

PERCEPTUAL PROTOTYPES
Towards a Sensory Pedagogy of Space

By

Athina Papadopoulou

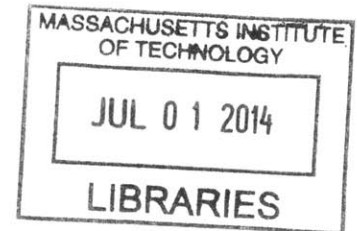
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ABSTRACT

Architecture education, by being enclosed in studios and by focusing on formal qualities of spaces, has been detached from the direct experience of space and has prioritized vision over the other senses. If we are to extend our spatial understanding, we need to expand the boundaries of our sensory perception by developing tools and situated learning strategies focused on the interaction between our bodies and the built environment.

I propose the Perceptual Prototypes as tools through which we can sense and experience space. My hypothesis is that the Perceptual Prototypes can augment our understanding of space by allowing us to focus on each of our senses individually. As precedents I discuss pedagogies of the Montessori method and the Bauhaus school, which focused on the separate training of the senses. I then draw upon studies in psychology and cognitive science to suggest that we can train our senses by 'sensing through' and 'experiencing through' the tools we use.

To demonstrate the pedagogical implications of my thesis, I first discuss the procedure and results of the workshop 'Perception Creatures' I co-taught during IAP. Students designed their own 'creatures' using sensors to study the body-space interaction. I then proceed with an experiment where I ask participants to explore a physical space by using a wearable tool – the Perceptual Prototype – that I developed. In the experiment the tool takes again the role of a creature, which is limited to a specific sense. Asking participants to act as host for this creature, I study how they experience the space by focusing on each of the different senses.

The results of the case studies demonstrate the enriched experiences and perceptions that emerge through the use of the Perceptual Prototypes suggesting a direction towards a sensory pedagogy of space through the use of tools as 'objects to sense with' in the learning process.

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“We call for the extension and overcoming of our senses. We want to explode all boundaries that have existed until now!!!...We call for haptism, just as we call for odorism!!!”

Raoul Hausmann, *PREscentism Against the Puffkein of the German Soul*, 1921

“Let us begin by wondering just what you are doing sitting there at your desk”

Marschall McLuhan, *The City as a Classroom*, 1977

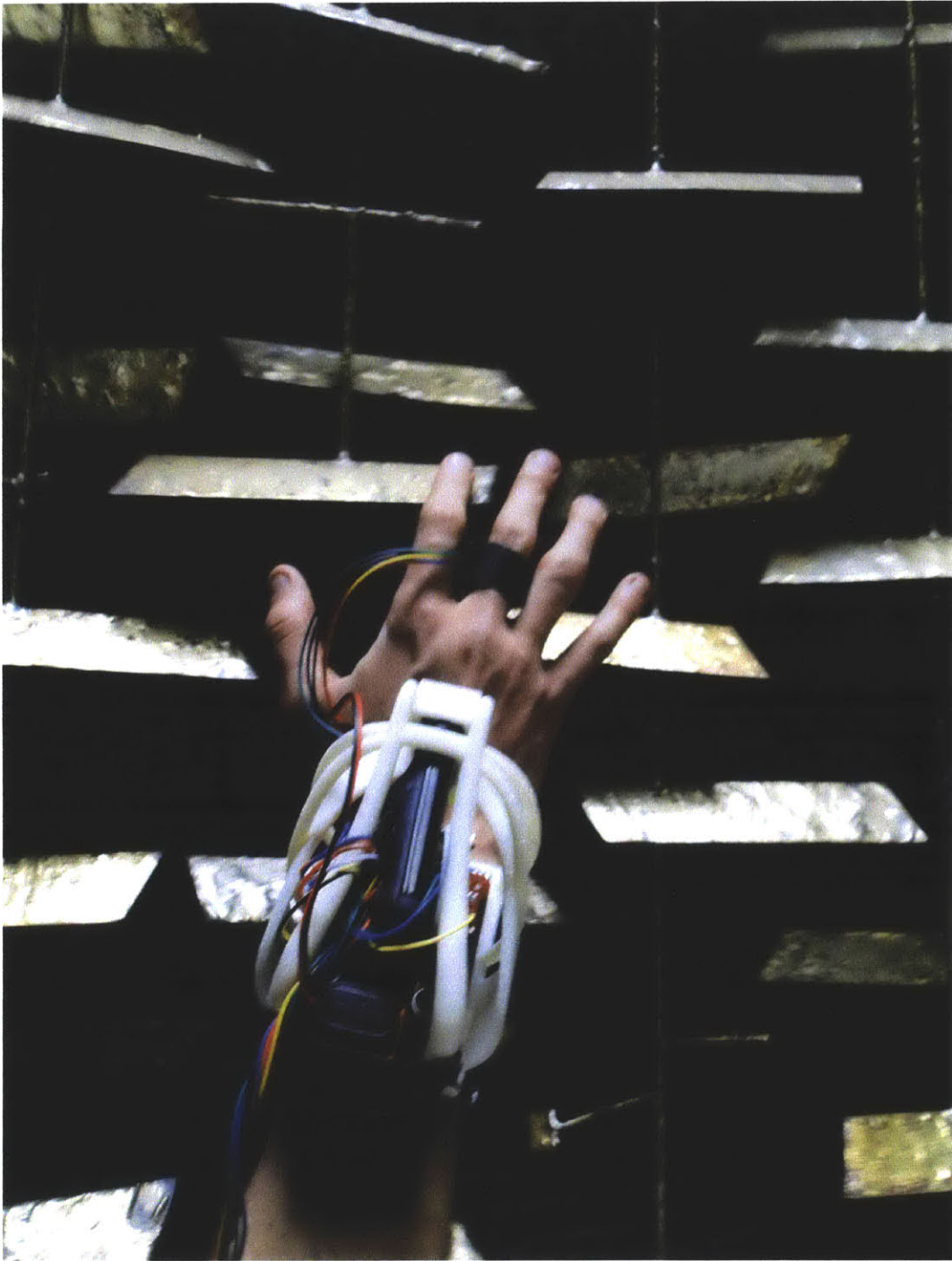


Figure 1. 'Sensing-thought' and experiencing-through' the Perceptual Prototype in the MIT Chapel.

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1. INTRODUCTION

By focusing on abstract formal qualities, architectural education has become largely detached from the sensory aspects of space. Extensive literature in design education has identified the limitations of common studio practices, which separate spatial learning from the actual environment and experience of space (Bhatia: 2006). The fact that the material and sensory qualities of a space elicit a direct psychological response in those who occupy that space is evident in our daily spatial experiences and has been the subject of scientific research in fields such as environmental psychology for decades (Gifford: 1997). These studies, however, have so far had only a tangential influence in the formal education of the architect. Moreover, although we develop an understanding of space through all our senses (Millar: 2008), architecture culture has prioritized vision over the other senses, leaving unexplored to a great degree the contribution of the rest of the senses to spatial experience and understanding.

If we are to extend our understanding of space, I suggest that we need to expand the boundaries of our sensory perception by developing tools for situated learning strategies focused on the interaction between our bodies and the built environment. My hypothesis is that *we can augment our understanding of space by focusing on each of our senses individually through Perceptual Prototypes*. I propose the method ‘make, sense-act, reflect,’ structured around these tools and aim to demonstrate the method’s pedagogical implications through two case studies: one workshop and one experiment.

To suggest a methodology that addresses matters of sensory perception in a situated learning of space, I draw upon the sensory pedagogies of Maria Montessori and László Moholy-Nagy. Maria Montessori suggested the separate training of each of the senses as a means to provide to the students an awareness of the different qualities of objects and properties of the environment; she believed that isolating the senses would result in students’ augmenting their sensory perception regarding the sense under study. The education of the senses entered architecture education with Laszlo Moholy-Nagy in the Bauhaus School. He also introduced the isolated training of the senses in a set of experiments and exercises that allowed

students to feel, measure and reflect on the subtle differences in material qualities and sensations.

Montessori and Moholy-Nagy's experiments were limited to classroom exercises and the material engagement with objects. I propose the use of Perceptual Prototypes as tools that can extend the education of the senses into space -- out of the classroom -- in order to allow students to experience and sense the qualities of the built environment. In technological terms, the Perceptual Prototypes are wearable devices that can track our sensory interactions with the environment. In educational terms, they become 'objects to sense with' and 'experience with' in the learning process. While the tracking of the senses becomes possible through the behavior of the tool, the focus on a specific sense becomes possible not through deprivation, as Montessori suggested, but through our psychological projection onto the tool.

To support the proposed educational role of the prototypes, I draw upon research in psychology as well as in cognitive science, which supports the view that the tools we use not only become extensions of our bodies and minds but that we can also experience, feel, and sense through them. Moreover, I discuss the role of self-tracking tools in the exploration of space and the embodied knowledge that emerges through the recorded data.

Through the workshop I aim to demonstrate how the steps of making the prototype, sensing and acting with the prototype and reflecting on the experience of space through the visualization of the recorded data, suggest a pedagogical method that augments students' awareness of the experiential and sensory qualities of space. Through the experiment, I aim to demonstrate in a more controlled process how the focusing on each of our senses individually through the prototypes expands the boundaries of our sensory perception and also provides us a greater awareness of the material and qualities of space. Thus, the steps 'make, sense-act, reflect,' in the case of the experiment, function as both an experimental and pedagogical method. The prototype used in the experiment is described as a work in progress, which under further development would provide a medium for direct of investigation of the body-space interaction. The heuristics and results discussed in this thesis suggest a direction towards a sensory pedagogy in architecture that could transform the experience of space into a generator of the making and designing of space

2. EDUCATION OF THE SENSES

2.1 SENSORY TRAINING IN THE MONTESSORI METHOD

In the middle of 19th and beginning of 20th century physicians and educators changed the focus of the treatment of cognitive and physiological deficiencies to the training of the senses. Jean-Marc Gaspar Itard and Edouard Seguin, both famous in the field of special education, believed that sensory education was the foundation for mental development. Itard argued that it is necessary to train each organ separately (Montessori: 1912, p.181). He believed that isolating the specific sense related to the child's deficiency, and working on the specific sense, would result in the recovery of child's abilities. For example, to train the sense of sound he used to have the children blindfolded and ask them to discern the differences in the perceived sounds. Edouard Seguin, who is also well known for his contributions to special education, founded his pedagogy on the idea that all five senses are variations of the sense of touch. Using sensory-motor exercises, he aimed to help children recover cognitive disabilities. For the training of the senses he used various techniques that involved the use of physical material. For example, for the visual sense he used as study materials physical blocks in various sizes and colors (Winzer: 1993, p.212).

Specifically relevant to the sensory training experiments is the work of Condillac, who, following the philosophical principles of Empiricism, argued that all human knowledge is transformed sensation. He contributed to the study of the senses in his book *Treatise on the sensations*, where he examined the senses one by one, through an imaginary narrative. He imagined a statue that gradually becomes alive by a step-by-step activation of each of the senses, beginning from smell and ending in touch. Condillac believed that it was necessary to distinguish what ideas are owed to each sense, to observe how the senses are trained, and how each sense relates to the others (Condillac: 1930). In his book, he invited the readers to identify themselves with the statue and try to feel and think of the environment through the isolated senses:

"I wish the reader to notice particularly that it is most important for him to put himself in imagination exactly in the place of the statue we are going to observe. He must enter into its

life, begin where it begins, have but one single sense when it has only one, acquire only ideas, which it acquires, contract only the habits which it contracts.” (Condillac: 1930, p. xxxvii)

The experimental methods applied in special education and psychology provided the background for the radical pedagogies in formal education introduced by Maria Montessori in the beginning of the 19th century. In the psychometric experiments of the end of the 19th century, psychologists used scientific instruments to measure the physiological and sensory response of subjects to specific stimuli. In the Montessori Method, Montessori stresses, however, that although her methods draw upon findings and methods of current experiments in psychology, the great difference is that her study materials do not aim to measure the senses but are adapted to cause the child to exercise the senses:

“In a pedagogical method which is experimental the education of the senses undoubtedly assume the greatest importance. Experimental psychology also takes note of movements by means of sense measurements. Pedagogy, however, although it may profit by psychometry is not designed to measure the sensations, but educate the senses. This is a point easily understood, yet one which is often confused.” (Montessori: p.167)

The focus of the radical pedagogy of Maria Montessori lies in what she calls “auto-education,” the self-development of the child through self-discovery and self-instruction. In other words, her method as a whole is founded upon the principle that less instruction is needed from the teacher; the children should learn on their own. Therefore, although her task, like that of the psychologists, is also to observe the reaction of the child to given stimuli, her goal is the discovery of an educational method that would contribute to the cognitive and physiological and psychological development of the child. Moreover, although she draws upon the methods of Itard and Seguin, her methods address common education. Therefore, the training of the senses is not regarded here as a form of treatment of deficiencies but as a way of learning to observe and discern the subtle qualities of the material environment. The aim of the education of the senses is “the refinement of the differential perception of stimuli by means of repeated exercises.” (Montessori: 1912, p. 173)

In her book, she describes different techniques to approach the training of each of the senses. For the visual sense, Montessori, like Seguin, uses wooden blocks in several forms, shapes and colors. The exercise takes the form of a game where children have to rearrange the blocks in specific given arrangements. To study the rest of the senses, Montessori, like Itard, keeps the students blindfolded in order to have them concentrate on the specific sense under training:

“Another important particular in the technique of sense education” Maria Montessori writes, “lies in *isolating the sense*, whenever this is possible. So, for example, the exercises on the sense of hearing can be given more successfully in an environment not only of silence, but even of darkness.” (Montessori: 1912, p.179)

To train the sense of touch, Montessori would give the students a variety of materials with different textures and ask them to discriminate the texture. For example, she used different types of sandpapers arranged on top of wooden boards. For the thermic sense, she asked students, while blindfolded, to play games that involved testing water of different temperatures with their hands. For the ‘stereognostic’ sense, she asked students, again blindfolded, to feel the contours of objects with their hands and place them in a specific order in wooden tablets or insets. Describing the stereognostic exercises, Montessori refers to the joy and excitement of the children when playing the sensory training games:

“They are proud of seeing without eyes, holding out their hands and crying ‘Here are my eyes!’ ‘I can see with my hands” (Montessori: 1912, p.190)

To train the auditory sense, Montessori used as didactic materials whistles and bells as well as small boxes filled with different substances that the student would shake to produce different sounds. In other cases, the auditory sensory training took the form of a performance where the children would sit in a quiet room, experience the silence and notice the subtle auditory qualities of space. “Let us close our eyes” Montessori would then whisper “Now, I hear the clock, now I can hear the buzzing of a fly’s wings, now I can hear the whisper of the trees in the garden.” (Montessori: 1912, p. 205) The goal of these types of games was to help children to learn to ‘discriminate the sounds’ but also to distinguish ‘sounds’ from ‘noises’:

“And when, besides the education of the ear, we have produced a vibratory education of the whole body, through these wisely selected sounds of the bells, giving a peace that pervades the very fibres of his being, then I believe these young bodies would be sensitive to crude noises” (Montessori: 1912, p.206)



Figure 2. Training the sense of touch. *The Montessori Method* (Montessori: 1912, p. 283)

Thus the training of the senses goes beyond physiological aspects to take on aesthetic moral imperatives. By helping students augment their perception of the environment, Montessori hoped to equip them with a sensory judgment for their future “adaptation in the environment”:

“We prepare with our method the infancy of the humanity of our time. The men of the present civilization are pre-eminently observers of their environment because they must utilize to the greatest possible extent all the riches of this environment” (Montessori: 1912, p.217)

No matter what the ethical imperatives were at the time when Montessori proposed her method, what is important to retain from her the radical pedagogies today is the proposition that the training of sensory perception should have a central place in education, as it is the foundation of physiological, psychological, creative and mental skills. Even if Montessori was preparing the children for their 'adaptation' to the specific social environment of the beginning of 20th century, in the end it was up to the child to decide which where the 'appropriate' sensory qualities and behaviors and which were not. In the auto-didactic method that Montessori proposed, the children, through their own , would eventually become aware of the sensory richness of the environment and create their own repertoires of senses and feelings; of textures, smells and sounds.

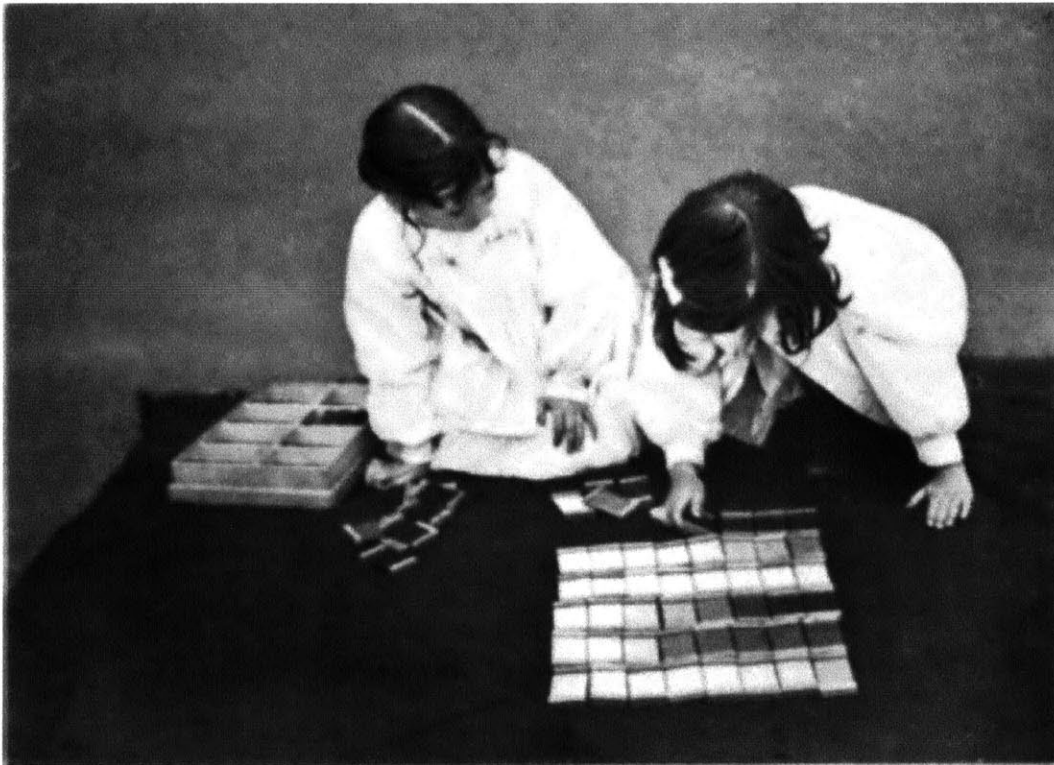


Figure 3. Arranging tables of silk in their chromatic order. *The Montessori Method* (Montessori: 1912, p. 188)

2.2 SENSORY TRAINING IN THE BAUHAUS SCHOOL

The education of the senses enters the Architecture Schools through the pedagogy of László Moholy-Nagy in the Bauhaus. In his book *The New Vision*, written in 1933, Moholy-Nagy devotes a section entitled 'Sensory training' to studio exercises on the pedagogy of the senses. Moholy-Nagy does not explicitly refer to Montessori's methods on training the senses, but one can assume that he was aware of Montessori's strategies, as he does refer to her as one of educators that the Bauhaus school should learn from.

Wishing to reform the formal pedagogy of the design disciplines, the Bauhaus set forth a radical agenda that promoted interdisciplinary learning. Criticizing the sterile educational environments that focus on specialized learning in the service of the system of production, Moholy-Nagy explains the mission of the Bauhaus school: it is an education for the 'whole man,' an educational agenda founded on the expansion of skills, experiences and knowledge under a unified design discipline that encompasses all arts and crafts. Precedents of this educational reform, were, according to Moholy Nagy, the radical pedagogies of early education in the United States and Europe, one among them the Montessori Method:

"In Europe –Czikek, Montessori, the Lichtwark school, Wende-kreis, Worpsswede (...) country educational homes, work schools, experimental schools, e.t.c, have in the last decades striven toward an organic education of the child. What remained was the application of the same principles to the education of the same youth and even of the grown up." (Moholy-Nagy: 1933)

The first year of the Bauhaus school, as Moholy-Nagy explains, was directed towards "sensory experiences" and the "enrichment of emotional values." Under this broader vision, he included the 'sensory training' in his pedagogy as a means to introduce materiality through the direct experience with the tactile qualities of objects. For him the tactile exercises provided to the novice students an understanding of aspects texture and tectonics that would be impossible to be acquired through books and descriptions (Moholy-Nagy: 1933).

Moholy-Nagy was concerned about making the students aware of the subtle differences between textures and material qualities. Touch, he argued, "may be divided into a greater number of separate qualities of sensations." It was through the training of the sense of touch by

specifically designed studio assignments that he believed the acquisition of this further categorization of sensations could be achieved. Moreover, according to Moholy Nagy, these exercises provided a sound foundation for “many sided sureness in the handling of materials in technical and artistic work.” Therefore, the aim of the sensory training exercises was twofold: They aimed at broadening the sensory lexicon of the students as well as rendering them more skillful. In other words, it was through the appreciation of different sensations that the technical skills would be better acquired.

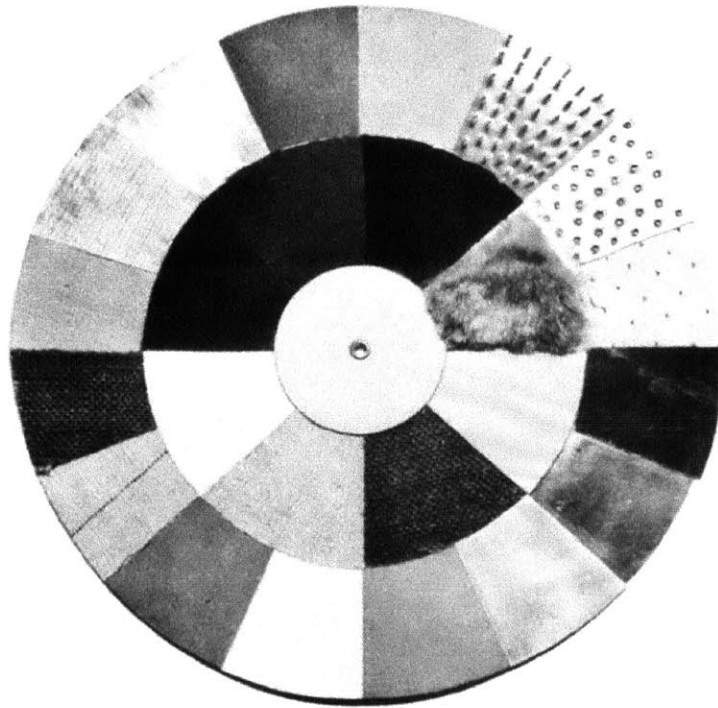


Figure 4. Tactile table for the training of the sense of touch. *The New Vision* (Moholy-Nagy: 1933)

Like Maria Montessori, László Moholy-Nagy considered as necessary the isolation of the sense under study. For example, the touch training assignments were introduced by a class experiment where students, while blindfolded, would identify different materials by using only

the sense of touch: fabrics, metals, leather, porcelain, sponges, even bits of bread (Moholy-Nagy: 1933).

After the experiments, Moholy-Nagy would issue specific assignments which allowed students to explore the senses by first fabricating the study materials for the specific sense and then by testing them. The student projects varied from tactile tables using multiple types of threads, tactile tables for pressure and vibration, to a “luna park” for the fingers and a “tactile symphony in rows.” Most of the examples shown in *The New Vision* are projects from tactile assignments. However, the projects were not limited to the sense of touch. The “Smell-o-Meter” for example, was a student project focusing on the exploration of smell; it allowed someone to “blend different odors in exactly given doses” in order to study their effect.

Although the sensory assignments permitted the students to ‘measure’ the sensations, though the testing of different textures, odors, and so on,, Moholy-Nagy stresses the fact that they had “nothing to do with scientific aims.” Rather, one can conclude that the sensory training in the Bauhaus school, like that in the Montessori method, was a tool for auto-education and experiential learning.

Montessori’s method was not the only precedent to Moholy-Nagy’s sensory pedagogy. His sensory training assignments were also a response both to the Dadaist call of Raoul Hausmann to expand the sensory experience through the arts and to Marinetti’s “Tactilism” (Wick: 2000). But unlike Hausmann and Marinetti, Moholy Nagy’s goal was not the creation of a new type of art or architecture but the establishment of a method that would “arouse and enrich the desire for sensation and expression” (Moholy Nagy: 1933).

Condillac’s imaginary statue, the radical methods of physiologists in the special education of the 19th century, Montessori’s sensory training methods, and Moholy Nagy’s sensory assignments, placed the senses in the focus of mental, physiological and creative development. A key factor in all the approaches reviewed in this chapter was the training of the senses through the separation and isolation of each of the senses. In being blindfolded while playing the tactile or sound games, students managed to go beyond visual awareness to explore the potentialities of the rest of the senses.

The necessity of being deprived of the visual sense in order to study the tactile sense, would render problematic any attempt to adapt these types of sensory training assignments into the study of space because unless people are naturally deprived of a sense, they cannot navigate complex built environments. To expand the notion of sensory pedagogy into space perception, we would have to find a different way to focus on each of the different senses. In the next chapter, I propose the strategy of filtering our senses through Perceptual Prototypes as a means to take education of the senses 'in situ' and therefore expand students' understanding of space through the direct experience of space.

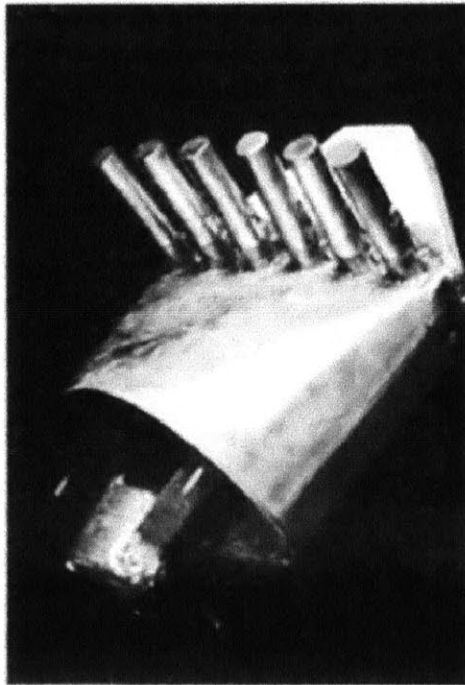
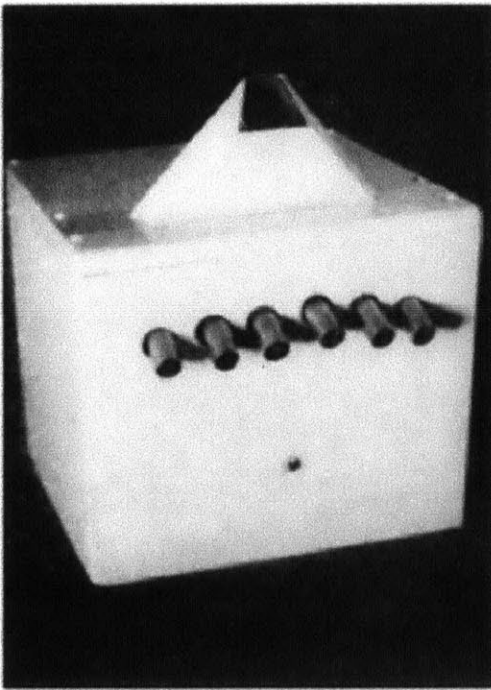


Figure 5. The 'Smell-o-Meter,' student project for measuring and training the sense of smell. *The New Vision* (Moholy-Nagy: 1933)

3. PERCEPTUAL PROTOTYPES

3.1 WHAT ARE PERCEPTUAL PROTOTYPES

In the previous chapter I discussed pedagogical approaches that focus on the sensory perception of the material environment. These pedagogical experiments demonstrate the importance of extending the boundaries of senses through an experiential learning that focuses on each of the senses separately through specific assignments that bring students into direct contact with materials and their qualities. To extend sensory education into “three dimensions” -that is, to go beyond the mere teaching of material qualities, which was the main focus of the precedents mentioned- the didactic materials should no longer be material objects but physical spaces. A sensory education of the three dimensions should focus on experiential learning through the active exploration of architectural space. To this end, the educational approaches adopted should also take into account the interaction with the body and the material environment. It is through our active engagement with space, through our movement and actions, that we develop an understanding of our environments. The importance of a body-centric and enactive approach to spatial understanding has been emphasized in phenomenological approaches in philosophy (Ponty: 1945) in pedagogical theories (Bruner: 1974) as well as in recent studies in cognitive science (Noe: 2006).

