Synergistic Space Potentials: Technology, Humans and Responsive Materials in the Design Process

Marcus Farr, Tongji University, China
Andrea Macruz, Tongji University, China
Alexandre Ulson, Centro Universitario Belas Artes, Brazil

The European Conference on Arts & Humanities 2020
Official Conference Proceedings

Abstract

This project investigates the role technology and neuroscience play in making meaningful connections between people, architectural space and furniture. It discusses why it is important to focus on designing with more significant impact, focusing on the quality of experience rather than quantity of objects. It moves on to indicate that design can harness this power for social changes and discusses how technological relationships with humans can be the center of the design conversation. To interrogate this further, we have created a series of simulations, based on a piece of interactive, intelligent furniture as the centerpiece to an architectural space. It utilizes a computational pattern that is coded to respond to human activity. It is subsequently materialized with temperature responsive bi-materials, which are coated thermochromically, and electrically programmed with micro-controllers, and then connected to a computer code that makes readings based upon human interaction. Through this process, it manifests a methodology that categorizes the test results into: Static, Repetitive, and Non-static morphologies. These question the potential of the prototype, making certain that no elements other than the furniture and its integral parts are used to investigate a series of outcomes. The paper offers definitions of the process in the following terms: Repetitive Morphologies = consistent basis actions; Non-static Morphologies = non repetitive actions based on input variables; Static Morphologies = actions that don't change, or are considered unsuccessful. As the computational patterns and colors change, we are made aware of the relationships between space, technology, and the human sensorium.

Keywords: Technology, Neuroscience, Materials, Design

Figure 1, left: Marina Abramović performance. Source: http://www.touchofclass.com.br
Figure 2, right: Reference image. Source: https://news.softpedia.com/news/Internet-Does-Bring-People-Together-152398.shtml

Introduction

Today, there are numerous technological tools that connect people with one another. Nevertheless, isolation and polarization are becoming more and more common in the everyday life of people. The link between technological innovation and social segregation is a societal issue that lends itself to a design problem. Is there a way that technology can help us to strengthen verbal and non-verbal communication rather than create isolation? Can this enhance the experience of designed spaces and generate stronger emotional connections in order to stimulate empathic relations? In other words, can we use technology to humanize humans?

As discussed in the abstract, this project investigates the role technology and neuroscience play in making meaningful connections between people and furniture design and architectural space. It began at Istituto Marangoni in Milan with professors Sergio Nava and Stefano Caggiano, and discusses why it is important to focus on designing with a more meaningful impact, focusing on the quality of experience and the potential for more sensitive interactions in what we make as designers, and presents a rationale that places quality of design over quantity of objects. It moves on to discuss how design can harness this power for better social experiences, and how relationships between people and technology can be at the center of the design conversation. To examine these questions, we have designed a piece of intelligent furniture as the centerpiece to an architectural space, and throughout the process have incorporated a series of simulations based on potential interactions between people and surface that are enhanced by technology. It utilizes a computational pattern that is coded to respond to human activity, and subsequently materialized with temperature responsive bi-materials. Explorations were made utilizing thermochromic coatings that were also electrically programmed with micro-controllers. This was then connected to a computer code that makes readings based upon human interaction. Through this process, it manifests a methodology that categorizes the test results into: Static, Repetitive, and Non-repetitive morphologies. These question the potential of the prototype, making certain that no elements other than the furniture and its integral parts are used to investigate a series of outcomes. The paper offers definitions of the process in the following terms: Repetitive Morphologies = actions that are consistent or based on the activities of one person;

Non-repetitive Morphologies = actions that are dynamic or move beyond mere repetitive results and are based on multiple inputs such as 2 people rather than 1; Static Morphologies = actions that do not change with consistency, or are considered unsuccessful. As the process unfolds, the computational patterns become dynamic and the thermochromic treatment make us more aware of the invisible forces at play. This process makes us aware of the relationships between space, technology, and the human sensorium.

Our methodology paves the way for future projects and larger scales, and discusses what worked and what didn't. It goes on to discuss how we see the process of public interaction unfolding as a spatial design strategy, and how the material investigations give way to 1:1 prototyping. It discusses how we used a marriage of computation and physical material studies to simulate a variety of potential outcomes and what these outcomes were, and finally, it discusses the way that this methodology was used to make specific material choices based on a series of failures and successes. It uses technology to bring people together with a built object.

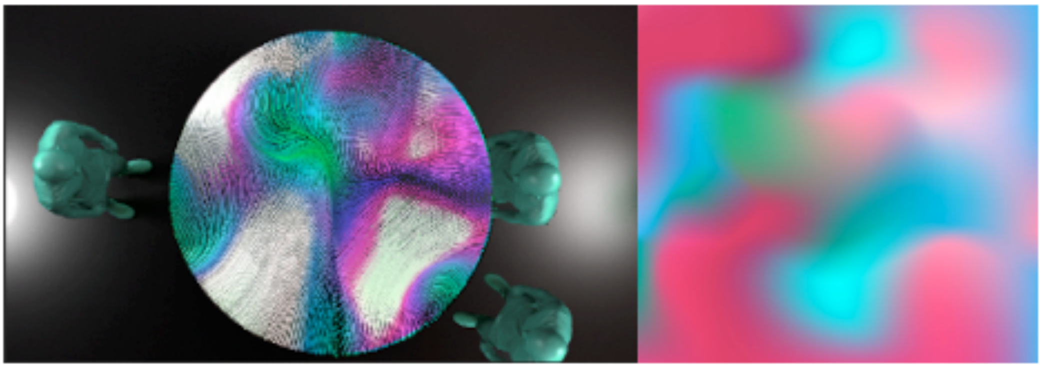


Figure 3: Drawing of a surface changing with multiple person interaction using Houdini; sensorium.

By investigating contextual awareness in the project presented, the paper explores exciting opportunities for multi-sensory design, and together with the use of different sensory elements explores the conception and creation of a piece of furniture that can change, in real-time, depending on the user input and bio-sensing. The project makes use of technology to capture one's body information using biosensors that measures heart activity, breathing rate, to create a synergistic relationship between this technology and optical surface material (thermal-chromic paint and bi-material to change rotation in the Z axis associated with electrical input) which is connected to a piece of interactive, intelligent furniture that presents this information back to the users in real-time. As users actively engage with the table, moods, emotions, and senses of well-being are brought to the forefront of the experience and user awareness. This information is displayed not virtually, but physically via a sensory approach to stimulate non-verbal communication between people, as a means to be more effective in communication, understand one another and to promote new experiences and meaningful encounters. Understanding is the key to empathy and, having a better conversation, is the main element to understand more each other.

In an age where technology and screen-based interactions continuously surround us, a physical, multi-sensory approach is revitalizing and provides new experiences. So, it is important that immersive physical experiences coexist and, that are balanced with digital ones. This allows us to re-engage with the world in a new manner, emphasizing the positive aspects of technology and reducing the bad ones, such as depression, FOMO, problems in comprehension and deep retention, among others.

