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Interior Architectural Facades: A Study into the Visual Impact on Emotional Experience

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INTERIOR ARCHITECTURAL FACADES:

A STUDY INTO THE VISUAL IMPACT ON EMOTIONAL EXPERIENCE

INTERIOR ARCHITECTURAL FACADES: A STUDY INTO THE
VISUAL IMPACT ON EMOTIONAL EXPERIENCE
by

Bailey Gocke

A Design Thesis
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CONTENTS

INTRODUCTION

"Design is the first signal of human intention." - William McDonough

Most theories describe emotion as a process whereby the body receives some stimulus in an environment, interpreting that stimulus and then producing a bodily response- or emotions. Emotions are our way of surviving our environments- they are our reactions to our interpretations. The key to all theories developed through disciplines and movements is the interpretation, this is what helps determine what reaction- or emotion- the user feels. We as designers can begin to control these interpretations and the reactions that the user has. Architectural facades- both interior and exterior- play a critical role in shaping the experience of a building- they are the first point of contact for users and offer claim the role of creating a lasting impression. Despite the importance placed on them, there is limited research into the incorporation of emotion research and architecture; and even less research into the study of facades and emotion. This thesis seeks to contribute to the knowledge behind the emotional impact that interior façade conditions have on the user.

To address this critical need, this thesis will investigate the interior visual impact of architectural facades on emotional experience based upon four parameters- pattern predictability, scale of pattern, degree of detail, and visibility of an image- through the development and implementation of an experiment process, set up and analysis. This study will expand the knowledge base behind both façade and emotion research in the design field. This will be accomplished through the use of VR testing spaces and EEG brainwave scans. This combination of technology is utilized within the sciences, but hasn't been expanded into the design fields until 2015.

At the completion of this project, a methodology and workflow will be developed for how to design, test, and study the emotional impact that an interior façade condition has on the user; as well as a data analysis strategy that can be incorporated into additional research. Results from the parameters tested will also be used to begin a "rule-of-thumb" collection to be utilized in addition to results already found through studies done previously- such as color, geometry, and lighting.

THESIS QUESTION:

How does the interior visual experience of architectural facades impact emotions?
How might pattern predictability, scale of pattern, degree of detail, and legibility of images impact emotion?

RESEARCH

Emotions play a fundamental role in human experiences, influencing our perceptions, behaviors, and overall well-being. The study of emotion is one that has been influenced through various academic disciplines, including cognitive science, environmental psychology, and the allied design arts. These fields have individually contributed to our understanding of how the built environment can evoke these emotional reactions.

COGNITIVE SCIENCE:

The discipline of Cognitive Science began with the shift in psychology towards the cognitive paradigm in the 1850's. This shift emphasized the role of mental processes in understanding human behavior and experience- rather than the behaviorist perspective that looked at the observable behavior. In the late 1890's, two psychologists- William James and Carl Lange- proposed the theory that emotions arise because of physiological changes in the body; these changes- such as increased heart rate, sweating, or trembling- generate the experience of emotion, otherwise known as our interpretation of bodily sensations. On the other hand, at around the same time, Walter Cannon and Philip Bard proposed an opposing theory that suggested that physiological responses and emotional experiences occur simultaneously and independently. These two theories continue to compete as we learn more about the complexities of emotions and physiological responses. In the 1970's, information-processing models emerged as the dominant framework within the study of how emotional stimuli is process, stored, and retrieved. One prominent model is facial expression models- these models identified universal facial expressions for emotions such as happiness, sadness, anger and fear. This is a model that is continually added to through additional research. The most recent research into emotion came in the 2000's- when computational models and animations came into play. The ability to study images of the brain through fMRI and PET scans continue to be used to further study how we interpret and understand emotion.

ENVIRONMENTAL PSYCHOLOGY

Environmental psychology began officially in 1965, when the American Psychological Association established the division. However, prior to this in 1911, psychologist Willy Hellpach began studying the impact of different environmental stimuli, such as color and form, on human activities like movement, mood, and overall engagement with their surroundings. In the 1960's, James Gibson influenced the study of emotion as stated by the cognitive sciences, by highlighting the role that the environment has in eliciting emotional responses and shaping perceptual experiences. This approach developed by Gibson influenced multiple movements within other disciplines- such as biophilic design. Late in the 1980's, the Environmental Stress and Coping Theory was introduced. This explored how environmental factors can induce stress and impact emotional well-being. This theory emphasized the importance of studying emotional responses to environmental stressors. Also in the 80's, the Attention Restoration Theory was introduced by Rachel and Stephen Kaplan. This theory explored the impact of natural environments on attention and cognitive functioning. This theory was expanded upon by Kaplan and Kaplan in the 1990's- this time title the Restorative Environment Theory. Restorative environments are natural or designed spaces that promote psychological restoration and reduce stress. This research has demonstrated the impact that exposure to restorative environments can have positive impact on emotions- leading to increased relaxation and improved mood.

ALLIED ARTS

The Allied arts have been contributing to the study of emotion since the 1750's when Edmund Burke plotted a new course for aesthetic theory. He contended that the emotions aroused by beauty and sublimity had nothing to do with numerical proportions or harmonic ratios, but rather with the relaxation and tensioning of the optic nerve. In 1873, Robert Vischer coined the term the define the process of neural modification- empathy- which is active process by which we "feel" ourselves into or neurologically simulate objects of artistic contemplation. Heinrich Wolfflin's 1886 dissertation opened with the question, "How is it possible that architectural forms are able to invoke emotion or mood?" Further studies and writings of this question came later- in 1954, Richard Neutra wrote the book Survival through Design- which urged architects to incorporate "current organic research and brain physiology" into their designs. In 1984, the concept of biophilic design was introduce by E.O. Wilson- and has been further developed through multiple design disciplines throughout the years. In the 1990's and 2000's, the Evidence-Based Design Movements as well as the User-Centered Design Movements were recognized and gained popularity.

EEG & VR PRECEDENTS:

In the field of affective computing in virtual reality, this study aimed to integrate technology components and apply them to the built environment. The researchers used participant's heartbeat dynamics and brainwaves to identify emotional output and correlate it with physical signs. The study focused on the parameters of illumination, color, and geometry. Regarding color, the study found that warm-tone colors were associated with high arousal, while cool colors were associated with low arousal, aligning with color theory principles. Geometry modifications focused on curvature, assuming that curved spaces generate a more positive valence level compared to angular spaces.

The study concluded that rooms 1, 2, and 4 aligned with the intended design goals, while room 3 had an arousal level that hovered between quadrant 2 and 3, suggesting an imbalance. Additionally, the paper confirmed previous findings that EEG-based inference of emotions achieved an accuracy rate of approximately 70-71%.

Another paper reviewed 30 research papers and journals on emotion recognition using EEG. It highlighted the prevalence of virtual reality as a tool for studying emotions. The study also found that the optimal time intervals for stimulus presentation ranged from 15 seconds to 1 minute for pictures and 30 seconds for videos. Longer durations of 1 to 1.5 minutes yielded more accurate and nuanced emotional responses, reducing extreme reactions. This highlighted the importance of sufficient interaction time with the stimulus.

The VR-specific studies explored parameters such as color, lighting, aspect ratio, and ceiling height. Some studies also examined how the placement of sensors on the skull influenced emotion recognition software, focusing on four specific sensors located on the frontal lobes and pre-frontal cortex of the brain.
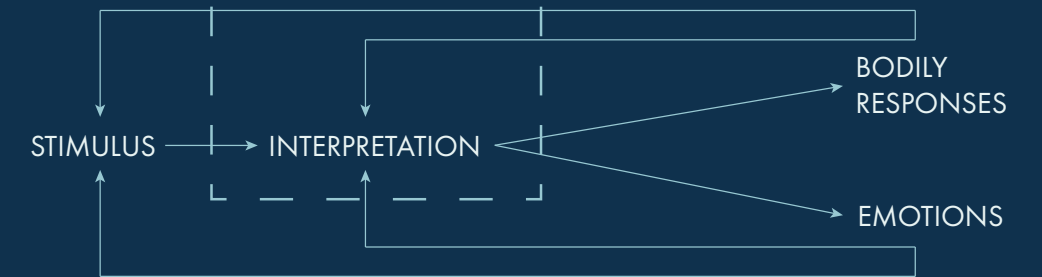
CENTRAL   STIMULUS → INTERPRETATION → EMOTIONS → BODILY RESPONSES

PARALLEL   STIMULUS → INTERPRETATION ← BODILY RESPONSES / EMOTIONS

PERIPHERAL   STIMULUS → INTERPRETATION → BODILY RESPONSES → EMOTIONS

COGNITIVE   STIMULUS → INTERPRETATION ← BODILY RESPONSES / EMOTIONS

Most theories describe emotion as a process whereby the body receives some stimulus in an environment, interpreting that stimulus and then producing bodily responses- or emotions. Emotions are our way of surviving our environments- they are reactions to our interpretations. The key to all these theories is interpretation- otherwise there is just a stimulus and no judgement is given on that stimulus by the body, and thus no emotion.

Timeline axis: 1750 — 1800 — 1850 — 1900 — 1950 — 2000 — Present

Allied Arts

1757: Burke plotted new course for aesthetic theory

1873: Term "Empathy" was coined

1886: Wolfflin's dissertation opened with question about emotion

1954: Survival through Design was written

1984: Concept of Biophilic Design introduced.

1990's: Evidence-Based Design Movement began

2000's: User-Centered Design recognized in design fields

2003: U.S. ANFA founded

Cognitive Science

1850's: Cognitive Revolution

1890's: James-Lange and Cannon-Bard Theory

1960's: Information Processing Models emerged

1970's: Facial Expression Research began

1988: Cognitive Neuroscience was established

1990's: Implicit Cognition was recognized

2000's: Beginning of Computational model research

2000's: Neuroimaging studies on Emotion Regulation began

Environmental Psychology

1911: Hellpach studied impact of environmental stimuli

1960's: Gibson's Ecological Approach

1965: APA established Environmental Psychology

1980's: Kaplan and Kaplan introduce Attention Restoration Theory

1980's: Environmental Stress and Coping Theory

1990's: Study of Restorative Environments began

Legend:
- Allied Arts
- Cognitive Science
- Environmental Psychology

METHODOLOGY

This thesis is seeking to contribute knowledge about the emotional impact that architectural facades have on the user. This knowledge will then be incorporated into a workflow that allows for designs to be created and tested within the experimental setup created during this phase of this thesis.

After gaining approval from the IRB council to use human participants within my thesis, I am utilizing students within Architecture Hall- all above the age of 19. To determine the participant pool size, I ran a power analysis- and found that I would need 20 students. To be on the safe side, I recruited 24 students, so I had the ability to throw 4 out if necessary due to issues during the testing process. To participate within the study, each student is required to fill out and sign the consent form stamped by the UNL IRB council. Finally, students will fill out a demographics questionnaire with basic information.

UNIVERSITY OF
Nebraska
Lincoln _____

We are asking you to participate in a research study. This form is designed to give you information about this study. We will describe this study to you and answer any of your questions.

Project Title: The Impacts of Architecture Facades on Emotion

Principal Investigator: Bailey Gocke
                                     Graduate Student- College of Architecture
                                     Email: bailey.gocke@huskers.unl.edu

Faculty Advisor: David Newton
                              Assistant Professor- College of Architecture
                              Email: david.newton@unl.edu

<u>KEY INFORMATION</u>

Provided is a short summary of this study to help you decide whether you want to participate. More detailed information is listed later in this form.

- The purpose of the research is to contribute to the knowledge behind the emotional impact that architectural facades have on the user.

- You will be asked to sit within a Virtual Reality environment and interact with the space itself.

- Participants must be 19 years or older to participate within this research study.

- Your participation in the study is expected to take 45 minutes on 3 separate days.

- There is risk of motion sickness and nausea while participating within the study- specifically while within the Virtual Reality environment.

- Your participation in this research is voluntary.

What the study is about
The purpose of the research is to contribute to the knowledge behind the emotional impact that architectural facades have on the user. The thesis question I am approaching is how do architectural facades impact emotions; more specifically, how might stick glazing systems be modulated for emotional impact? Why focus on stick glazing? With the innovation of technology, the ability to make more visually complex patterns has become easier. This thesis is seeking to contribute the knowledge behind the emotional impact that architectural facades have on the user; Additionally, a methodology will be developed based upon this research for how to apply this knowledge.

Page 1 of 3

Last Updated: January 23, 2023

IRB# 20230122513EP
Date Approved: 01/25/2023

What we will ask you to do
We will ask you to first complete a demographics survey as a way of identifying any outliers within the research results based upon the answers given within the survey. Once this survey is completed, we will ask you to sit within a Virtual Reality environment that consists of a glass pavilion. You will be within the pavilion for 45 seconds to allow for peak reaction time to occur and then you will be asked and shown a survey for an oral confirmation of what you are feeling within that space. This process will continue through a series of rooms, but the routine of the research will remain the same throughout. To make the above task happen, you will be fitted with both a VR helmet and an Emotiv EEG brain scan. Emotiv measures brainwaves and signals in real time, showing visually what pieces of your brain are currently active. We will be looking at how much excitement and interest your brain is showing in relation to a specific architectural façade. These levels will be tracked in relation to a baseline that will be gathered at the beginning of the testing phase. The baseline in this study is, for 45 seconds each, the participant sitting with their eyes open looking at a white wall and then eyes closed.

Emotiv headset placement

Risks and discomforts
While participating within this research study, the participant may experience feelings of nausea or motion sickness. This will most likely occur during the Virtual Reality portion of the study. This is a known risk while using Virtual Reality, and the participant can ask for a break during any portion of the study.

Privacy/Confidentiality
Confidentiality of records, both EEG data and personal information, will be de-identified to preserve confidentiality of the participant. This will be done by assigning an ID number to each participant at the beginning of the process. Any identifiable information will be secured on password-protected computers within a password-protected Excel file.
Please note that email communication is neither private nor secure. Though [I am/we are] taking precautions to protect your privacy, you should be aware that information sent through e-mail could be read by a third party.

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Last Updated: January 23, 2023

IRB# 20230122513EP
Date Approved: 01/25/2023

Data Sharing
De-identified data from this study may be shared with the research community at large to advance science and health. We will remove or code any personal information that could identify you before files are shared with other researchers to ensure that, by current scientific standards and known methods, no one will be able to identify you from the information we share. Despite these measures, we cannot guarantee anonymity of your personal data.

Taking part is voluntary
Your participation is voluntary. You may refuse to participate before the study begins or discontinue your participation at any time during or after the study.

Withdrawal by investigator, physician, or sponsor
The investigators may stop the study or take you out of the study at any time should they judge that it is in your best interest to do so or if you do not comply with the study plan. They may remove you from the study for various other administrative and medical reasons. They can do this without your consent.

If you have questions
The main researcher conducting this study is Bailey Gocke, a graduate student at the University of Nebraska-Lincoln. Please ask any questions you have now. If you have questions later, you may contact Bailey Gocke at bailey.gocke@huskers.unl.edu. If you have any questions or concerns regarding your rights as a subject in this study, you may contact the Institutional Review Board (IRB) for Human Participants at 402-472-6965 or access their website at UNL | IRB/Human Subjects Research | Research Compliance Services.

You will be given a copy of this form to keep for your records.

Statement of Consent
I have read the above information and have received answers to any questions I asked. I consent to take part in the study.

Your Signature_____ Date_____

Your Name (printed)_____

Signature of person obtaining consent_____ Date_____

Printed name of person obtaining consent_____

This consent form will be kept by the researcher for five years beyond the end of the study.

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Research on the use of EEG and VR to study emotion-specifically in architectural spaces- has yielded some important insights through history. EEG data has been utilized to correlate emotional responses with brainwave patterns, which has provided more objective assessments of emotional experiences within the architectural environments. VR allows for the creation of controlled and immersive environments where researchers can manipulate architectural features and observe real-time emotional responses.
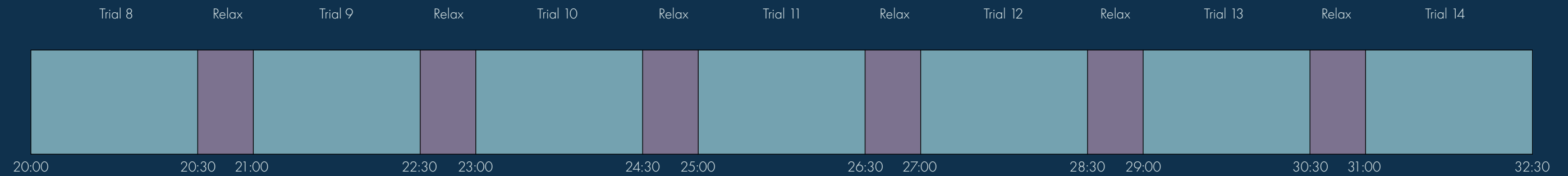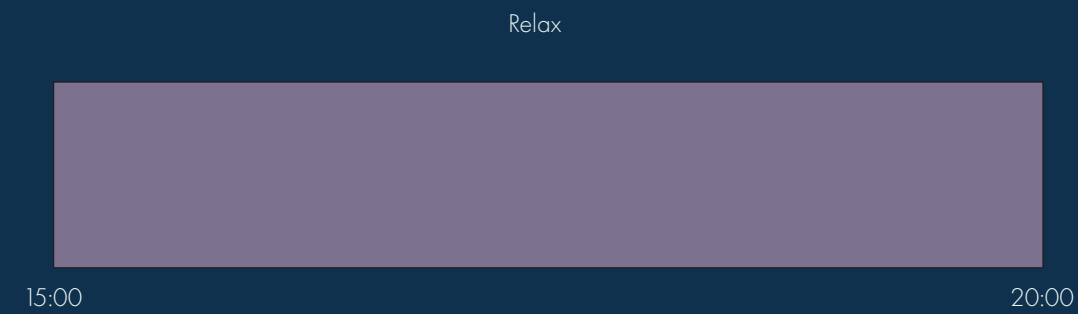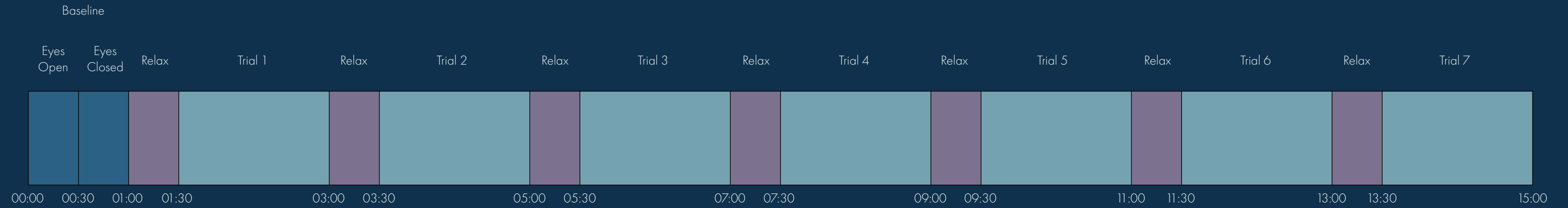
LIMITATIONS:

There are limitations with the technology that I am using. For example EEG can only infer emotions based upon previous research. This means that I cannot definitively say that the user is feeling 1 specific emotion. Additionally, the methodology that I am exploring only takes into account the brainwaves of the participant- I am not studying or taking into account the known signs associated with emotions like heart rate, skin temperature and breathing patterns. The other limitation that I am taking into consideration is the noise artifacts, or other environmental triggers- within my testing space. I cannot control every possible environmental factor, so I tried to find the quietest place I could.