To take the sensory approach in education ‘out of the desk,’ I propose the use of Perceptual Prototypes as ‘objects-to-think-with’ space and ‘objects-to-experience-with’ space. In technological terms, the Perceptual Prototypes are devices equipped with technologies that capture sensory input from the environment. In educational terms, they are guides into an educational play that intends to expand students’ spatial understanding by augmenting their sensory perception.

My hypothesis is that by thinking and acting through the Perceptual Prototypes we can focus our attention on each of our senses separately and consequently augment our perception of space by exploring the boundaries and potentialities of our senses through our bodily interactions. Thus, the Perceptual Prototypes become the vehicles that permit the active

exploration of space in situ. They become the method that allows us to filter our senses and experience space in different perspectives.

In chapter 3.2 I will provide a review of studies and theories in psychology and cognitive science that serve to support my claim that we can shift perspectives by thinking and feeling through objects. If it is possible indeed to shape our cognition and experience through material agents as argued in the literature that I will discuss, then, as I will argue in chapter 4, it would be also possible also to channel our senses through such agents.

However, merely thinking through ‘things’ is does not suffice to support my argument. The fact that the ‘things’ I propose as tools of thinking are ‘prototypes’ with embedded sensor mechanisms plays an important role for both the implications of the educational method I propose as well as for the method of the experiment I conduct. In chapter 3.3 I aim to clarify the role of technologies in shaping our thinking and guiding our senses in the perception of space by discussing relevant projects and pedagogical approaches.

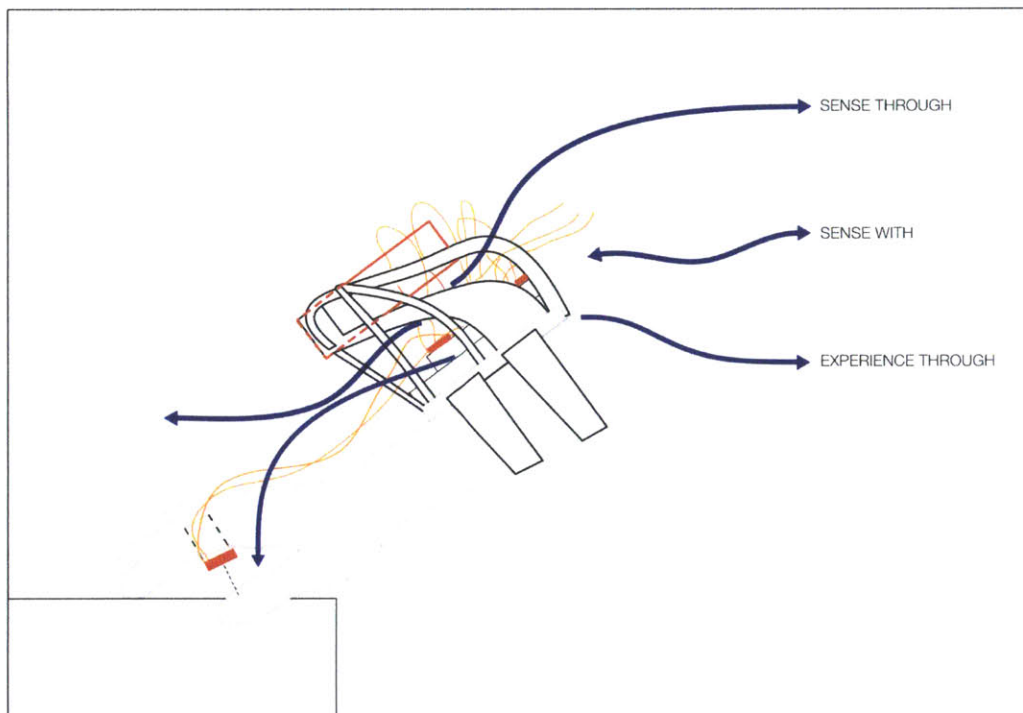


Figure 6. Sensing through, sensing with and experience through the prototype

3.2 MEDIATED EXPERIENCE

Our interaction with things and our tendency to attribute anthropomorphic characteristics to objects begins from early infancy. Children become attached to things and engage in imaginary dialogues with their toys. Puppets, dolls, and stuffed animals are transformed from inanimate inert things to living creatures. The moment that we engage in imaginary relationships with the material world signifies a stage of physiological and cognitive growth. The things we play with become, in Winnicott's terms, the "transitional objects" from the purely subjective egocentric world of infancy to the recognition of a decentralized reality constructed through the perspectives of 'others' (Winnicott: 1971; Ackermann: 1996, 2005).

Stepping in and out of our viewpoint is necessary to make the assemblage of the multiple fragmented views of our subjective experiences. "Only when a learner actually travels in a world by adopting different perspectives, or putting on different 'glasses' can a dialogue begin between local and initially incompatible experiences" (Ackermann: 2004)



Figure 7. Switching perspectives. Image retrieved from: <http://ministry-to-children.com/learning-station-ideas/>

Shifting perspectives by putting ourselves into “other people’s shoes” is, according to Sayeki, analogous to “throwing ourselves” into an object. In “Anthropomorphic Epistemology” Sayeki (2011) suggests that it is always by extending our empathy into objects, that we understand and experience the environment. Sayeki argues that there are two ways to look at things: One is “from the outside” the other “from they inside.” Taking the example of a simple teacup he elevates the objects into the drivers of our perceptual apparatus: “To see a cup from the outside is to examine its appearance and materials. To see it from the inside is to project your whole being to the cup itself.” If you see it from the inside “you will feel as if you have been transposed in the condensed time and space of the cup’s ontogeny. (...) Then you would see the world through the eyes of the teacup, then you would talk to cup and the cup would respond through his history and future interactions with the world.” (Sayeki: 2011)

Sayeki goes on to develop the theory of “Kobitos” as a means to explain our interactions and empathy with the material world. He argues that we dispatch “Kobitos,” imaginary selves, into people and things. Through this distributed self we identify with objects, mimic imaginary behaviors and feel through other people and things.

The argument that we ‘think with objects’ and ‘think through’ objects is also supported the cultural and science and technologies studies. In Turke’s terms, things can be become “evocative objects” through which the self is being transformed. Turkle (2011) demonstrates that simple technologies of self-reflection and transcription like diaries, to current digital tools like computers, portable devices, and phones, all become extensions of our body and mind; they shape our interpersonal relations, the way with think and act in the world. More than that, the “evocative objects” of our childhood, from toys to tools to machines to symbolic objects, can be become the vehicles of our later social and career aspirations. Pickering discusses the influence of machines and “material agency” in scientific thinking, Latour discusses the relations between human and non-human agents in the social and political realm (Ihde: 2002) , Ihde (2002) the construction a mediated self through technologies, and Harraway (1991) the characteristics of the “cyborg,” which constitutes a new type of social being.

Evidence that our cognition is shaped through our interaction with the environment can be also found in the theories of distributed cognition (Hutchins: 1996) and extended cognition

(Clark: 2008). Drawing upon these theories, Malafouris (2013) in his Theory of Material Engagement, aims to place the material objects in the center of the discussion of our cognitive processes and cognitive development. According to Malafouris, “things shape the mind.” He claims that cognitive development as well as human evolution is impossible to be thought of out of the realm of material objects. Following Clark’s argument that there is a “cognitive leakage” from our mind to the world, he goes deeper into the significance of objects to claim that the minds in not necessarily “co-located with the brain” and that the mind in fact “extends beyond the skin.”

His arguments are not only based in cultural and anthropological studies but also on scientific experiments. Experiments with animals using tools as well as with humans performing specific cognitive functions that acquire the use of specific tools prove that our engagement with objects and processes shapes our cognitive apparatus through the metaplasticity of cerebral neurons (Malafouris: 2013).

Extending the discussion of material agency set by scholars in the study of technology and science studies, he demonstrates the ‘cognitive dance’ that occurs in the creative processes of “making.” He raises the question of agency in pottery making, by commenting on the cognitive exchange between the artist, the clay and the wheel. To elaborate on his claims regarding the extended mind approach, he revisits the riddle of the “blind man with the stick” set by Gregory Bateson , arguing that the stick and the man become one; the stick becomes an extension of the hand and therefore also an extension of the mind (Malafouris: 2013).

To summarize, research in psychology, cognitive science, along with cultural studies shows that not only is it possible to think with objects and tools, and experience the world through objects and tools, but that in fact the objects and tools we interact with shape our mind and self. If it is possible to we gain a different understanding of the world by projecting ourselves as a material agent, then this agent, as I aim to demonstrate, could expand the boundaries of our sensory perception through our bodily interactions with the world.

3.3 TECHNOLOGIES FOR EMBODIED SPATIAL KNOWLEDGE

If projecting ourselves into an object, as argued in the previous chapter, seems enough to allow us to switch perspectives and experience the world from a different standpoint, then one would reasonably wonder about the role of technologies in the tools that I propose.

First of all, not all objects are equally appropriate to qualify as being “transitional objects,” i.e., objects that we can identify with. Research in psychology demonstrates that “animate” objects or toys are more likely to serve as objects of projection rather than “inert” toys (Ackermann: 2005). Objects exhibiting a behavior of their own are more easily treated as animate creatures. This, for example, applies to responsive toys that interact with the user and the environment. But the object need not necessarily be responsive by movement or action, as is a more powerful ‘transitional object.’ It is the fact that the object demonstrates a specific behavior that allows it to take on agency in human-object interaction.

In the case of the Perceptual Prototypes I argue that it is their behavior as tracking devices that renders them more powerful as tools in both psychological and educational terms. In both the workshop and the experiment that I will be discussing in the next chapters, the Perceptual Prototypes are fabricated tools embedded with sensors that track our actions in space and record our sensory inputs. Their purpose is not to measure the sensations but to allow for observation and reflection on our body-space interaction. In the same way that Maria Montessori used psychometric methods to educate children, , the Perceptual Prototypes, as tracking devices, aim to offer an expanded understanding of space by depicting our bodily interactions with the environment.

Tracking the body data through technologies is a technique used by the proponents of the “Quantified Self” movement as a means to obtain a better awareness of the self. In the Quantified Self movement, dedicated self-trackers share their experiences and the knowledge that emerges by recording daily personal data. Phone applications and self-made tools are used to measure data related to health, performance, mood and activity. Self-Tracking, according to Gary Woolf, co-founder of the movement, is a way to take control of the data in a data-driven world and turn digital technologies into tools of self-evaluation and discovery rather than tools

for optimization (Woolf: 2008). The self-tracking technologies need not be digital. However, the idea of automated tracking processes adds a level of surprise by revealing processes and actions that often go unnoticed and therefore expands the notion of self-awareness beyond physical observation. As Woolf notes in one of his entries on the Quantified Self blog:

“The idea of quantitative self-reflection – knowing yourself better through numbers – is only interesting if the knowledge you get is not more easily available elsewhere. It’s the counter-intuitive knowledge, the “surprise” knowledge, that is the most fun, the most interesting, and perhaps even the most valuable.” (Woolf: 2007)

If, as the advocates of the Quantified Self movement proclaim, the automated tracking of our body data can offer us a greater awareness of self then wouldn't it be possible through tracking our body data in our interactions with space to gain a greater awareness of how the built environment affects our bodies and mind?

One can indeed detect the tendency to use tracking technologies as a means to provide a body-centered awareness of space in a couple of current projects. One example is Christian Nold's (2009) 'Bio-Mapping' project. In that project, Nold uses a simple tool consisting of a biometric sensor and a GPS device to capture people's emotional response to the environment. He gives these devices to participants and asks them to carry with them while walking in the city. He then invites people to add their own comments to these emotion-tracks and makes these data available for sharing by importing them to Google Earth.

Nold's urban experiments result in annotated maps where one can see the "emotional states" and subjective observations of participants overlaid on top of the urban grid. He defines the emotion-mapping process as a "self-reflective and participatory methodology". He uses technologies as an exploration of the self, aiming at giving to the participants, through the emotional cartography of the city, the power to critically comment on and evaluate the built environment.

Nold's approach is not of course without precedents. Nold refers to his maps as a type of 'psychogeography', obviously alluding to the Situationists' psychogeographical maps and the notion of the Derive. However, what seems novel in approaches like Nold's is the idea of using

sensor devices as ‘mediational tools’ for gaining spatial awareness. Another example in the arts along the same line of thought was the “Running Stich” project by Jen Southern and Jen Hamilton (Sotelo-Castro: 2009). Running Stich was a 5m x 5m projection of a map that showed the journeys of participants as traced by GPS phone applications. The visitors of the exhibition were asked to walk through the city using a GPS device and then return to the exhibition, where they would see their routes mapped onto this participatory cartography. While en route, their trail was projected in real time on this tapestry map, allowing other visitors of the exhibition to keep track of this live exploring performance. The project aimed at providing the opportunity of body-centered spatial knowledge by taking advantage of tracking technologies (Sotelo-Castro: 2009)

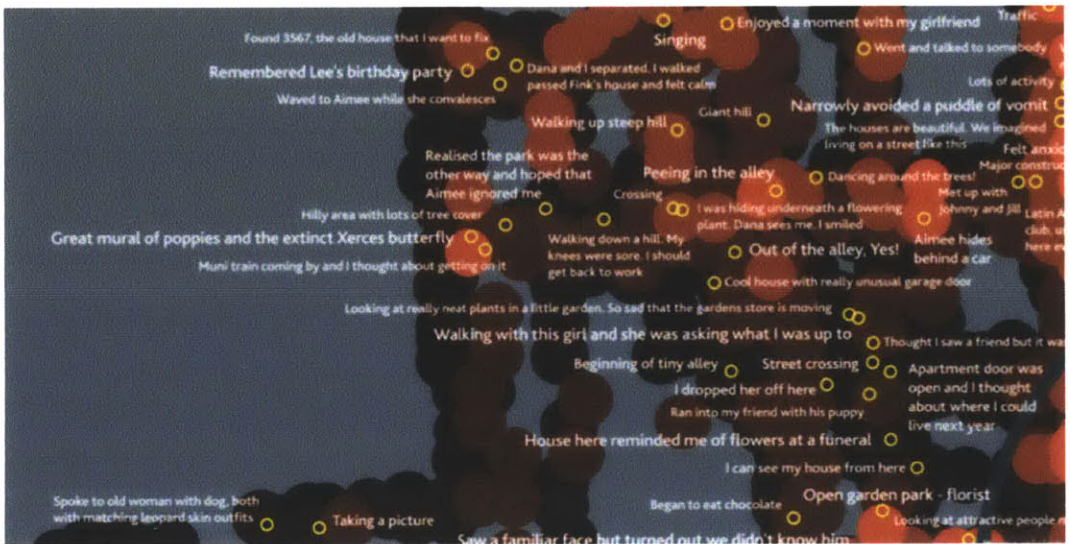


Figure 8. Christian Nold, Bio-Mapping, Detail of the San Francisco Emotion Map. (Nold: 2009)

If, as discussed above, tracking devices used today in art practices offer an alternative mode of ‘psychogeographic derives’ and urban exploration, the potentialities of this method as a tool to explore space in the building scale seem to have not yet been explored. Moreover, the educational value of using tools that would help one to gain an experiential based understanding of space based on one’s own movements and actions also seems to be unexplored territory. I argue that instead of regarding the output of these tracking tools and sensor devices as a mere art object, we could incorporate them into the learning process about

space. In that case, we could approach sensor technologies and computational tools as “objects to think with” in the learning process that would help develop a spatial understanding from the perspective of the body.

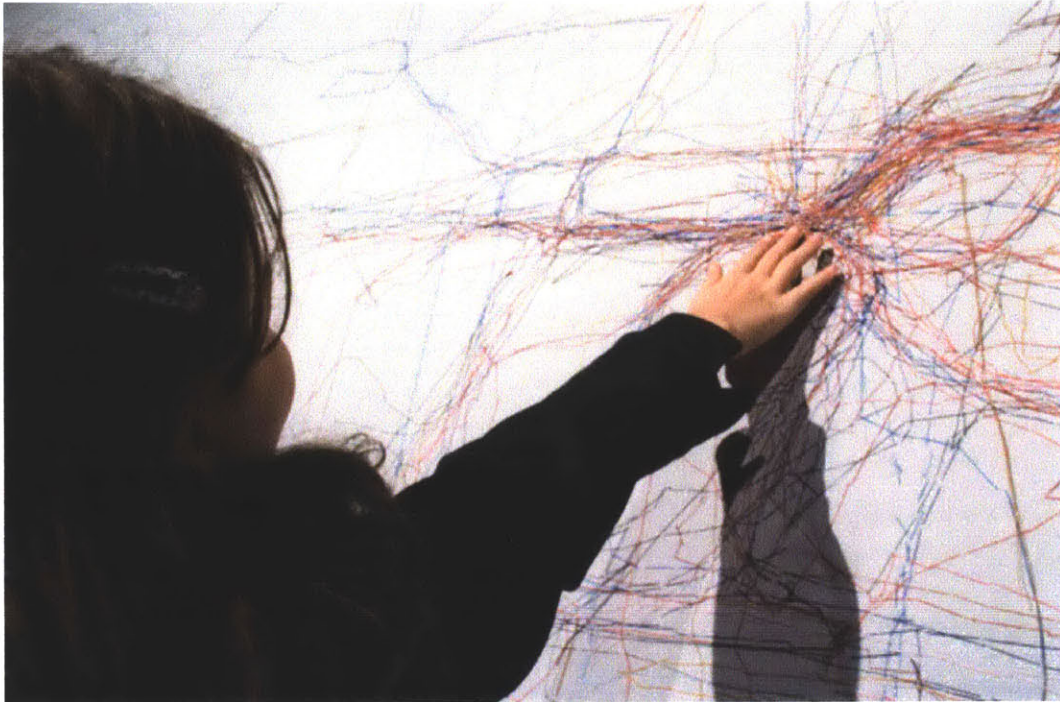


Figure 9. Jen Southern and Jen Hamilton *Running Stitch*, 2006. Image retrieved from: <http://journal.media-culture.org.au/index.php/mcjournal/article/viewArticle/192>

Seymour Papert uses the notion “objects to think with” in *Mindstorms* to signify the importance in using technologies in a manner that promotes situated and self-directed learning. He introduced the LOGO programming as a pedagogical tool through which children could develop formal thinking in a concrete manner and therefore take control of their knowledge (Papert: 1980). In the LOGO language a little robotic turtle, guided by the instructions of the user, generates lines on the floor while moving. One of Papert’s greatest insights, in his early works was “to tap children’s knowledge about their own movement in space” (Ackermann:

2004), As Papert (1980, p.63) argues, “Drawing a circle in a turtle geometry is body syntonic in that the circle is firmly related to children’s sense of and knowledge about their own bodies.”

Although the LOGO language is addressed to children, it is not only children who develop a spatial knowledge relative to the body. A great amount of literature in cognitive science argues for a body-centered knowledge and perception of space. According to the embodied cognition approach (Johnson: 1990), the body shapes the way we think and communicate. According to the enactive cognition approach (Noe: 2006), spatial perception is only gained through our bodily actions. Moreover, research in cognition and memory demonstrates that the way people recall spaces, is mainly body-centric; the space is reconstructed through the cognitive reconstruction of the paths and movement in space (Cohen: 1985). Therefore, if we are to focus on an embodied approach to space understanding, we could consider using a body-centric “object to think with” in representing our interaction with space. Using technologies as “tools to think with” in architecture implies that computation tools could be used as vehicles for situated learning, rendering concrete experiential aspects of space that are usually taught in an abstract manner. Moreover, rather than being regarded as tools for optimization and quantification of spatial knowledge, technologies could be regarded as tools that allow for reflection on our spatial experiences.

4. CASE STUDY 1: PERCEPTION CREATURES IAP WORKSHOP

4.1 THE SCOPE OF THE WORKSHOP

How do the ways we sense space influence the way we make space? Can we challenge the ways we design by exploring the ways we perceive? This workshop aims to extend our understanding of architecture by studying the interaction of the body and the environment. Each student team will invent its own 'creature' that will act as a perception machine for the analysis and design of space. The creature, which can be either an extension of the body or an autonomous device, will provide the sensory data from a physical space. The sensory data will then form the perceptual framework for designing new spatial experiences. The workshop will be structured around three exercises: The first, to design and make the perception creature. The second, to experience a physical space through the creature's body, collect and present the data. The third, to make a space from the creature's experience by attaching material and volumetric qualities to sensory inputs.

(Athina Papadopoulou and Cagri Hakan Zaman, Short Description in *4.553 Workshop in Architectural Computation, Syllabus*, MIT, IAP 2014)

In January 2014, Cagri Hakan Zaman,¹ and I designed and taught the workshop "Perception Creatures: Inventing Ways of Sensing Making Space." The duration of the workshop was approximately sixteen days, January 13-29, and was open to both undergraduate and graduate students from all disciplines. Our aim was to create a multi-disciplinary environment where students would work in teams and share their background knowledge as well as learn new design, making and spatial thinking skills. The class had a 6-hour daily duration and was located in one of MIT's architecture studios. None of the participants had previously taken a class in the architecture department.

Our vision was to invite the students to explore the boundaries of sensory perception through an active exploration of space mediated by the tools they would design and fabricate. Architecture pedagogy, focusing on assignments within the studio environment, has relied to a

¹ Cagri Hakan Zaman is a graduate student in the SMArchS Design and Computation Group, MIT. The workshop was supervised by Professor Terry Knight.

great degree on object-based projects that explore the creative possibilities of form, thus limiting student's spatial understanding to visual patterns and volumetric relations in an abstract context. Our goal was to embed situated learning into teaching design fundamentals, to combine the teaching of design and making through in-class exercises but also to provide the opportunity for direct spatial experience.

Using sensors, the students were able to record sensory inputs from the environment; using computation tools, they would be able to study and represent the body-space interaction by visualizing of the sensory data in generative drawings. The combination of making and programming exercises, along with the active collection of data was intended to provide a feedback loop between concrete and abstract knowledge; between on the one hand, the physical exploration of space and exercises with physical materials, and, on the other, the reflection on the sensory data and representation of the bodily actions in space.

To focus on the study of the body and the senses but also, as mentioned above, to teach the basic processes of design and making, we set forth the idea of the "Perception Creatures," which became the core theme of the workshop as well as its title. Students had to design and make a creature, embed sensors in the making process to attribute behaviors and perceptual operations, explore physical spaces with the creature, represent sensory inputs captured through the creature's experience, and last, reflect on spatial possibilities that could unfold by sensory perception as a generator of architectural form.

By having the task to make a "creature," with which students would explore space, they would become familiar with both design and fabrication techniques. Moreover, they would have to think about how the creature would perceive the world, thus speculating on the properties of the creature's senses as well as of its body, which would be the perceptual apparatus in the study of space. This conceptual exploration would render students familiar with how bodies act and interact with space. Moreover, in order to collect the sensory data, the creature would act as the "object-to-think-with" in the actual exploration of physical spaces. The students would then have the opportunity to reflect -- through the designed object that they have created -- on how the bodies interact with the environment and study the sensory qualities of space. Programming the sensors and visualizing the sensory data would render student familiar with

the basics in programming and electronics as well with rule-based and generative creative processes.

Our goal was to challenge common ways of thinking about space, by asking students to speculate and reflect on the following questions: How can we capture experiential qualities of space? How can we extract perceptual patterns from body movements, sensory inputs, environmental conditions or activities happening in a space? How can perception act as generator for spatial formation?

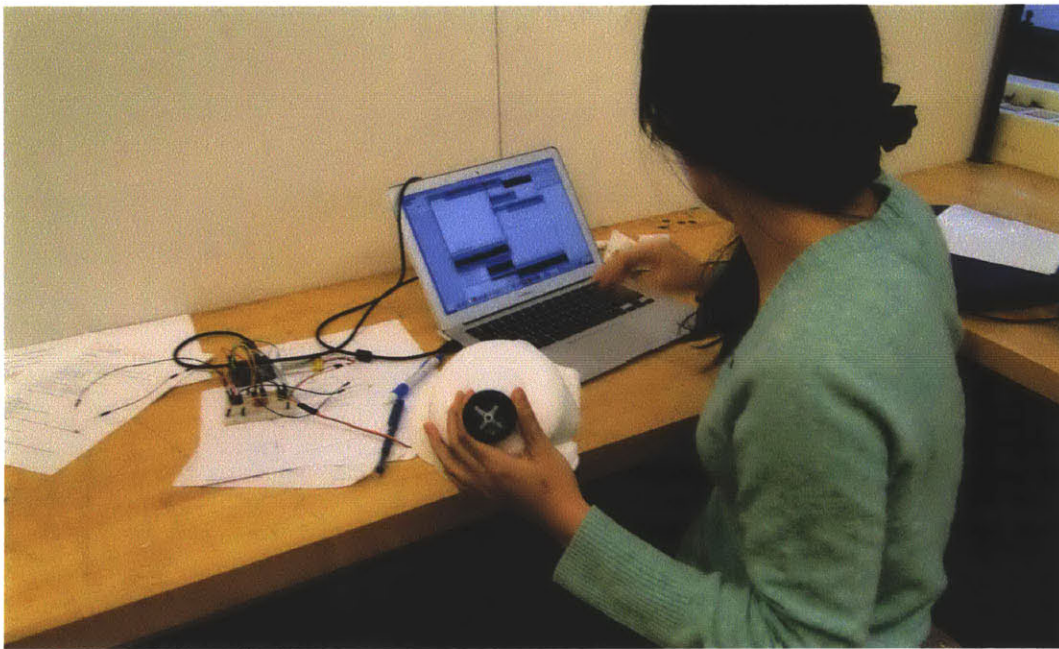


Figure 10. 4.553. Perception Creatures Workshop. In the process of making.

4.2 THE PROCESS OF THE WORKSHOP

The workshop was initially designed to be structured around three exercises: the first was to make the creature, the second was to explore spaces, collect and visualize the data, and the third was to generate new spatial form based on the recorded sensory data. Due to the fact that none of the students had prior experience in designing and given the time constraints of the workshop, we limited the course to the first two exercises.

The first task of the first exercise was to research sensory perception mechanisms and brainstorm on the design of their own creature. Students were to research and speculate on the senses by looking at the perceptual mechanisms of animals, machines, fictional and mythical creatures. They studied how these creatures perceive their environment, what perceptual mechanisms these creatures have to interact with the world and how the structures of their bodies influence their perceptions of the environment. Beyond an investigation on human senses, they researched non-human perceptual mechanisms such as echolocation, magnetoreception, electroreception and searched precedents in Borges' *Book of Imaginary Beings* and Henderson's *Book of Barely Imagined Beings* as well as other sources.

The students were given templates that had a form similar to RPG games, where they placed the precedents they were interested in and specified the creature's sensor abilities, body strengths and weaknesses. Their task was come up with their ideas for a perception creature that would either have the form of an autonomous device or of a wearable device that would become an extension of their own body. Eye-helmets, hand-glasses, an air-flow jelly fish and perceptually augmented plants were some of the ideas thrown into the table.

The students were provided with Arduino microcontroller kits and set of sensors and were introduced into programming, graphic, and modeling software. In the process of becoming familiar with the basic software needed and the possibilities of sensor mechanisms, the students were reflecting on their design concept so as to determine the architecture of the creature, how they could implement its "perceptual apparatus" and the specific behaviors they would like it to have. After experimenting with study models and concept sketches, their final task for the first exercise was to fabricate the creature, incorporate and test the sensor mechanisms, and write a

narrative that would describe how and why the creature would act in space and respond to environmental stimuli.