Using this project as a vehicle, the paper analyzes and revises the role of technology not only as a simple tool to extract information and design projects, but also as a platform to better understand one another and to have more efficient communication, and consequently, to nurture empathic and altruistic attitudes. It proposes a new way of designing for the future, fostering social, political, and environmental changes for a new and more humanized society.

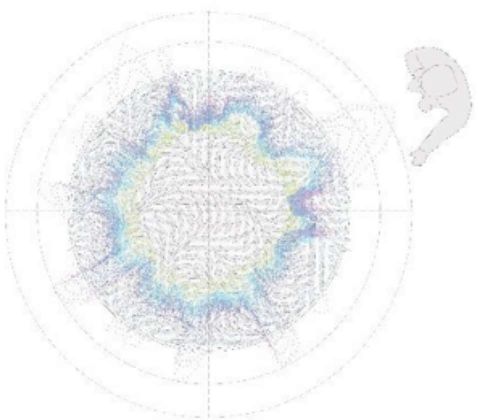
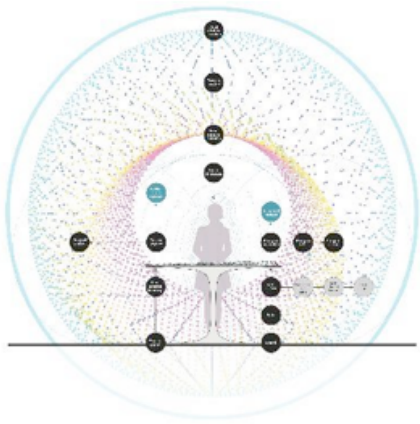



Figure 4: Plan diagram of table showing energy related to human.
Figure 5: Elevation diagram of table showing energy, technology related to human.

Forms of Communication: Verbal & Non-verbal

"*The most important thing in communication is hearing what isn't said.*" [1] Peter F. Drucker

Verbal communication is a broad term for communication involving words, whether they are spoken, written, or signed. Verbal communication coexists alongside non-verbal communication, which can affect people's perceptions and exchanges in significant ways. Edward G. Wertheim, Ph.D. Northeastern University, wrote a paper called *"The Importance of Effective Communication"* that exposes how non-verbal communication interacts with verbal communication: "We can reinforce, contradict, substitute, complement or emphasize our verbal communication with non-verbal cues such as gestures, expressions, and vocal inflection."[2] Verbal communication is enhanced when a person is an effective listener. Listening does not simply mean hearing; it necessitates understanding another person's point of view, and for that, non-verbal communication plays a significant role. The ability to communicate nonverbally can be improved by paying closer attention to other people's unspoken behaviors such as eye contact, gestures, posture, body movements, personal appearance, tone of voice, among others. Being aware of what we say and how we say it is the first step to successful communication.

Albert Mehrabian, professor of psychology at UCLA, says that, when communicating about feelings and attitudes, words account for only 7% of the total message that people receive. The other 93% is contained in our tone of voice and body language.[3] Therefore, non-verbal communication should be stimulated for us to have a more productive conversation and to bond more, promoting more meaningful encounters. Understanding is the key to empathy and, having better communication is the main element to understand each other more.

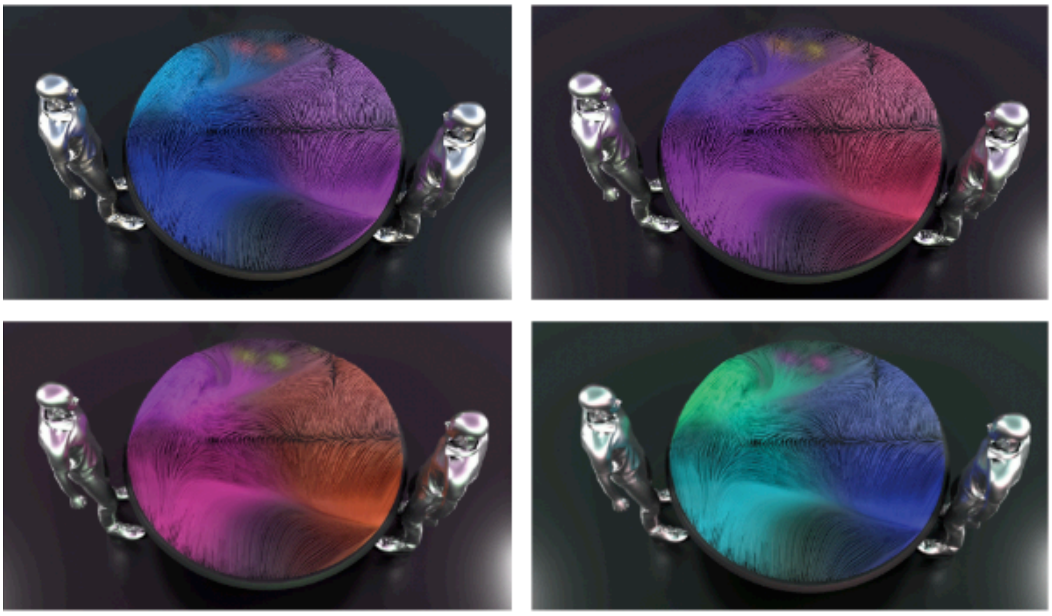


Figure 6: Simulations of surface changes with multiple person & non-verbal interaction, using Houdini.

Forms of Communication: Sensorium

Neuroscientists are continuously exploring the connection between the brain and the sensorial channels, through which we understand and perceive the world. For example, touching something with a texture can change a person's mood and influence the decisions a person makes.[4] Touch also seems to be very important to a human's well-being, and it has been found to convey compassion from one human to another. But maybe the most interesting topic related to this theme is how human sensorium can intensify emotional connections. For example, some studies indicate that eye contact is vital to social encounters. "One brain-scan study found that when people that sustained eye contact, they began to blink simultaneously, and after a while, their brain activity synced up. These long gazes can make people feel more attracted to one another. Eye contact also signals that the person could reciprocate your affections." More and more, designers are exploring sensorial channels to build an emotional connection between the product and the user.