Within the VR environment the biggest limitation is that I cannot simulate every aspect- such as the feeling of daylight on the face- however I have found previous research that found that you don't need to simulate everything if it is visually see it.

50'-0"

40'-0"

24'-0"

60°

12'-0"

5'-0"
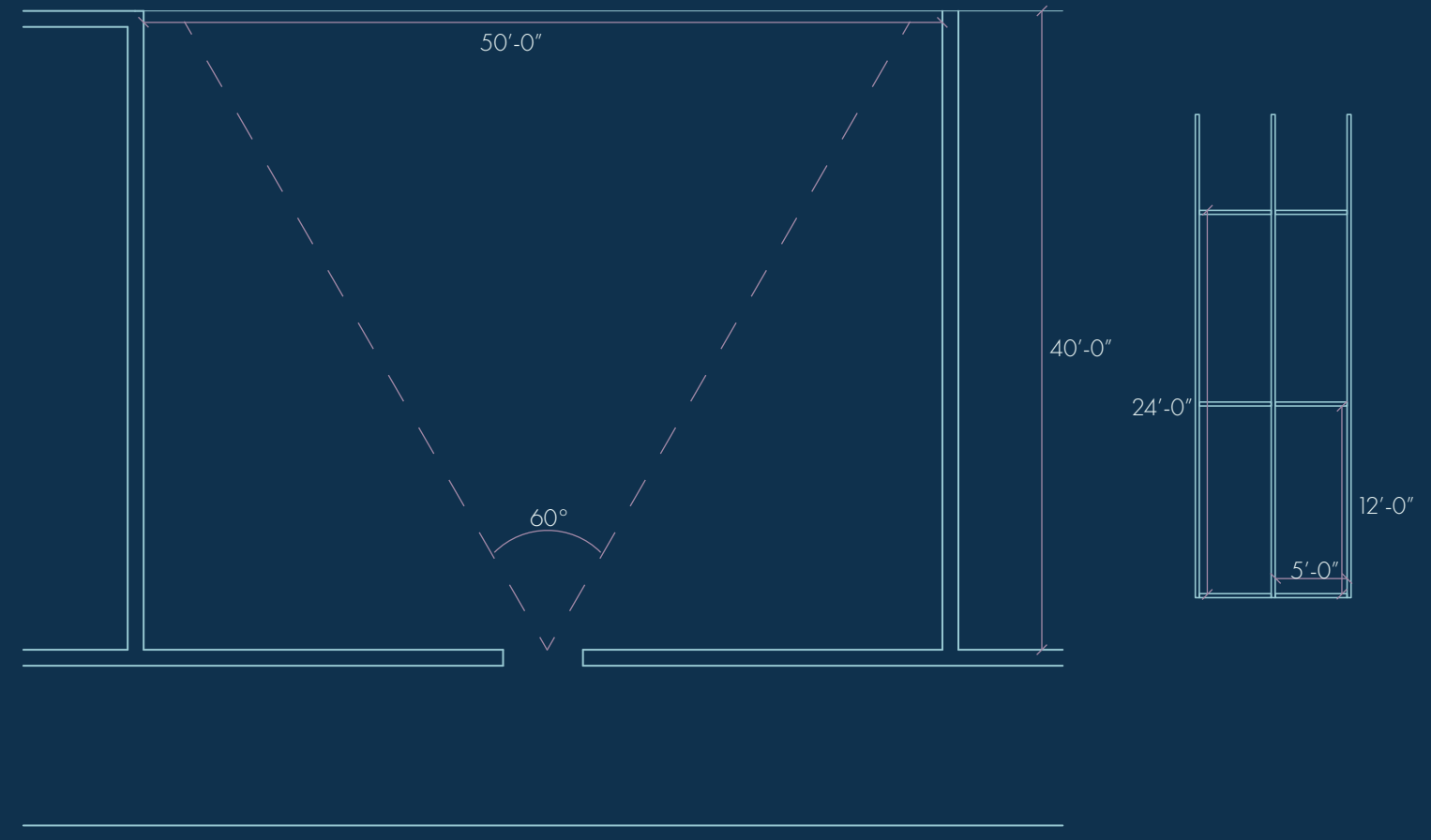
The testing environment is set up to be part of a low-rise mixed use building. This gave me a basic floor plate dimensions to begin setting up each testing space- in this case 40' depth and a 24' height. From there the rest of the floor plan was based upon rules of thumb- so a 60 degree eyesight line, which informed the 50' façade.

Baseline

| Eyes Open | Eyes Closed | Relax | Trial 1 | Relax | Trial 2 | Relax | Trial 3 | Relax | Trial 4 | Relax | Trial 5 | Relax | Trial 6 | Relax | Trial 7 |

00:00 00:30 01:00 01:30 03:00 03:30 05:00 05:30 07:00 07:30 09:00 09:30 11:00 11:30 13:00 13:30 15:00

Relax

15:00 20:00

| Trial 8 | Relax | Trial 9 | Relax | Trial 10 | Relax | Trial 11 | Relax | Trial 12 | Relax | Trial 13 | Relax | Trial 14 |

20:00 20:30 21:00 22:30 23:00 24:30 25:00 26:30 27:00 28:30 29:00 30:30 31:00 32:30

The testing experiment begins with taking a baseline of the participant- this is done for 30 seconds with eyes open, and then 30 seconds with eyes closed. This gives me an average to base reactions off of as the participant goes through the testing spaces. Once the baseline has been taken, the participant walks down the hallway- which lasts for 30 seconds between each room. For the timing of the testing- the participant will be in the room for 1:30 total, but during that time I will be prompting them to move around, whether it be closer or further from the façade.

Participant Questionnaire
Name: _____
Age: _____
Gender: _____
Ethnicity: _____
Hometown: _____
Major: _____
Year: _____
How much sleep have you got this week? _____

Date :

Admin:
Test Start Time: _____   End:_____

Arousal

II

I

Valence

III

IV
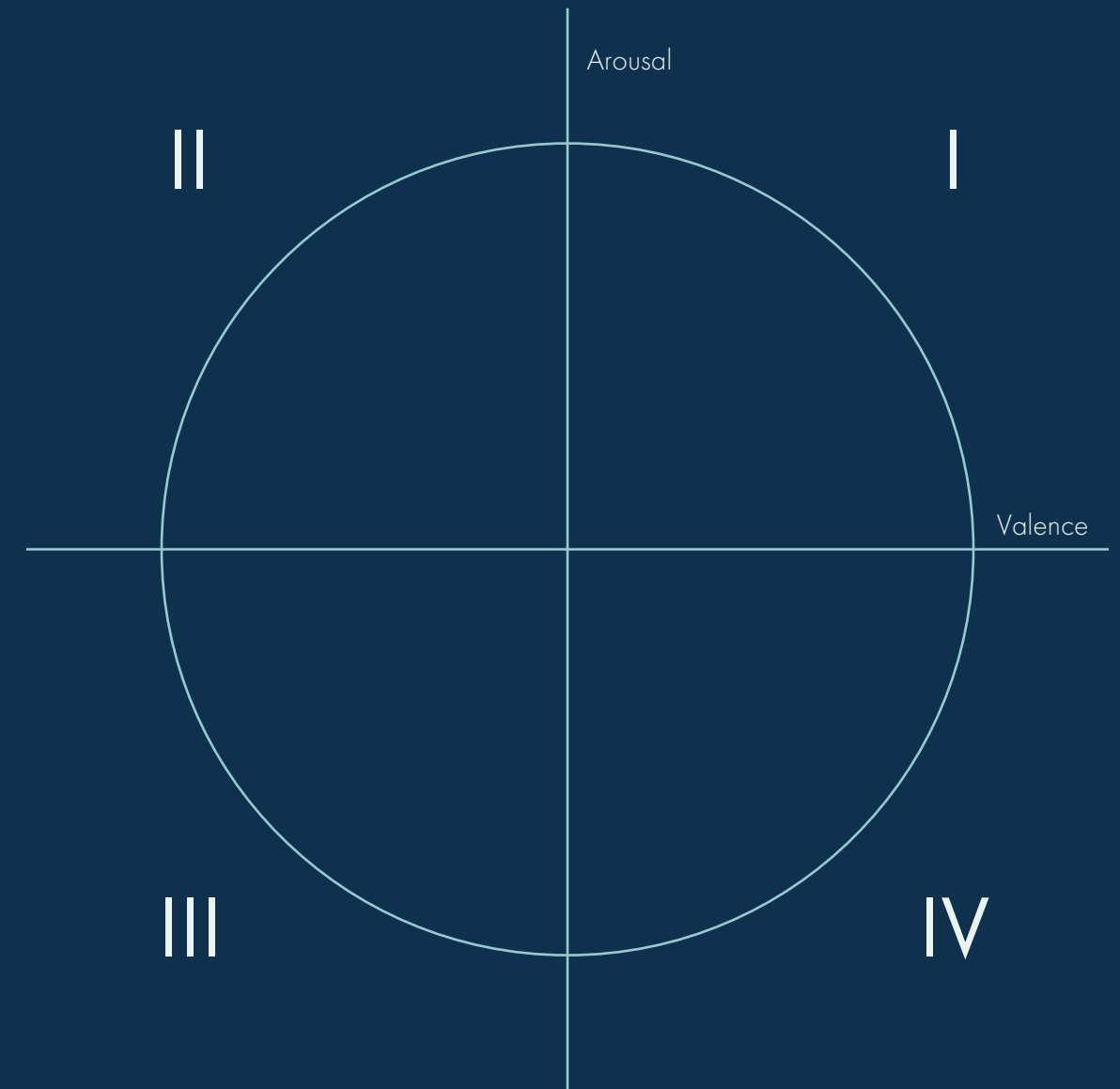
As part of the IRB process, I was required to have all personal information gathered from the participant in a printed form formate. These basic demographic questions will be used to begin to rule out any outliers within the data process- or be used to conclude why a certain result is happening.

EEG and emotion research has classified outputs based upon the above graph. Arousal refers to the intensity of the emotion felt- or the strength of the associated emotional state. Valence describes the extent to which an emotion is positive or negative. During the testing, I ask participants to rank themselves on this chart.

Initial Pattern Hypothesis: In architectural façade conditions, based upon traditional practices, how does the predictability of the pattern affect the user- at what level does this begin to appear?
I developed 4 facades to test this hypothesis- each looked at a different combination of local or global recognition of pattern. The local pattern looks at the immediate surrounding shapes, while the global pattern looks at the entire façade as a whole.

   1: can be identified both locally and globally.
   2: can be identified globally, but not locally.
   3: cannot be identified locally or globally.
   4: organic pattern with no recognizability.
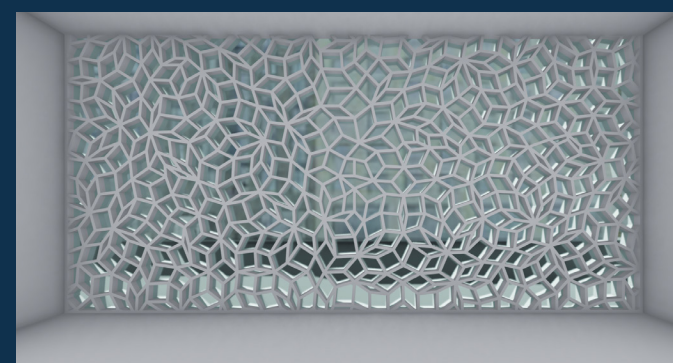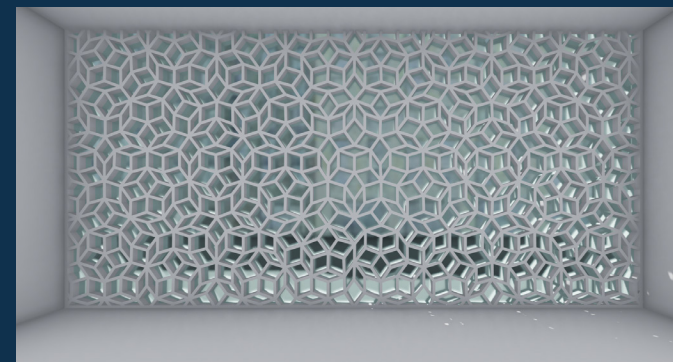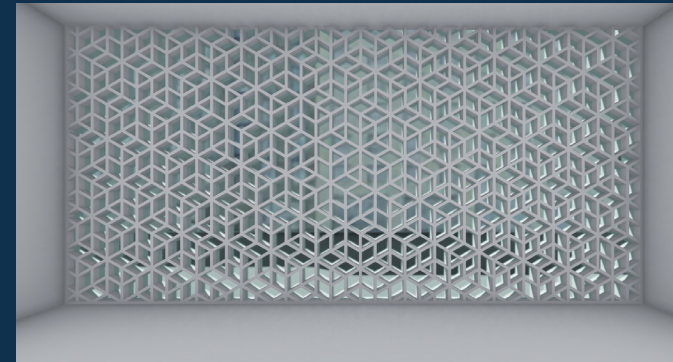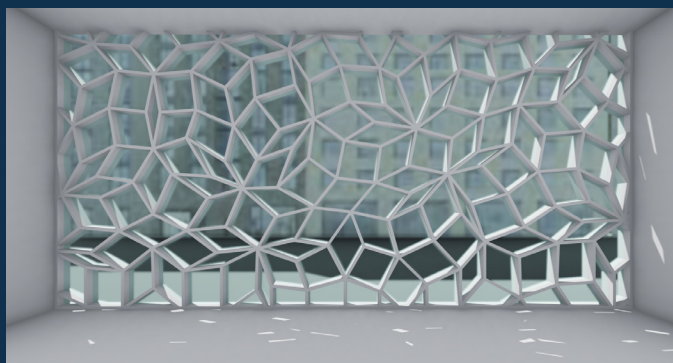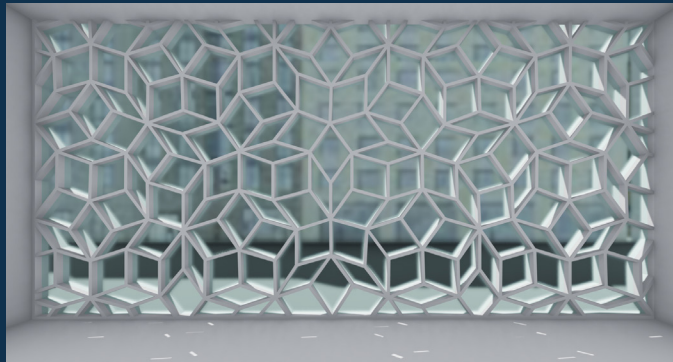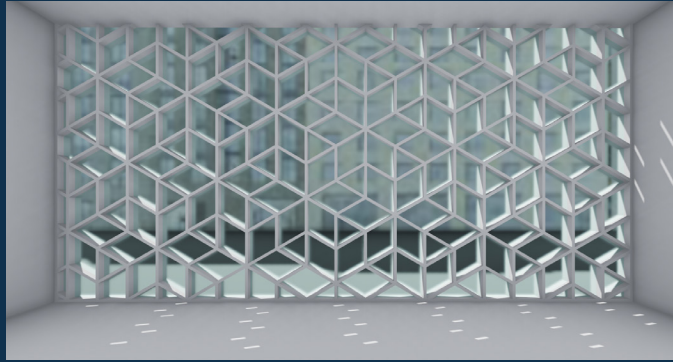
Initial Scale Hypothesis: In architectural façade conditions, based upon traditional practices does the scale of a pattern alter our perception of the predictability of a pattern?
 • I took three of the pattern façade systems developed, and scaled them down by ½. This gave me three additional data sets to study to determine if the scale does in fact make a difference- or if it is going to overwhelm the participant.