Alice Huang and Zachary Balgobin, undergraduate students in Mechanical Engineering, designed and fabricated a 'timid' sound creature, which, using actuators and microphones, responded to the aural environmental stimuli by changing its direction in space to move away from the sound sources. They named their hearing-only creature Fraidy Lug and described its behavior in the following narrative:

"The Fraidy Lug is a creature that lives in the darkness of the magic forest. They travel individually and are very independent creatures as the sound of their own species will also scare them off since they cannot see the source of sounds. It can't see and won't stop to think, for it only flees. Since they exist in strong numbers in the magic forest, this strategy works! The Fraidy Lug is truly an "afraid ear" and runs away from all sound – friend or foe."(Alice Huang and Zachary Balgobin, 4.553 Documentation)



Figure 11. 4.553. Perception Creatures Workshop. Hannarae Han sensing and acting in space with the "Plantanimal"

Hannarae Han, also an undergraduate student in Mechanical Engineering, was interested in the fusion of plant and animal perceptual behaviors. Looking at the interaction between these two living systems suggested to her the "Plantanimal" a creature that exhibits animal behavior while being majorly affect by light, humidity and temperature, aspects that contribute to the well-being of plants:

"Plantimals are a cross between plants and animals. Light, humidity, and temperature are the factors that mainly affect plantimals, since they depend on photosynthesis to obtain nutrients.(...)plantimals are able to immediately determine whether the conditions are met for them to reside in that area. The response is in the form of a heartbeat, which is the characteristic that places plantimals as not plant or animal, but somewhere in between." (Hannarae Annie Han, 4.553 Documentation)

The Plantanimal was a 3d-printed autonomous creature with light, humidity, piezo sensors and actuators, responded to the micro-climate of space by turning its head towards light and that generated sounds in different tones in response to its satisfaction with the environmental conditions. Another student, Allegra Fonda-Bonardi, first-year graduate student in Urban Studies and also a dancer, chose to work on a wearable device that would act as extension of her body and generate specific body movements in space according to sensory inputs. She focused on the study of color and on motion rules that would result from different color inputs. To achieve this, she used both color sensors and actuators. The activation of actuators generated from the recorded colors resulted in vibrations in different combinations that signaled specific directions in her body movements in space. She named her creature Colorbee to allude to the response of bees to colors:

"The Colorbee is playful creature who uses its hosts (humans) for flight and mobility by directing their movement through vibration. It has a color-sensing antenna that alights on the finger of its human host. When the antenna senses a color, it vibrates in a particular pattern, indicating the direction it wishes its host to move. Hosts move through a variety of spaces with lots of color: Gardens, art museums, markets, and other spaces." (Allegra Fonda-Bonardi, 4.553 Documentation)

After the making of the creature, the first task for the second exercise was to experience physical space on campus with the creature in order to investigate aspects of spatial perception

through a learning-by-doing approach. Reflecting on their research from the previous exercise, students were asked to use their perception creature in order to collect sensory data from space. The active exploration of space would engage the students in a reflection on the senses and the body *in situ*. Students had to reflect on their narratives and the behaviors they had attributed to the creatures in order to choose the space and make the field observations and recordings of the senses.

After collecting the data, the second task was to represent the data using the Processing language in a way that was meaningful for their concept. The goal in the data representation was not a 'scientific' recording of measurements but a creative visualization that would render visible experiential aspects of space that remain unseen in common modes of representation. To this end, the relationship between the visual output, their design concept and possible spatial qualities that would emerge in the generative drawings were stressed. The goal was to motivate students through the exercise to uncover spatial qualities that are not addressed in common architecture spatial analyses: the sounds and noises in crowded or seemingly quiet spaces, the rich varieties of colors in an everyday space such as a grocery market. Through the visualization, the student would invent ways to render these qualities spatial by incorporating the notion of time and the path of the moving body.

Acting in space, collecting the data, and visualizing the data were the three parts of the second exercise that invited students to speculate and provide answers to questions such as the following: How many different qualities of the investigated sense can we capture? How can we express these qualities through some means of representation? How can we incorporate time, motion and the moving body in a spatial representation of the senses?

Students picked various spaces on the MIT Campus to test their creatures' behavior and collect the sensory data: La Verde's market, Lobby 7, the Sol Le Witt Room in Building 8. Then, by using the processing programming language, they used the data to make visualizations based on rules that corresponded to the actions of the creature. The visualizations in most cases resulted in generative drawings that represented body movement in an animated series of shapes (of either the creature or the host) as well as the captured senses. The rule-based

generated process made possible the reflection on the spatial experience focused on the specific sense under study.

The third exercise, which was finally omitted due to the lack of architectural background of the students, aimed at investigating ways of making new spaces out of recorded spatial experiences. The goal was to go from the making of an object to explore space to the making of space by reflecting on the senses. Students would experiment in the creative process of architectural formation by reversing the common ways of making space. Instead of regarding sensory experience as the outcome of spatial formations, students would treat the senses as space generators in the design process. In other words, students would use the data captured by the creatures to design a new space that would reflect the recorded qualities. The goal of the third exercise was to bring into the discussion and making processes questions regarding the relation of sensory qualities to the materiality and geometry of space. Students would propose a narrative to translate the sensory inputs into volumetric and programmatic outputs defining the experiences of the designed space.

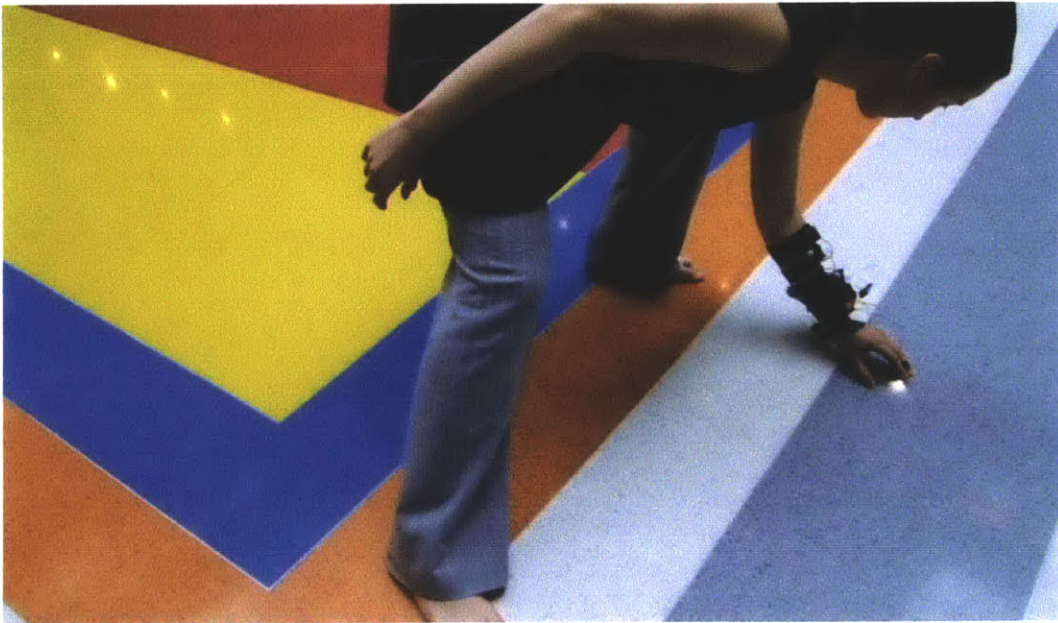


Figure 12. 4.553. Perception Creatures Workshop. Allegra Fonda-Bonardi exploring Sol Le Witt room at MIT with her “Colorcreature.”

4.3 OBSERVATIONS AND CONTRIBUTIONS

In both the first and second exercises of the workshop, the students were asked to go through a process of diagramming, sketching, and modeling as a means of documenting and expressing their ideas. In other words, we followed common procedures of design fundamentals classes by introducing students to architectural procedures of developing and presenting an idea. Each exercise was followed by a public discussion with reviewers where students had to defend their projects by showing the precedents of their idea, the initial sketches, the logic behind the procedures of design and making, and the final products. In that respect, the workshop did not differ from common studio practices. The aspects that did differ from usual pedagogical approaches were the incorporation of sensing and acting in the form of situated knowledge of space and the making of an object as a vehicle for sensory-based spatial understanding.

The importance of situated learning, in the form of engaging educational practices, has been emphasized in both Constructivism and Constructionism. Constructivists, Vygotsky (1980), Piaget (1970) and Bruner (1974), have all argued in one way or the other for direct educational approaches where knowledge is constructed through experience. At the same time, however, they diminished the value of experiential knowledge by regarding it as the first step toward abstract, formal ways of knowing. It was Papert (1980) who, through Constructionism, took the argument of experiential learning further, by emphasizing situated learning through the tools and mediums and technologies with which we learn and dissolved the boundaries between concrete and formal knowledge that was previously set by Constructivists. In the context of architecture and design, aspects of experiential learning-by-doing have been employed since the Bauhaus school in architecture and have been recently re-addressed through the 'makers movement' (Sharples et al: 2013) and the use of digital fabrication technologies.

In the workshop we conducted, the making of the Perceptual Prototypes (the 'perception creatures') as an important learning-by-doing process that offered students a knowledge of materials, design, electronics and fabrication. The making of the perceptual prototypes addressed the role of technologies as means for thinking. Matt Ratto (2011), drawing upon Papert's vision, introduced the term 'critical making' to refer to practices that not only engage

students in learning-by-doing but blend material engagement with conceptual engagement through the making process. Ratto argues the following:

“The use of the term *critical making* (...) signals a desire to theoretical and pragmatically connect two modes of engagement with the world that are often held separate –critical thinking, typically understood as conceptually and linguistically based, and physical ‘making,’ goal-based material work.” (Ratto: 2011)

By conducting workshops, Ratto aimed at proving that we can use the process of making to address social issues. His intention was to render 3d-printing and electronics vehicles for social engagement. In other words, it was not the knowledge of sensors and printing per se that he aimed to provide, but the use of these tools as objects-to-think-with concepts related to society such as, participatory practices, networking, and so on.. He states that, in these workshops, his goal is “to make concepts more apprehensible, to bring them in ways to the body, not only the brain, and to leverage student and researchers personal experiences to make new connections between the lived space of the body and the conceptual space of scholarly knowledge.”

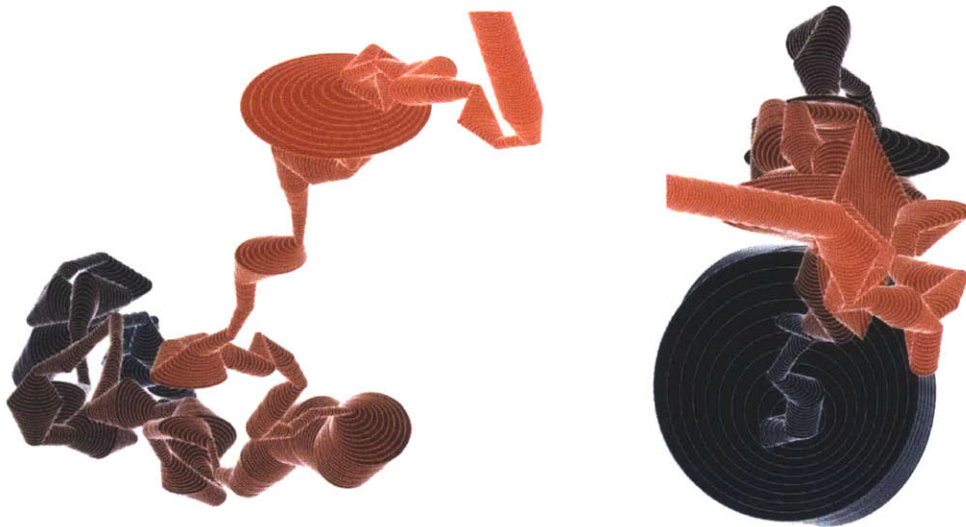


Figure 13. 4.553. Perception Creatures Workshop. Alice Huang and Zachary Balgobin, visualization of the sound recordings in Processing

If Ratto's argument is that he turns making into "critical making" by using technologies to raise social issues, my argument is that in the making process of perceptual prototypes making becomes "critical" in that it raises issues of sensory perception. As in Ratto's case, the focus shifts from the object itself as a material entity to the architecture of the body and the mechanisms of perception that are being simulated through the use of sensors. The perceptual prototype does not necessarily have to be 'anthropomorphic' to address these issues; as long as it relates to the human body as a wearable device or a tool that complements or accompanies our spatial perception, it generates critical thinking concerning the relation between the body and the environment.

In the 'perception creatures' workshop, in the processing of learning how to use sensors, students also learned more about their senses by reflecting on the possibilities of their creature's interaction with space, the possible behaviors that the space would generate, and their own movements in space. Along with studying the use and connections of the color sensors Allegra, who invented the "Colorbee" that would be attracted to colors and record the colors of the environment, looked at the psychology of colors and at ways to make meaningful connections between different colors and movement reactions..

Alice, and Zach reflected on the auditory spatial inputs and how sounds generated from the environment and from people's actions would affect the behavior of their creature. Hannarae, reflected on how environmental aspects of temperature and humidity affect space and the bodies within space. Thus, the perceptual prototypes – in the form of perception creatures -- became objects-to-think-with in the making process. The sensors, microcontrollers and materials of making, all become the tools through which students could reflect on the perceptual apparatus of beings and on experiential matters of space.

The perception creatures engaged students in a 'critical' type of making where issues of space perception and bodily reactions to space become the reflective feedback loop process when working with sensors. Moreover, the creatures became an extension of the body and mind of the students while thinking about space in situ. In order to record auditory data through their sound creature, Zach and Alice took 'Fraidy Lug' to various physical spaces at MIT. By

observing the creature's reaction to sound and the change in its movement directions, they were able to notice in a concrete manner the slight variations of auditory spatial qualities.

Allegra, who experienced space with the 'Colorbee' claimed that she was "becoming more aware of the colors by constantly observing the colors of materials in her surroundings." The exploration of different spaces -- the Sol Le Witt Room at MIT and La Verdes market at MIT -- offered possibilities of new types of spatial comparisons based on color sensation and movement.

Hannarae, who designed and made the 'Plantanimal,' had to take a different approach in her spatial explorations, since her creature was neither moving by itself, like the 'Fraidy Lag', nor moving with her body, like the 'Colorbee.' Therefore she defined rules on how she would move in the space with the creature to record the data. It was interesting to observe how the creature became the 'mediational object' not only for the student's experience but also for the experience of the people who happened to be the spaces she studied. People were surprised by noticing this fabricated creature left in various locations in common areas at MIT, and curiously followed the movement of the creature's head when it turned towards the light source.

Whether as observers, guides, or semi-autonomous hosts of the creatures, the students engaged in a spatial experience that allowed them to evaluate space through focusing on specific senses. By filtering the senses through the perceptual prototypes, students became aware of qualities of space that are often barely noticed in our everyday experiences. Targeting sensory inputs that go beyond formal qualities of space, allowed students to obtain a better understanding of how senses other than vision and/or non-geometrical qualities of the visual realm contribute to the perception of the built environment.

5. CASE STUDY 2: EXPERIMENT IN THE MIT CHAPET AND THE MORSS HALL

5.1 THE SCOPE AND HYPOTHESIS OF THE EXPERIMENT

In the previous chapter, I described the process and results of the 'Perception Creatures' workshop as an applied case that explores the possibilities and pedagogical implications of the use of Perceptual Prototypes in the learning process. By offering observations on the instruction methods and the students' projects, I demonstrated that both the act of making the 'creature' and the process of experiencing space with the 'creature' engaged students in an active reflection on the perceptual qualities of space. I elaborated on how, by making a mono-sensory Prototype that played the role of an animate creature, students could concentrate their attention on the qualities of space associated with a specific sense. In other words, I argued that the use of the Prototypes is a method that, like the Montessori and Bauhaus methods, can lead to the separate training of the senses and expand our spatial understanding.

The use of technological tools as objects-to-think-with seems to open possibilities for a sensory pedagogy of space. However, a more controlled study was needed to validate my argument, as the observations from the workshop rely on a limited study in the scope of a design course. How could we evaluate the use of Perceptual Prototypes as perceptual filters? Could we indeed claim that using sensory-focus tools to guide us into space, channels our senses in ways that extend our spatial understanding? Could these tools offer us an awareness of space beyond its formal qualities, uncovering tactile and auditory dimensions neglected in the common ways of perceiving and experiencing space?

In order to try to answer the above questions, I conducted an experiment focused on the interaction between the body, the prototype and our sensory perception of space. In the experiment, a similar method to the workshop is being followed, but this time only part of the process is tested with the participants. For the purpose of the study, instead of asking the participants to make their own Perceptual Prototype, their own 'creature,' the prototype is given to them. What is actually being studied is the participants' behavior in space with the prototype as well as their reflection on that experience. The prototype takes again the role of a 'living creature,' which, under different instructions, is limited to a specific sense.

The prototype is a 3d-printed wearable device that participants wear on their hands and records data related to touch, sound, vision, as well as movement through use of a complementary chest-strap with sensors. The prototype has embedded in its structure a microphone, a proximity sensor, a camera and a real-time clock. A compass and accelerometer are attached to the chest-strap, and an additional camera is placed on a hat that participants also have to wear. The participants are tested in four different groups. In three of the four groups the participants are told that the tool has the role of a creature limited to a specific sense. The rest of the participants are told that the 'creature' they are wearing sees, hears and touches. However, all data from all sensors and cameras are recorded in all cases. The participants are asked to act as hosts of the creature and provide to it the experience of a specified physical space.

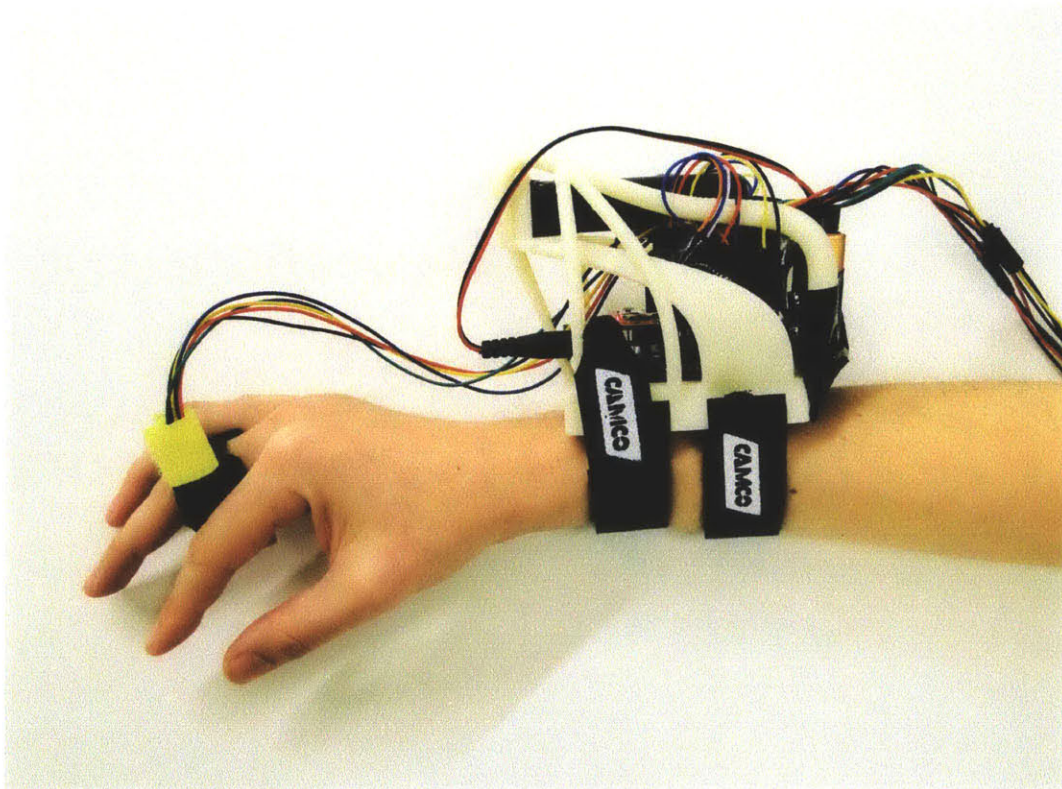


Figure 14. The prototype made for the experiment



Figure 15. One of the participants in the experiment wearing the prototype, chest-strap and head-camera

By observing how people experience the space in the different groups, I examine whether *we can augment our understanding of space by focusing on each of our senses individually through the prototype*. The experiment is grounded upon two initial hypotheses: The first hypothesis is that *we are conditioned to perceive space mainly through vision*. The second hypothesis is that *we can augment our spatial understanding by intentionally focusing on each of the rest of the senses*.

For both statements to be valid, the following conditions should be met: *The results for the control group given the 'vision creature' should demonstrate similarities to the results to the control group given the 'all senses-creature.'* And, *the results for each of the rest of the groups should significantly differ from the above*.

Unlike in the workshop, the 'reflection' step on the participant's side is done not through the visualization of the data, but through a manual process using given templates. The prototype is used here as an observation tool to allow me to compare the qualitative and quantitative data provided by the participants. However the data are studied under the limited scope of the functionality of the tool. In its current state of development, the prototype's function does not yet allow for capturing complex movement patterns. In section 5.5, suggestions for further development are made that would allow its function in an extended scope. Even if the prototype's role is discussed here under this limited framework, its implications, if further developed, are significant as it could serve both as an observation tool in future research and as a pedagogical tool for reflection.

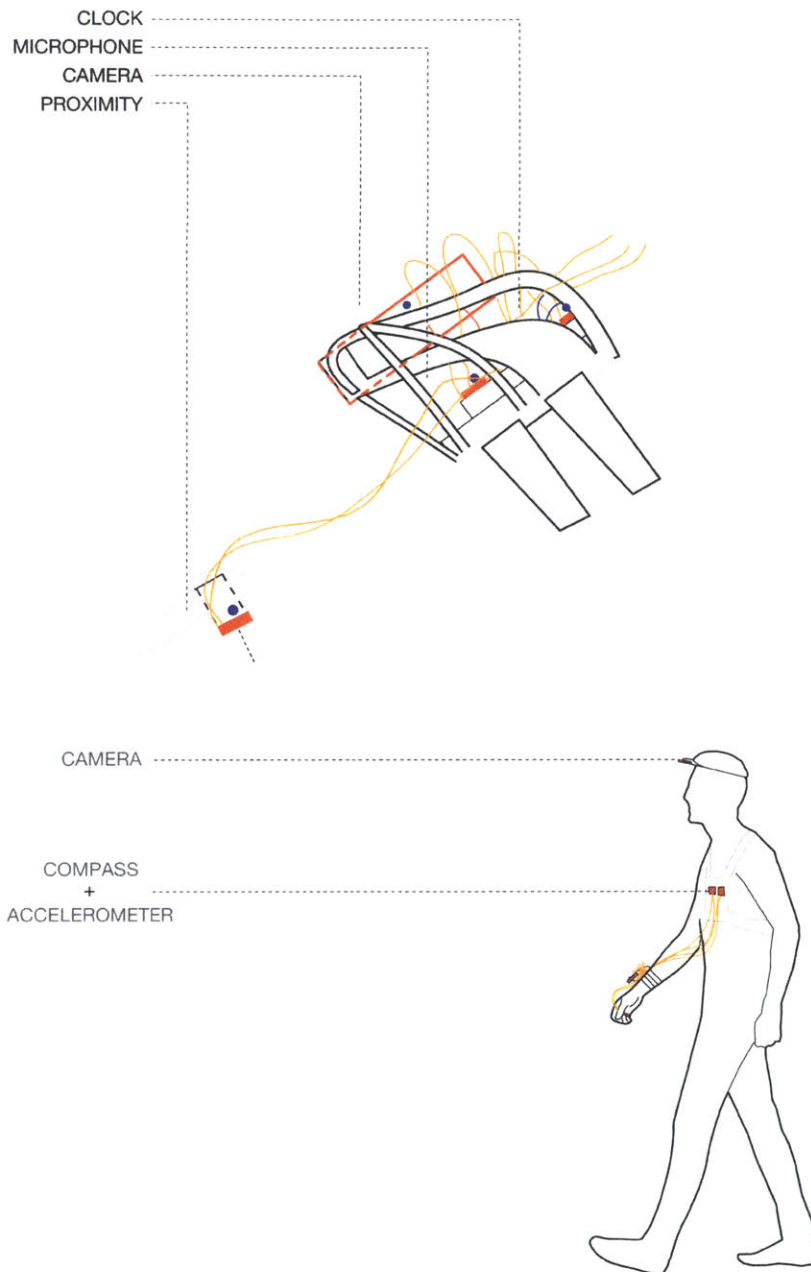


Figure 16. Diagram depicting the basic function and components of the prototype and the complementary equipment

5.2 THE PROCESS OF THE EXPERIMENT

Twenty-four graduate students from the Architecture School at MIT participated in the experiment. The participants were divided into two groups of 12. The first group used the prototype to explore the interior space of the MIT Chapel, designed by Eero Saarinen and built in 1955. The second group used the prototype to explore the interior space of Morss Hall, a multi-purpose room in the ground of the Walker Memorial building at MIT, designed by Welles Bosworth and built in 1916.²

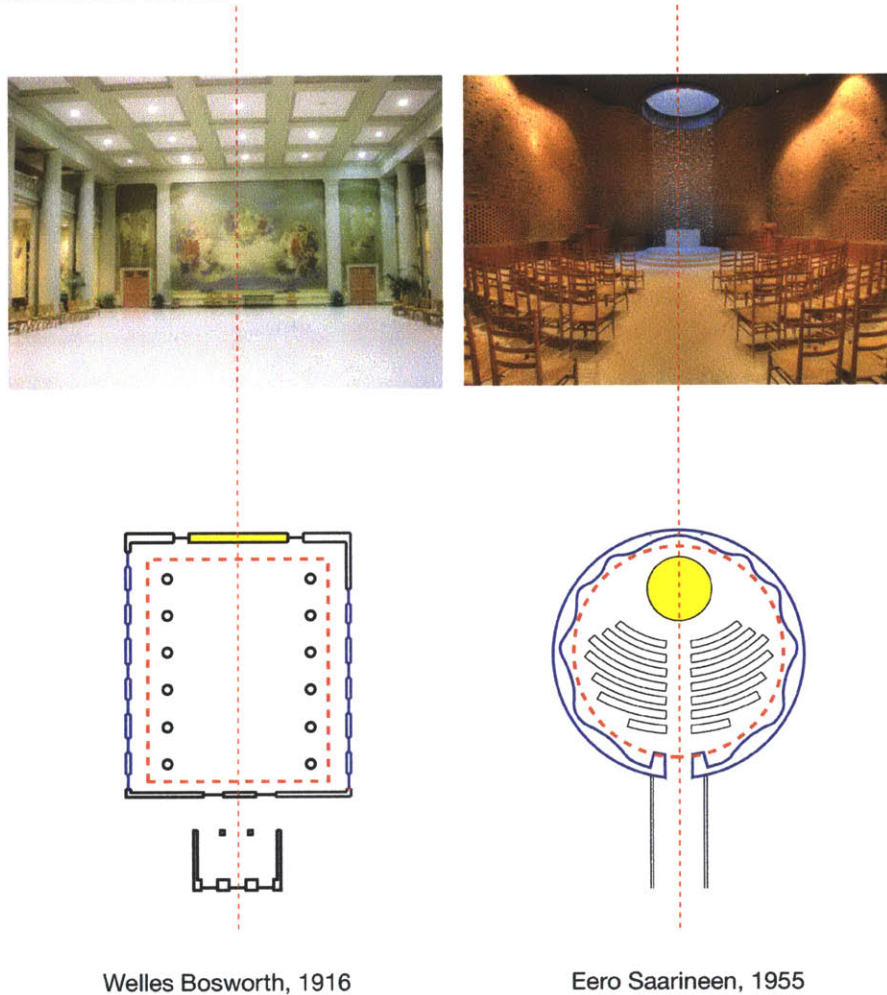
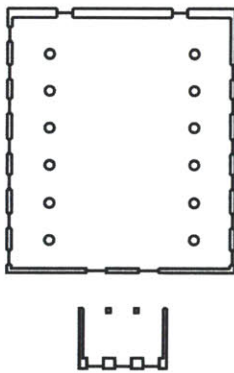
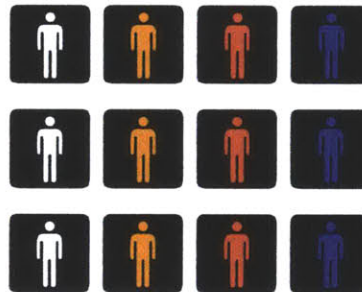
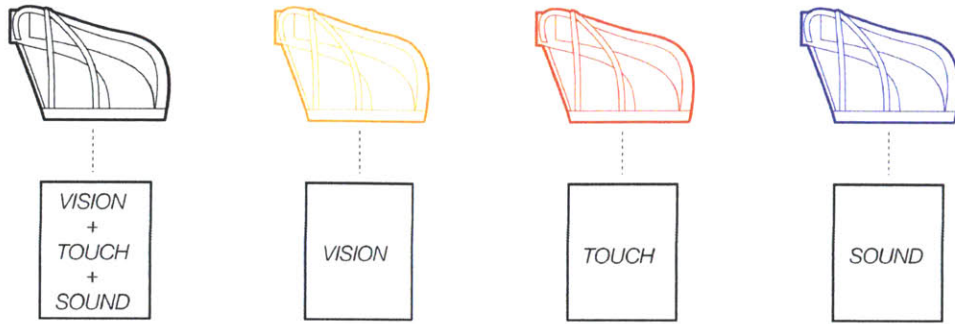
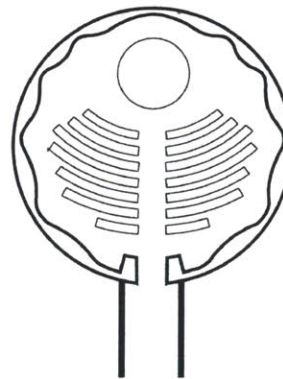


Figure 17. Diagram depicting the main axes of symmetry and the salient visual elements in the two spaces

² <http://studentlife.mit.edu/cac/spaces/walker-memorial>



MORSS HALL



MIT CHAPEL

Figure 18. Diagram depicting the division into different groups and spaces in the experiment: 2 spaces, 24 participants, 4 roles for the prototype, 3 participants per space are assigned one of the differently sensing creatures

The two spaces are significantly different in regard to the architectural language used, their materiality and use. The Chapel's modern lexicon is shown in both its pure geometry as well as in the simplicity of its interior in the materials used to build it. Morss Hall has classical references and was designed after the gentlemen's clubs of the 19th century.³ Whereas the Chapel has an explicit function as a church, a fact that also implies a certain type of experience to be transmitted through its lighting and materials, Morss Hall, is more a receptacle for different types of events. Although different in all these aspects, the spaces are of similar size and both of them are symmetrical with a walking area at their outer boundary and a significant visual element at the end of their central axis. In the case of the Chapel, the significant visual elements are the lighting coming from the roof as well as the hanging metal sculpture behind the altar, designed by Harry Bertioia. In the case of Morss Hall it is the murals painted by Edwin Howard Blashfield.