To move further into the understanding of sensorium, we can look at light quality and shadow. Shadow is the absence of light; therefore, it is possible to know the light by its shadow. This sentence represents the importance of opposites. In reality, we appreciate so much a positive situation, because we have been through a negative one and, through comparison, it helps us to put in perspective values and experiences, decreasing or increasing their level of importance. Technology has brought both positive and negative effects on our lives. On one hand, it has brought a positive impact in keeping us more informed, connecting better with each other, enhancing our user experience, accessing us in our daily activities, etc. On the other hand, technology is creating new disorders and diseases such as depression, FOMO (fear of missing out), and diminishing our comprehension and deep retention, affecting the morality of people, among other things. [5]

According to Andy Clark, a professor of philosophy and Chair in Logic and Metaphysics at the University of Edinburgh, *"we are already cyborgs or "human-machine hybrids",* which means the physical merge of flesh and electronic circuitry, without the need for wires, surgery, or bodily alterations. He argues that it is arbitrary to say that the mind is contained only within the boundaries of our brain because it has always collaborated with external, nonbiological sources to solve better the problems of survival and reproduction of the Humans. He states that, "*with the advent of texts, PCs, coevolving software agents, and user adaptive home and office devices, our mind is just less and less in the head. In other words, the separation between the mind, the body, and the environment are seen as an unprincipled distinction.* [6]

Following this line of thought, if we are already cyborgs and technology is increasingly contributing to that, we have to enjoy the positive aspects and put some boundaries, reduce or extinguish the bad ones. Moreover, if the opposites enable us to boost experience and add value to a situation, it is interesting to design a product that increments that, through technology, by filtering the received input data and balancing the output outcomes.


Figure 7, left: Reference images of human cyborg technology & human-machine hybrids. Source: https://canadajournal.com.br/canada/a-influencia-da-tecnologia-e-a-sua-cada-vez-maior-presenca. Figure 8, right: Unsplash, Zana Latif.

Methodologies

With these theoretical ideas in mind, this paper also explores the potential design contribution that can arise from a process that employs computational logic and new media as tools for prediction, and how this can offer an acute method for designers to learn throughout the process of making. This process of simulation also aids in creating a more robust prototype. Using digital tools such as micro-controllers, Rhino, Grasshopper and Houdini, paired with physical testing, it interrogates a workflow between computational design, production methods & material logics. Through this process, it manifests a methodology that categorizes the test results into static, repetitive, and iterative morphologies. These question the potential of a prototypical object, in this case, a piece of furniture, making certain that no elements other than the object and its integral parts are used to investigate a series of outcomes. Our definitions of the process are based on the following terms: Repetitive Morphologies = actions that are consistent or based on the activities of one person; Non-repetitive Morphologies = actions that are dynamic or move beyond mere repetitive results and are based on multiple inputs such as 2 people rather than 1; Static Morphologies = actions that do not change with consistency, or are considered unsuccessful. Through computer simulations and continuous material investigations, we come to a better understanding of how we can position our object in an environment that is human centered. Befitting the conference, it is heavily influenced by *"learning through interactive design decisions" and the "convergence between natural & artificial systems and the learning process"*.

The results here range from a one-person interaction, to a group of interactions, and offers insight into how this project could work at a larger scale in the built environment. Although there is much to discuss and the methodology associated with this project offers immense speculations for future projects, this particular paper discusses how computational technology merges with materials, and how designers can use this to inform the design process in a more intelligent way. As simulations for the project began to expand, it became necessary to break them down into a series of categories that show how our results could impact the overall design, and to show how the different simulations could affect our decision-making process for future projects, and to show and understand how the simulation could give meaning to our design decisions. In doing this, we are interested in using the computer to assist in making decisions relative to a physical prototype. Trying to simulate a person's state of being, excited, calm, etc., is difficult to do when making a physical model, but much easier and more accessible with a series of digital models. To explore this further, we used a Houdini model to generate patterns for how color could be simulated based upon information gained from the UpMood algorithm, and a Rhino model to explore the visual capacity in the process of different material states such as changes in physical composition as a result of the differences in temperature.

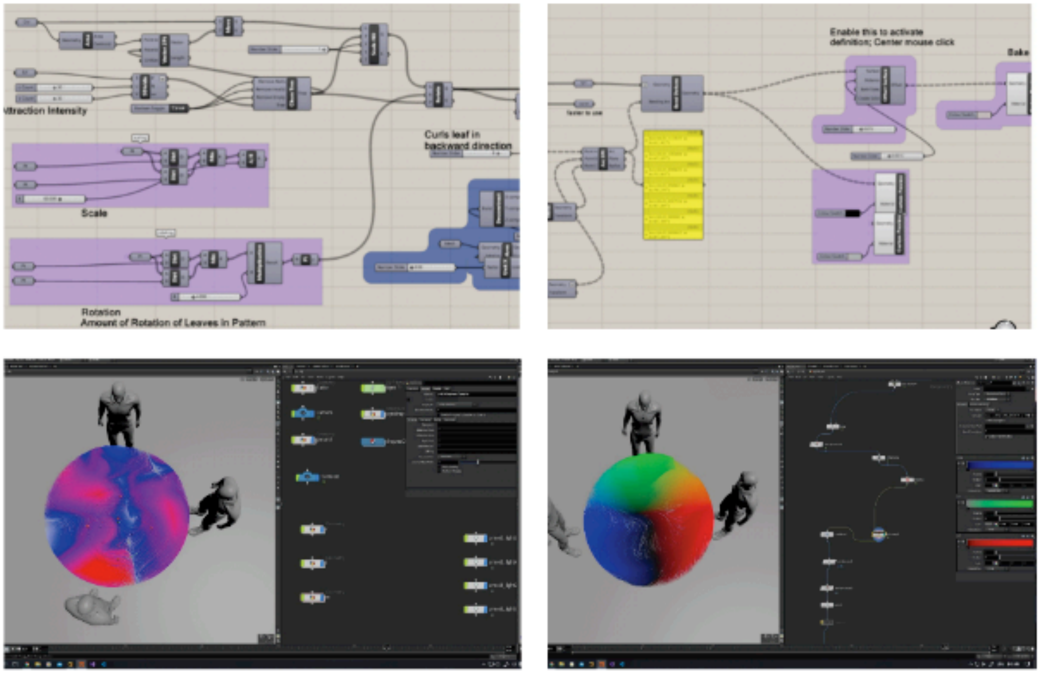


Figure 9: Computational scripting using Rhinoceros, Grasshopper and Houdini. A. Saghafifar. A. Abdelnaby.

The process of design in this process was not something we had experienced before due to the fact that the final version of what we wanted to build was very expensive and time consuming to construct. It required an intense amount of electronic manipulation and conversion of algorithmic data. The digital workflow allowed us to not only visualize before building, but make decisions for how we wanted this expensive prototype to be built in the end which was different compared to a traditional furniture prototype. Also, during the process of designing the interface, it is also difficult to test physically in the beginning. For this project, we felt that in some ways designing the "process", was more important than designing the finished product. There was an ongoing discussion of how the project was working, how it was going to work compared to how it feels when it works.

Repetitive Morphologies are actions that are consistent or based on the activities of one person. Non-repetitive actions are described as an interface with two or more people. This process looks specifically at what happens when one individual is interacting with the table. During this process we began by testing several different kinds of bi-materials including combinations of bi-metal materials along with combinations of metal materials with natural materials such as metal and paper together. The bi-material utilizes in this project refers to a materiality that is composed of two separate metals joined together and consists of layers of different materials that vary in thickness and property. The bi-materials are useful in converting a temperature change into recognizable form displacement, and then changing back to an initial position after the increase in temperature has worn off. The embodied energy of the materials become visual as the energy released/absorbed allows for the displacement to become evident and therefore is very useful in working with temperatures and electronic inputs.