Initial Imagery Hypothesis: In architectural façade conditions, based upon traditional practices, can the participant identify the image, what level does this happen at? Does the final image (full image) elicit the same reactions as the original image does?
Three facades were developed for this hypothesis-each increasing the visibility and clarity of the image.
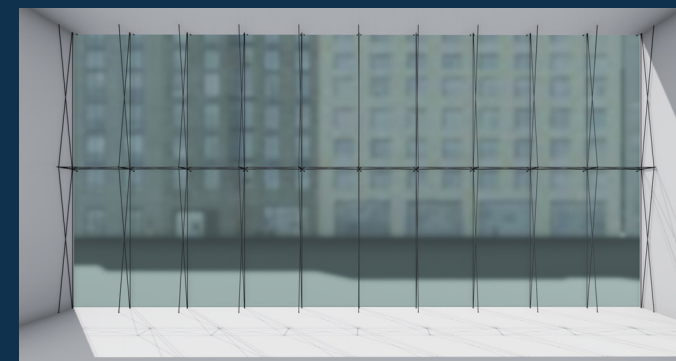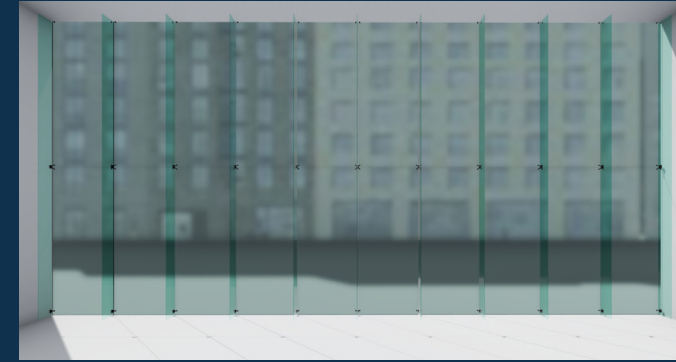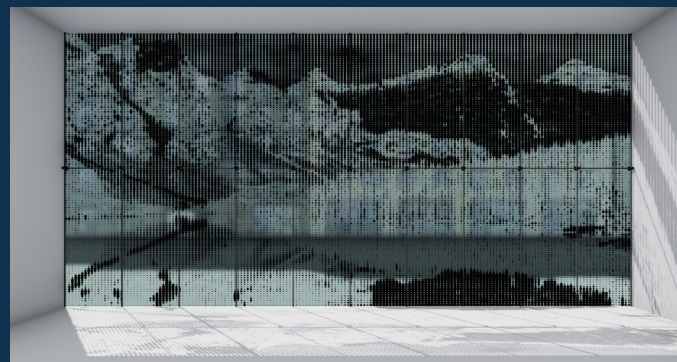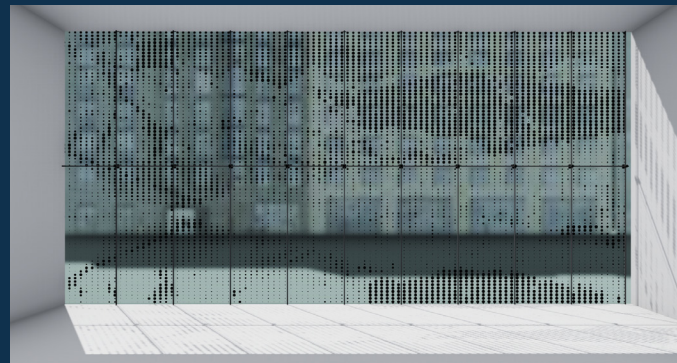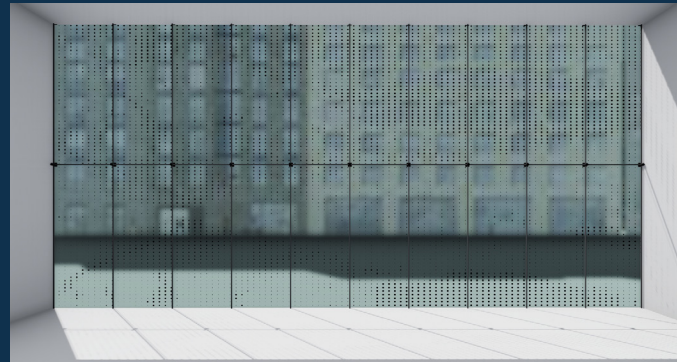
Initial Detail Hypothesis: How does the level of detail in the façade structure impact the users perception of the testing space, does this have an impact at all? This hypothesis was developed to serve as a baseline for myself to determine if my participants were actually noticing detail, or if they were looking at the patterning and images.
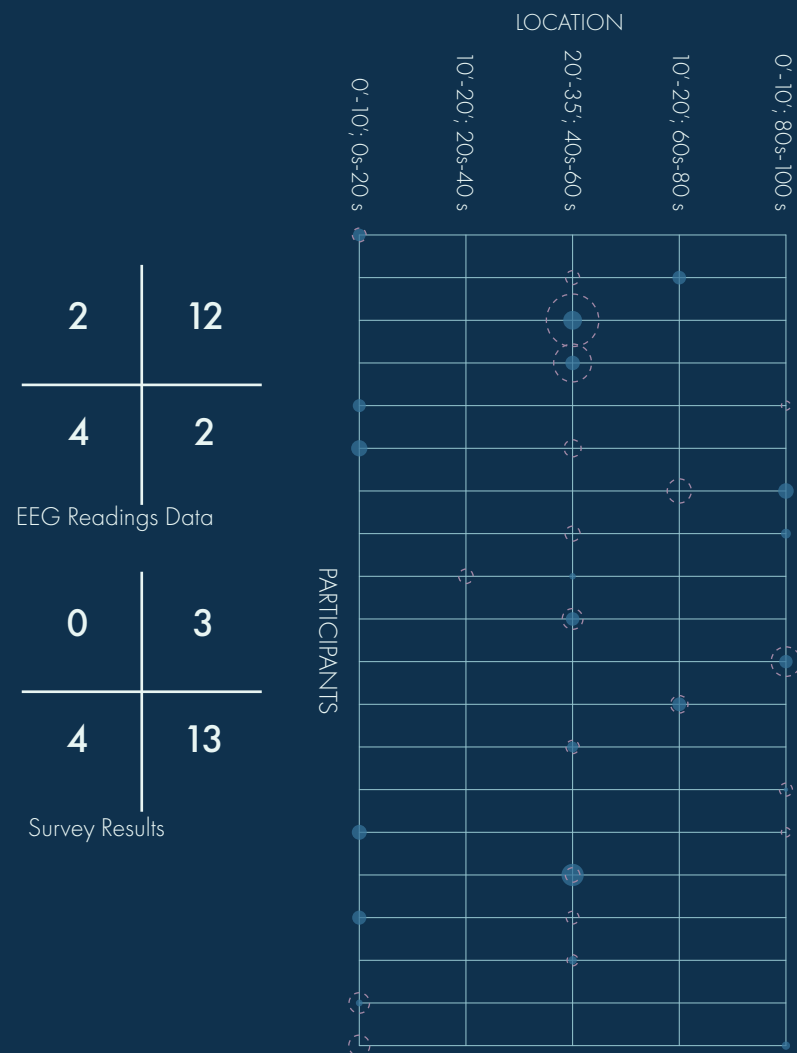
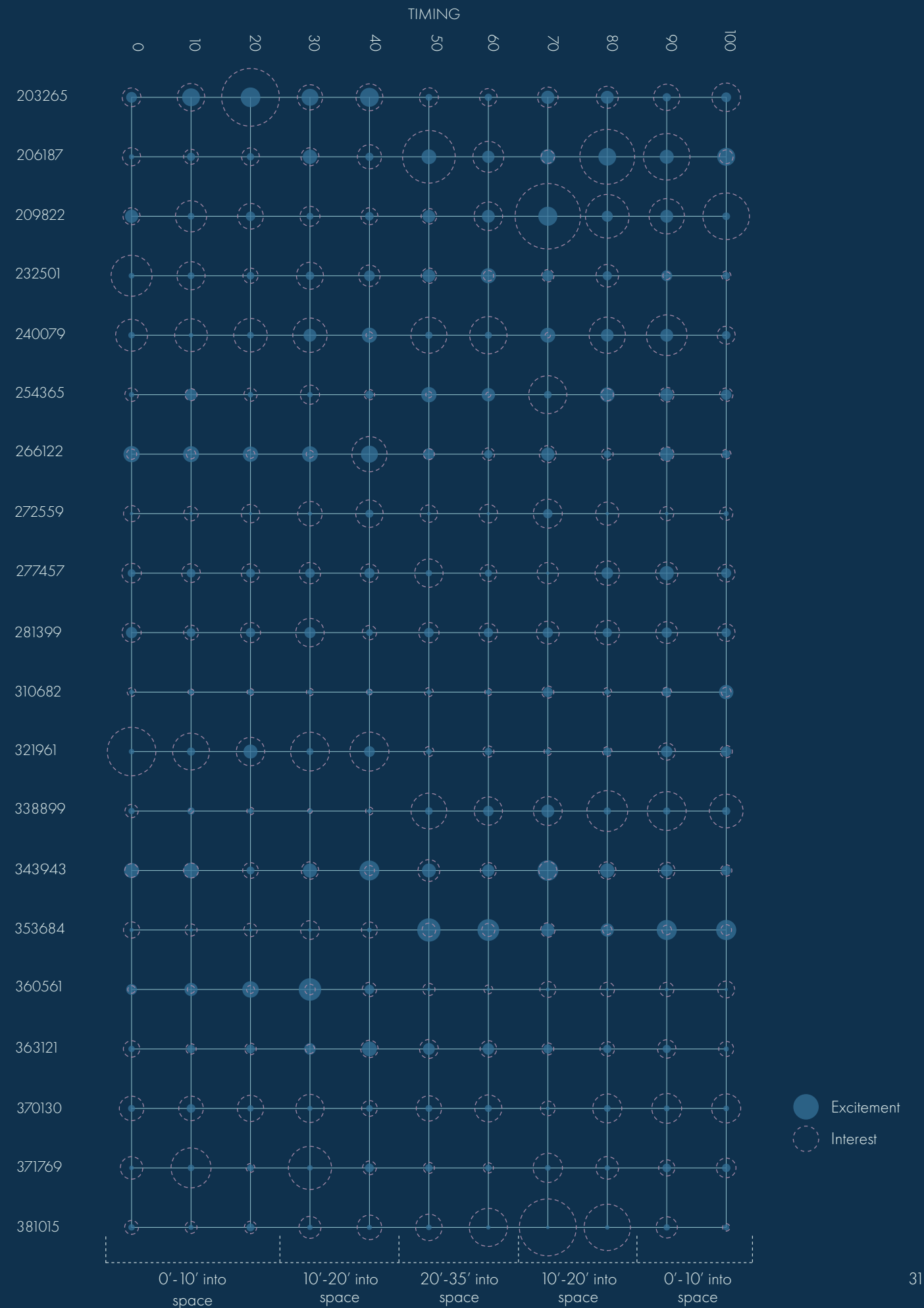RESULTS
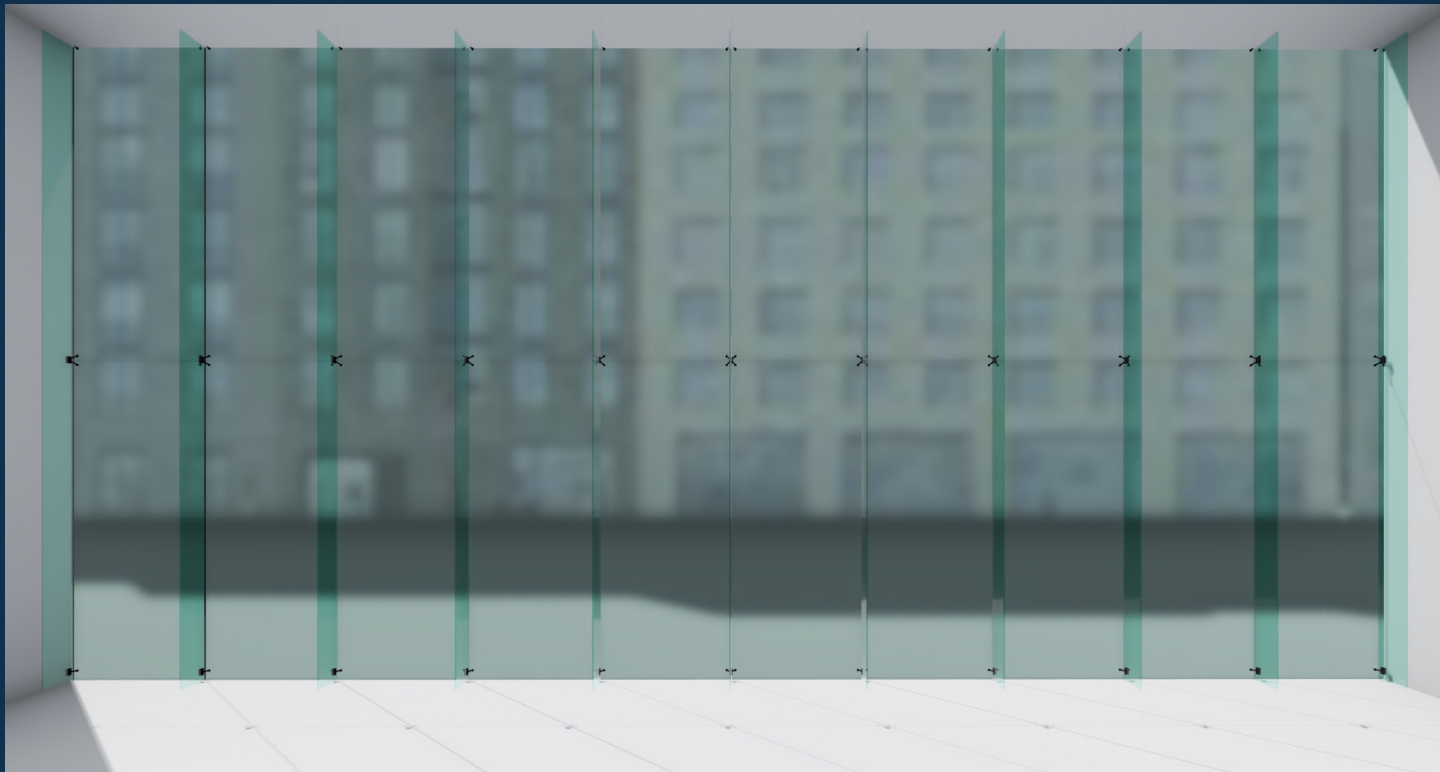
Elevation

Conclusions:

The first facade looks at the structural detail of the digital space- this system is a glass fin mullion system. This façade was found to be within the positive valence side of the circle- this means an overall positive emotion was felt by the user within this space. Over 50% of the participants experienced a spike in either their valence or arousal levels when closest to the façade. Overall the average valence and arousal levels of the participants was slightly elevated- but no participant doubled their baseline levels.

When looking at the peak differential, the peaks seem to be relatively mild when comparing to the average differential. However, when comparing these values as a percentage- the peaks are exponentially bigger- with the largest peak being over 300% of the baseline.

Overall, this space promotes positive emotions that aren't overtly intense for the user- and can/should be utilized in the everyday setting.

2	12
4	2

EEG Readings Data

0	3
4	13

Survey Results

LOCATION

PARTICIPANTS

TIMING

PARTICIPANTS

203265
206187
209822
232501
240079
254365
266122
272559
277457
281399
310682
321961
338899
343943
353684
360561
363121
370130
371769
381015

0'-10' into space
10'-20' into space
20'-35' into space
10'-20' into space
0'-10' into space

Excitement
Interest

DIFFERENTIATION

PARTICIPANTS

-7 0 7 14 21 28 35 42 49 56 63

203265
206187
209822
232501
240079
254365
266122
272559
277457
281399
310682
321961
338899
343943
353684
360561
363121
370130
371769
381015

○ Base Excitement
○ Ave. Excitement
○ Peak Excitement
○ Base Interest
○ Ave. Interest
○ Peak Interest

PERCENTAGE CHANGE

PARTICIPANTS

-70 0 70 140 210 280 350 420 490 560 630

203265
206187
209822
232501
240079
254365
266122
272559
277457
281399
310682
321961
338899
343943
353684
360561
363121
370130
371769
381015