Each of the two groups is further subdivided into four groups. Each one of the four groups is given different instructions regarding the use of the prototype. According to the instructions, the prototype - although all data are being recording in all cases - takes the role of a different sensing creature: it is either a sound creature, a hearing creature, a touching creature, or a creature that sees, touches and hears. Each of the four sub-groups in each group is assigned each one of the four categories. Each of the participants takes part in the process individually. The participants are asked to experience the space for 10 minutes while wearing the prototype, an additional chest-strap and a camera on their head. Before walking in the space they are given the following instructions:

"A creature of another kind is visiting MIT. It experiences the world only through the sense of [specific sense named here] and can also sense your movement. You have volunteered to act as a host for the creature and provide him/her the experience of this space."

After experiencing the space, the participants are given two templates to fill out. The first is an *action template*. The action template is a template depicting the plan of the space in its basic form and includes a basic action notation system that the participant can use to draw his/her path and sensory interactions in the space: a red continuous line for fast movement, a red

³ Ibid

dashed line for slow movement, a circle with filled in black color to denote 'stops,' a black circle with varying radius to denote sound, an array of black lines to denote touch, and a triangle to denote 'staring.' Each of the sensing symbols is overlaid on top of the path. The participants are asked to recall their movement and actions in space and represent them through this notation system. After doing so, they are asked to explain their strategy, if any, and why they moved and acted in the manner they did while experiencing the space.

After drawing their paths and actions and responding to the question, the participants are given a *mood template*. The mood template has two parts: The first refers to the experience of the participant, the second to the 'experience of the creature.' The participants are asked to reflect on their experience and fill out the template according to given colors that correspond to specific feelings. They also have the option to add one more type of mood in the index of colors. Similarly to the action template, the mood template has an outline of the space in the form of a plan. After filling out the first part the participants are asked to think on behalf of the creature and fill out the template according to how they think the creature must have felt in the space. In the end I ask them to reflect on both their own experience and the creature's experience and to explain the differences.

The purpose of the templates is to act as reflection devices, making the participants revisit their experience in the space and elaborate on their feelings and actions. The purpose of the second part of the mood template - the 'creature's experience'- serves as the third layer of reflection, allowing the participant to gain an awareness of the contribution of the senses on space perception, through the comparison between their own senses and the limited senses of the creature.

The last step of the experiment is the analysis of the qualitative and quantitative data using as materials the video recordings, the interviews, the templates, and the data recorded in the prototypes through the embedded sensors.

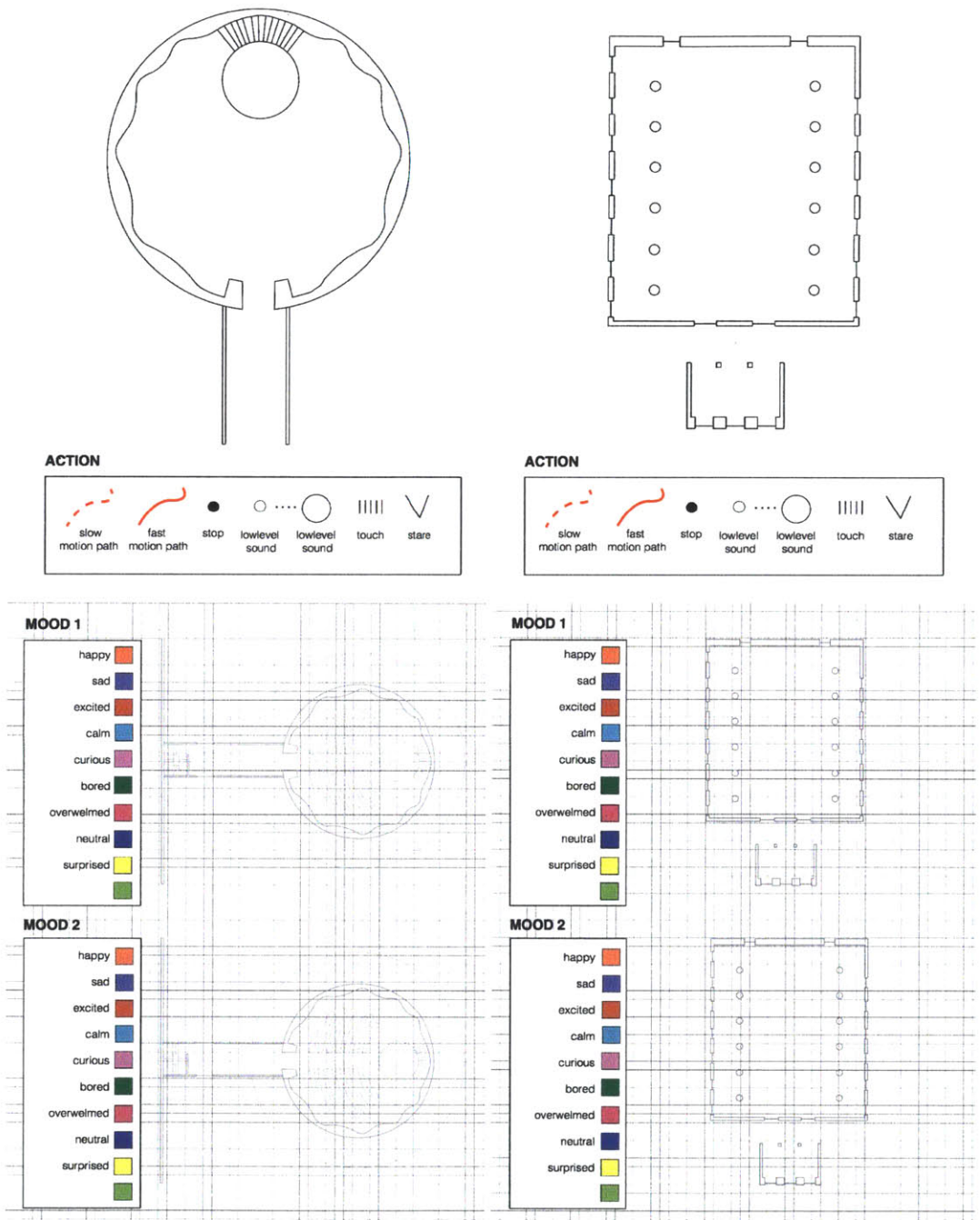


Figure 19. The Action Templates (above) and the Mood Templates (below) that were given to the participants. Mood 1 corresponds to the experience of the 'host.' Mood 2 corresponds to the experience of the creature.

5.3 RESULTS AND OBSERVATIONS

5.3.1 SOUND: ENACTIVE SOUND AND ENVIRONMENTAL SOUND

5.3.1.1. THE ENACTIVE APPROACH IN SOUND PERCEPTION

Five out of the six participants in the sound group (1sC, 3sM, 4sC, 5sC, 6sM)⁴ moved around the perimeter and the center of the space while intentionally producing noise through their own action. The objects they interacted with were the main architecture references in the spaces. In the case of the Chapel, they interacted with the metal structure behind the altar as well as with the curvilinear wall. In the case of Morss Hall, they interacted with the colonnades on both sides. Both of the participants in Morss Hall who followed this strategy moved around the columns in a manner that produced a wave along the colonades. The four participants also produced discrete sounds with their feet, emphasizing the sound produced by walking in a rhythmic manner and in some cases switching between a fast and a slow pace. In the case of the Chapel, the participants produced sound by playing the piano and also experienced how the metal installation sounded when touched.

The participants employed this enactive strategy as a means to communicate the formal qualities of space, the difference in materiality and, the potential use of spaces. Through the echo of the space, they intended to communicate ‘to the creature’ how big is the space, and through the walking pace and the rhythmic sound produced, the inner structure and main axes of the spaces.

5.3.1.2. AWARENESS OF MATERIALITY AND AUGMENTED PERCEPTION IN THE ENACTIVE APPROACH:

The enactive approach led to a greater awareness of the materiality in the space. Participant 3sM, in the Morss Hall, noted that: “If you touch the materials, you realize from the sound they make that this is not stone, it is something else, you become aware that it is fake representation of classical architecture.” Apart from gaining a better awareness of the materials, the enactive

⁴ The templates, as filled-out by participants, are included in the Appendix, p. 79

approach led to a different conception of the architectural elements and enriched experience. If we compare the mood annotations of the external wall of the Chapel in the mood templates, we see that the participants in the sound have assigned diverse and multiple feelings to it, whereas in most of the other cases the wall has been assigned only one or few feelings.

This difference becomes evident if we compare, for example, the case 5aC from the all-senses group and the case 4sC from the sound group. Whereas in 4sC the wall is experienced as a continuous surface, marked as 'curious' all along, in the case of 4sC it is fragmented, switching between 'neutral' and 'excited'- excited on the curved side and neutral on the bumped side. The participant noted the following in the interview:

“When I was walking through the space, especially the perimeter, I liked being inside of the parts that are concave, this to me was exciting to get to those moments, but then in the boundary or that pushes out, I was kind of neutral because... I was excited in the other one. Don't you feel the same? I feel that whenever you are in the circle area that is closer to the wall you feel excited because you can look outside. And that's also where I felt curious, looking from the gap of the wall.” (4sC)

The participant 4sC adopted an enactive approach and while following the periphery of space knocked on the brick wall and accentuated the sound of her footsteps. From the above narrative, we can conclude that the close contact with the wall, through sound and touch interaction, produced multiple sensations and augmented the sight perception. By being perceived in its details and through all the senses, the wall as an element resulted in an enriched experience and took on a different significance than in the 5aC case where the participant interpreted it as a monolithic element.

5.3.1.3. ENACTIVE APPROACH IN SOUND PERCEPTION IN OTHER THAN THE SOUND GROUP:

Enactive sound was not the intention in any of the participants in the other groups. This observation becomes evident by comparing their actual experience, the actual sound inputs as documented in the videos and recorded through the sound sensor, and they way the participants annotated the perceived sound in the action template. For example, the sound

made by their movement, although present in all cases, is not annotated in the vision, touch and all-senses group, while in the sound group it is annotated in a sequence of circles along the paths.



Figure 20. The sculpture behind the altar in the Chapel, functioning as an 'instrument.' Participants in the experiment experiencing the space by knocking and touching the materials.

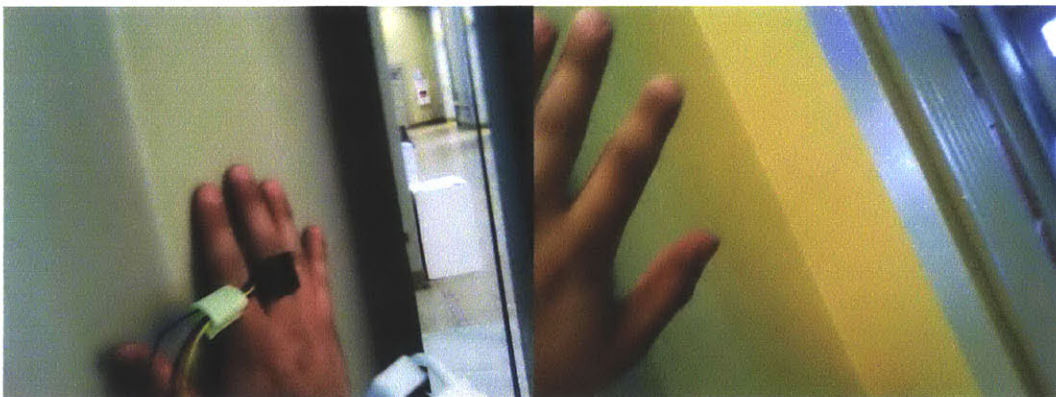


Figure 21. Gaining awareness of materiality through the enactive approach. Participants in the experiment knocking on the columns in the Morss Hall.

5.3.1.4. ENVIRONMENTAL SOUND:

References to environmental sounds were limited or absent. In the sound group, one of the participants reported the sound of the water (5sC). Another one reported the sound of the birds (1sC). Apart from these two observations no reference or annotation to environmental sounds occurred, except for one participant in the vision group who annotated as sounds the conversation that he happened to have with two people that appeared in the space (1vM). No special activity or function was taking place in the spaces during the experiment. The spaces were not, however, 'sealed' or isolated from outside sounds or sounds generated from people passing through or visiting the space. As documented in the video and recorded in the sound sensors, in all cases environmental sound was present, generated by the sources mentioned above.

5.3.1.5 DISCUSSION ON THE ABSENCE OF ENVIRONMENTAL SOUND:

If we are to interpret the absence of sound in the descriptions we might need to consider the following case of a participant in the all-senses group that took part in the preliminary experiments. In his case, the room was full of noise from tables being rearranged to accommodate of a forthcoming event. However, the participant did not annotate any the presence of sound in the template, nor did he mention noise as a parameter in his experience. When he was asked why he omitted this information, the participant stated that "the sound from the tables being rearranged is just noise, it is not meaningful sound."

Although this was an observation from just one of the participants, it suggests that people may distinguish between what they consider meaningful sounds and trivial noises. Also, interesting to note is the case of the participant 2sM who, according to what stated in his the interview, moved according to salient views in space instead of trying to experience the sound. When asked if he considered the parameter of sound, the participant stated "the strongest way to perceive the space is total visual." The fact that he focused on vision instead of sound is also evident in his movement patterns. He strategically followed visual axes through his movement, targeting specific views.

These results suggest that, sound is only taken in consideration if subjectively regarded as contributing to the experience, as in the case of music - all participants who tried playing the piano in the Chapel, reported this as sound experience - and otherwise is ignored. One can assume that the dominance of vision overshadows aural experience. However, the absence of annotation of the existence of environmental sound could also be interpreted as the experience of silence. The annotation of the feeling of being calm might be related to the absence of sound. This is not explicitly stated, however, apart from the case of the participant 3sM that mentioned in the interview that he felt calm because the space was quiet.

5.3.2 ACTION PATHS: THE PLANNED AND THE UNPLANNED APPROACH

5.3.2.1 DESCRIPTION AND OBSERVATION ON THE PLANNED AND UNPLANNED APPROACH

Comparing the action templates, we can observe two types of approaches towards movement in space. The first seems 'unplanned.' In this approach, the participants seem to move and act in the space with on-the-fly decisions, according to what attracts their attention. This can be a light source, the curiosity to touch a material that caught their attention, or a spontaneous decision to lie on the floor to see the ceiling, or move around as if dancing, to switch multiple views. This approach produces a multiplicity of movements and great differentiation among the participants that follow it.

The second approach seems strategically 'planned.' Unlike the unplanned approach, the participant seem to have a specific strategy as to how to move and act in the space which is based on the understanding of space in layers: The participants first walk along the outer edge and then move towards the details in the center. Following this approach, participants in the sound group in the Chapel walk along the undulating wall while touching or knocking on it to produce sound, then move to the altar where they produce sound by interacting with the hanging sculpture, then end in the center where they either sit on a chair and/or touch it to produce sound. The touching group in the chapel follows similar actions, with the difference that the intention is the touching feeling and not the sound produced. Participants 'scan' through touch the perimeter of the wall, then move towards the altar, where they experience through touch the altar table and the sculpture, then finally move towards the center to communicate the tactile qualities of furniture.

It is interesting to note the exception of one participant in the sound group (5sC) who only walks along half of the perimeter of the wall. As she argued in the interview, the sound produced while walking in the central axis would provide the spatial information regarding the symmetry of the space. This difference reveals a perceptual difference between the sense of sound and touch. In the case of touch, the constant contact with material objects is required, whereas in the case of sound it is not.

In Morss Hall the same actions are performed in the planned approach in the sound and touch with the difference that instead of the outer wall, the first layer of the sensory exploration are the colonades. This reveals a perceptual difference between the two spaces, as the colonades are revealed as the perceptual perimeter of the space, whereas the wall is the perceptual perimeter in the case of the Chapel. Because the colonades are series of points in space rather than a continuous surface, in half of the cases the participants move in and out of their axis, generating a wave movement pattern.

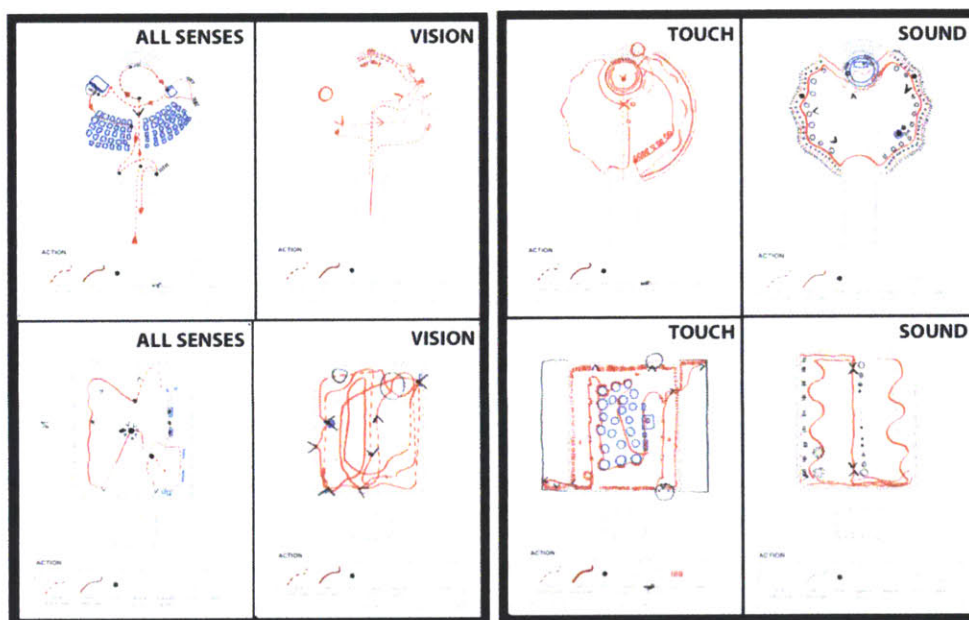
Most participants in the sound group (3sM, 4sC, 5sC, 6sM) and touch group (2tC, 4tM, 5tC, 6tM) followed the planned approach, but only two in the all-senses group (3aC, 4aM) and only one in the vision group (5vC) followed the planned approach. In the rest of the cases the unplanned approach was adopted. It is interesting to note that one of the six participants in the all-senses group, who, contrary to the rest, focused mainly on touch instead of vision, followed the planned approach (3aC).

5.3.2.2. DISCUSSION ON THE UNPLANNED AND UNPLANNED APPROACH

The fact that in most of the cases in the all-senses group and the vision group, the seemingly 'unplanned' approach was followed, provides evidence to support the hypothesis that we are conditioned to perceive space mainly through vision. Although the approach seems 'unplanned,' the apparent non-organized sequence of actions can be attributed to the way visual perception of space functions. In order to 'scan' the space and gain an understanding of it in its totality, the participants in the all-senses and vision group, mostly guided by vision, moved into multiple and different locations in order to gain different views of the space. Also, different visual elements acted as attractors that shaped the paths through on-the-fly decisions.

Two reasons may explain why most participants in the touch and sound groups followed the 'planned' approach. The first is that, by taking an enactive approach, the participants in the sound group also explored the space by touching. Spatial perception through touch, unlike vision, develops through continuous bodily contact with surfaces. To communicate the spatial qualities and to gain the experience of the space, the participants had to 'scan' the interior space by following all the surfaces in the perimeter and then continuing on to the inner

elements. In both the visual and touch and sound approaches the understanding of space is gradual, and develops step by step through our interaction of space; however, the expression of our actions is different. In short, to gain an understanding of space through different senses different movement and actions patterns are required. This interpretation draws upon Alva Noe’s enactive approach to perception, according to which “all perception is touch-like,” and perception of space is acquired though time “by skillful probing and movement.” (Noe: 2006, p.1)



 Seemingly anorganized movement

 Organized movement in layers

Figure 22. Typical examples of the four groups demonstrating the difference between the unplanned approach (left) and the planned approach (right)

5.3.3 MOOD TEMPLATES: COMPARING THE PARTICIPANTS' EXPERIENCES

5.3.3.1 THE SYNERGY OF SOUND AND TOUCH AND THE EXPERIENTIAL MEANING OF MATERIAL OBJECTS

The fact that most of the participants followed an enactive approach to sound perception, linked the sense of sound to the sense of touch, as the first became the result of the second. The reverse is also the case: two out of six of the participants in the Chapel (1tC, 2tC) and two out of the six in the Morss Hall (3tM, 6tM) referred to enactive sound as significant element in their experience. This is because -as noted in the interviews and documented in the videos- sound was produced while touching the objects, which added an unexpected aural experience to their exploration. In the case of the Chapel, significant element in the participants experience was the vibrating sound of the metal pieces in the sculpture as well as the sound of the piano. In the case of the Morss Hall, a significant element in the participants' experience was an ephemeral object that happened to be there: a set of metal hangers. While the piano was referenced in the all-senses group, the sound of the hangers as well as the sound of the vibrating metal pieces was referenced only in the touch and sound group. The participants referred to these interactions as "exciting" or "happy" experiences. Moreover, one of the participants in the Chapel touch group mentioned in the interview that "the space felt like an instrument." (2tC)

5.3.3.2. DOMINANT MOODS

Comparing the mood templates, we can observe a similar pattern between the vision and all-senses group. In nine out of twelve cases the prevalent mood noted is "calm," whereas in the sound group and the touch group in seven out of twelve cases the prevalent mood is "excited." In the Chapel, in most of the cases in the vision and all-senses group, the notations indicate that there is an area of calmness in the center and curiosity in the borders of the space, with spots of happiness, excitement and boredom. This reflects a general action path of feeling calm while entering and walking towards the altar; the spots of happiness and excitement are references to specific objects of attraction - the altar table, the sculpture, the podium, and specific spots explored in the wall. In Morss Hall, in most of the cases in the vision and all-senses group, curiosity is concentrated around the attraction points: the murals on the two walls and the

windows on the other two walls. A feeling of calmness is generated when one enters and walks towards the mural.

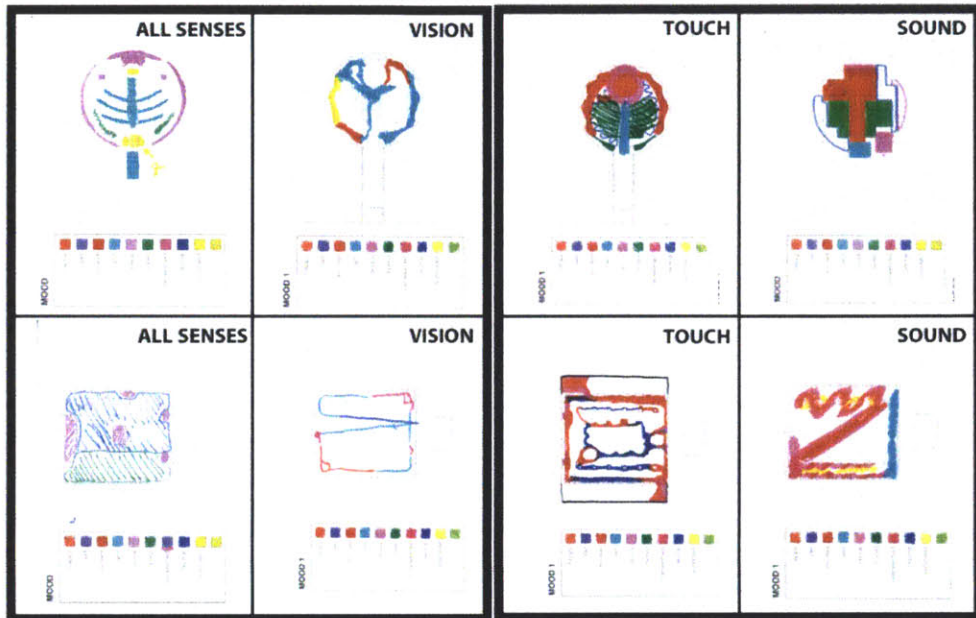
In the case of Chapel, in the touch and sound groups emerges a common pattern that has the mood 'excited' marked in the path towards the altar as well as the altar itself and the mood 'bored' or 'neutral' in the seating areas. Also, a mixture of moods of happiness, curiosity and excitement is marked on the undulating wall. In the case of Morss Hall, in the sound group and touch group, excitement, curiosity and happiness are concentrated around the columns as well as around the openings and murals in the external wall. Also, in the sound group, a whole variety of moods is inserted into the template, following the gradual development of space perception through the performed actions. In the sound group, the mood results in Morss Hall and the Chapel are equally rich and diverse, whereas in the touch group, the mood results in the Chapel are richer and diverse than those in Morss Hall. This fact reflects a qualitative difference between the two spaces, as the Chapel has a richer variety in materials than Morss Hall.

5.3.3.3. DISCUSSION ON THE COMPARISON OF DOMINANT MOODS

The fact that the prevalent mood – calm - in the all-senses and vision group is the same provides evidence to the argument that we are preconditioned to perceive space mainly through vision. The fact that the dominant mood – excited - is the same in the sound group and the touch group is a reflection of the enactive approach taken as well as of the augmentation and enrichment of experience as a result on the focus on these specific senses. When participants physically interacted with the space, they often felt "excited," whereas those who were in the vision and all-senses group reported feelings of "calmness," probably because of the focus on the visual elements and the silence.

Moreover, the participants in the sound and touch groups noted that they felt excited by the experiment itself as well by discovery of tactile and auditory qualities in the elements they interacted with. As noted from one of the participant in the touch group, in the space of the Chapel, the focus on touch revealed "so much potential for touch" (1tC). The discovery of touch also led to the discovery of sound and vision. As noted a participant in the touch group in the space of Morss Hall: "Beginning the path I felt mostly curious because of the different surfaces,

the curvilinear ones and the paintings. Then I saw the hangers where I felt really happy because it was not only the touch but also the sound that I heard.” (3tM)



Dominant mood:
calm



Dominant mood:
excited

Figure 23. Typical examples of the four groups demonstrating the difference in the dominant moods

5.3.3.4. WHAT THE CREATURE'S EXPERIENCE REVEALS

When asked to fill-out the template for the creature's experience, twenty-three out of the twenty-four participants annotated the experience differently from their own, except in one case in the vision group (6vM) where the participant drew an identical mood diagram for the creature and stated that "My experience and the creature's experience are the same."