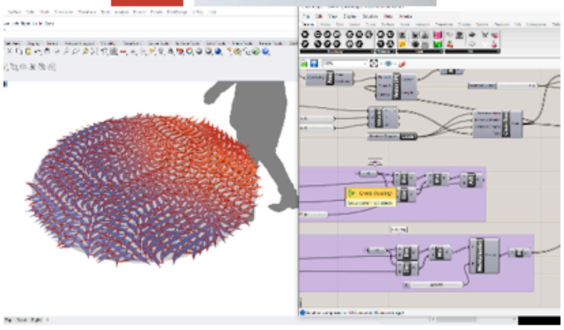


Figure 10, left: Different paper colors and thickness, together with metals used for the bi-material tests. (In the end, a 120 grams red paper was chosen along a 10mm thickness aluminum sheet.) Figure 11, right: Drawing using Rhino and Grasshopper showing the transformation of the bi-material. (The bi-material bent because of differences in the dilatation coefficient of the materials.) A. Saghafifar.

It was apparent that the bi-metal materials were not going to work for this particular project due to the fact that we were unsuccessful laminating the materials together in a consistent way and because of this composition would break down when combined with different temperature variations. Also, the two coefficients of expansion for the bi-metals was attractive in the beginning due to the obvious visual perception the material provided. Examples of this are bending when heated and then returning back to its original state when cooled. In this way, the bi-metals behaved as expected, however, it did not fall into our desired temperature ratios for the way we were designing the heating interface. In the end, the thickness of the various bi-metals we explored proved to be problematic because the correct thickness of the metals was not achievable at the scale of the table in this particular setting.

As we began researching and manufacturing our own material combinations, it became clear that an extremely thin metal combined with special thickness of paper was the most successful in responding to the given criteria. The metal allowed for enough rigidity, and the paper material allowed for a more direct relationship between the thermochromic paint and the temperature differences. The resiliency of the material palette, both in terms of the thermochromic coatings, and the responsiveness of the bi-material was a critical factor. Our studies indicated that 500 watts of potency was enough to achieve our desired outcome but the speed and rate of thermal expansion needed additional ranges to portray the full range of options that the table provided for human interaction. As the table is going to be covered in glass, the glass creates an envelope that works in a range of 500 -1800 watts. At 500 watts the biomaterial starts to move, but it moves in a slower rate. The higher the temperature, the more the metal deforms and the more it is respondent to the temperature. The activation temperature for the thermochromic paint is 30 degrees Celsius.

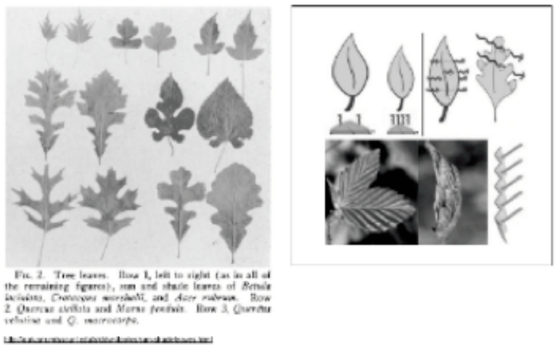


Figure 12, left: Logic studies for the shape of the leaves. Source: http://wegreening.blogspot.com/2016/04/blog-post_28.html and http://www.daadgroup.org/pub/eCAADe%202014%20v2%20-ElA%20-Fio%20250dpi.pdf
Figure 13, right: Initial drawings by the authors explored shape grammars of leaves and how these shapes worked with bending when heated. Decisions were ultimately made regarding the performative qualities of the leaf shapes.

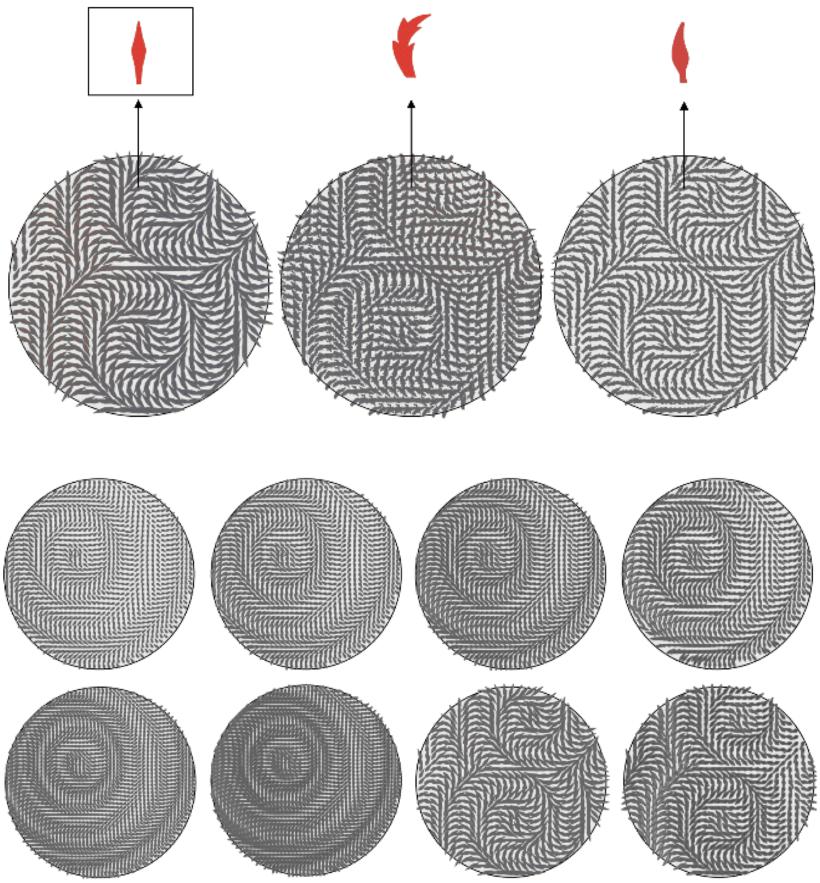
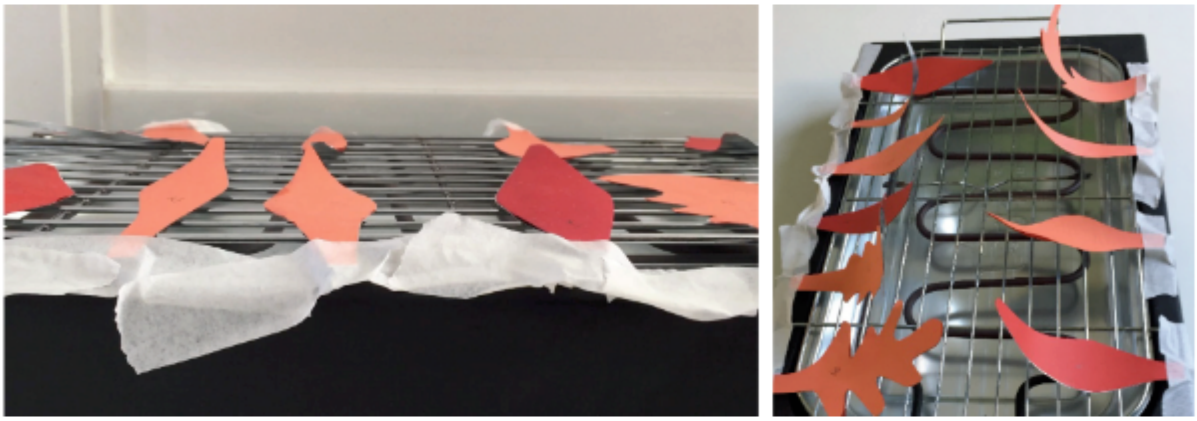
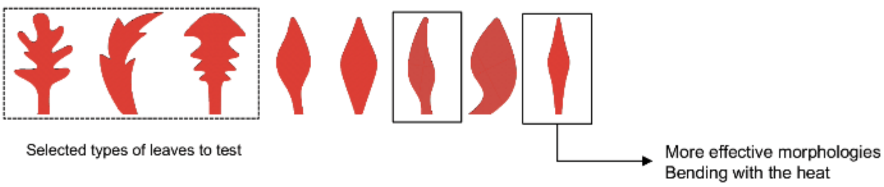