○ Base Excitement
○ Ave. Excitement
○ Peak Excitement
○ Base Interest
○ Ave. Interest
○ Peak Interest
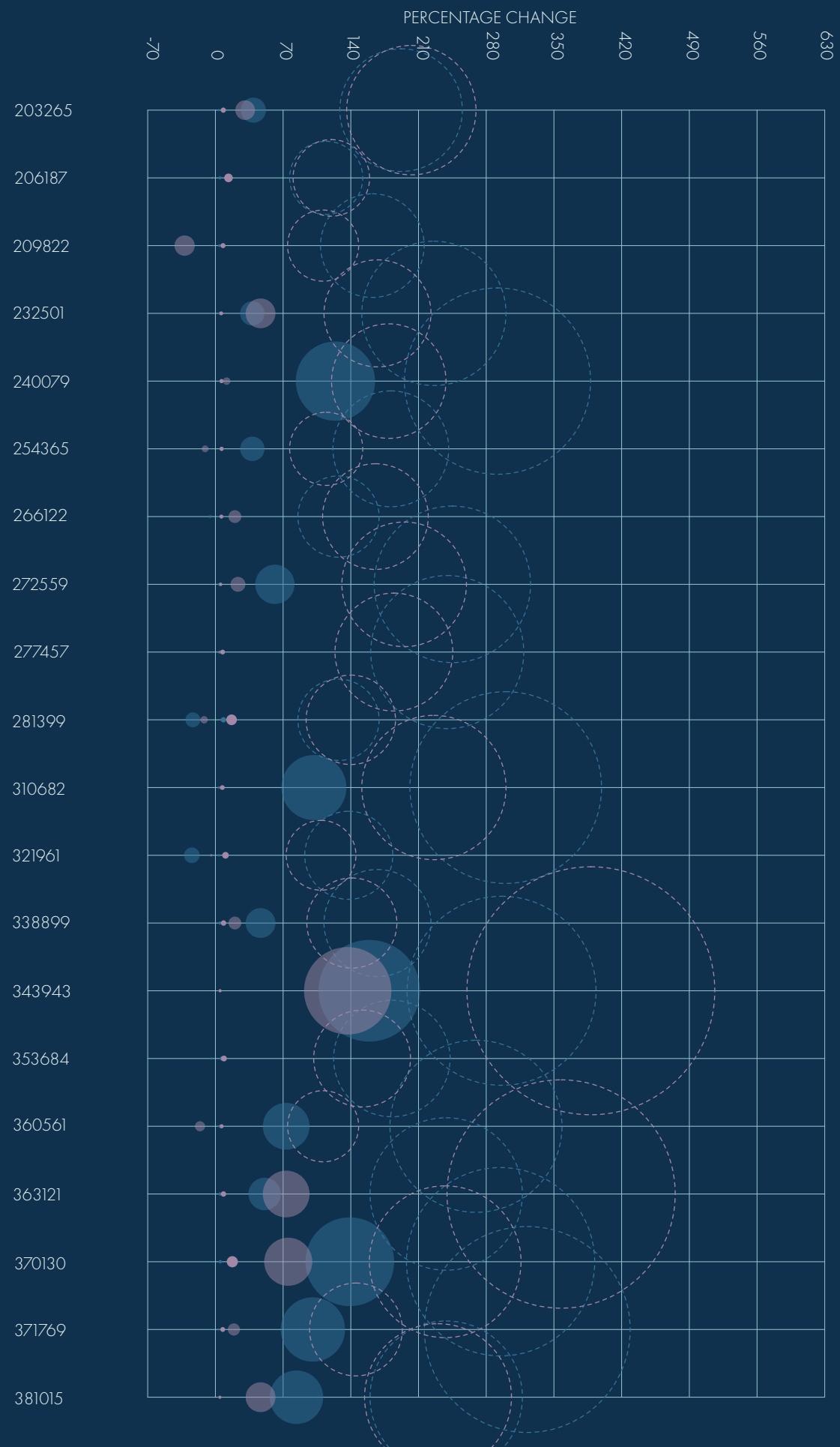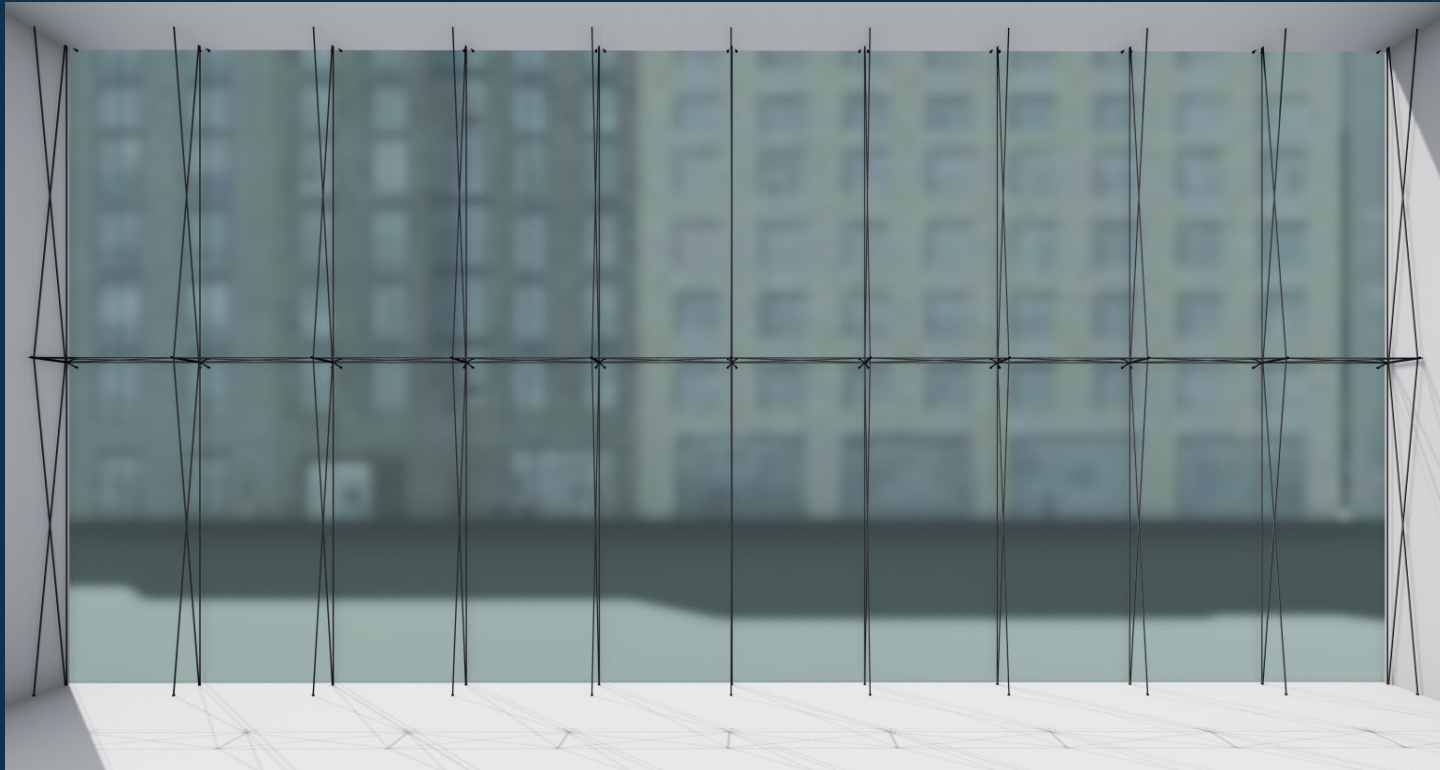
Elevation

Conclusions:

The second façade looks at the structural detail of the digital space- this system is a cable truss system. This façade was found to be on the high arousal side of the circle- meaning that emotions felt here are more intense, whether they are positive or negative. Peaks for both valence and arousal were experienced mainly at the furthest and closest points to the façade. Overall, the average valence and arousal levels of the participants were slightly elevated- no participant doubled their baseline levels. When looking at the peak differential, the peaks seem to be relatively mild when comparing to the average differential. However, when comparing these values as a percentage- the peaks are exponentially bigger- with the largest peak being over 500% of the baseline.

Overall this space promotes intense emotions from the user- and can be utilized in the everyday setting, but should be utilized in settings that can handle and accommodate for these more intense emotions.

4	13
3	0

EEG Readings Data

10	2
3	5

Survey Results

LOCATION

PARTICIPANTS

TIMING

PARTICIPANTS

- Excitement
- Interest

0'-10' into space   10'-20' into space   20'-35' into space   10'-20' into space   0'-10' into space

DIFFERENTIATION

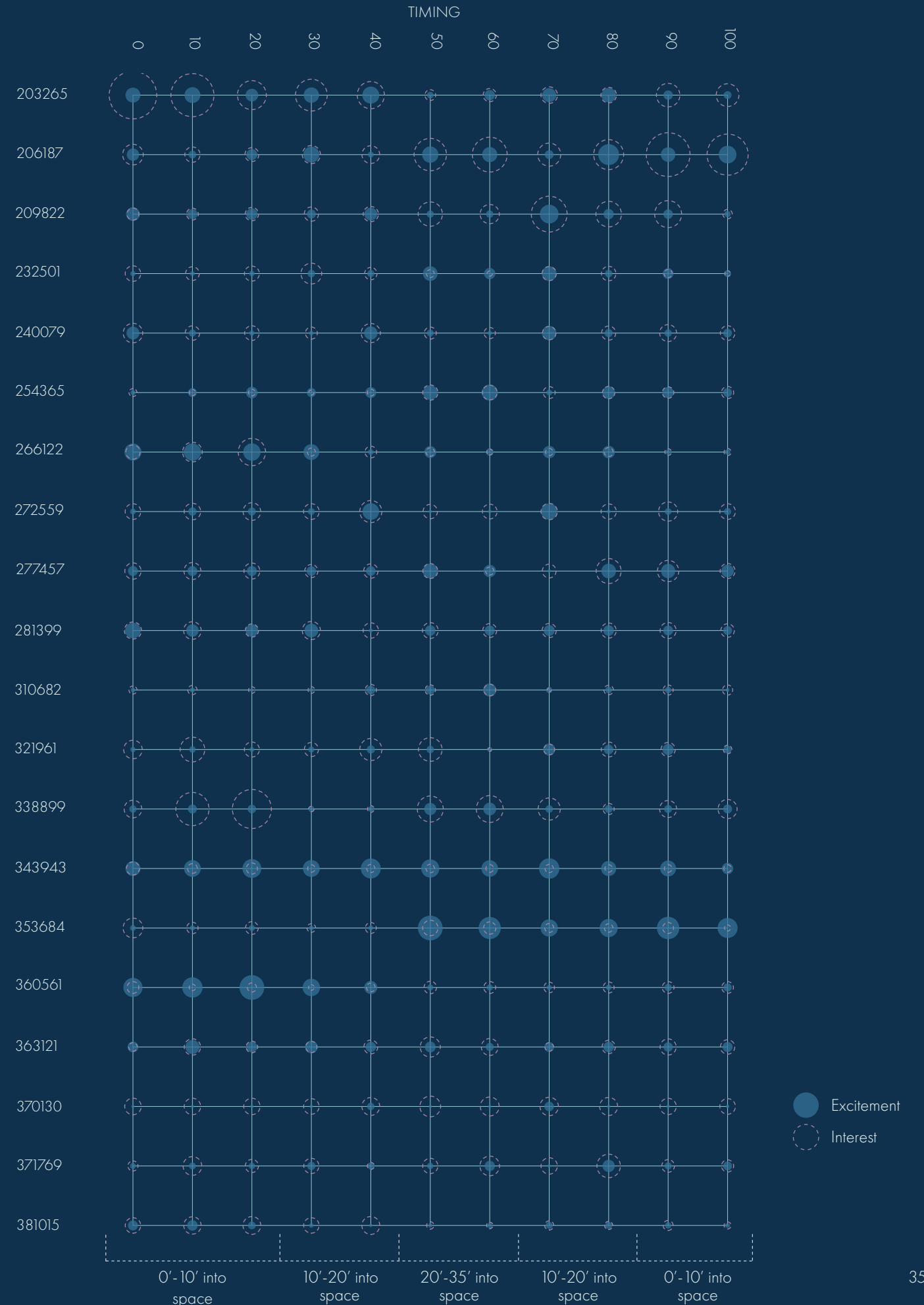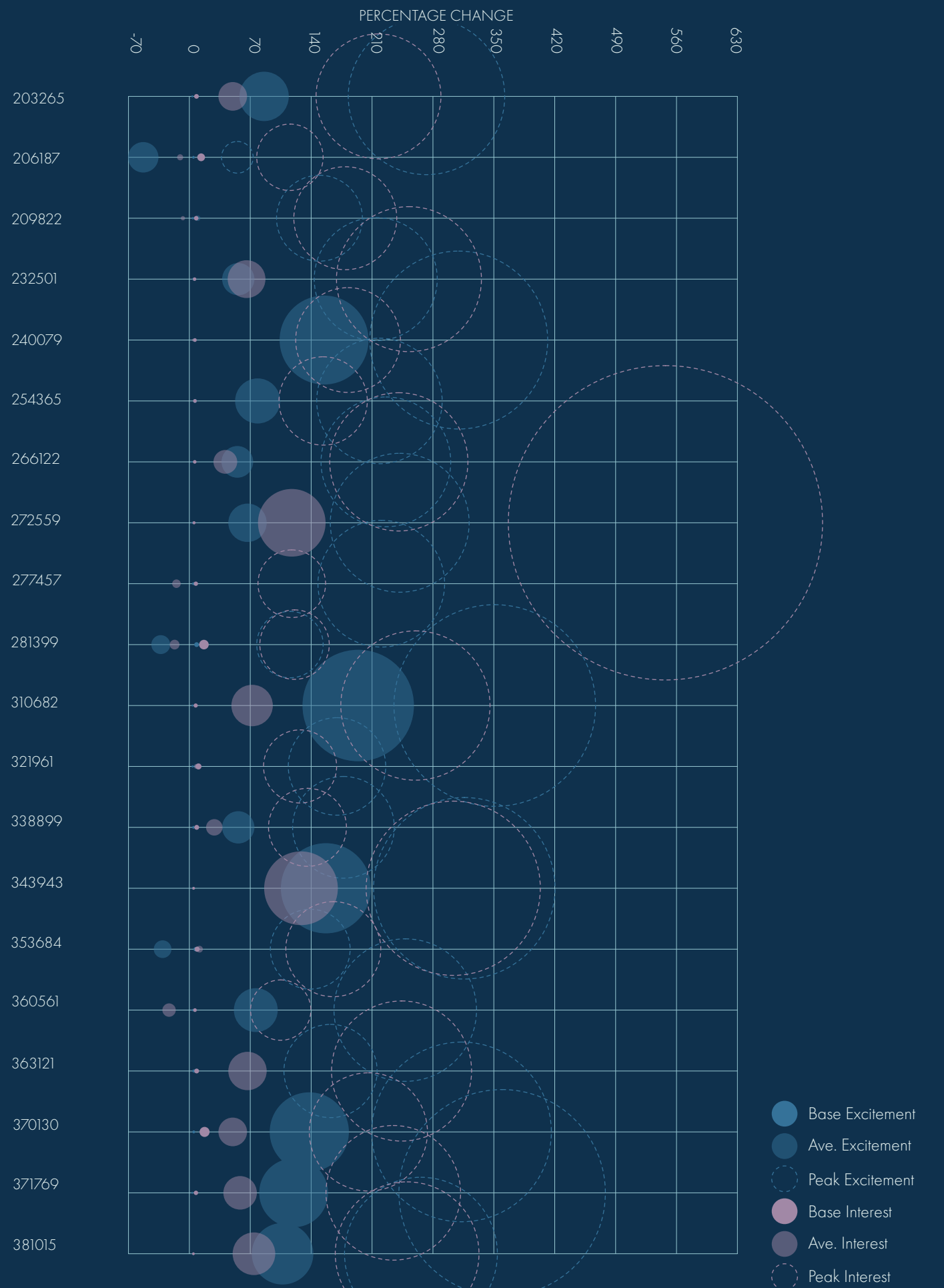-7 0 7 14 21 28 35 42 49 56 63

PARTICIPANTS

203265
206187
209822
232501
240079
254365
266122
272559
277457
281399
310682
321961
338899
343943
353684
360561
363121
370130
371769
381015

PERCENTAGE CHANGE

-70 0 70 140 210 280 350 420 490 560 630

PARTICIPANTS

203265
206187
209822
232501
240079
254365
266122
272559
277457
281399
310682
321961
338899
343943
353684
360561
363121
370130
371769
381015

Base Excitement
Ave. Excitement
Peak Excitement
Base Interest
Ave. Interest
Peak Interest