In the sound group and the touch group, in both of the two spaces tested, the participants elaborated on the creature's experience by imagining how their experience of the space would be if it was limited to only the creature's sense. This brought to the surface an awareness of the function of the different senses in space perception. A case that illustrates this argument is the case 4tM in the Morss Hall. In both the part of the template that corresponded to her own mood and the part of the template that corresponded to the creature's mood, the participant used only the red and blue colors, the red denoting the feeling of being 'excited' and the blue denoting the feeling of being 'bored.' However, a different proportion of blue and red was recorded in each case. In the case of the creature's mood, the amount of the red color exceeded the amount of the blue color. The opposite was the case in the host's mood. When asked to reflect on the difference between the two experiences, the participant replied that because the creature cannot see, its excitement lasts longer: it does not expect what will appear next in its path, and it does not know what is there until it touches it:

"I think the difference (between mine and the creature's experience) is that I can see that there is repetition ahead so I am not as excited about it, I am kind of more just neutral, whereas the excitement and happiness lasts longer for the creature because the repetition is unexpected. Because it just touches... the pattern becomes known through the experience and then eventually more towards the middle it becomes monotonous and then it is less exciting...but in the beginning when it recognize the pattern is exciting. So that's the case for the windows and the columns as well." (4tM)

What became evident the reflection on the creature's experience was the feeling of being deprived of vision. This feeling, as mentioned above, brought an awareness of the function of the different senses, and how the qualities of space become apprehended through different

modalities, but also demonstrates that we are habituated to perceive space mainly through vision. This dominance of vision is illustrated in the participants' narrative through the expression of the inability to communicate without vision the qualities of space. A participant in the Chapel touch group noted the following when asked about the creature's experience:

"The creature should probably be pissed off...I don't think it would be happy when I walked around the altar and maybe around the chairs.... I think it would be very frustrated for sure in some areas because I couldn't tell it anything. There are many things that couldn't be communicated..." (5tC)

Contrary to the participants in the sound and touch group, the participants in the vision group did not feel deprived of the other senses when narrating their experience of the space, neither did they attribute the difference between their own experience and the creatures' to the fact that the creature had only one sense, whereas they could also touch and hear. Having assumed the primacy of vision as hypothesis for the experiment, this fact was expected and confirms my hypothesis. However, as mentioned already, the participants did not identify themselves with the creature either.

It was revealed as a surprise that four out of the six participants in the vision group mainly attributed the difference of the creature's experience to its smaller scale and to the fact that the creature had never 'experienced' the space before. The fact that the participants were wearing the prototype on their hands combined with the fact that the prototype had a camera which took the role of the 'creature's eyes' resulted in the treatment of the camera as a third eye. Thus, 'seeing' also through their hand, the experience of the participants was augmented because they turned their focus to details and aspects of space that they would otherwise not notice - from small objects left in between the bricks of the undulating wall in the Chapel, to the view when in close contact with the glass covering the water around the Chapel, to the contents of the trash can in Morss Hall.

The fact that the participants were part of a scenario that defined the prototype as a 'creature of another kind' led to the interpretation, especially in the vision and the all-senses group, that the creature had no prior experience of the specific spaces but no previous

experience of any similar material qualities and objects found in the spaces. This resulted in ‘resetting’ the experience of space; seeing the space through ‘new eyes.’ This effect is evident if one compares the colors in the part of the mood template associated with the host’s experience with those associated with the creature’s experience. In the latter, the feelings such as “calm” have been replaced with feelings of “curiosity” and “excitement.”



Figure 24. The prototype functioning as a ‘third eye.’ A participant in the experiment focusing on the details of the brick wall in the MIT Chapel

5.4 SUMMARY OF THE RESULTS AND CONCLUSIONS

1. Dominance of Vision

The comparison between the actions and experiences of the participants as documented in the templates, the videos and the narratives, demonstrated that the results in the vision group proved similar to those of the all-senses group. The participants that were assigned the all-senses creature mainly focused on vision in the way they acted in space and experienced space. At the same time -similarly to the participants in the all-senses group- the participants in the vision group, did not consider the lack of the other senses in their narratives on the experience of space. Therefore, the results support the hypothesis that we are conditioned to perceive space mainly through vision.

2. The focus on either sound or touch individually, through the prototype, expands our understanding of space by augmenting all sensory perception.

Compared to the vision and the all-senses group, the experience of the participants in the sound and touch group -as documented in the templates and the interviews- proved to have more variety and be more enriched. The task of intentionally focusing on one sense - other than vision - resulted in enacted approaches that involved multisensory bodily interactions with space. The act of hearing generated both auditory and tactile interactions and vice versa. The bodily interaction with the elements in space also resulted in the enrichment of visual perception, as details in the material qualities of objects were brought to the surface.

3. The focus on vision individually, through the prototype, expands our understanding of space by augmenting visual perception.

Although it was initially assumed that focusing only on vision would not result in the expansion of perception, it was revealed through the process that by adding a camera to the participants' hands, the prototype acted as a 'third eye' that allowed users to focus on details that they would otherwise not notice. Moreover, the act of reflecting on the creature's

experience functioned as a second filter in perceiving space, which allowed participant to imagine their experience in space through 'new eyes.'

4. Limitations in the awareness of auditory environmental sensory inputs suggest that the visualization of the digital recordings could be a useful means for reflection

The action templates and the mood templates acted as medium for reflection, providing a greater awareness of space to the participants. The visualization of the data recorded through the prototype could function as a third layer of reflection, one which would allow participants to compare their experience, as documented in the templates, with the digital capturing of the bodily interactions in space. Because participants appeared to ignore sounds as environmental sensory inputs, reflecting on the visualization of the digital data would make them more aware the auditory qualities of space. Moreover, comparing the actual path they have taken in space and the paths as recorded in the prototype would reveal differences regarding between the actual experience of the participants and they way they perceive their interactions in space retroactively.

5.5 DESCRIPTION OF THE PROTOTYPE AND DATA PROCESSING

The prototype was 3d-printed in plastic in an ABS printer and Velcro straps were added so that it can be adjusted to the participants' wrist. Its base was designed to fit the size of an Arduino Uno R3 microcontroller (2.10 by 2.70 inches) and its height was adjusted to fit the height of Arduino board with the SD card Arduino shield on top, the jumper wires and the Looxcie 2 camera. The camera's height from the base was adjusted to allow for observation of what participants touched in space. The following sensors were connected to the Arduino board: An electret microphone to record the environmental sound, an infrared proximity sensor (VCNL4000) to detect when participants' hands are in contact with a surface, a triple axis magnetometer and accelerometer (LSM303DLMTR) to gather information regarding the participants' orientation in space, and a real-time clock to allow me for accurate matching between the participants' actions and the recordings. The triple axis magnetometer and accelerometer is attached to a chest-strap that the participants wear in addition to the prototype.

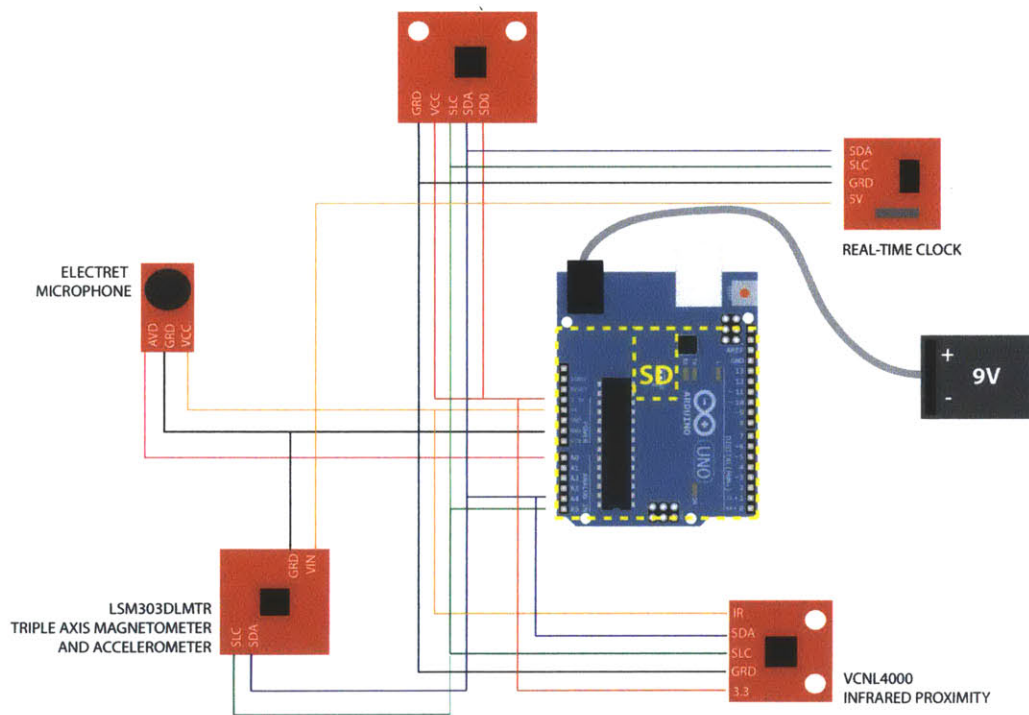


Figure 25. Diagram of depicting the connections of the sensors used to the Arduino microcontroller. An SD shield is used to gather the data in a text file.

The data are collected in an SD card, located in an SD Arduino shield and then imported as a text file in Processing. The Arduino board is powered by a 9 Volt battery, which is connected to the board through a barrel jack adaptor. The values of the magnetometer and accelerometer are used to calculate the heading of the orientation as a final value. The value from the proximity sensor as well the values from the x and y acceleration, sound and clock, are also stored in the text file (txt) in the SD card.

In the program I developed in Processing, the values from the txt file is imported as an array of strings which are then converted to float values. An instance of a 2D unit vector is created, whose location and heading are updated in the main program according to the input values from the txt file. By updating the unit vector, a new unit vector is visualized on the screen. Each unit vector, when visually added to the previous one, creates the movement path traced by the participant in space. A threshold is defined to distinguish movement from pause according to the x and y acceleration values. When pause is detected a circle is generated in the existing location of the vector, whose diameter varies according to the time of pause (the number of acceleration inputs evaluated as pause). Each time a new unit vector is instantiated, the sound value is mapped to a value defining the diameter of circle whose center is specified by the x and y coordinates of the unit vector. The size of the circle signifies the sound levels at the specific location in space.

The proximity sensor is calibrated to detect whether an object is at a very close distance to the sensor, therefore signifying touch. A threshold was defined after observation to determines whether the touch condition is true or not. If it is true, then a line is drawn that has as a starting point the x and y coordinates of the unit vector and a constant length. The orientation of the line corresponds to the heading of the unit vector, signifying the direction of the action of touch in space. Although the length of the line in the case demonstrated here is constant, it could account for variation by mapping the value of the proximity sensor to the size of its length.

The algorithm can be significantly improved to account for the complexity of body movements in space if the velocity of the vector is inferred from the acceleration values. In the current state of the prototype's development, it is assumed that the body in space is moving under a constant speed, thereby distorting the length and directions of the actual path. A

gyroscope could be added for more accuracy in the detection of movement and pause as it would allow one to distinguish between the motion caused from body rotation and the motion caused from walking. Although in the current state of the prototype's development, the visualization does not allow for mapping the complexity of movement in space, it can still provide information regarding the intensity and duration of the sensory interactions in space.

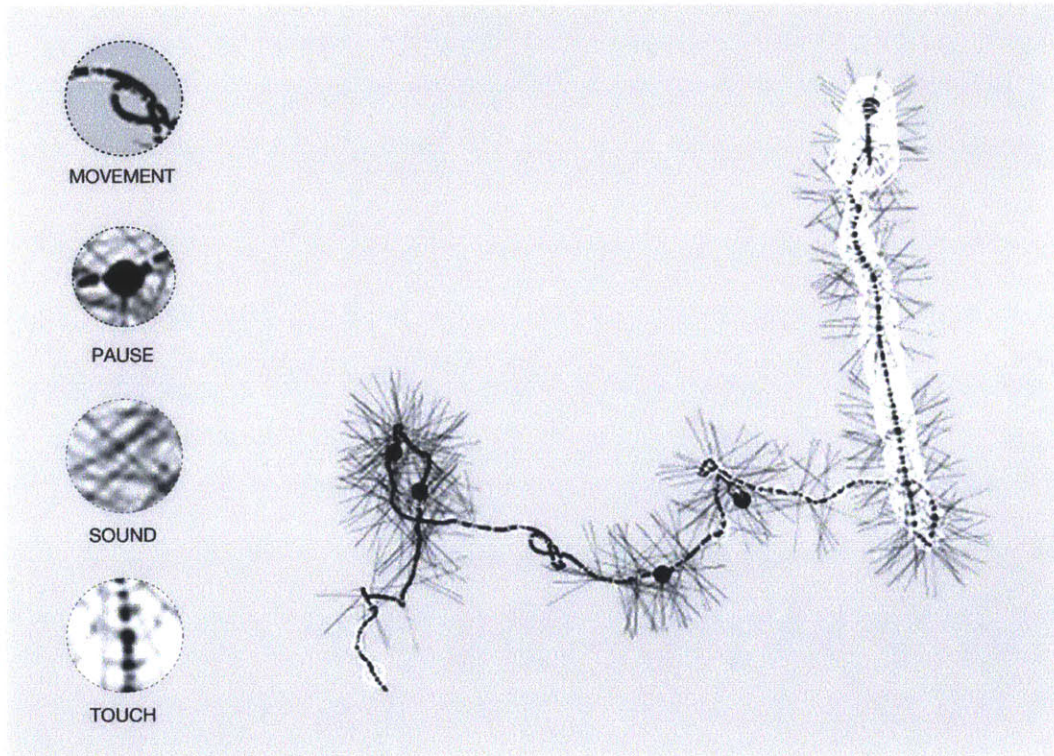


Figure 26. Example of the data visualization. Orientation of the body in space is mapped into a path through the creation of unit vectors. Sound is mapped into a circle -with radius relative to the intensity of the sensory input- and touch into a line for each moment x that the location of the vector is being updated. Pause is expressed through the generation of black circle with a radius relative to the time of the pause.

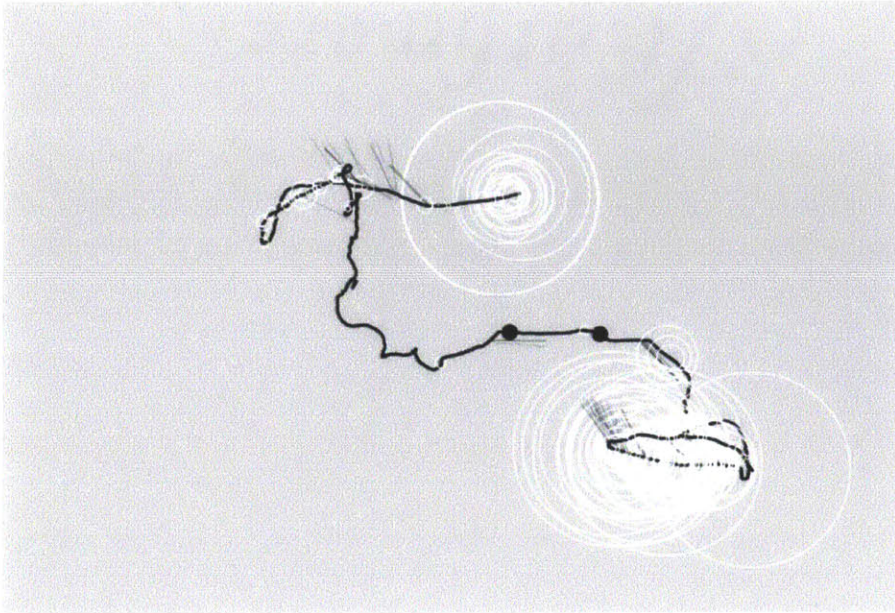


Figure 27. Example of data visualization from the sound group

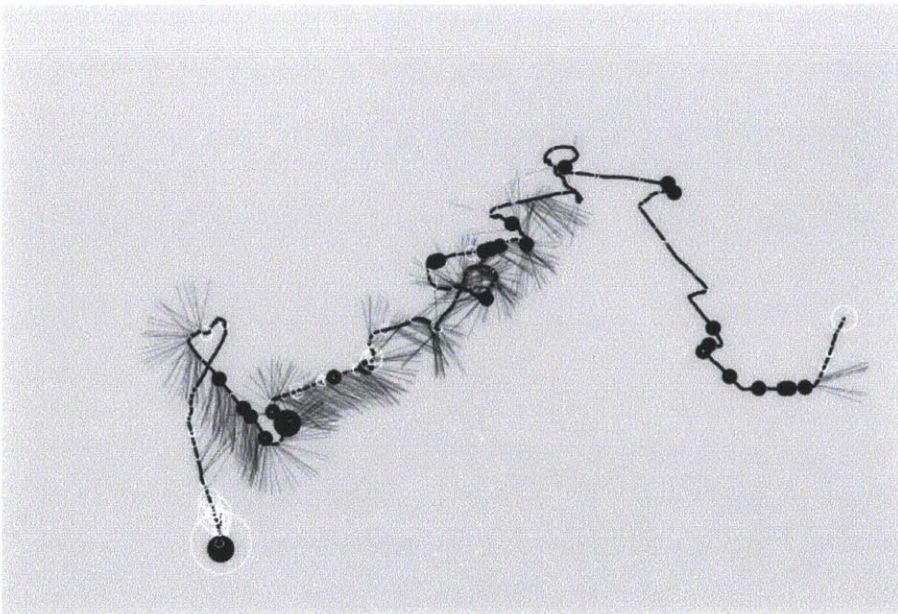


Figure 28. Example of data visualization from the touch group

PROCESSING CODE:

1. Main Program:

```
Body[] attrib;
Body body;
int counter;
String[] data;
void setup() {
  size(1200,1200);
  smooth();
  data = loadStrings("PARTICIPANT1.TXT");
  body= new Body (0,0,5,1500,-1000,0);
}
int index=0;
void draw() {
  if(index<data.length){
    float[] values = float(splitTokens(data[index], ",./"));
    body.update(values[0],values[1],values[2],values[3],values[8]);
    body.display();
  }

  index++;
}
```

2. Class 'Body':

```
class Body {

  PVector location;
  float heading;
  PVector velocity;
  float acceleration;
  float sound;
  float diameter;
  float velmult;
  float accx;
  float accy;
  float soundmap;
  float proxim;
  boolean touch;

  Body (float heading, float sound, float diameter, float accx, float accy, float proxim) {
    location = new PVector (width/2,height/2);
    velocity = new PVector (0,0);
    this.heading = heading;
    this.sound = sound;
    this.diameter = diameter;
    this.accx = accx;
    this.accy = accy;
    this.proxim = proxim;
  }

  void display() {
    noStroke();
    fill(0);
    ellipse(location.x,location.y,diameter,diameter);
  }
}
```

```

noFill();
strokeWeight(1);
stroke(255);
if (sound>0.5){
soundmap = map(sound, 0.5, 3.30, 0, 150);
}
else {
soundmap = 0.0;
}
ellipse(location.x,location.y,soundmap, soundmap);
if (touch==true) {
stroke(0);
strokeWeight(0);
fill(150);
pushMatrix();
translate(location.x, location.y);
rotate(radians(heading));
line(0, 0, 30, 30);
popMatrix();
}
}
void update(float heading, float sound, float accx, float accy, float proxim) {
this.heading = heading;
this.sound = sound;
this.accx = accx;
this.accy = accy;
this.proxim = proxim;
if (accx<=1500 && accx>=1000 && accy>= -1000 && accy<=-500){
velmult=0;
diameter+=10;
}
else {
velmult=1;
diameter=2;
}
if (proxim>= 3200) {
touch=true;
}
else {
touch=false;
}
velocity= PVector.fromAngle(radians(heading));
velocity.mult(velmult);
location.add(velocity);
println (heading);
println (degrees(velocity.heading()));
}
}

```


6. CONTRIBUTIONS

1. Identified a problem and suggested a method based on the use of perceptual prototypes that would allow for multisensory and situated learning.

The focus on abstract formal qualities and the limitations of the studio environments do not allow for a reflection on the direct experience of space and also limit spatial understanding to the sense of vision. To embrace a multisensory approach towards architecture education I drew upon the education of the senses in the Montessori method and the Bauhaus School, research in psychology and cognitive science as well as current examples of body-centered self-tracking devices. I proposed the use of Perceptual Prototypes as pedagogical and research devices, which, by acting as perceptual filters, expand our sensory perception. Moreover, by acting as recording devices, allow for reflection on our spatial experiences. The prototypes are proposed as the core mechanisms of a method with broader implications which can be summarized in three steps: make, sense-act, and reflect. The Perception Creatures workshop I conducted serves as an example of how the prototype and the three steps structured around it can be applied in architecture education.

2. Conducted an experiment which:

-Demonstrated that the perceptual prototypes allow us to focus on each of our senses individually

The pedagogical implications of the proposed method -framed though the precedents mentioned and discussed in the results of the Perception Creatures- were tested in the more controlled study of the experiment in the MIT Chapel and the Morss Hall. The experiment demonstrated that through our psychological projection onto the prototype we can intentionally focus on each of our senses individually. This method was suggested as an alternative to the deprivation method proposed by Maria Montessori. The identification with the prototype while sensing and acting in space and the retroactive reflection through the prototype retroactively proved as an equally effective way to channel our senses.

-Provided evidence that focusing on each of our senses individually augments our understanding of space

In the experiment tested two hypotheses: that we are conditioned to perceive space mainly through vision, and that focusing on each of the other senses individually would result in augmenting our sensory perception. By comparing the different groups in the experiment, it was demonstrated that the behaviors and experiences of those focusing only in vision and those non filtering their senses were similar, thus proving the dominance of vision. On the other hand, focusing only on either sound or touch resulted in augmented sensory perception not only in reference to the specific sense but also to all other senses. The enactive approach adopted by the sound group and the tactile investigation of space in the touch group led to enriched interactions with space, which in turn resulted in the discovery of material qualities and the generation of variety of sensations. This observation reveals in fact a difference between the method proposed in this thesis and the one proposed in the Montessori Method. Whereas the isolation of a specific sense through deprivation aimed at augmenting only the specific sense under study, the sensory filtering through the prototype –in the case of touch and sound– resulted in augmenting all sensory perception. At the same time, it was surprising that focusing in vision only also resulted in augmented perception of space though the treatment of the prototype as an additional visual channel.

3. Demonstrated the first steps towards the development of a perceptual prototype which can serve as tool for observation and reflection in the learning process

In the experiment I used templates that allowed participants to reflect on their actions and experience in space. Through the mental ‘re-visiting’ of the space, the participants became more aware of their interactions with the environment as well of its materials qualities. However, as observed in the experiment, types environmental sensory inputs such as sound went unnoticed in most of the cases tested. The use of device that can ‘objectively’ track the sensory interactions between the body and the space would therefore serve as an additional layer for spatial awareness as it would allow for comparison between the quantitative and qualitative data. Moreover, as observed in the experiment, when manually tracing their path retroactively,

people tend to simplify or slightly alter their experience. Thus, mapping the complexity and details of the movements in space, would serve as a more means for observation.

Moreover, as discussed in the Perception Creatures workshop, a self-made prototype that would allow for these types of body-center representations of space could alter the way we design and make space by motivating us to regard sensations as generators for formal investigation. Making the prototype, sensing and acting through it, and reflecting through it suggests a methodology for learning about space focused on experience. The making, sensing and acting, and reflecting steps, structured towards the prototype demonstrate a direction towards a pedagogy of space that would render designers and makers more aware of the psychological and sensory effects of the built environment.

