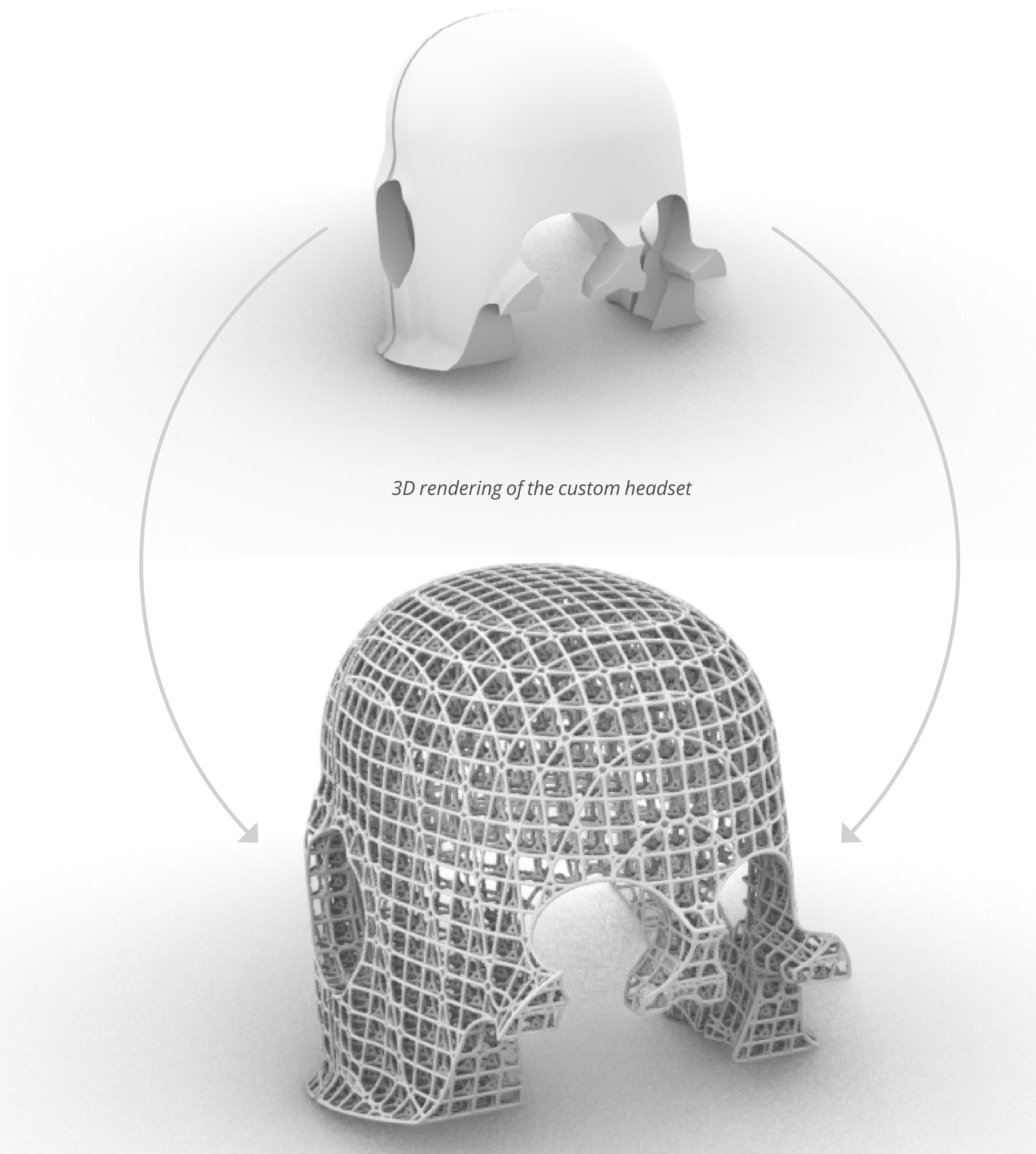
This specific lattice design was created using Forward AM's Ultrasim® 3D Lattice Engine.

Before delving into the capabilities of the Ultrasim® 3D Lattice Engine, let's first take a look at what a three-dimensional lattice is. In the simplest terms, a lattice consists of a **3D pattern** that is repeated to form a partially hollow structure, and that is most of the time, used to provide **flexibility** or **shock absorption properties**.

Using the Ultrasim® 3D Lattice Engine is a 3 step process:

1. First, we select the right lattice from the pad library, providing the right support and flexibility.
2. Then, in the software, we import the 3D file of the solid part that we would like to convert to a lattice.
3. Finally, we let the software apply the desired lattice structure to the existing shape, export it and print it!

The research team collaborated with Sculpteo's Studio to develop the lattice structure for their experimental object. Sculpteo provided several initial iterations, which were tested using a lattice test pad to identify the optimal design. Once the ideal lattice was chosen, we used the Ultrasim® 3D Lattice Engine to create the first versions and printed them for testing. The results were promising, and we proceeded to refine the design by adding a few extra elements using CAD tools.



3D rendering of the custom headset

ULTRASINT® TPU01:

The Multijet Fusion Ultrasint® TPU01 (or MJF TPU) objects printed through Sculpteo are created from a fine **Thermoplastic Polyurethane powder**. This material offers durable, strong, and flexible parts.

MultiJet Fusion Ultrasint® TPU01 is a perfect 3D printing material choice if you need to produce parts requiring shock absorption, high elasticity, and energy return. This material is particularly adapted to flexible lattices and complex parts.

"Working with Sculpteo has been an incredible experience. Their team has been instrumental in helping us design and refine a prototype for our research project. Their expertise and support have been invaluable in transforming our basic ideas into a workable design."

James Bonaiuto, neurosciences researcher

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