Figure 14: Decisions for leaf profiles based on consistency and compositional patterns with relative size and responding pattern.

Figure 15, left: Electrical resistance coils with different available ranges. Source: https://produto.mercadolivre.com.br/MLB-737802511-2-resistencia-eletrica-caixa-dagua-c-termostato-1-resist-_JM?quantity=1.

Figure 16, right: Ceramic infrared heating, another option for the table prototype. Source: https://www.eletrothermo.com.br/ (Instead of the ceramic & coil resistance, studies indicate the use of graphene could also be successful in future tests.)





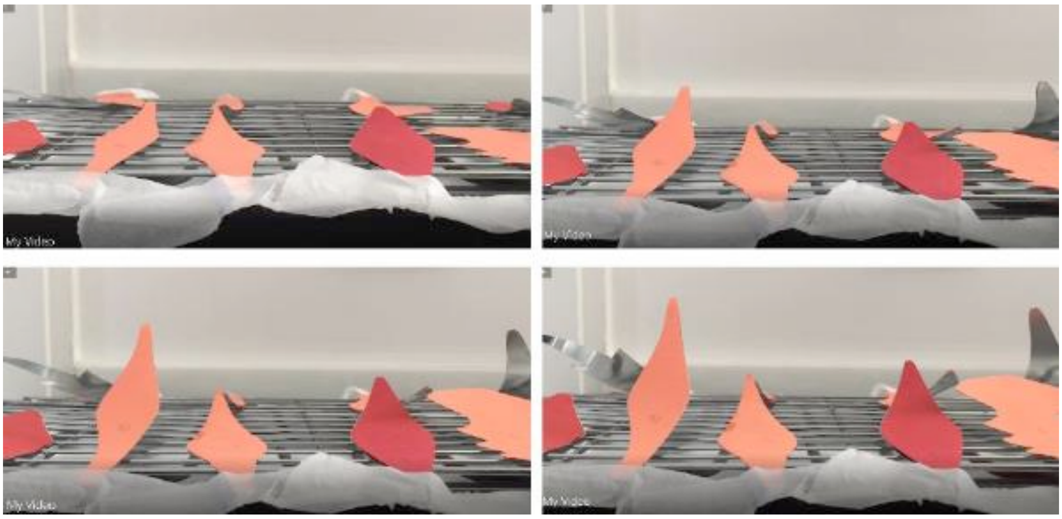


Figure 17, above: Material testing, bending & heating at beginning and end of the test. Subsequently, the decision was made to utilize the morphologies that bended most successfully with heat. Below: Video frames of the leaves bending. (Research indicated 40 seconds for the leaves to bend and 2 minutes for it to return to the initial position.)

The project incorporates Leuco dye, a water-based ink. With this as a coating, colors can change in the presence of temperature variation. This is a phenomenon that certain substances exhibit known as thermochromism. The process is reversible up to 60 degrees, and Irreversible from 60 degrees onward. It allows for the mixing of shades between paints of the same turning point, but in this case, it wasn't mixed. The color intensity in this process depends on the designer's needs, but the weight of the covering (paint coat) should be 2 to 3 times that of a normal paint. The dyes are rarely applied on materials directly; they are usually in the form of microcapsules with the mixture sealed inside. The dyes most commonly used are spirolactones, fluorans, spiropyrans, and fulgides. The acids include bisphenol A, parabens, 1,2,3-triazole derivates, and 4-hydroxycoumarin and act as proton donors, changing the dye molecule between its leuco form and its protonated colored form; stronger acids would make the change irreversible. We found that leuco dyes are available for temperature ranges between about −5 °C (23 °F) and 60 °C (140 °F).

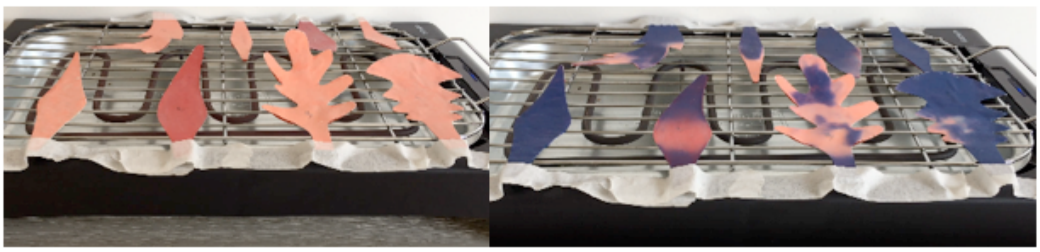


Figure 18: Video frames of the leaves changing colors.

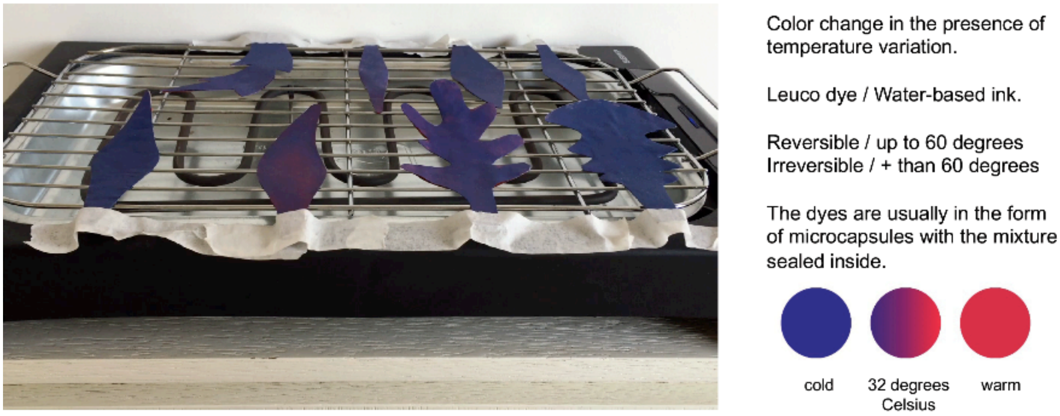


Figure 19: Color palette of leaves based on temperature.