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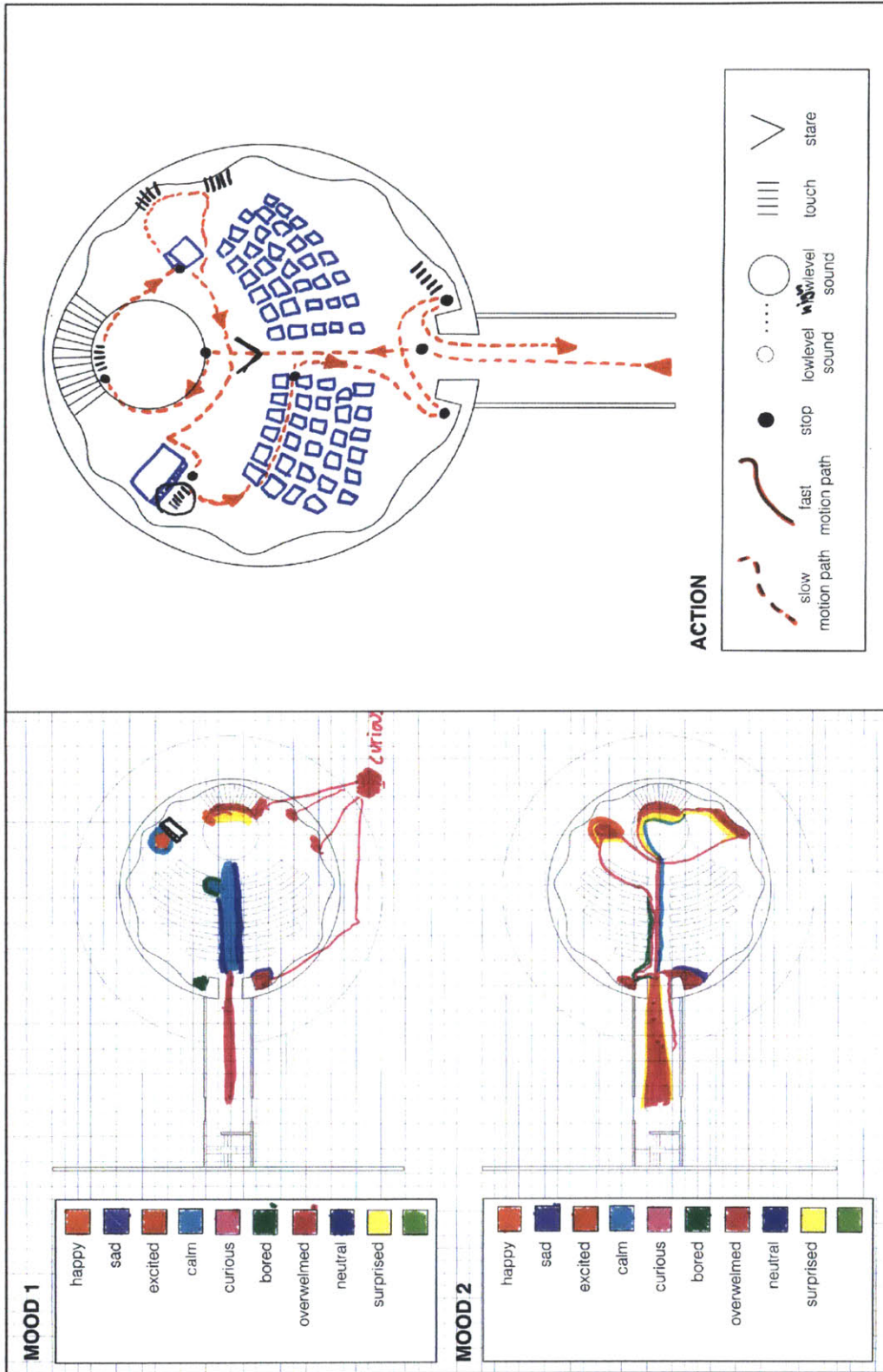
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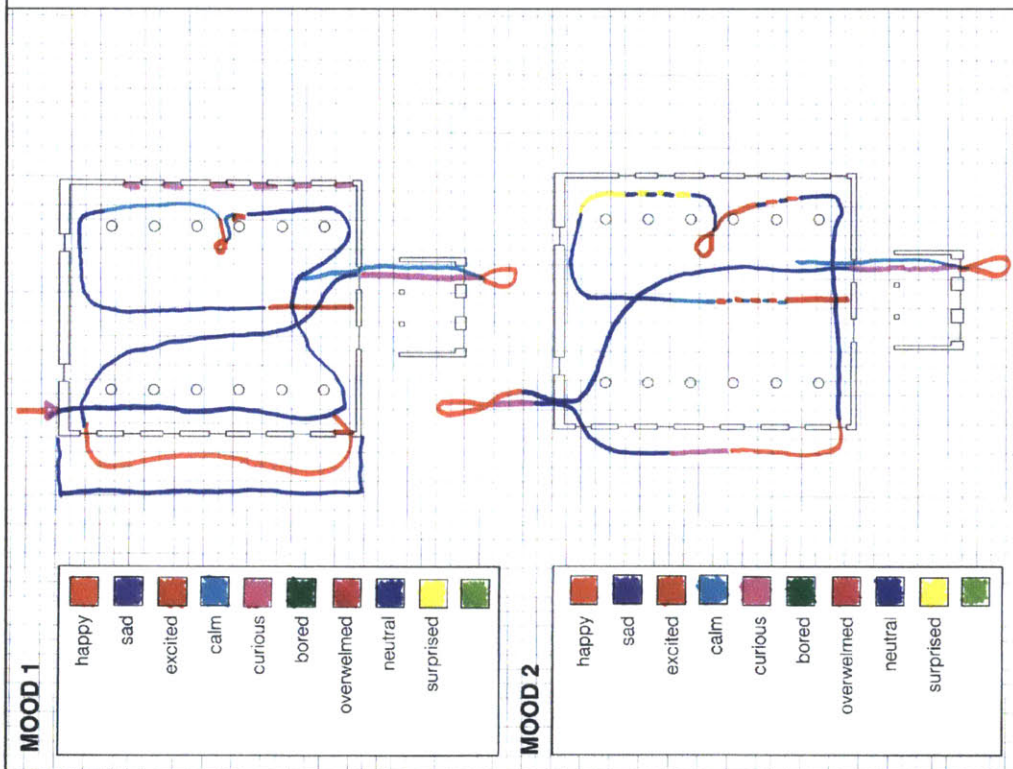
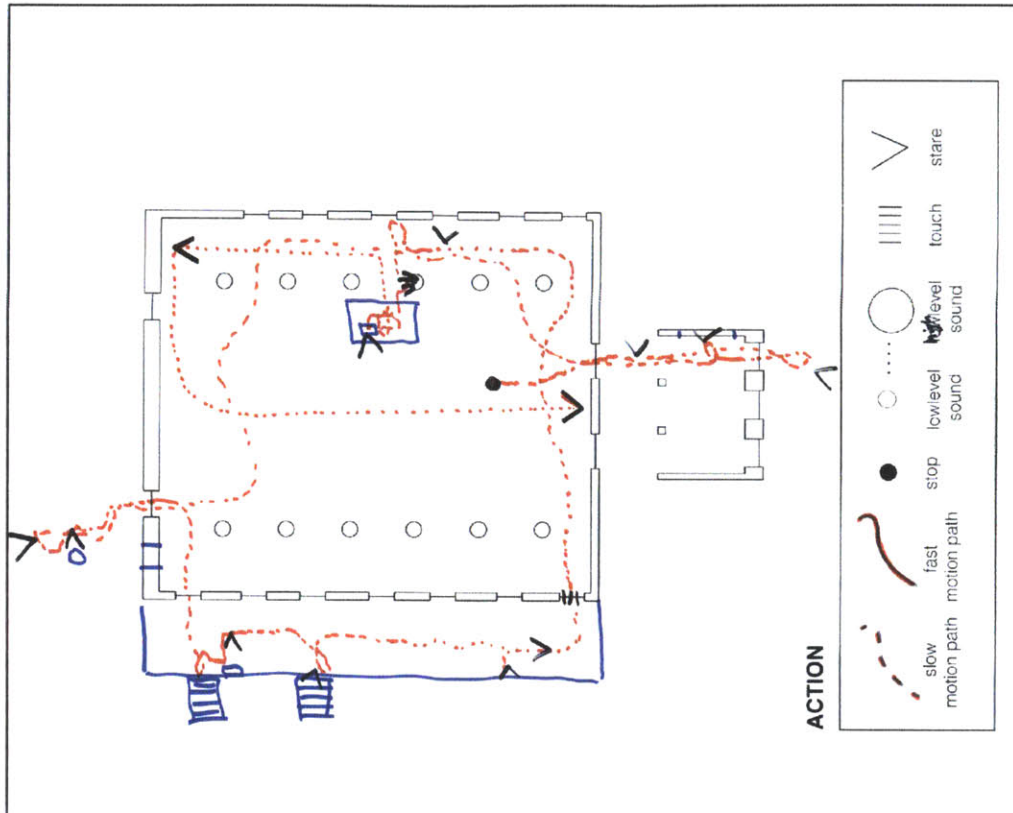
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APPENDIX

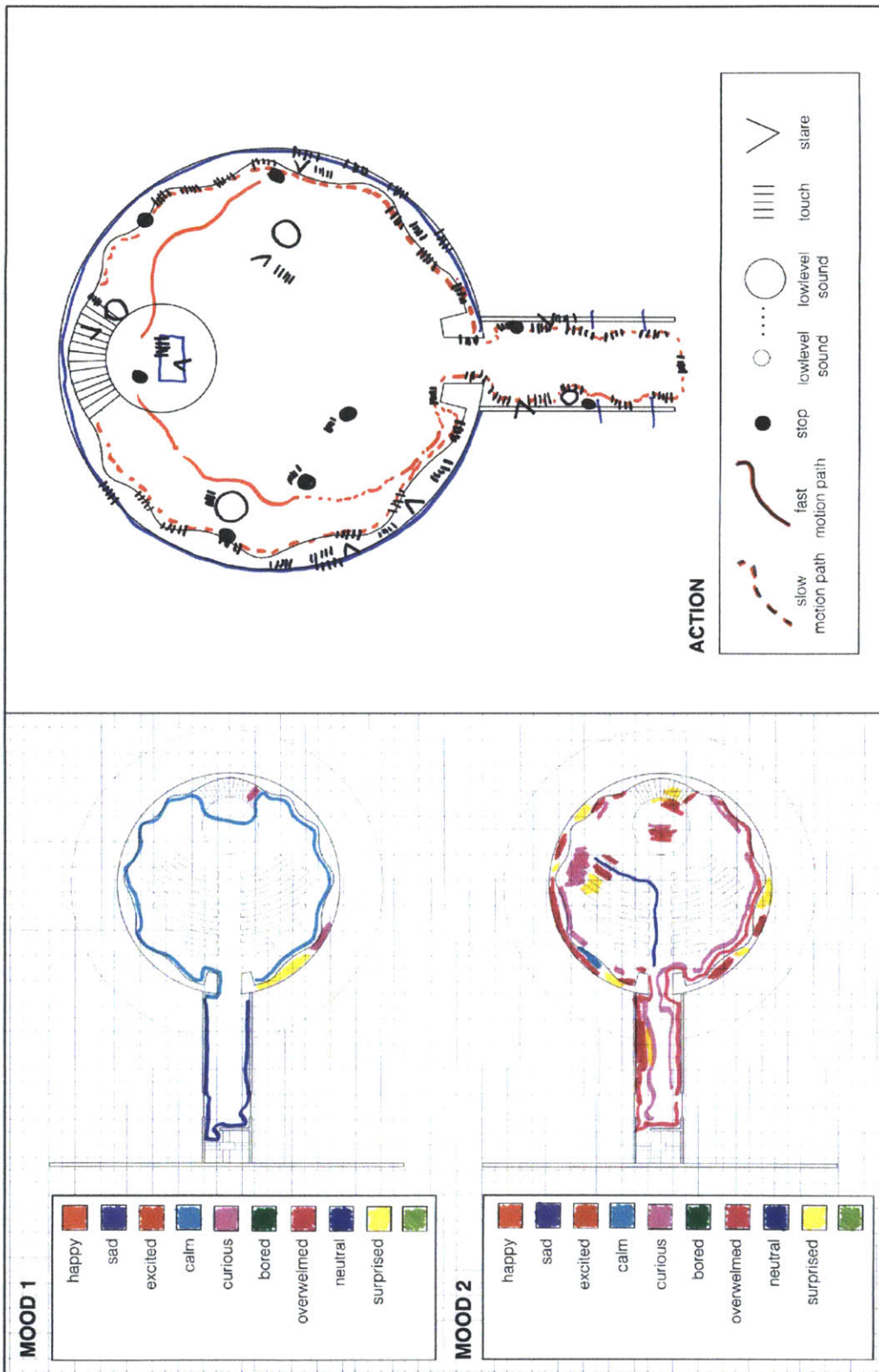
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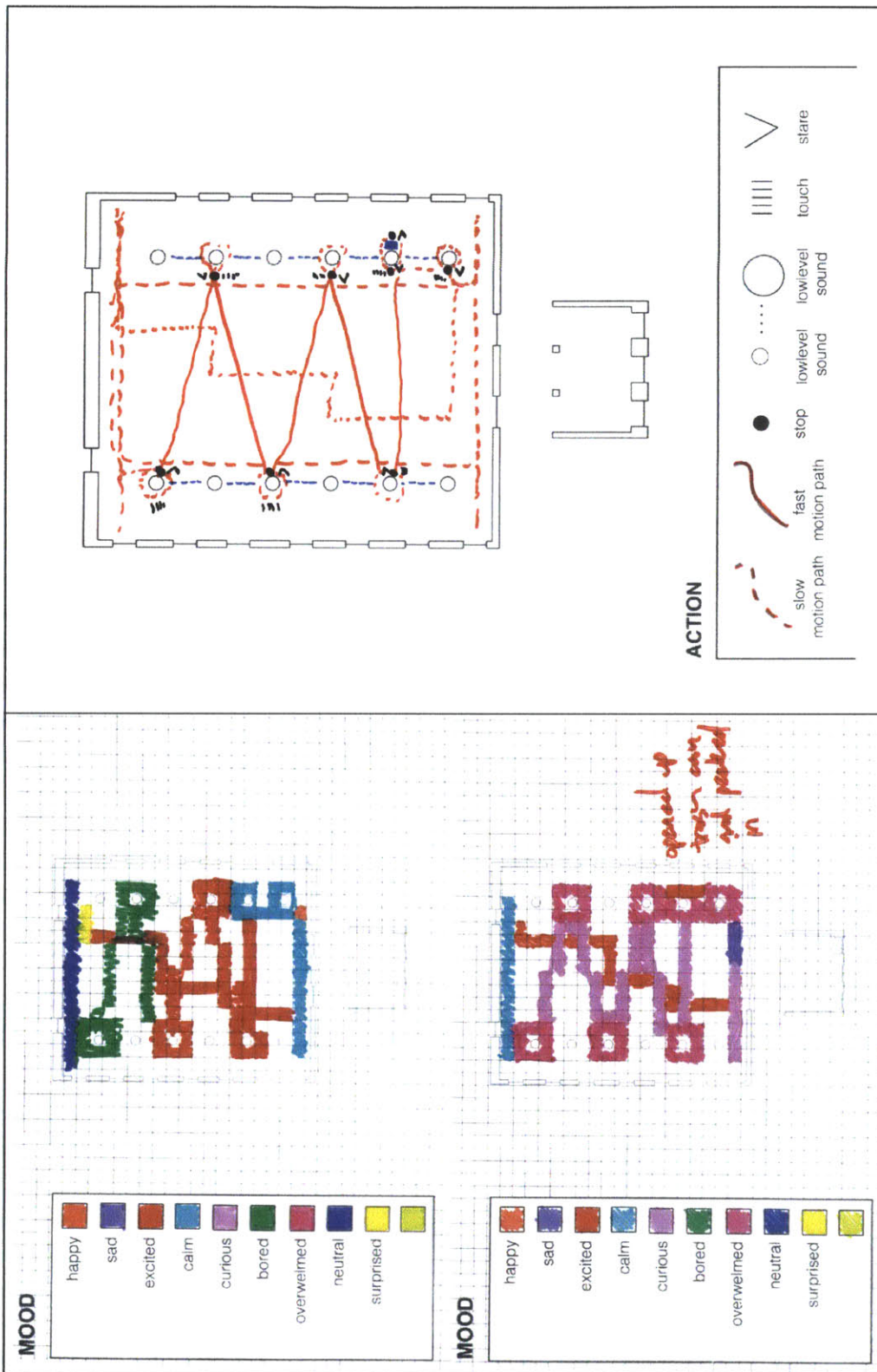
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[ALL SENSES]

MOOD

happy	sad	excited	calm	curious	bored	overwhelmed	neutral	surprised	
-------	-----	---------	------	---------	-------	-------------	---------	-----------	--

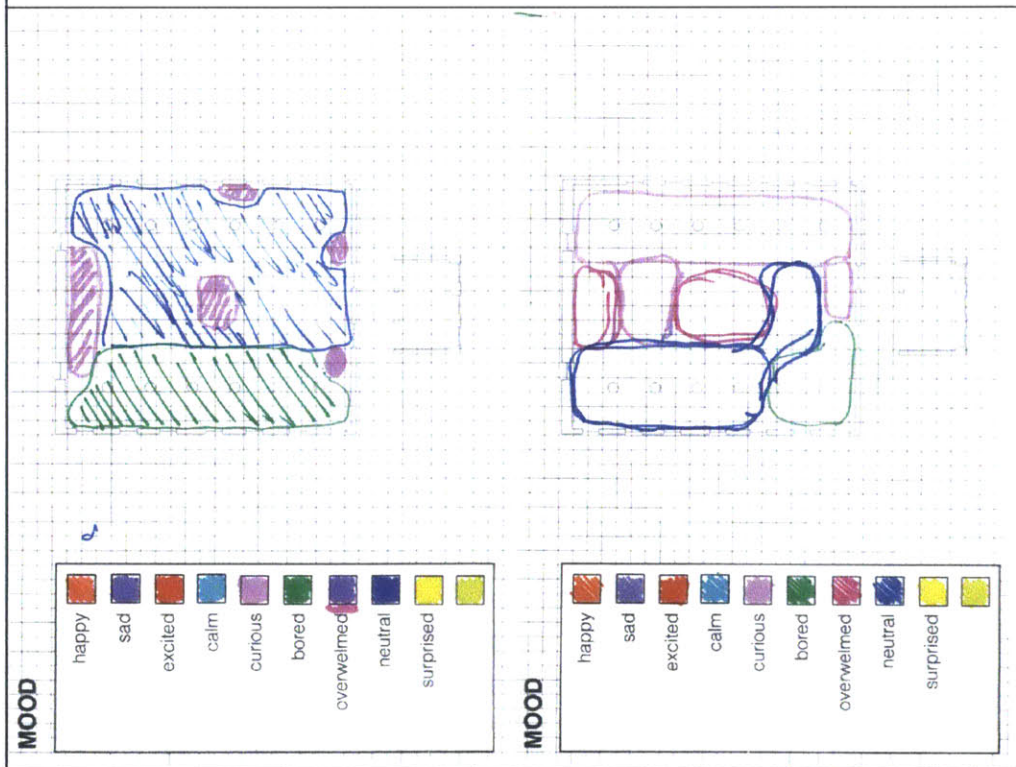
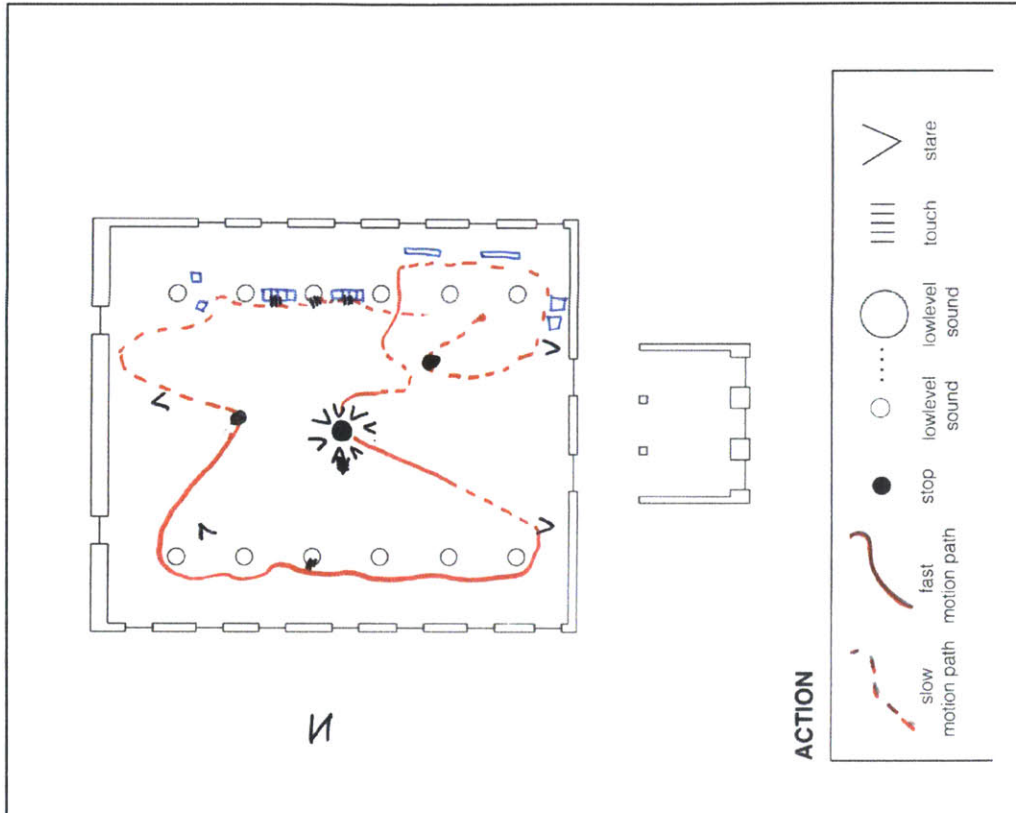
MOOD

happy	sad	excited	calm	curious	bored	overwhelmed	neutral	surprised	confused
-------	-----	---------	------	---------	-------	-------------	---------	-----------	----------

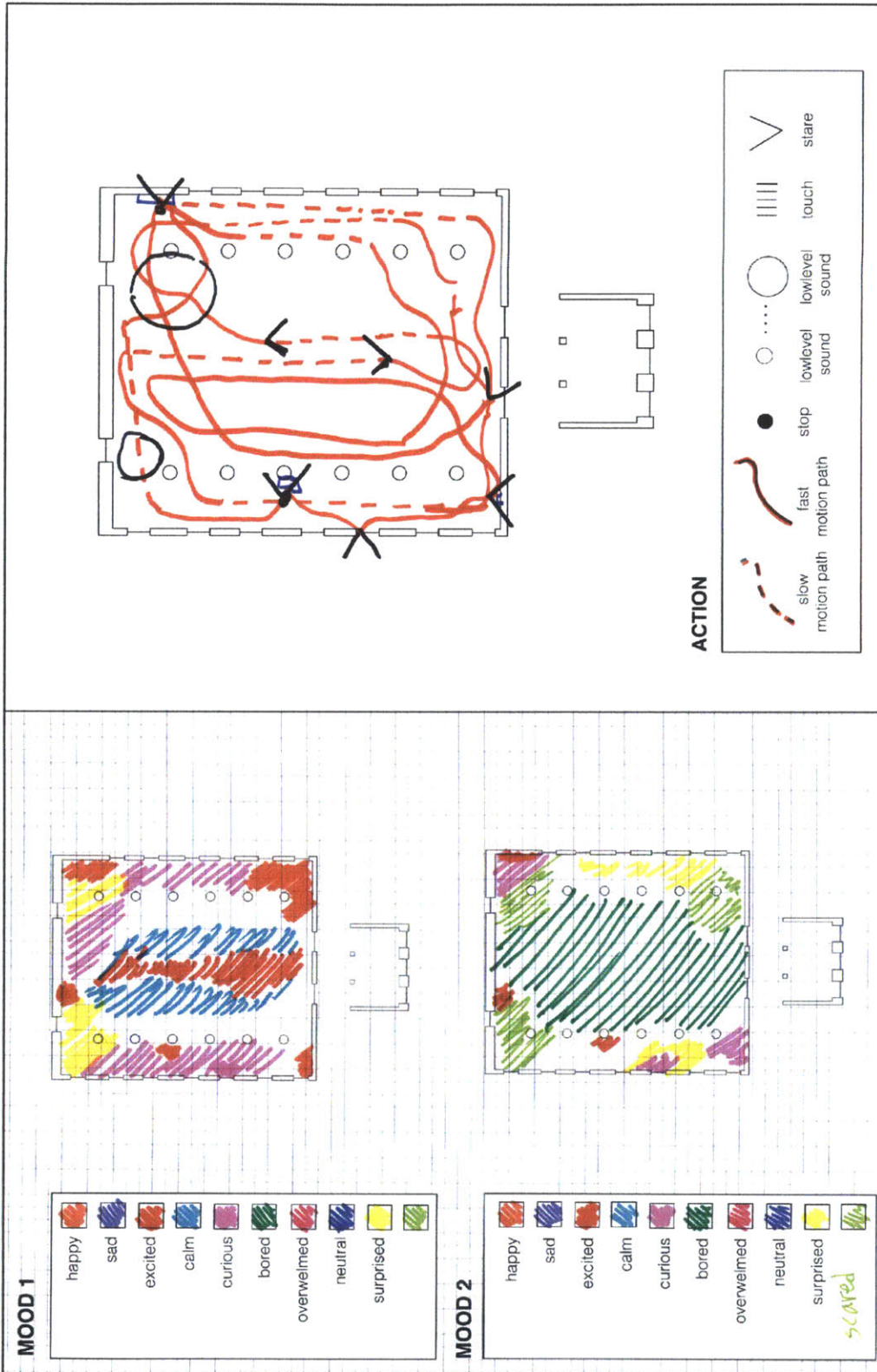
ACTION

	slow motion path
	fast motion path
	stop
	lowlevel sound
	lowlevel sound
	lowlevel sound
	touch
	stare