Base Excitement
Ave. Excitement
Peak Excitement
Base Interest
Ave. Interest
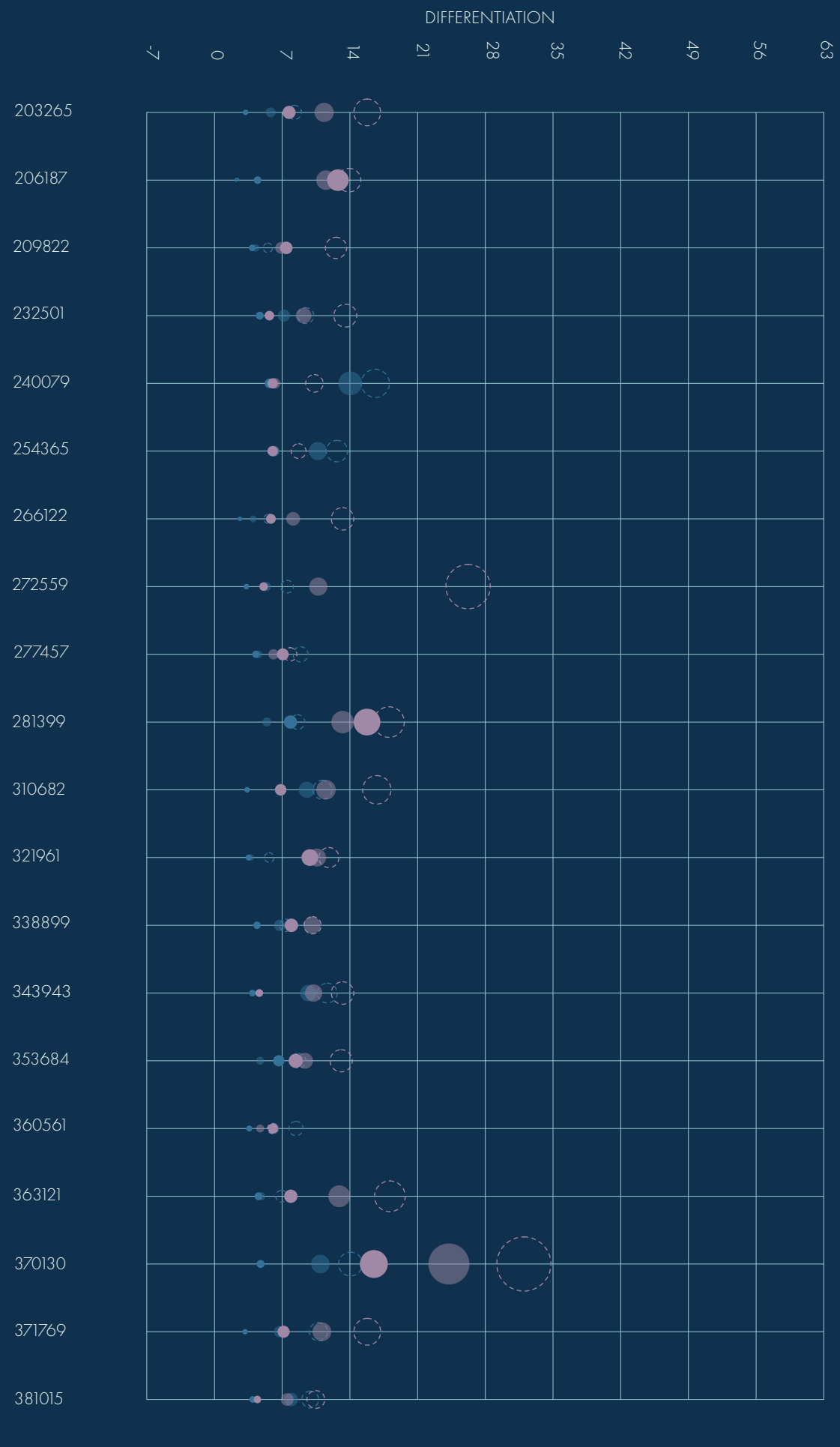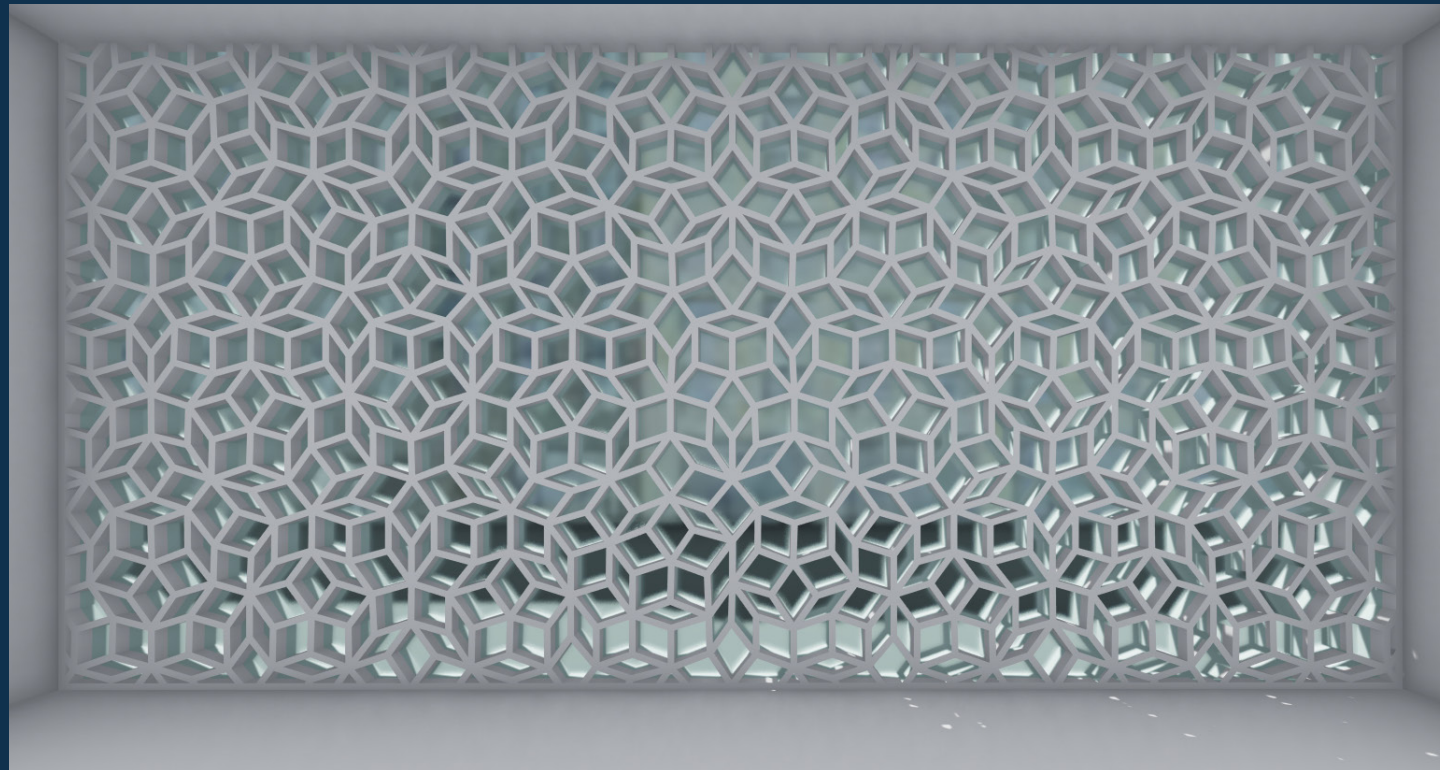Peak Interest

Elevation

Conclusions:

The third façade looks at the predictability of the pattern, as well as the scale- this system uses a ½ scale pattern that should be able to be identified globally, but not locally. This façade was found to be within the positive valence side of the circle- meaning positive emotions were felt by the user. Peaks for arousal happened at the point where the participant was closest to the façade. On the other hand, peaks for valence happened at the point furthest from the façade. Overall, the average valence and arousal levels of the participants were slightly elevated- no participant doubled their baseline levels. When looking at the peak differential, the peaks seem to be relatively mild when comparing to the average differential. However, when comparing these values as a percentage- the peaks are exponentially bigger- with the largest peak being over 300% of the baseline.

Overall, this space promotes positive emotions for the user- and can/should be utilized in the everyday setting- though can be overwhelming and provide a shock factor at the initial viewing.

EEG Readings Data

1	15
2	2

Survey Results

12	8
0	0

LOCATION

PARTICIPANTS

TIMING

PARTICIPANTS

- ● Excitement
- ○ Interest

0'-10' into space   10'-20' into space   20'-35' into space   10'-20' into space   0'-10' into space

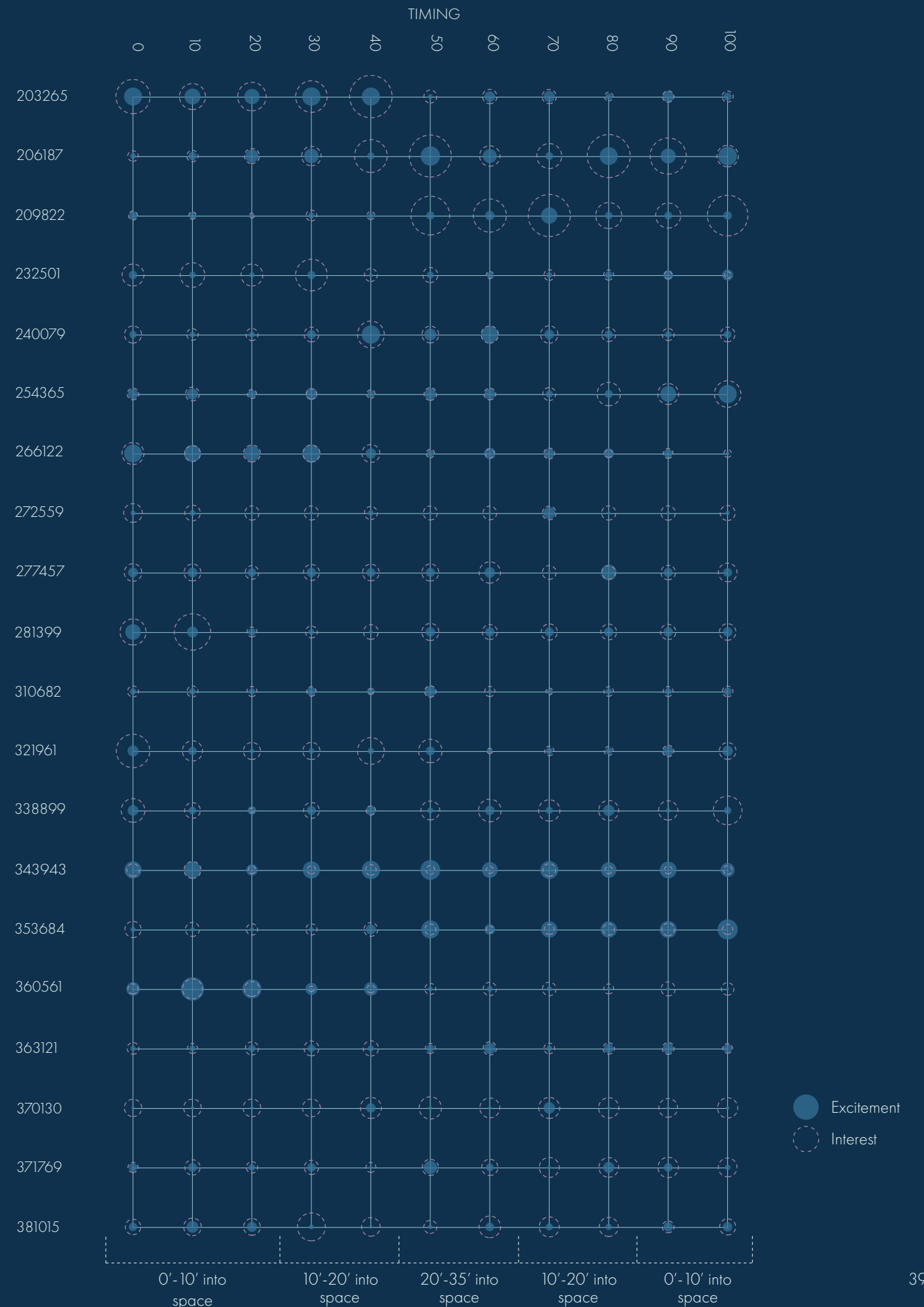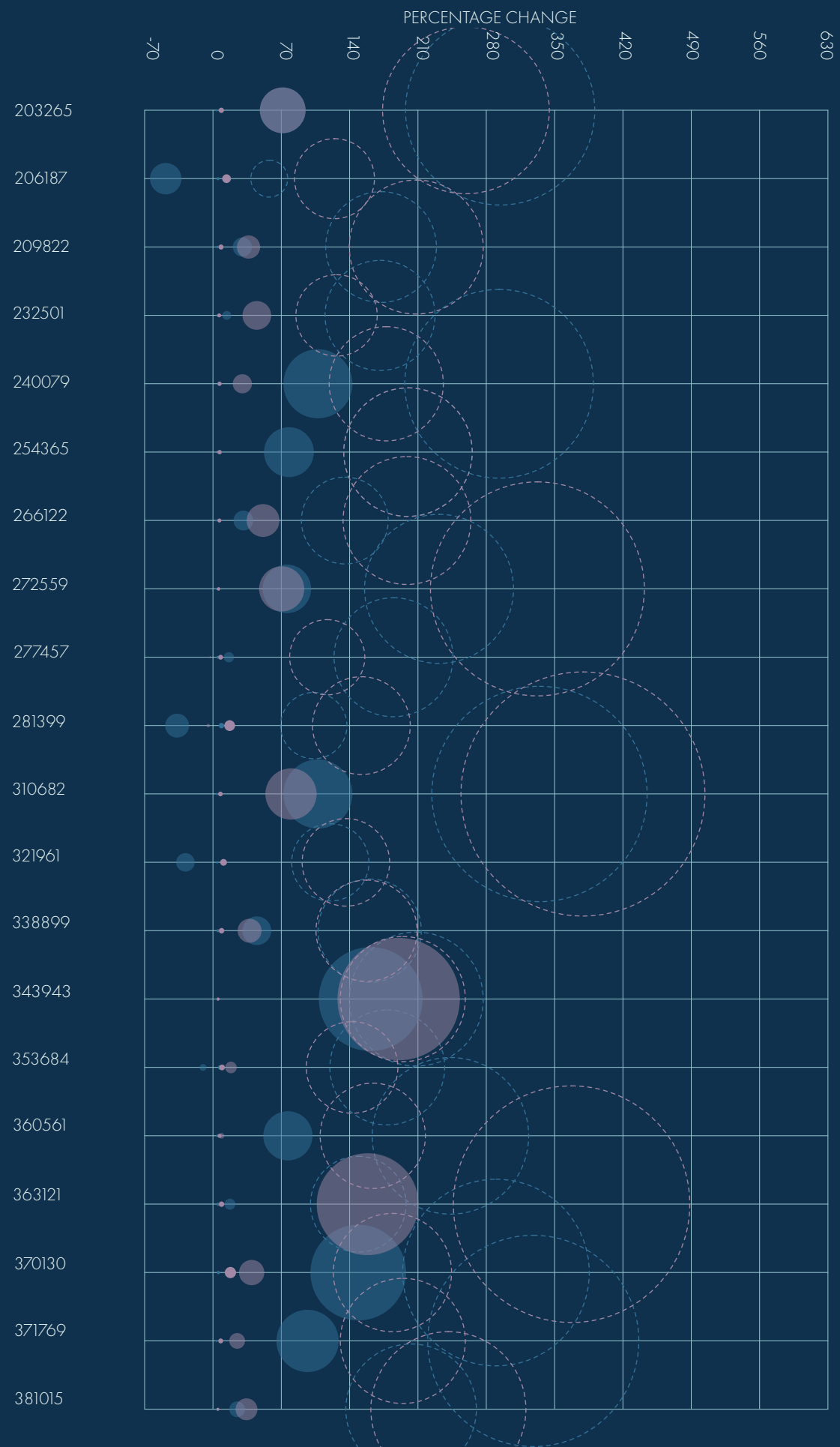-7 0 7 14 21 28 35 42 49 56 63

PARTICIPANTS

203265
206187
209822
232501
240079
254365
266122
272559
277457
281399
310682
321961
338899
343943
353684
360561
363121
370130
371769
381015

Base Excitement
Ave. Excitement
Peak Excitement
Base Interest
Ave. Interest
Peak Interest

PERCENTAGE CHANGE

-70 0 70 140 210 280 350 420 490 560 630

PARTICIPANTS

203265
206187
209822
232501
240079
254365
266122
272559
277457
281399
310682
321961
338899
343943
353684
360561
363121
370130
371769
381015

Base Excitement
Ave. Excitement
Peak Excitement
Base Interest
Ave. Interest
Peak Interest

Elevation

Conclusions:

The fourth façade looks at the visibility of an image- for this system, the image shouldn't be legible to the user. This façade was found to be mainly within the positive valence side of the circle but had participants in every category. Peaks for arousal and valence happene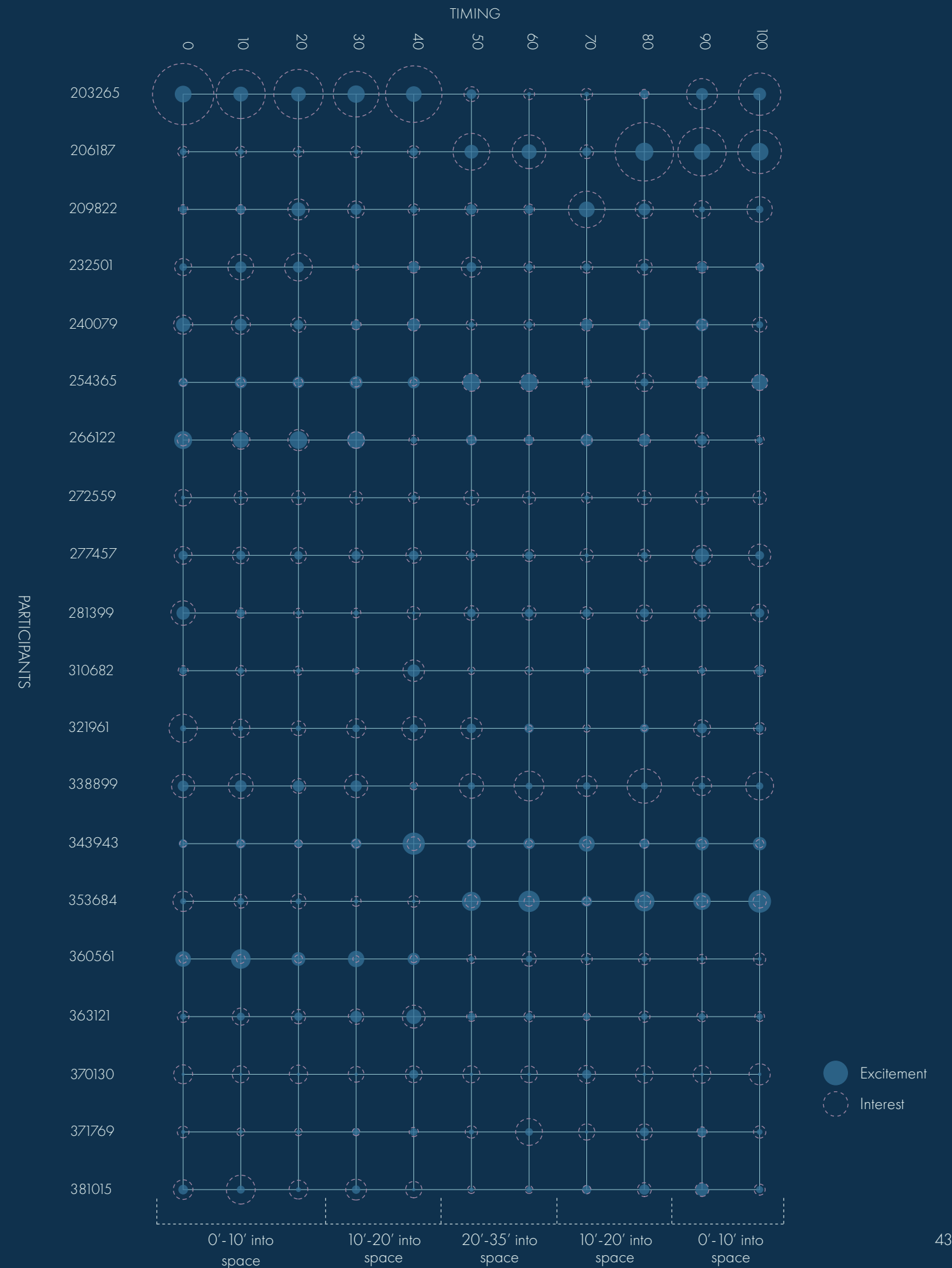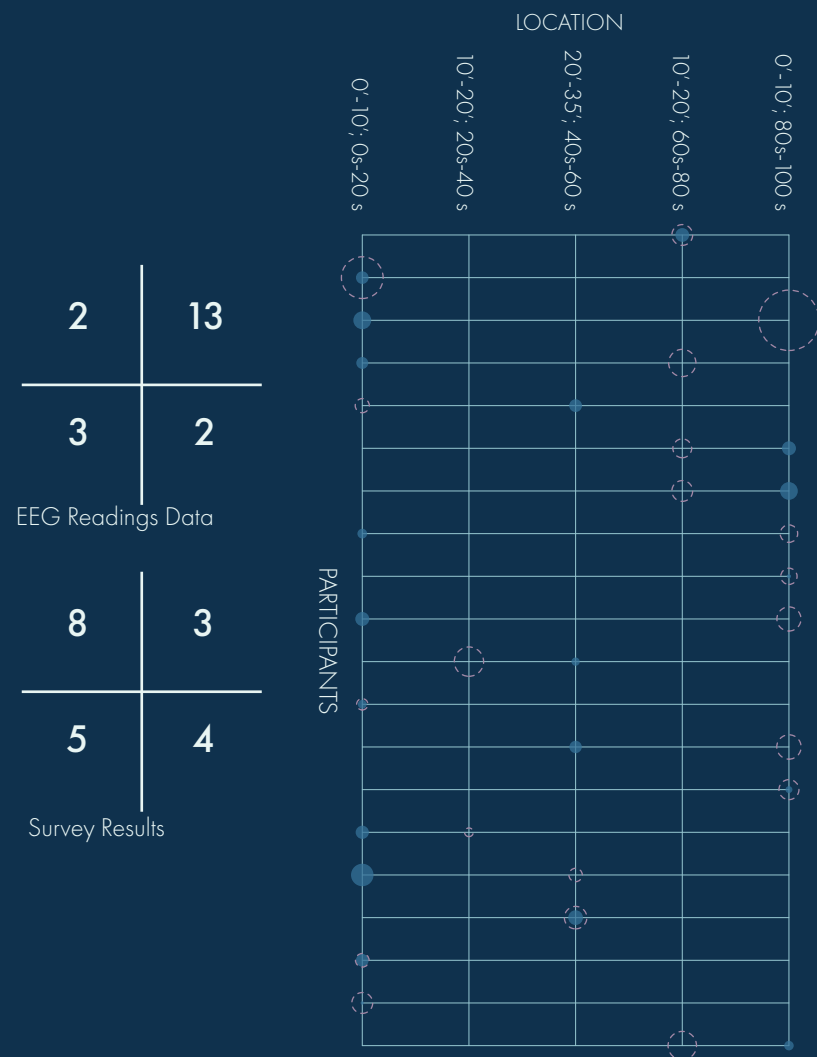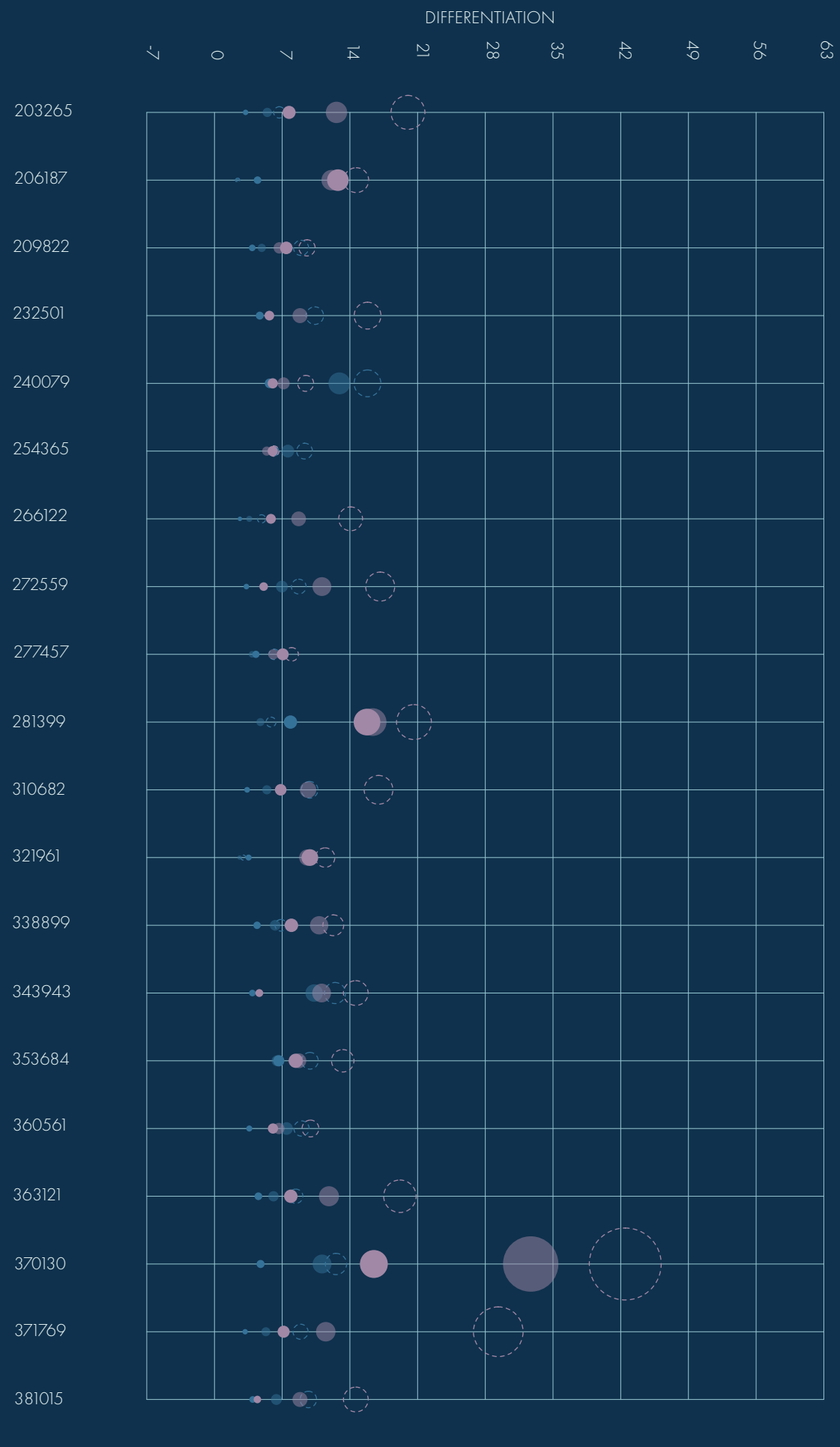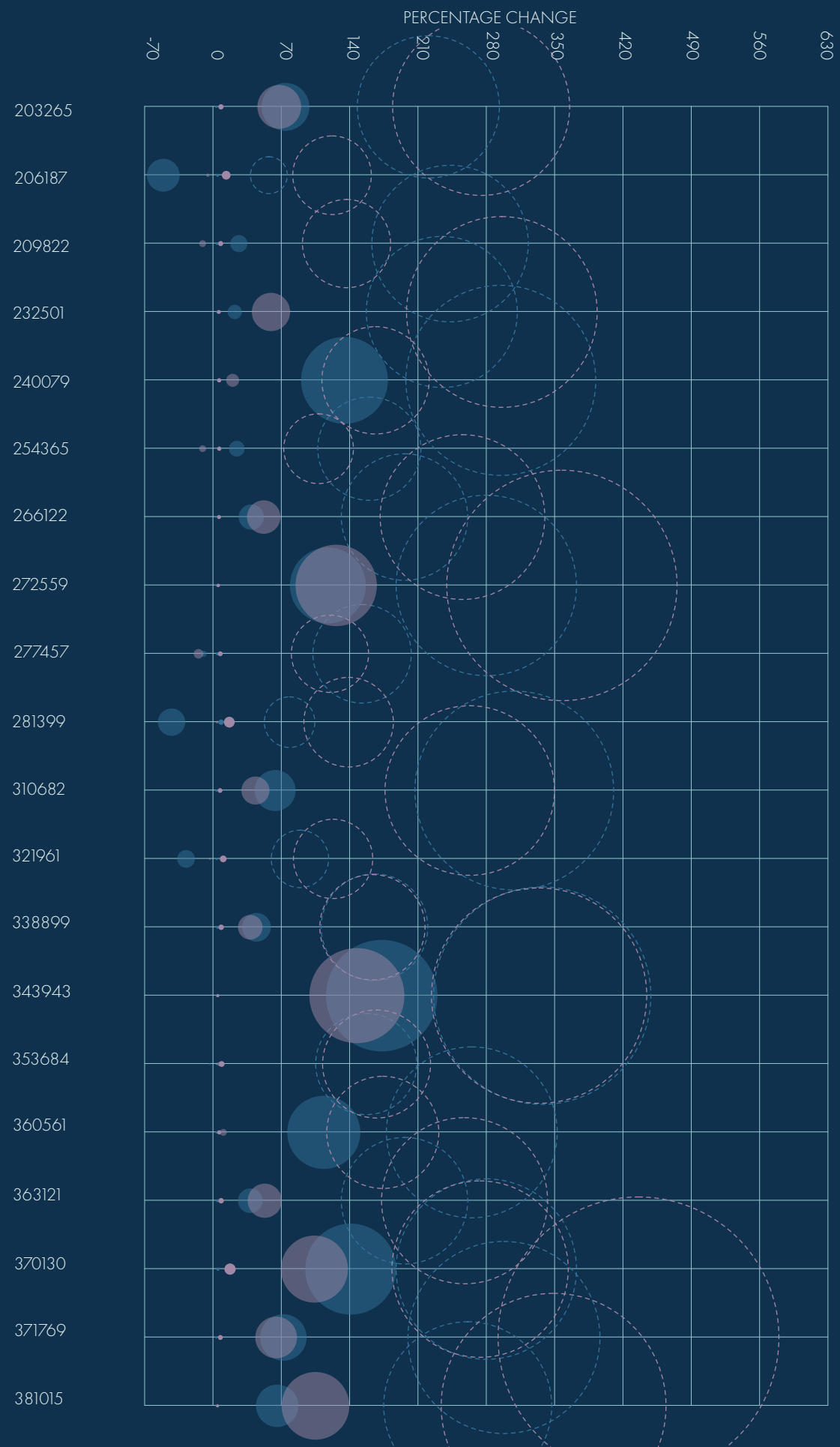d at the furthest point from the façade- one point to note is that peaks in valence happened mainly in the last 20 seconds of the experiment. Overall, the average valence and arousal levels of the participants were slightly elevated- three participants doubled their baseline levels. When looking at the peak differential, the peaks seem to be relatively mild, with a few exceptions, when comparing to the average differential. However, when comparing these values as a percentage- the peaks are exponentially bigger- with the largest peak being over 400% of the baseline.

Overall, this space promotes generally positive emotions for the user- and can/should be utilized in the everyday setting, this façade can also double as a solar shading device as well.

2	13
3	2

EEG Readings Data

8	3
5	4

Survey Results

LOCATION

TIMING

Excitement
Interest

DIFFERENTIATION

PARTICIPANTS

-7 0 7 14 21 28 35 42 49 56 63

203265
206187
209822
232501
240079
254365
266122
272559
277457
281399
310682
321961
338899
343943
353684
360561
363121
370130
371769
381015

○ Base Excitement
○ Ave. Excitement
○ Peak Excitement
○ Base Interest
○ Ave. Interest
○ Peak Interest

PERCENTAGE CHANGE

PARTICIPANTS

-70 0 70 140 210 280 350 420 490 560 630

203265
206187
209822
232501
240079
254365
266122
272559
277457
281399
310682
321961
338899
343943
353684
360561
363121
370130
371769
381015

○ Base Excitement
○ Ave. Excitement
○ Peak Excitement
○ Base Interest
○ Ave. Interest
○ Peak Interest

Elevation

Conclusions:

The fifth façade looks at the predictability of the pattern- this pattern of this system should not be able to be identified either locally or globally. This façade was found to be within the positive valence side of the circle. Peaks for both valence and arousal happened mainly at the furthest point from the façade- arousal peaks happened at the beginning of the experiment, while valence peaks happened mainly at the end. Overall, the average valence and arousal levels of the participants were slightly elevated- three participants doubled their baseline levels. When looking at the peak differential, the peaks are mild- with most participants looking to be within 7 points of the baseline levels and when comparing to the average differential. However, when comparing these values as a percentage- the peaks are exponentially bigger- with the largest peak being almost 500% of the baseline.