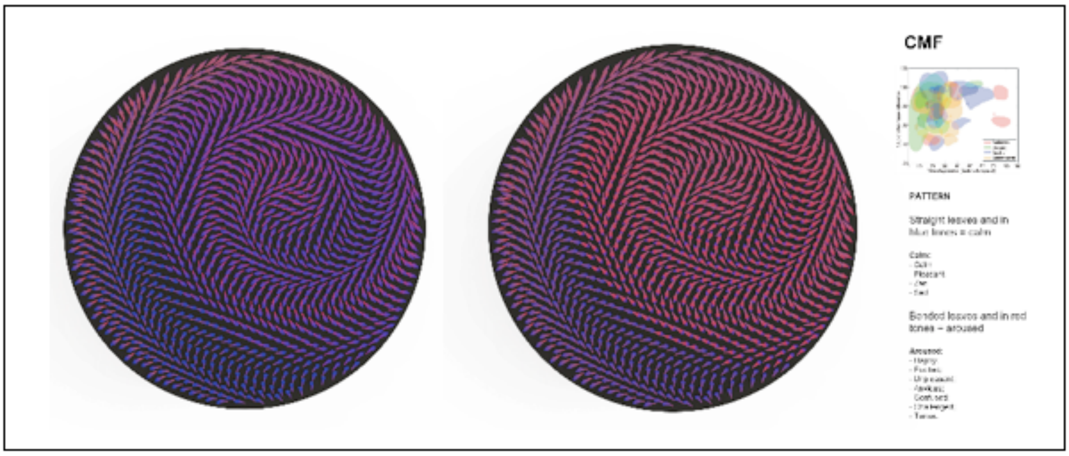


Figure 20: Plan drawings of the table incorporating color change based on temperature.

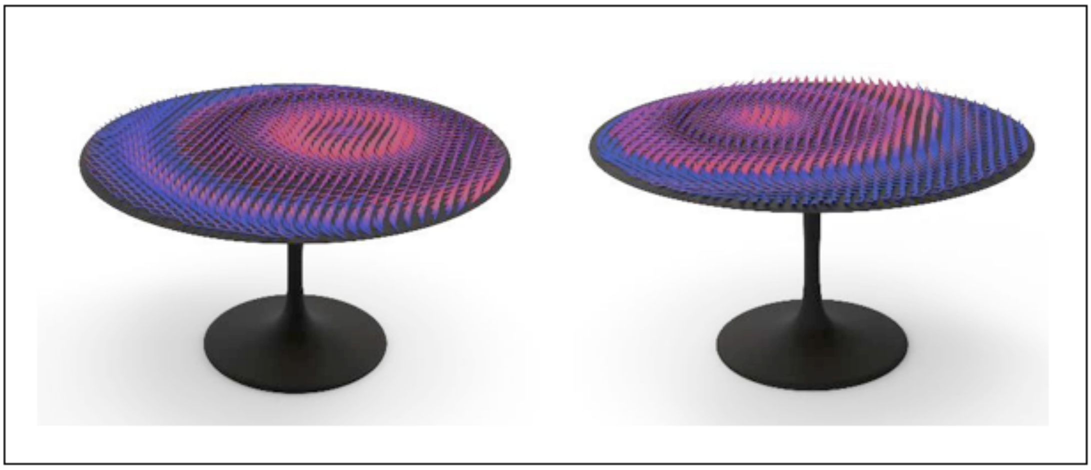
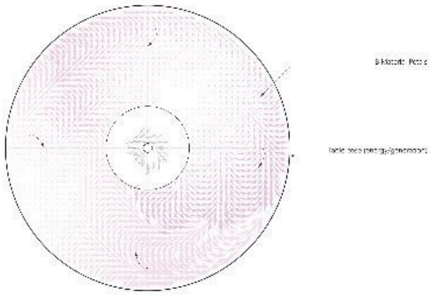


Figure 21: Drawings of the table incorporating color change based on temperature.



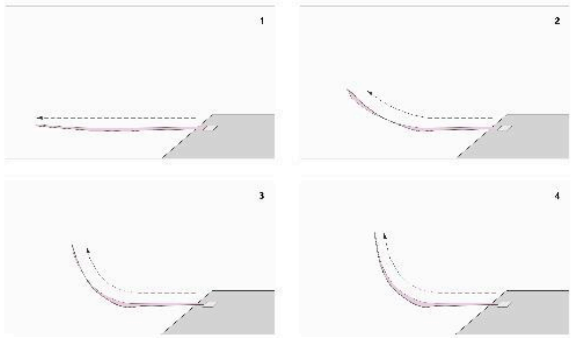


Figure 22, left: Plan drawing of sensory table, with petals bending and changing colors in response to sensory information. Figure 23, right: Diagrams of metal/paper bi-material petals as they respond to heat. A. Sebastian.

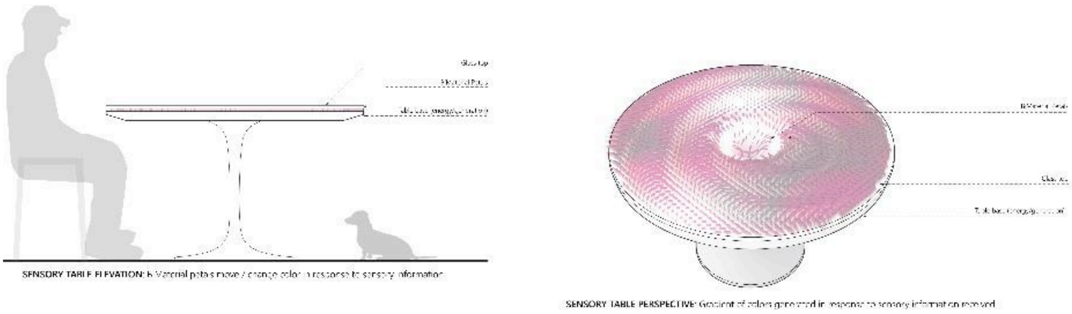


Figure 24: Elevation & perspective drawing of sensory table. A. Sebastian.