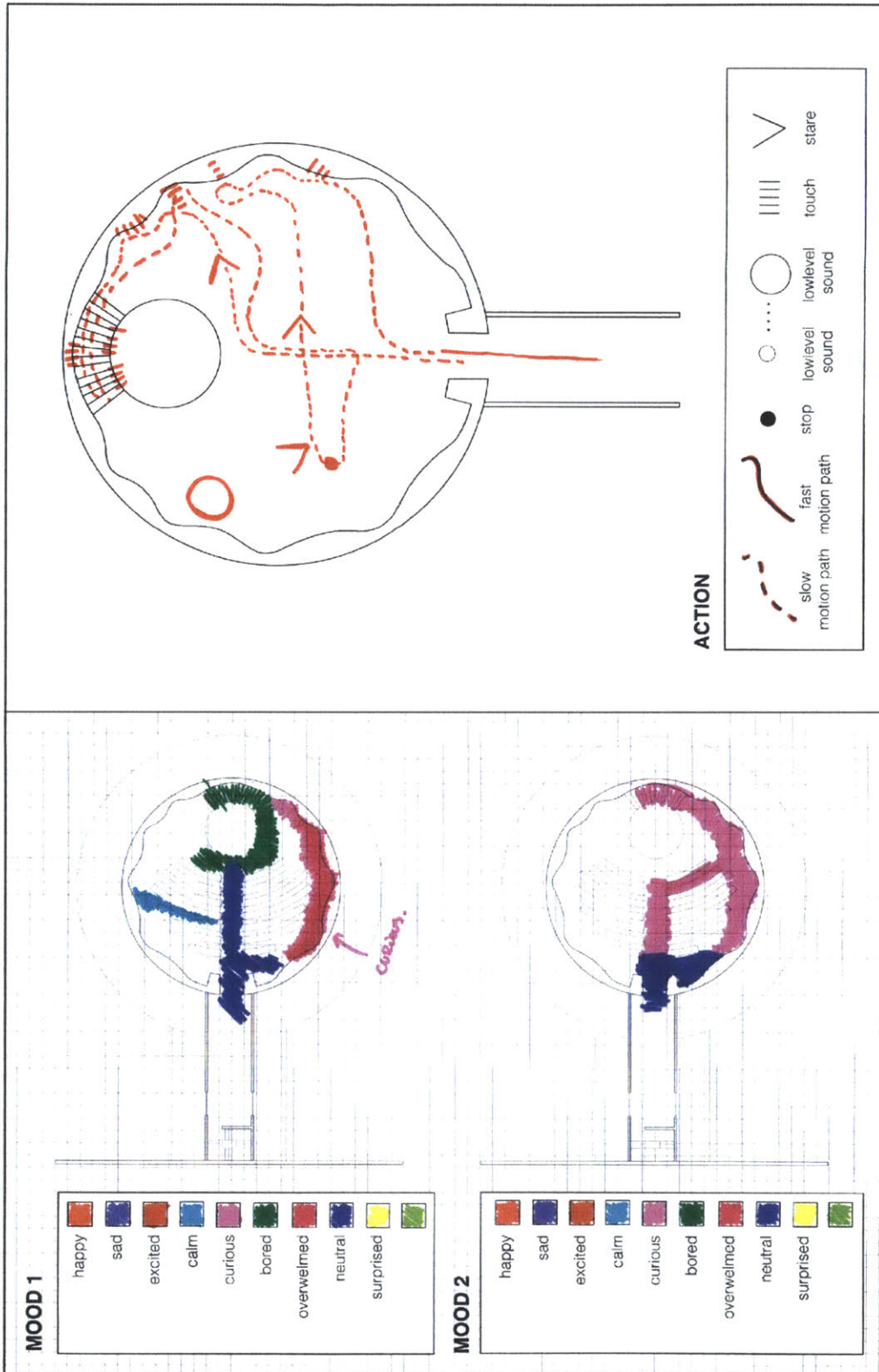
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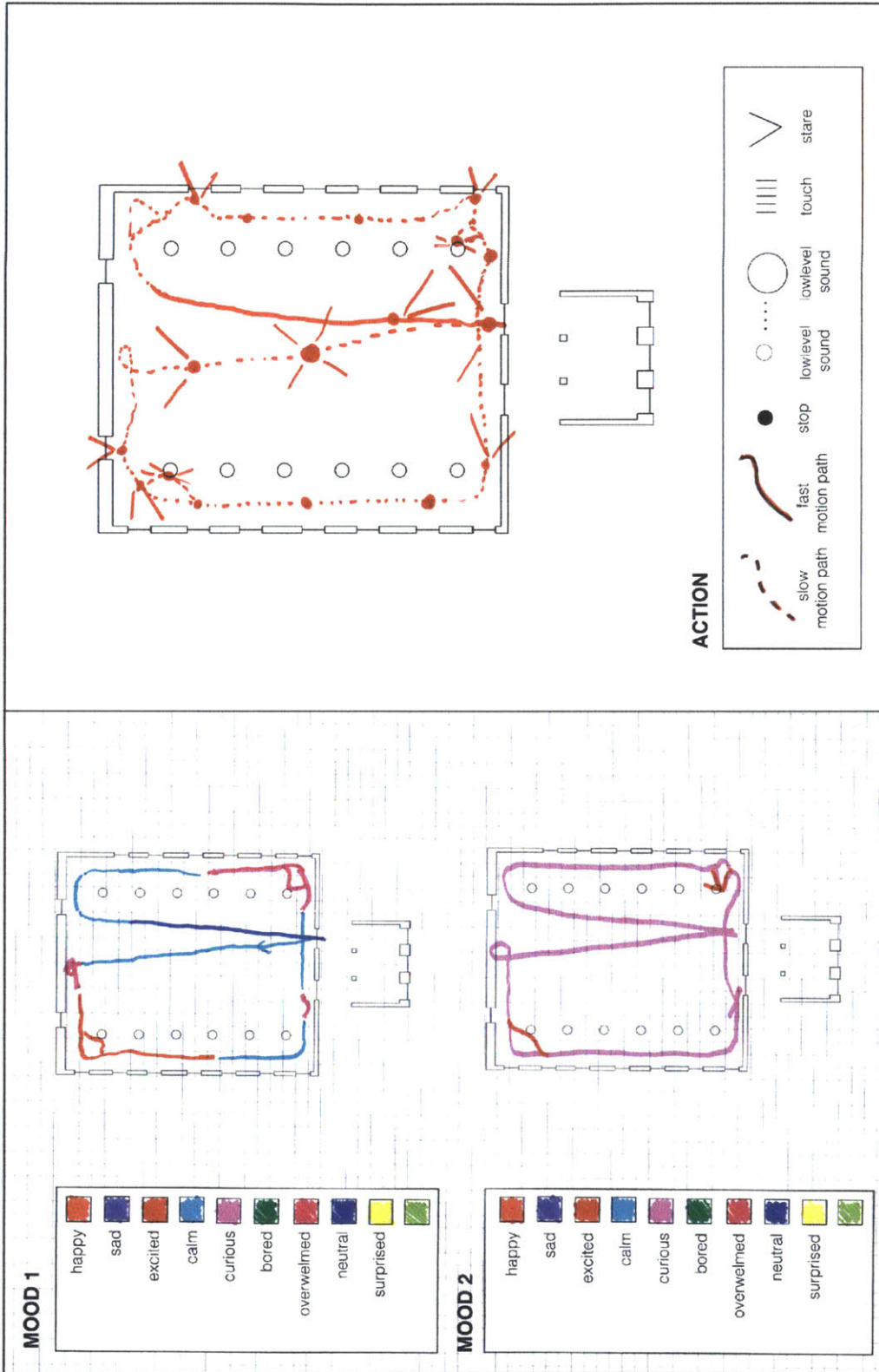
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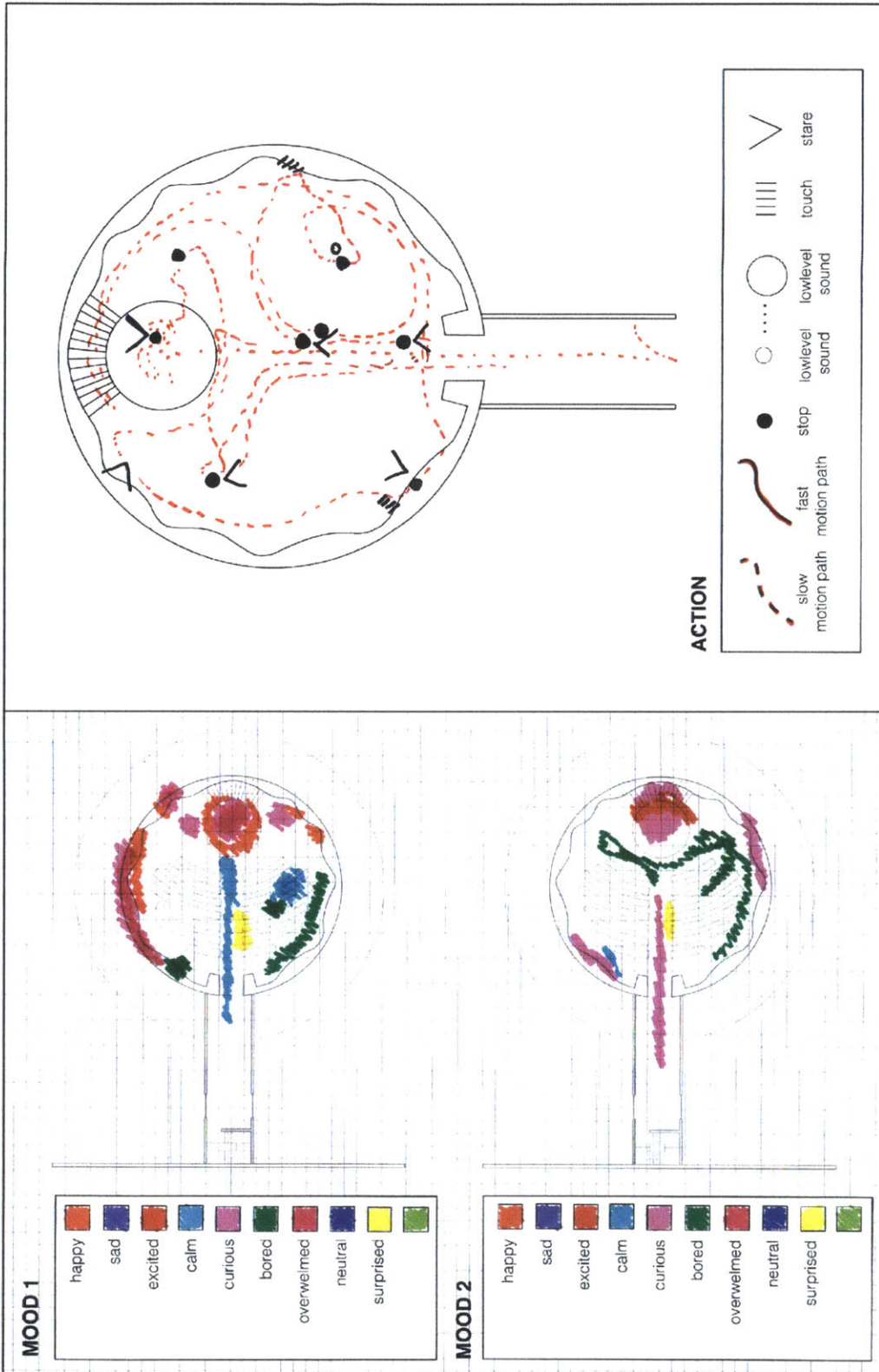
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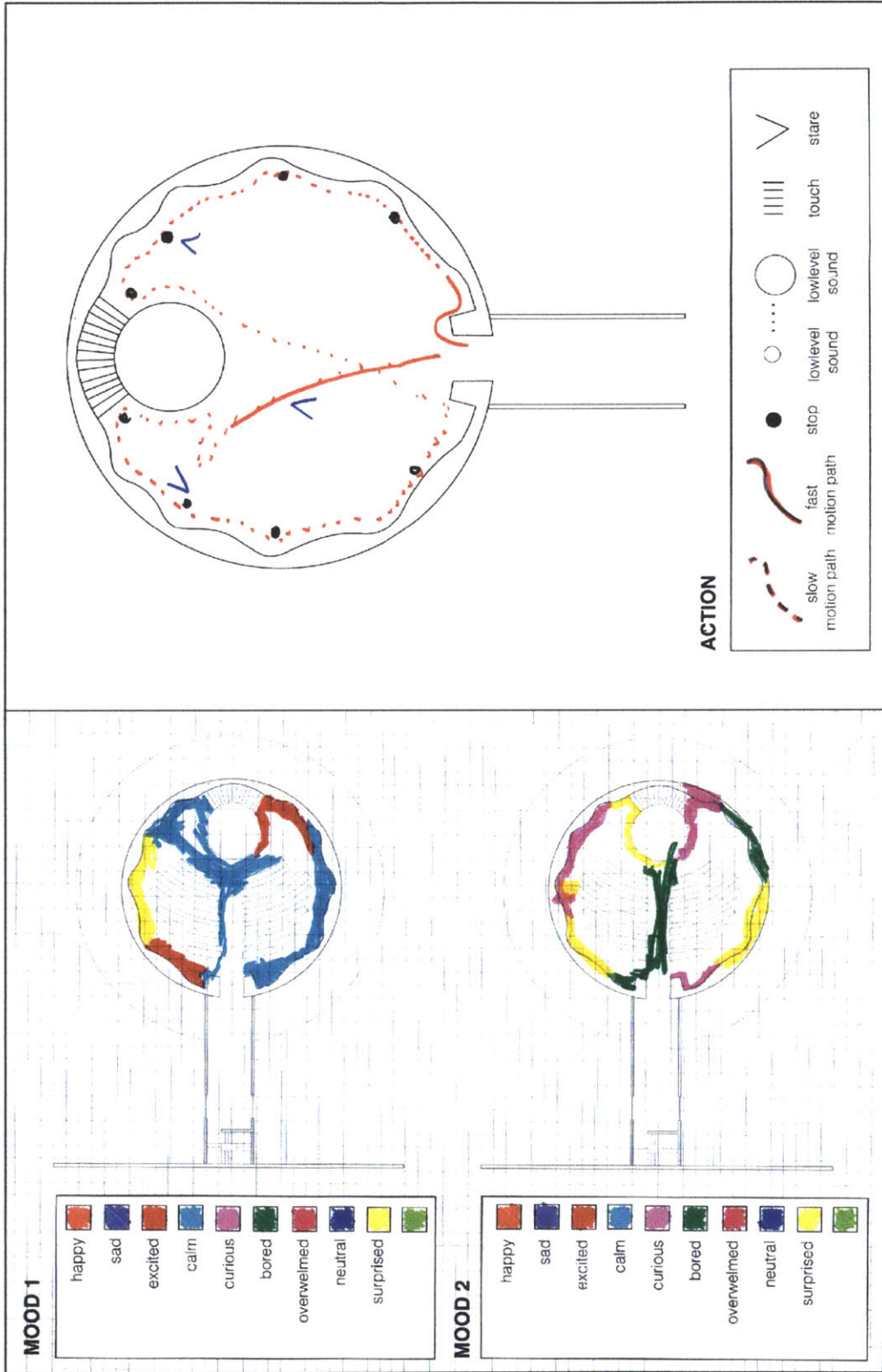
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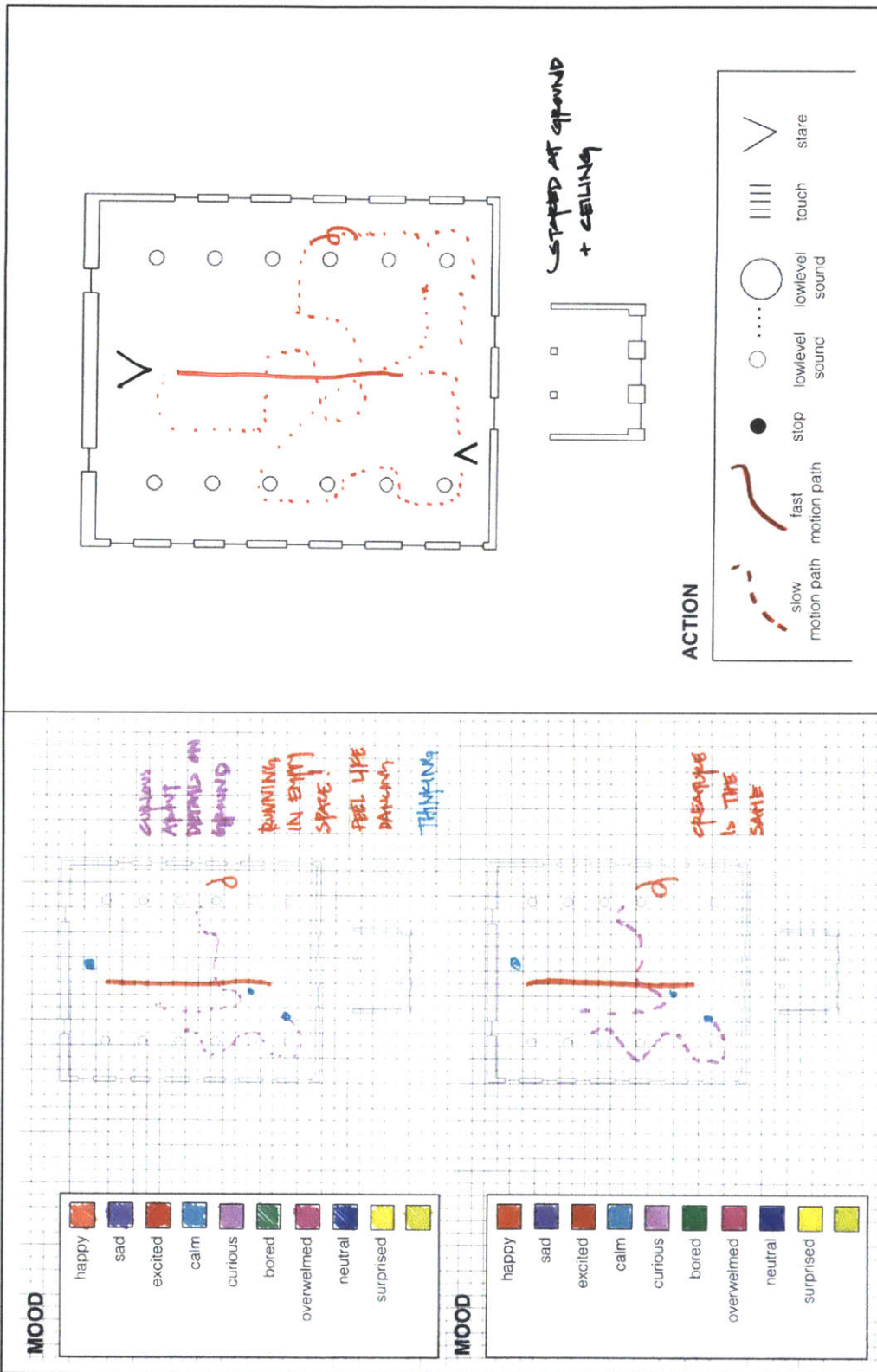
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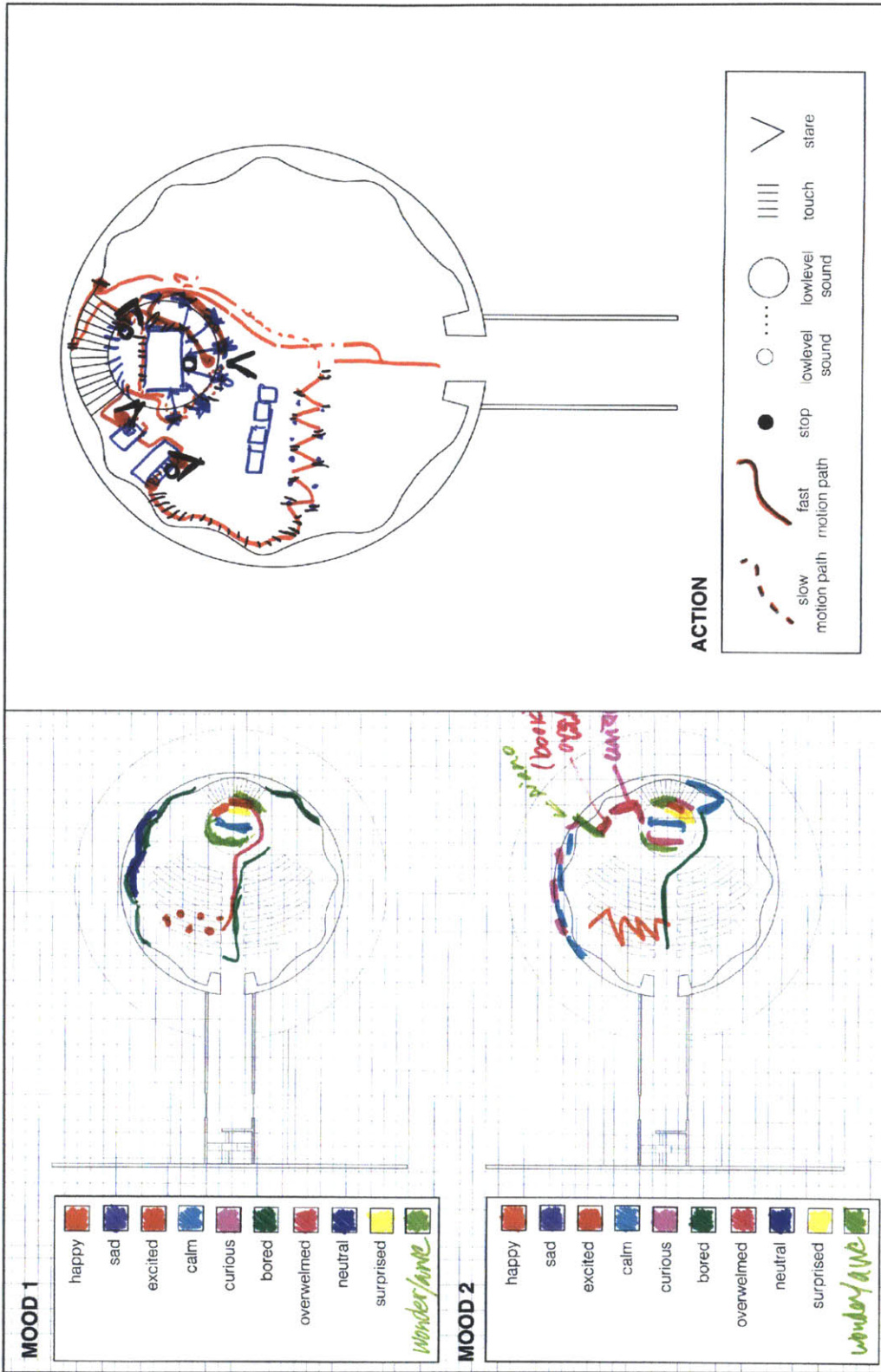
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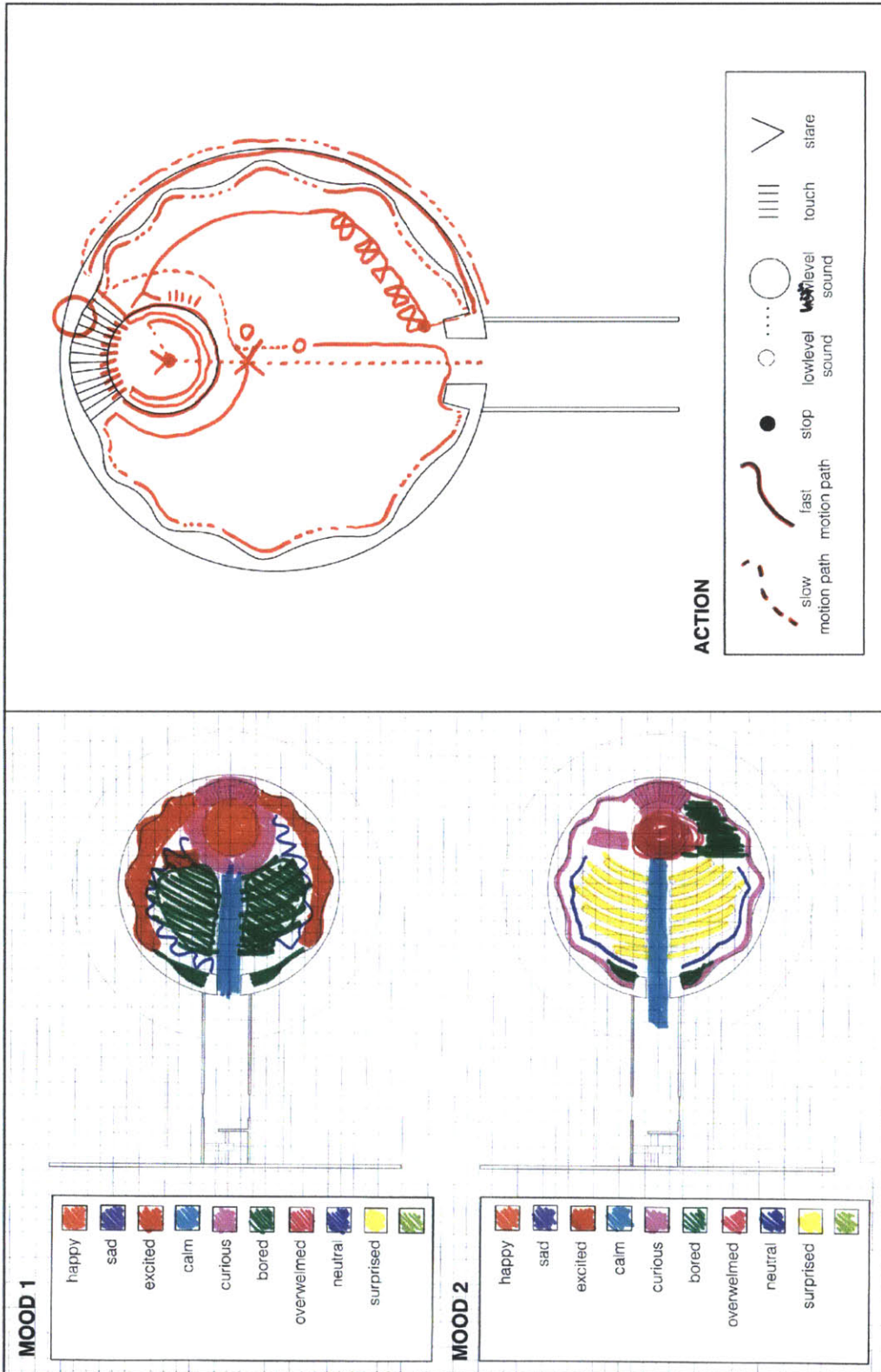
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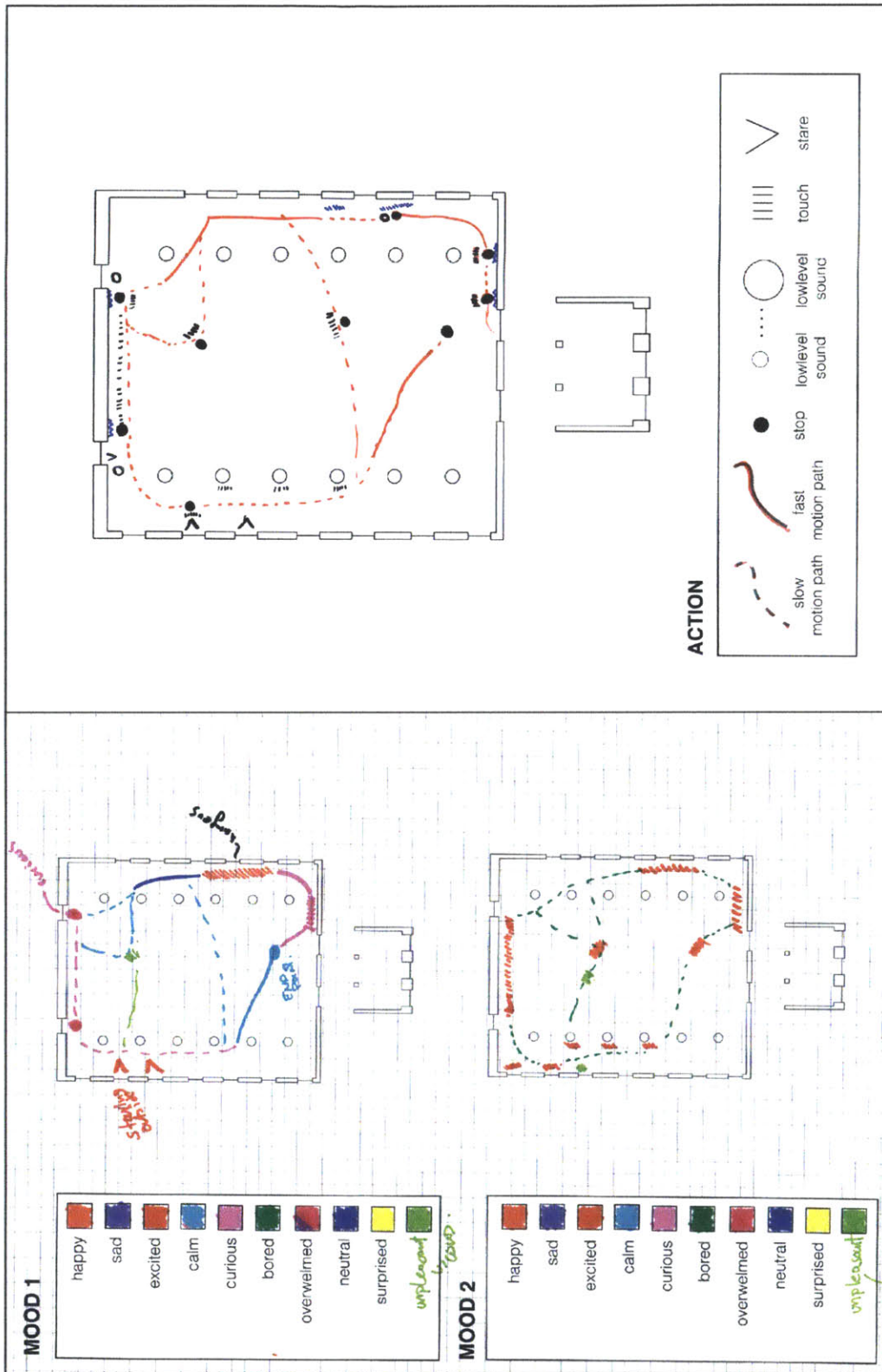
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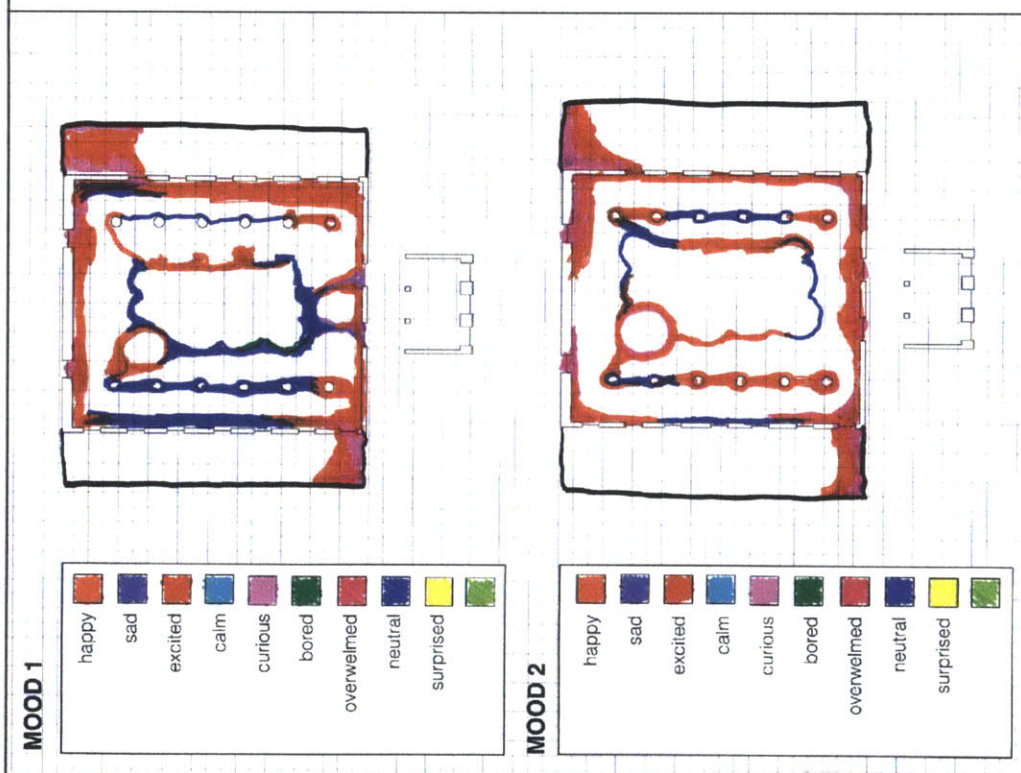
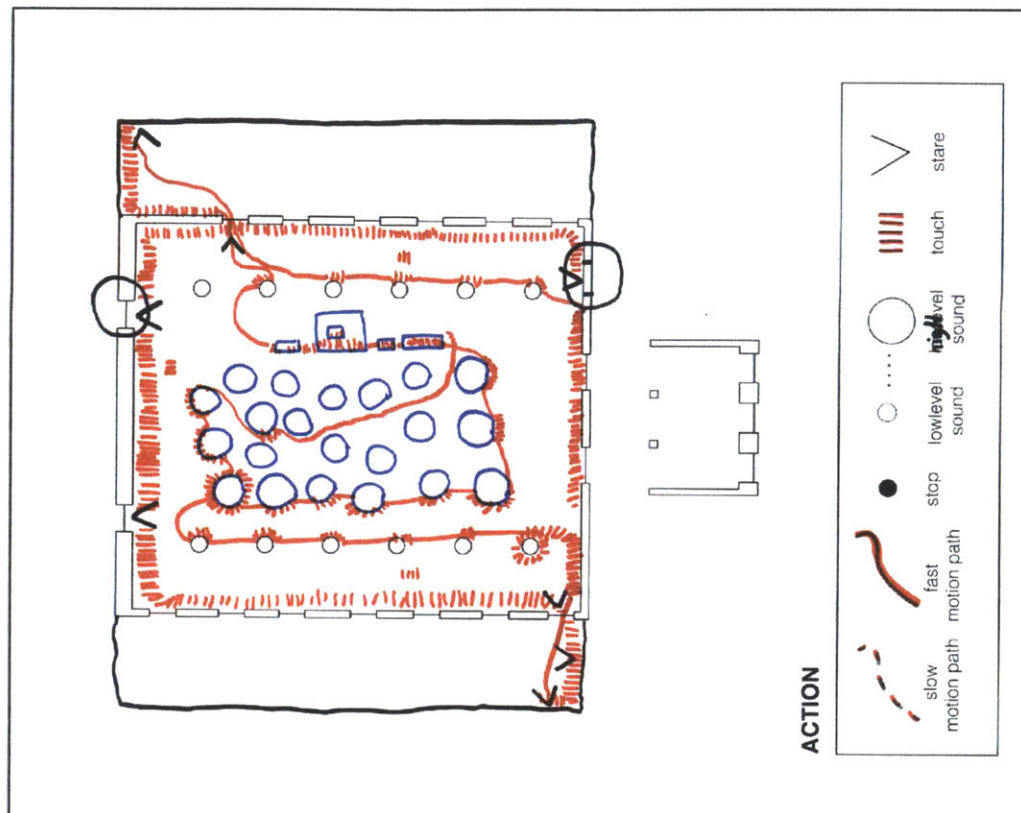
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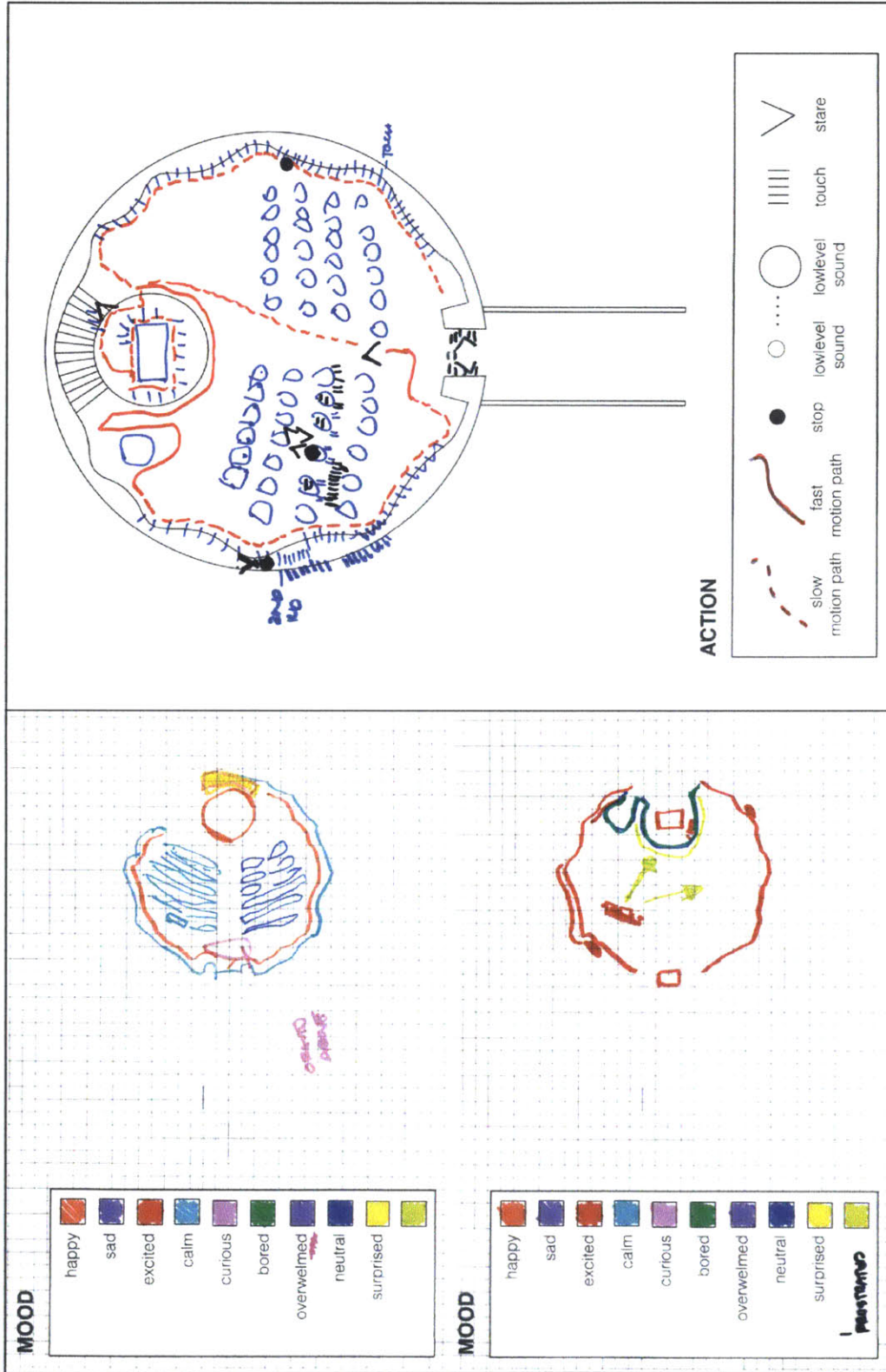
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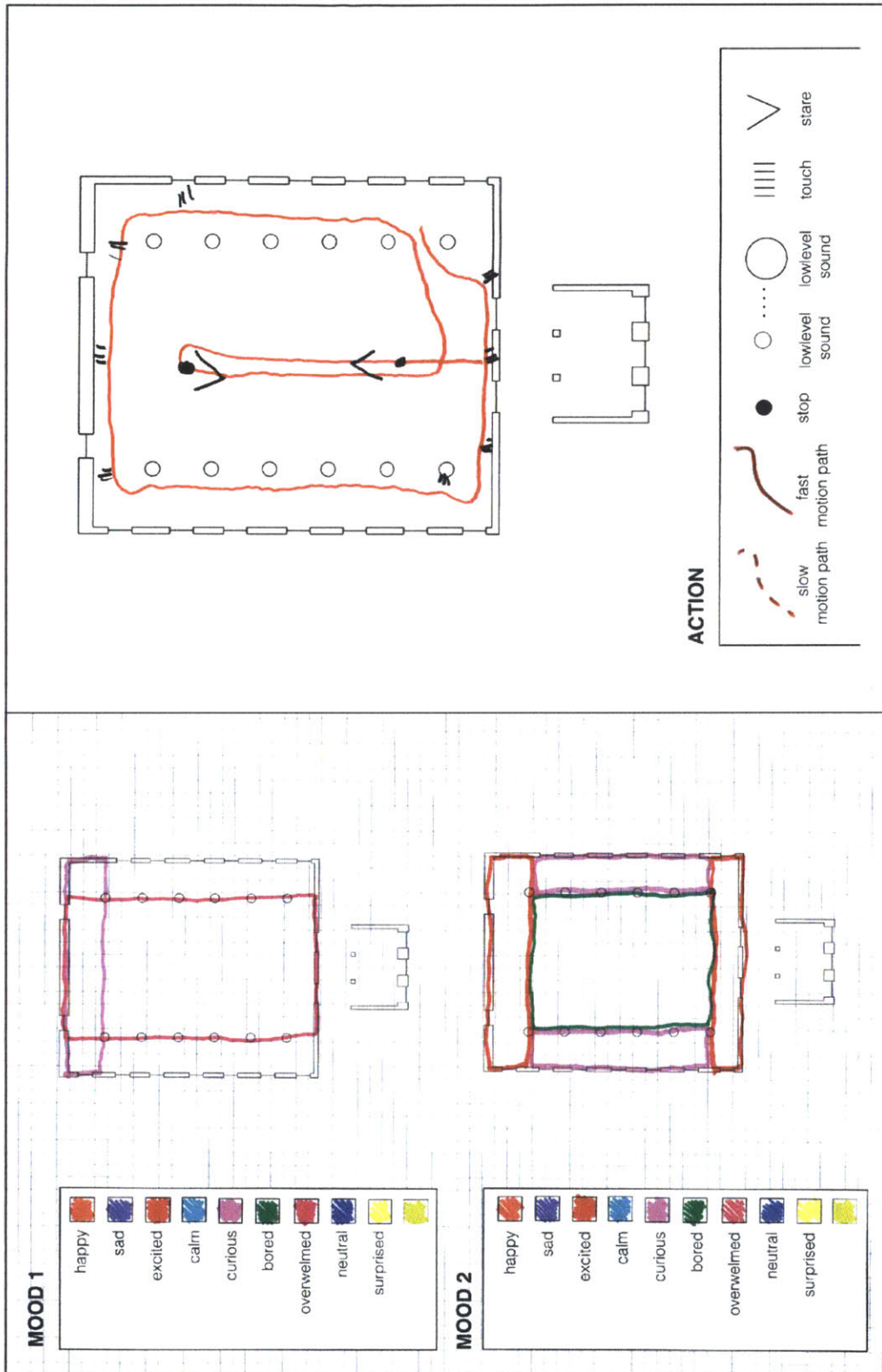
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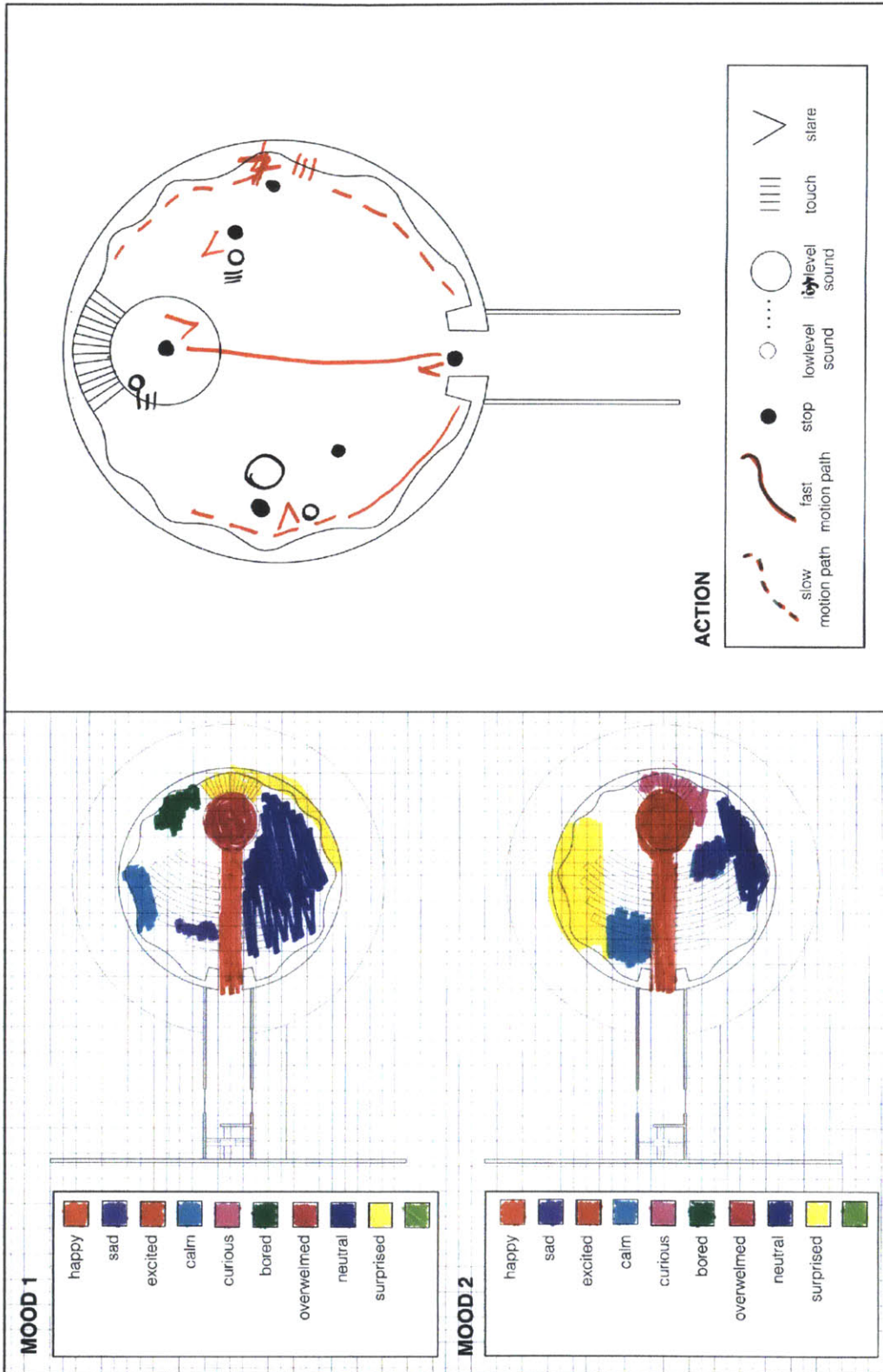
MOOD 1