Overall, this space promotes positive emotions for the user- and can/should be utilized in the everyday setting- though can be overwhelming and provide a shock factor at the initial viewing to some users.
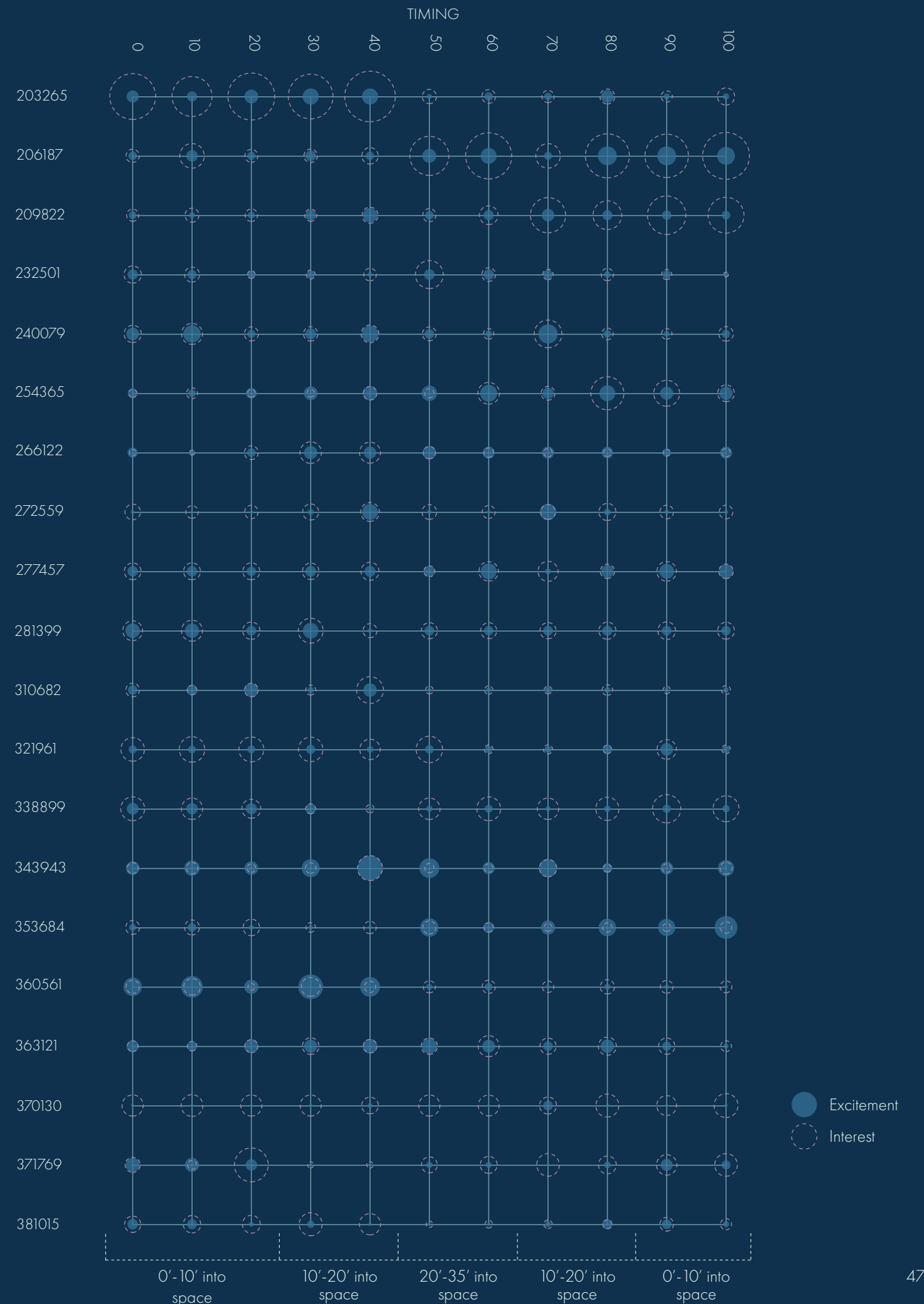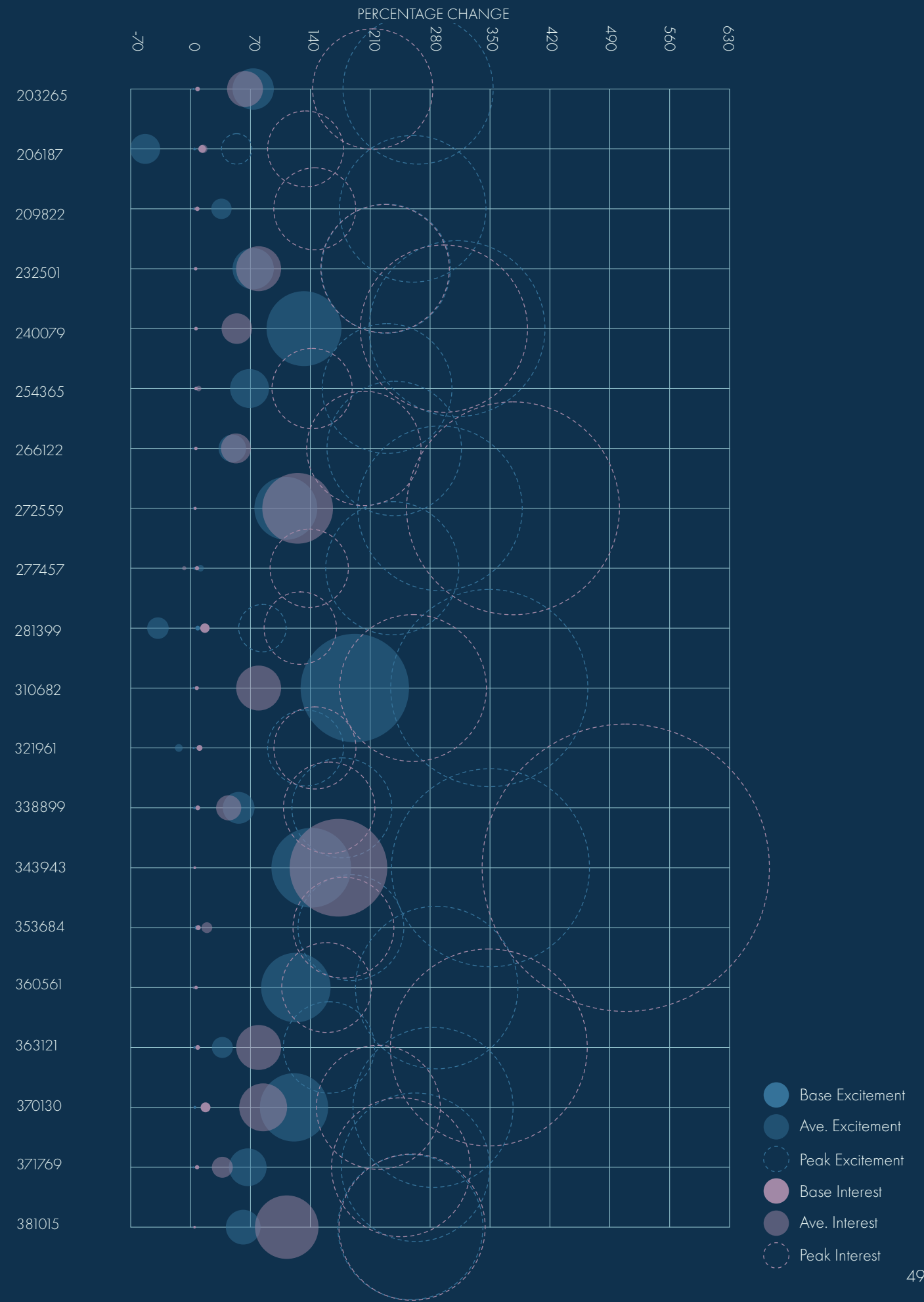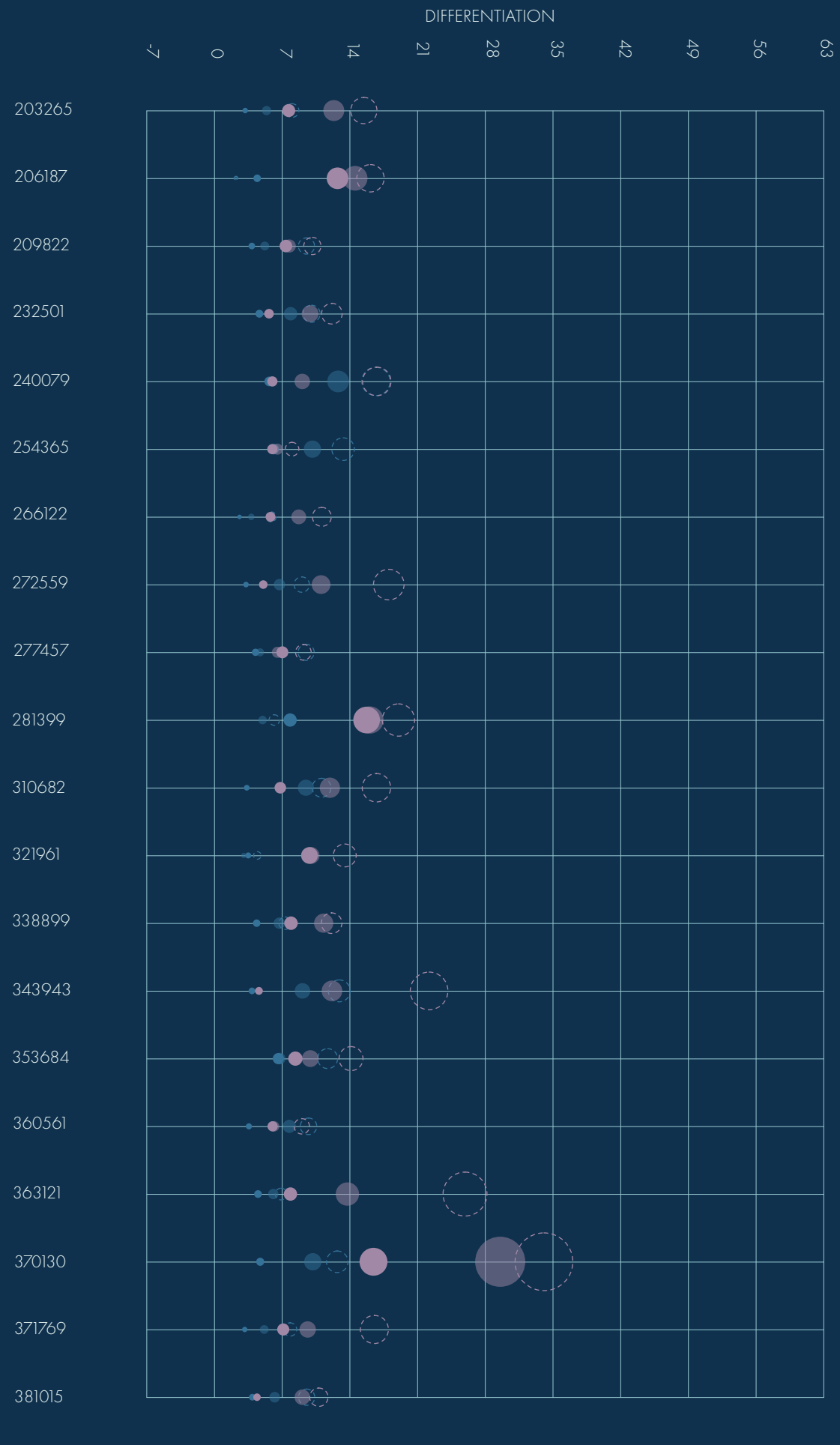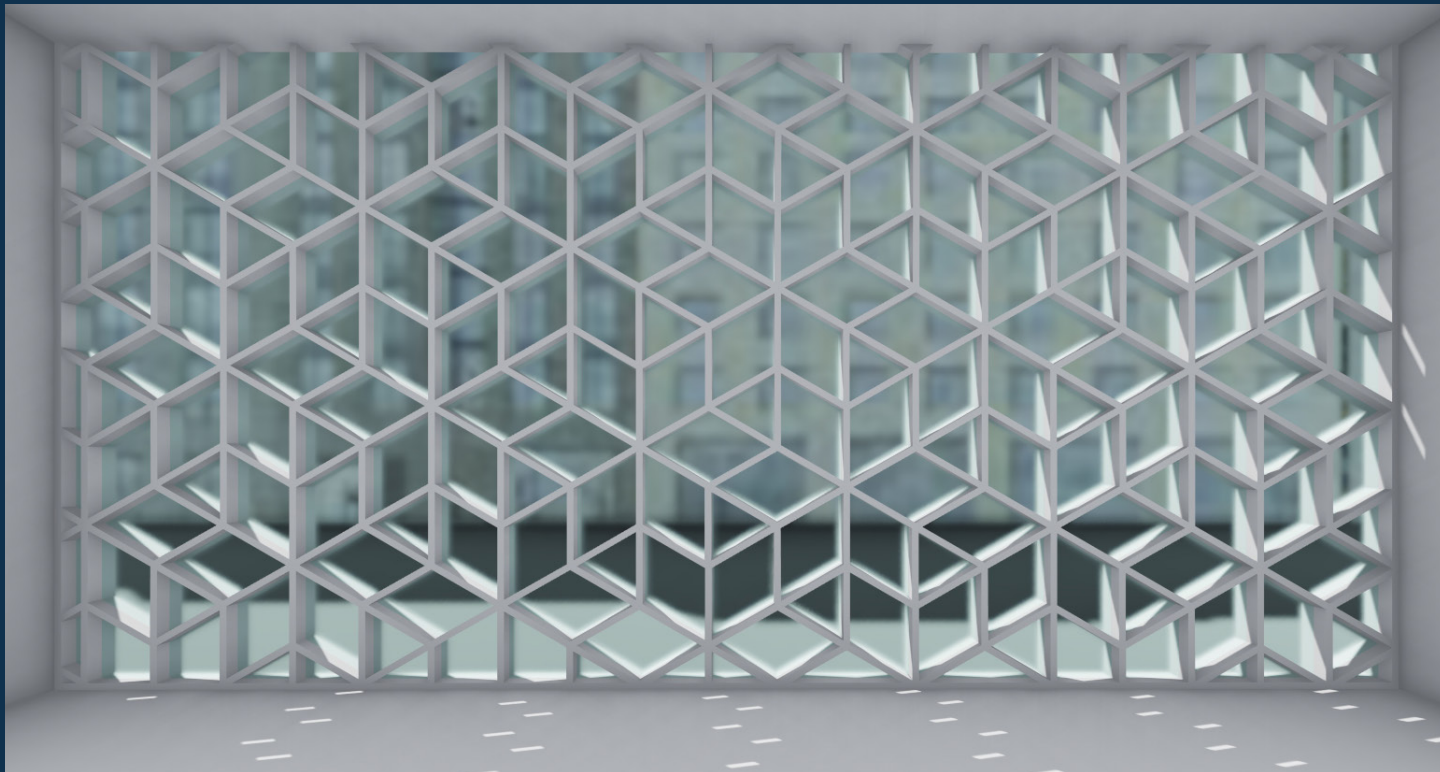
| 1 | 16 |
| 0 | 3 |

EEG Readings Data

| 7 | 10 |
| 1 | 2 |

Survey Results

LOCATION

TIMING

Excitement
Interest

DIFFERENTIATION

PARTICIPANTS

203265
206187
209822
232501
240079
254365
266122
272559
277457
281399
310682
321961
338899
343943
353684
360561
363121
370130
371769
381015

-7 0 7 14 21 28 35 42 49 56 63

Base Excitement
Ave. Excitement
Peak Excitement
Base Interest
Ave. Interest
Peak Interest

PERCENTAGE CHANGE

PARTICIPANTS

203265
206187
209822
232501
240079
254365
266122
272559
277457
281399
310682
321961
338899
343943
353684
360561
363121
370130
371769
381015

-70 0 70 140 210 280 350 420 490 560 630

Base Excitement
Ave. Excitement
Peak Excitement
Base Interest
Ave. Interest
Peak Interest

Elevation

Conclusions:

The sixth façade looks at the predictability of the pattern- the pattern of this system should be easily recognizable and should be predictable as you look anywhere on the façade. This façade was found to be positive valence- but had a few participants who fell within the negative. Additionally, this façade was found to have high arousal- and had more intense output from the user. Peaks for valence happened at the end of the experiment, when the participant was the furthest from the façade. Arousal peaks happened periodically throughout the experiment- with the most happening f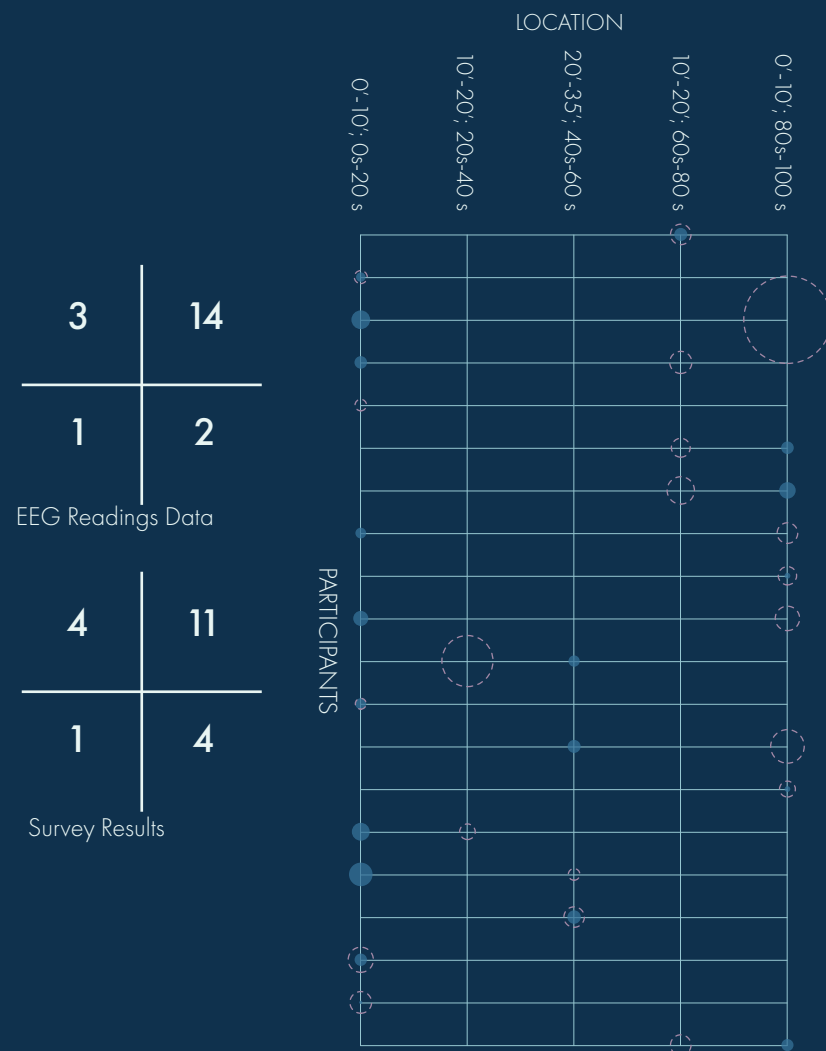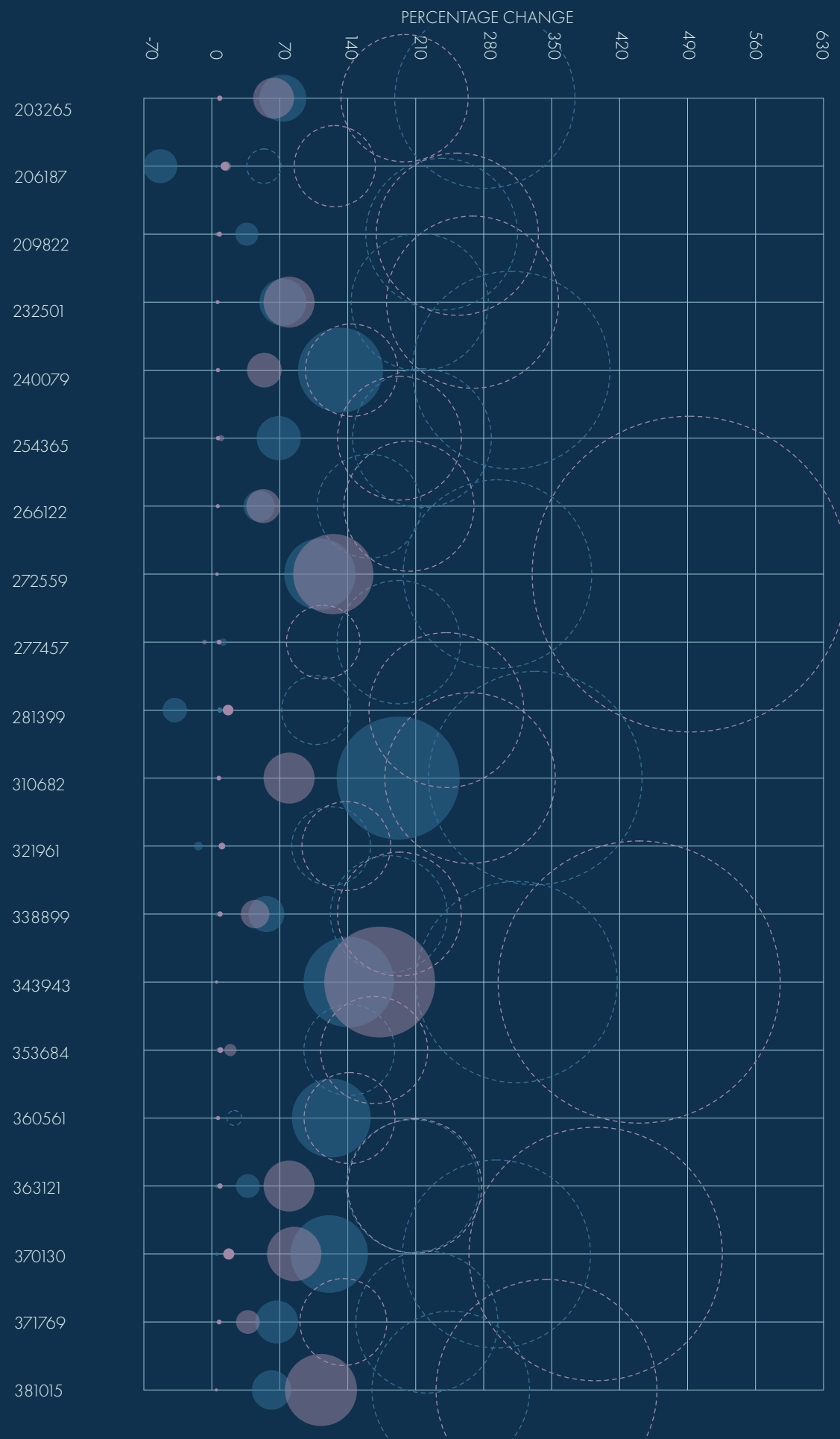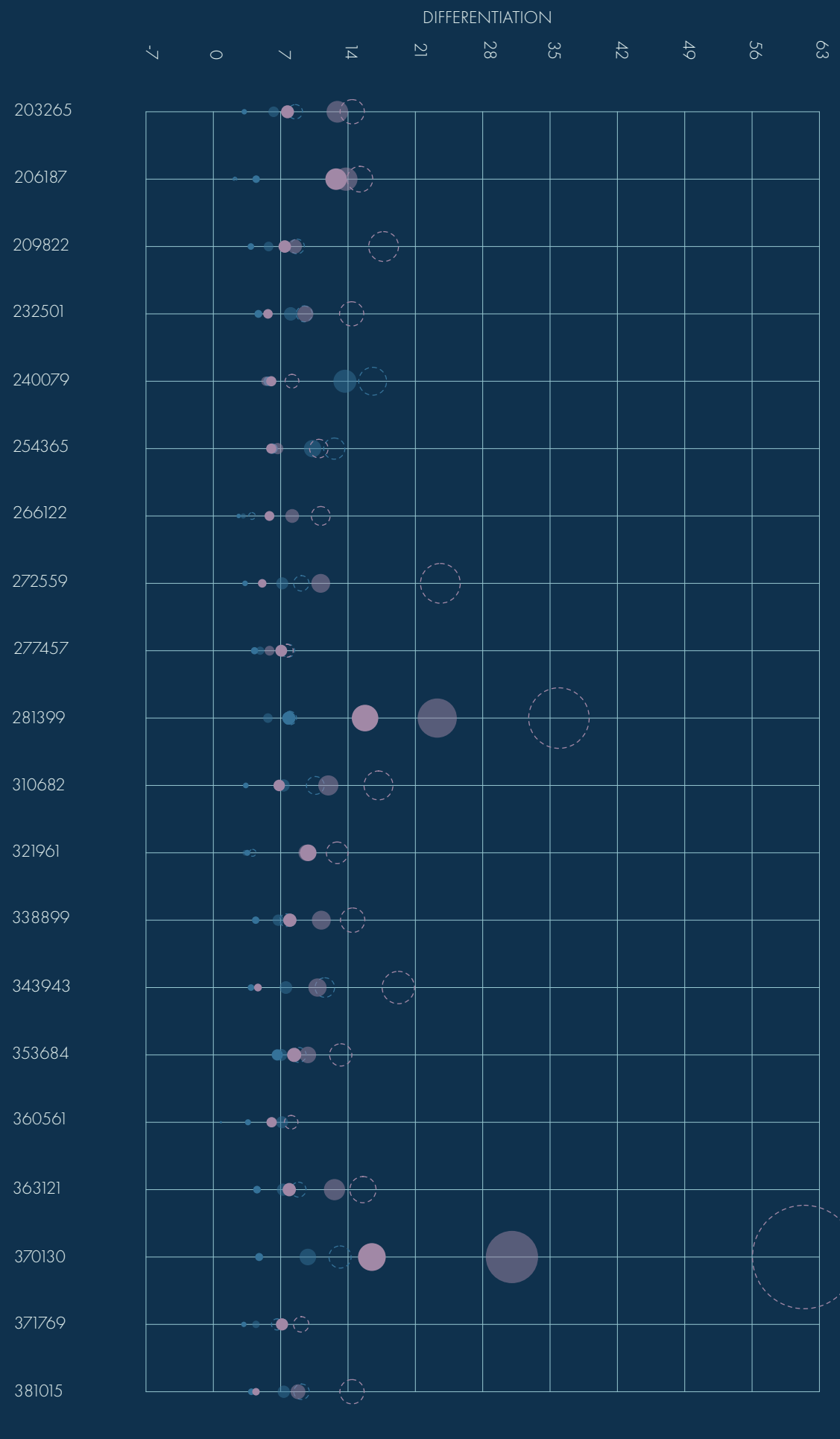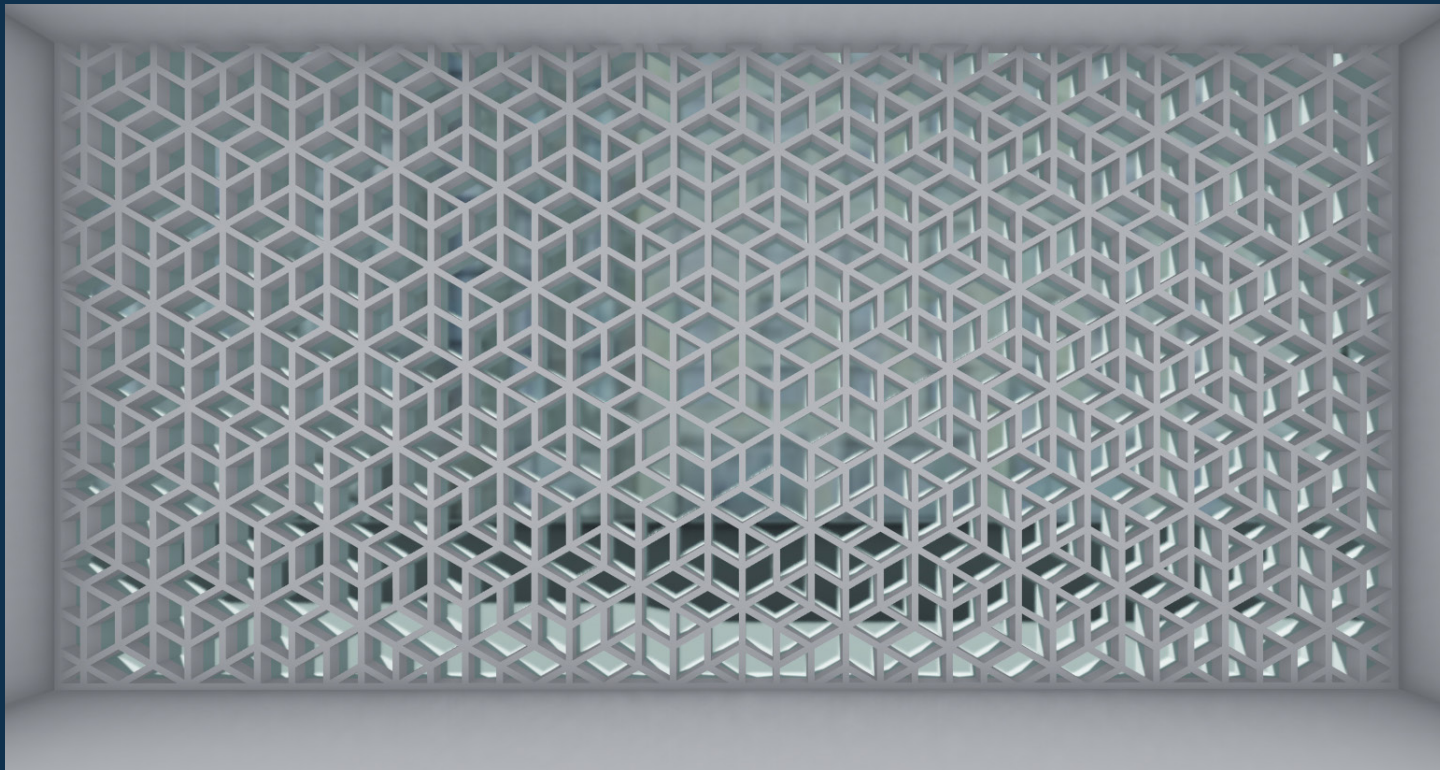urthest away from the wall. Overall, the average valence and arousal levels were slightly elevated, with two participants having more extreme reactions.