Methodologies & Sensorium Technologies

In order to predict the potential overlap between the architectural, the sensorial, and the augmented, we worked with UpMood technologies to begin understanding how to measure and estimate how people might feel or respond in a given environment. To monitor and evaluate how people perceive certain criteria, users wore emotion-sensing bracelets when they visited the project. These collect biodata from the user and result in 11 different emotional states: calm, pleasant, unpleasant, happy, sad, excitement, anxious, confused, challenged, tense. This data was continuously fed into an App that revealed the different states back to the user. The evaluations and the use of these overlapping technologies acted as a way to gain insight into a more profound human experience. Through this process, the project addressed user insight relative to emotional patterns and management.

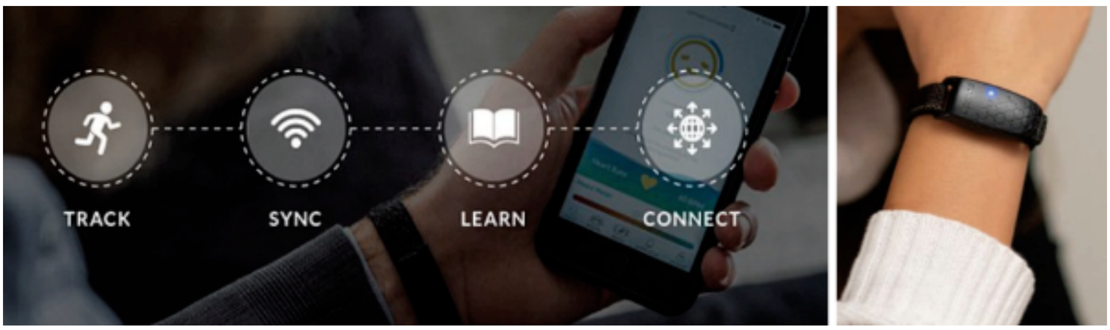
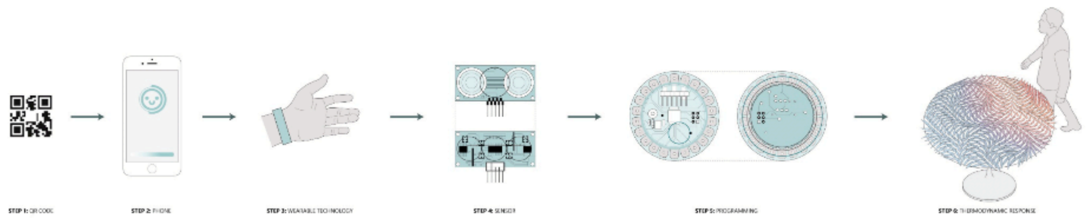


Figure 25: UpMood technologies (App+bracelet). Source: UpMood.

In the paper, *The Nature of Feelings: Evolutionary and Neurobiological Origins*, the author Antonio Damasio writes, “Survival depends on a homeostatic range”, and “feelings and experiences facilitate the learning of the conditions for homeostatic imbalances plus the anticipation of conditions. Feelings are mental experiences that accompany a change in the body state.” He goes on to write that, “external changes - displayed in the exteroceptive maps of vision or hearing (sensorium) are perceived, but largely not felt. It can trigger drives or emotions, causing a change in the body state, and subsequently felt.” Homeostasis, the tendency towards a relatively stable equilibrium between interdependent elements, especially as maintained by physiological processes, is a big part of human survival,-and is relevant to the theories of Damasio. Human survival depends on homeostasis, or the regulation of the body's self-repair and defense. The body can regulate itself without the person having a feeling, or “conscientious experience”. However, when the person does have a feeling, and therefore he/she is aware of it, it facilitates the learning of a change in body state for a better prediction of future situations and thus increases behavioral flexibility. With these concepts in mind, this installation tries to increase felt experiences, using the different stimuli to increase senses and also offer a recording of what a user felt to bring about potential self-awareness.

Wearing UpMood bracelets allowed us to monitor different emotional states in real time as we interacted with the project. What we found is that the technology can be sometimes accurate and sometimes surprising indicating that our heart rates change in different ways and can be highly situational. It was an interesting part of our experiments with this project because it allowed us to interact with a user in a way not normally accessed in architectural projects. The conclusions for these findings via UpMood wearable technologies indicate that stable peaks, highs and lows, in experience are crucial to accuracy and variance from person to person can differ. There can also be discrepancies between what the users “thought” they were feeling, and what the technology actually indicated. Fluctuation in experience will also affect the results.



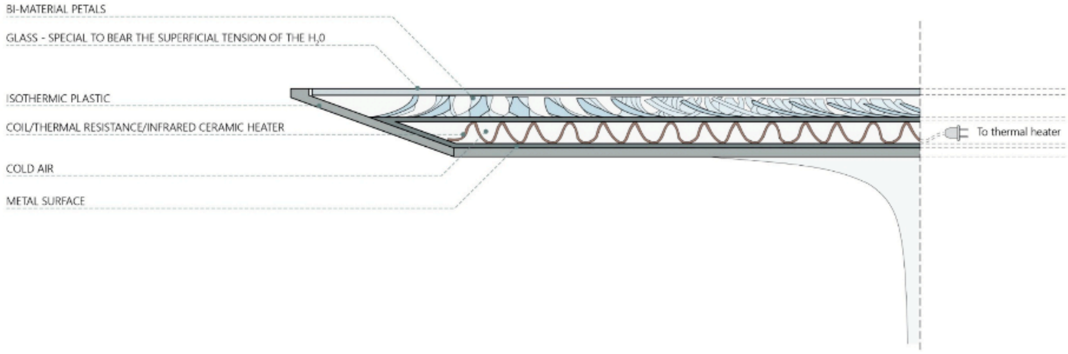


Figure 25: Diagrams of technological integration and table operation. A. Sebastian.

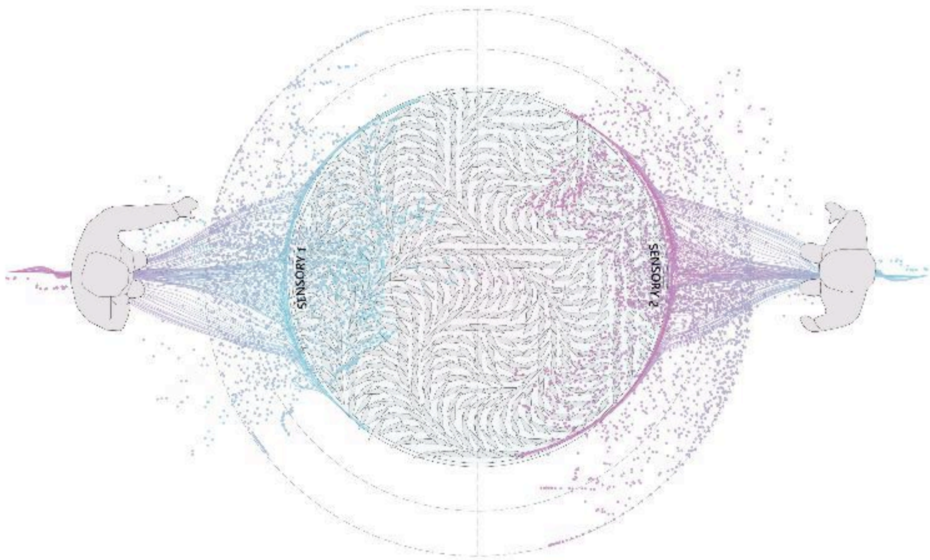


Figure 26: Plan diagram of human/sensor interaction. A. Sebastian.