- happy
- sad
- excited
- calm
- curious
- bored
- overwhelmed
- neutral
- surprised

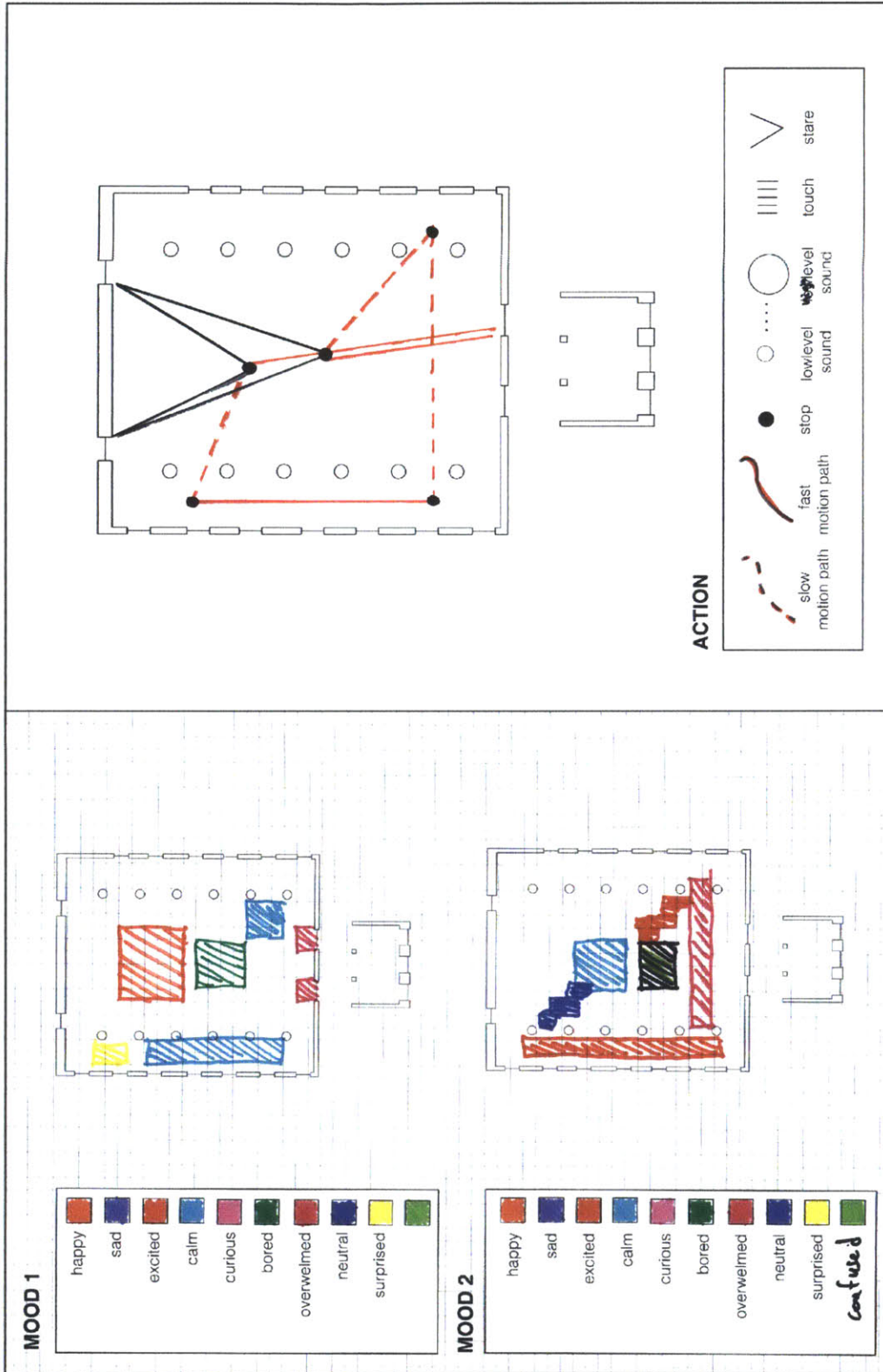
MOOD 2

- happy
- sad
- excited
- calm
- curious
- bored
- overwhelmed
- neutral
- surprised

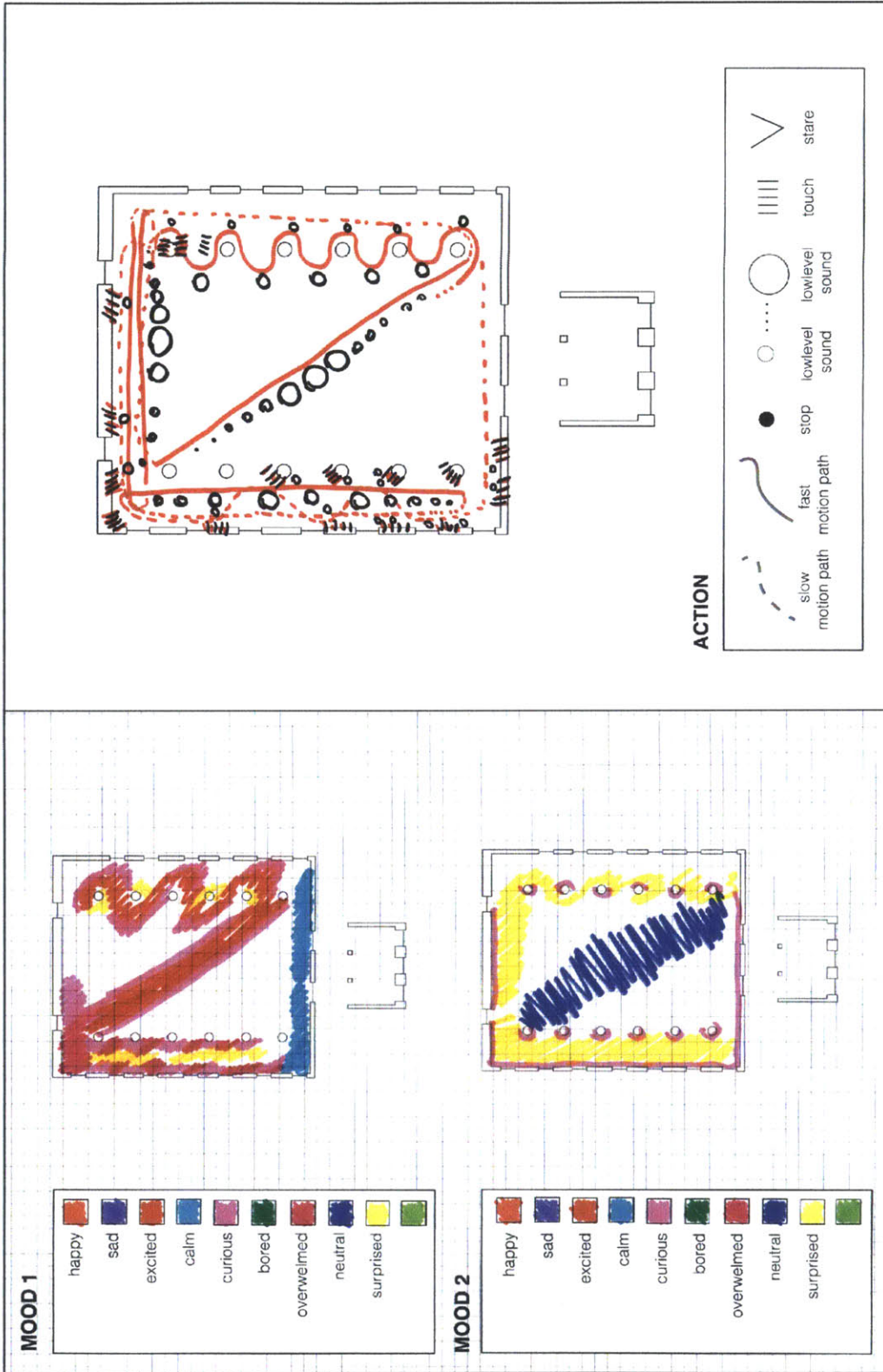
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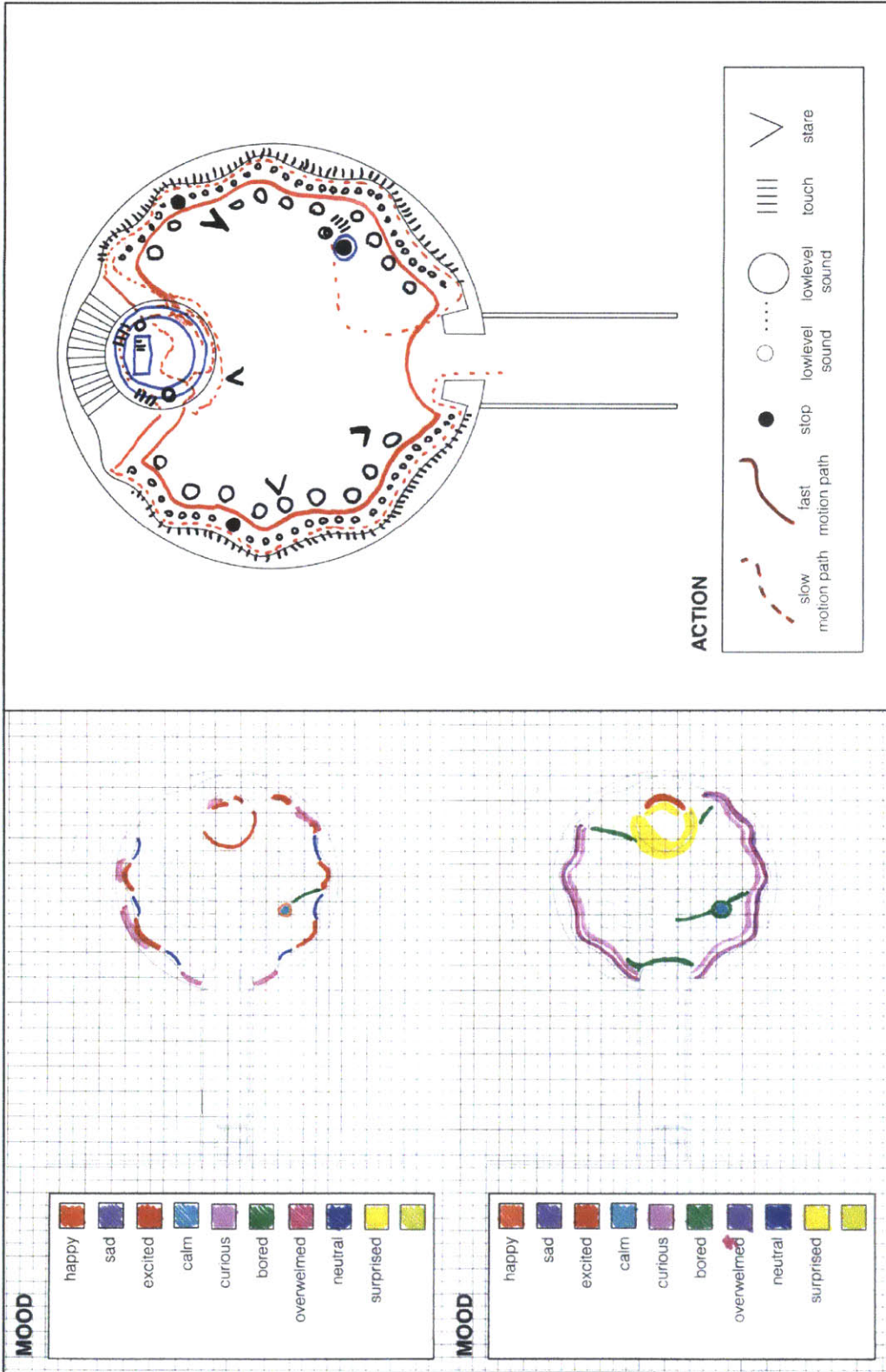
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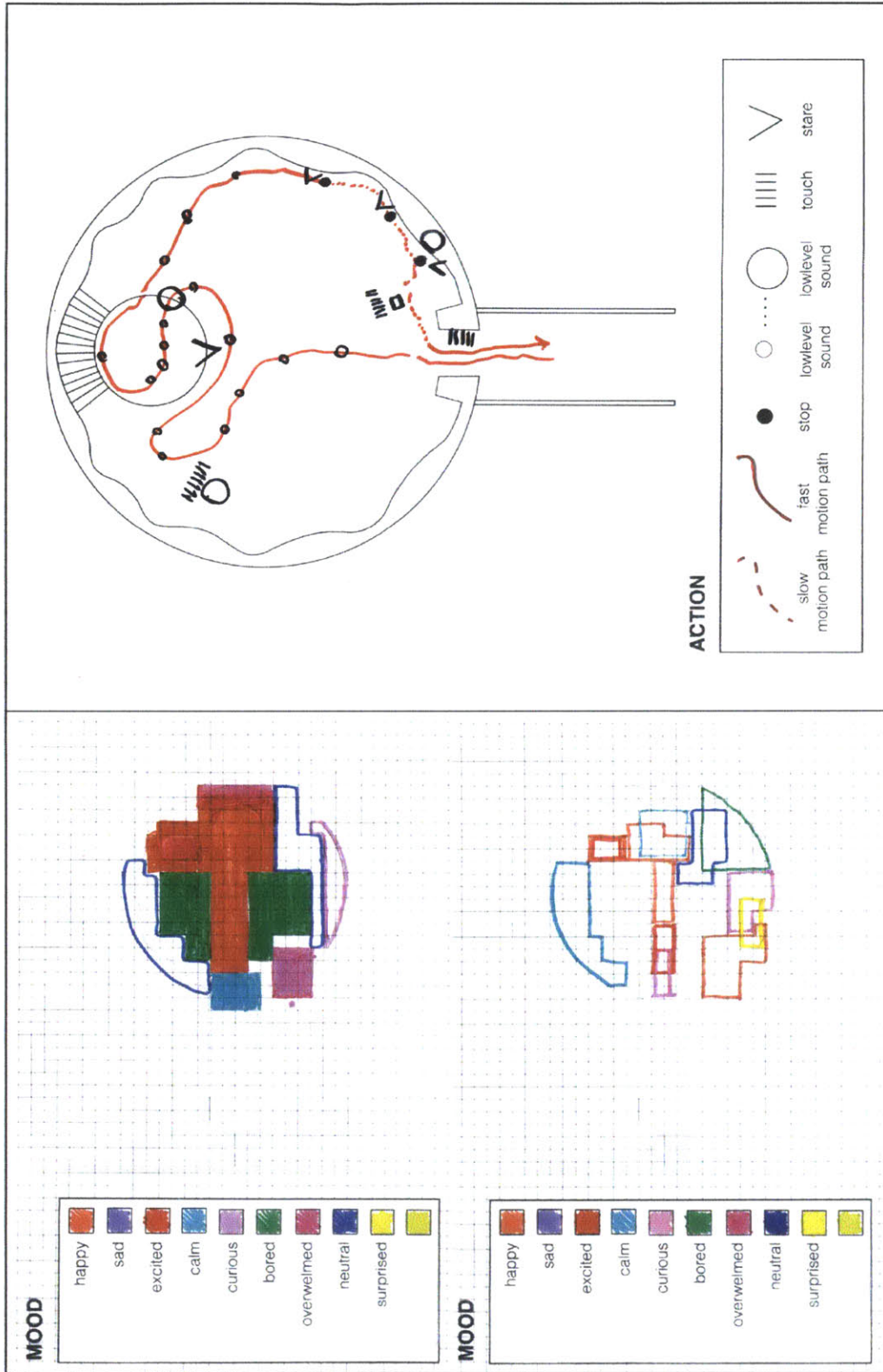
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