Figure 27: Testing setup, putting technology into play. (In our tests, the table changes its behaviour according to emotions captured by the UpMood bracelets, reacting to two possible states, 'Calm' shown at above-right, and 'Aroused' shown at below-right.

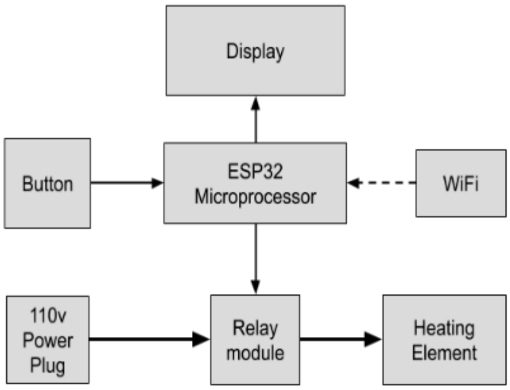


Figure 28: Hardware prototype, table operational diagram.

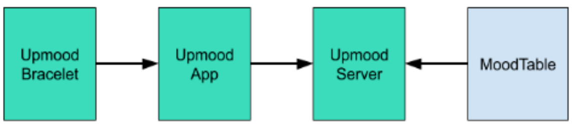


Figure 29: Hardware prototype, table operational diagram.

The table hardware consists of a heating element, a microprocessor with WiFi, a relay module and LCD display, in addition to other auxiliary components. To receive the information, the ESP32 microprocessor from Expressif must be connected to the internet through a WiFi network, which will be used to communicate with the

Upmood server, and firmware updates via OTA must also happen. Once emotions are received from the server by the microprocessor, they are shown on the display and the heating element is activated or deactivated by the relay module. For testing and demonstration purposes, the table also has a manual override mode, where the heating element can be activated or deactivated regardless of the information received by the server. The set described will be referred to as MoodTable

MoodTable changes its behavior according to the emotions captured by the Upmood bracelet, reacting to two possible states, being Calm and Aroused. In order for MoodTable to react to emotions, the Upmood bracelet captures the heartbeat of the person using it, the Upmood App then receives this data and sends it to the Upmood Server, where it is analyzed by the algorithm and translated into emotions. In turn, MoodTable communicates with the Upmood Server through a REST API (see reference images, diagrams), which returns the information of the linked people and their emotional state in JSON format. The entire process happens automatically and, as long as MoodTable is connected to the internet and the App is receiving data from the bracelet and subsequently sending it to the server, the table will react to the emotions of whomever is using it. The two states, "Calm" and "Aroused", which are responsible for activating or deactivating the table are obtained from the grouping of various emotional states captured by the bracelet. The emotional states are as follows:

Calm: Calm; Pleasant; Zen; Sad
Aroused: Happy; Excited; Unpleasant; Anxious; Confused; Challenged; Tense

Therefore, when the emotion captured by the bracelet is defined as "Zen", the table enters the state of "Calm". Although a person's emotions change quickly depending on the situation, from this segmentation by two states, it was possible to have a uniform and consistent response between all emotions within both states.

Conclusions

This paper documents and critiques the process of a furniture project that was designed to induce a sensory experience and ask questions about the capacity to design with technology and a wider taxonomy of choices that can impact our experience in architecture. It explores these concepts relative to digital design and material interactions in the field of bi-material, thermal properties, and the human sensorium. It started by employing typical parametric & computational software, thinking of the potentials between the digital and the real, and incorporated this potential by accepting the role of material manipulation and response to temperature as a way to interact with architectural space and people. The purpose was to engage people sensory experiences that force humans to re-perceive our physical world. The outcomes imply that through research and design, stronger sensorial experiences can be used to increase awareness, perceptibility, and create new design conversations.

The outcome of this particular project at the time of writing is still underway, however what we have learned offers a great deal of input relative to humanizing the design of everyday objects to allow a more heightened experience and relationship between human and object. The use of computer simulations allowed us to begin to predict and forecast how our design could respond to specific levels of human interaction. The use of bi-materials allowed us to create physical and visual responses that relate directly to human interaction, and the role of sensors and wearable technology allow us to further dial in and program the project in a way that illustrates human connectivity and interaction in real time.

One of the most effective approaches towards this topic is defended by Phillipe Starck: to make less: design, material, and energy to end up with more. [7] In the future people will live in smaller places and they will have fewer things, just keeping the objects that are really important or useful. In that scenario, it is interesting to think about how technology can help us to create meaningful objects, that achieve a deeper level of emotional connection with its users. How a furniture piece enhances verbal and non-verbal communication and stimulates, though technology, cooperation to create a more humanized society?

This piece of furniture has a sensory approach to emphasize the positive aspects of technology and reduce the bad ones. So, it enhances the sensorial channels to provide the users new experiences and to build emotional connections with one another. Furthermore, through non-verbal communication, this table helps people to be open, honest, and integrated, stimulating real and meaningful rapports. In this way, one can understand the other better and have more efficient communication. Consequently, this increases empathy and encourages cooperation.[8]

Acknowledgements

In alphabetical order:
Ahmed Abdelnaby, Houdini consultant.
Charles Kit Yi Lo, UpMood consultant.
Arian Saghafifar, Scripting assistance.
Alina Sebastian, Diagramming assistance.
All images courtesy of the authors & consultants except where noted.

References

1. Drucker, P. (8 Nov. 2017). Peter Drucker Speaks, Drucker School of Management. www.Youtube.com. Accessed 15 June 2019.

2. Wertheim, E. G. (2008). *The Importance of Effective Communication.* Northeastern University.

3. Rees, J. (5 Apr. 2019). Mehrabian's Communication Theory, Verbal, Non-verbal, Body language. www.businessballs.com. Accessed 15 June 2019.

4. Bradt, S. (24 June 2010). How touch can influence judgments. www.news.harvard.edu. Accessed 15 June 2019.

5. Caggiano, S. (2018). Convergent Design: On The Role of Product and Furniture Design in Enhancing User Experience as The Digital and Real World Converge. Academia.

6. Clark, A. (2000). *Natural Born Cyborgs: Minds, Technologies, and the Future of the Human Intelligence*. Oxford University Press, Ch. 4).

7. Hackethal, A. (23 June 2015). Material Tendencies: Philippe Starck. www.architonic.com. Accessed 20 June 2019.

8. Brown, B. (June 2010). The power of vulnerability. www.ted.com. Accessed 20 June 2019.