When looking at the peak differential, most participants had mild peaks in their readings- while some participants had a higher peak that almost doubled their baseline number. When comparing these same values as a percentage however, participants had a greater percentage change- with a peak of almost 400% of the baseline.

Overall, this façade promotes positive emotions- but still gave more mixed reactions that similar spaces. This façade can be utilized for everyday setting- but there are better configurations than this.

3	14
1	2

EEG Readings Data

4	11
1	4

Survey Results

LOCATION

PARTICIPANTS

0'-10'; 0s-20 s
10'-20'; 20s-40 s
20'-35'; 40s-60 s
10'-20'; 60s-80 s
0'-10'; 80s-100 s

TIMING

PARTICIPANTS

203265
206187
209822
232501
240079
254365
266122
272559
277457
281399
310682
321961
338899
343943
353684
360561
363121
370130
371769
381015

0'-10' into space
10'-20' into space
20'-35' into space
10'-20' into space
0'-10' into space

Excitement
Interest

DIFFERENTIATION

-7 0 7 14 21 28 35 42 49 56 63

PARTICIPANTS

203265
206187
209822
232501
240079
254365
266122
272559
277457
281399
310682
321961
338899
343943
353684
360561
363121
370130
371769
381015

PERCENTAGE CHANGE

-70 0 70 140 210 280 350 420 490 560 630

PARTICIPANTS

203265
206187
209822
232501
240079
254365
266122
272559
277457
281399
310682
321961
338899
343943
353684
360561
363121
370130
371769
381015

Base Excitement
Ave. Excitement
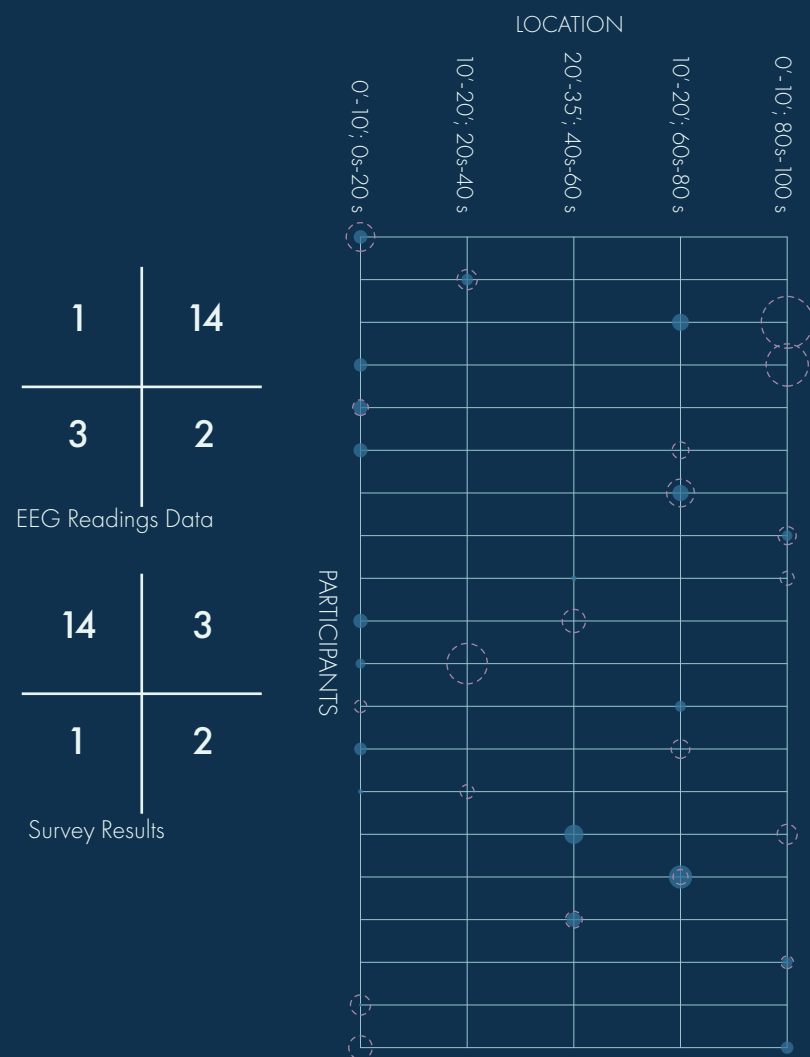Peak Excitement
Base Interest
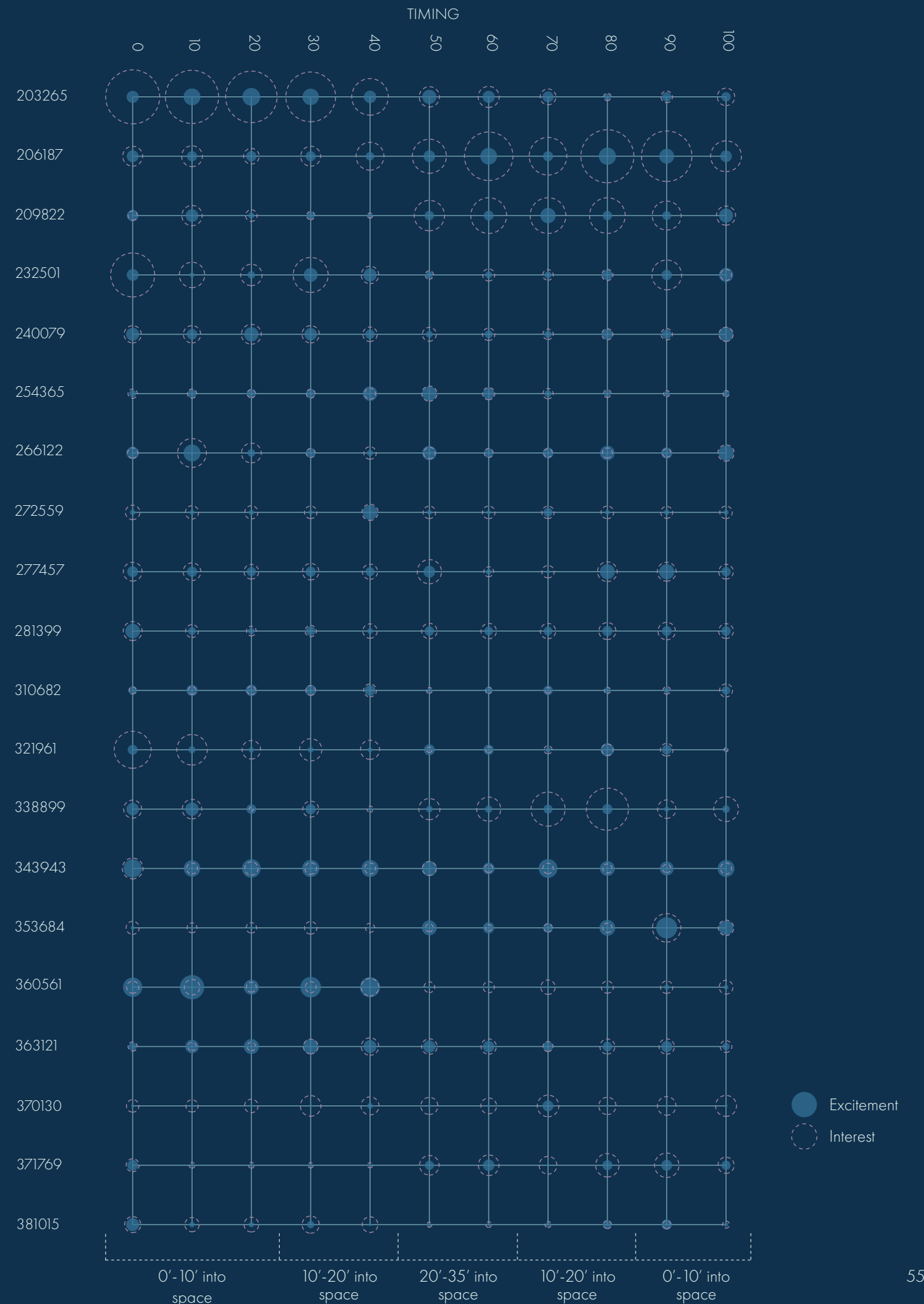Ave. Interest
Peak Interest

Elevation

Conclusions:

The seventh façade looks at the predictability of the pattern, as well as the scale- this pattern is at a ½ scale and should be recognizable both locally and globally. This façade gave overall positive valence, but bordered along the lines of having a negative valence and low arousal. Users were not as engaged with this space as previous ones. Peaks for both arousal and valence happened when the participant was furthest from the façade. Overall, the average valence and arousal levels were slightly elevated, with two participants doubling their baselines.

When looking at the peak differential, the peaks seem to be relatively mild, with a few exceptions, when comparing to the average differential. However, when comparing these values as a percentage- the peaks are exponentially bigger- with the largest peak being over 400% of the baseline.

Overall, this façade promotes positive emotions- but can have mixed reactions for different users. This façade can be utilized for everyday settings- but there are more realistic façade conditions that function better.

1	14
3	2

EEG Readings Data

14	3
1	2

Survey Results

LOCATION

PARTICIPANTS

TIMING

PARTICIPANTS

Excitement

Interest

DIFFERENTIATION

-7   0   7   14   21   28   35   42   49   56   63

PARTICIPANTS

203265
206187
209822
232501
240079
254365
266122
272559
277457
281399
310682
321961
338899
343943
353684
360561
363121
370130
371769
381015

PERCENTAGE CHANGE

-70   0   70   140   210   280   350   420   490   560   630

PARTICIPANTS

203265
206187
209822
232501
240079
254365
266122
272559
277457
281399
310682
321961
338899
343943
353684
360561
363121
370130
371769
381015

Base Excitement
Ave. Excitement
Peak Excitement
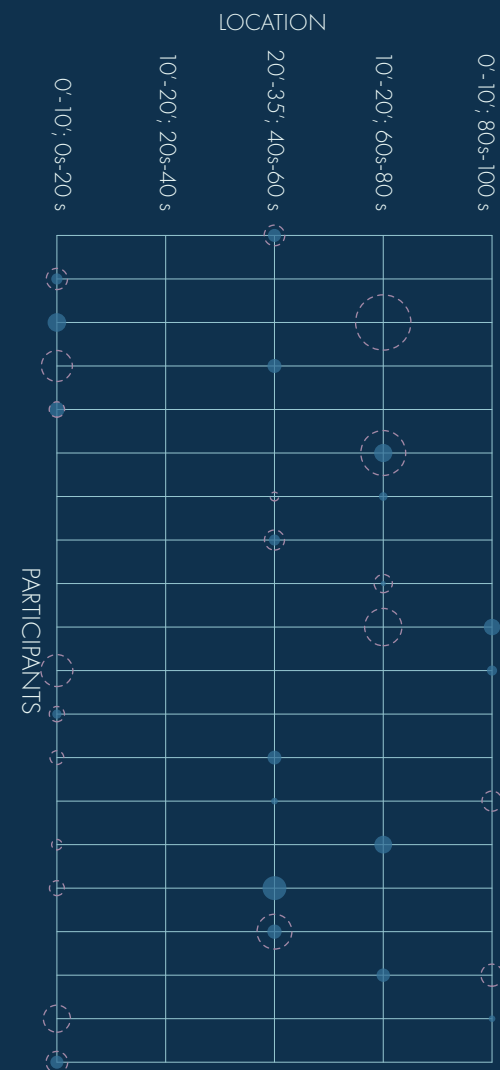Base Interest
Ave. Interest
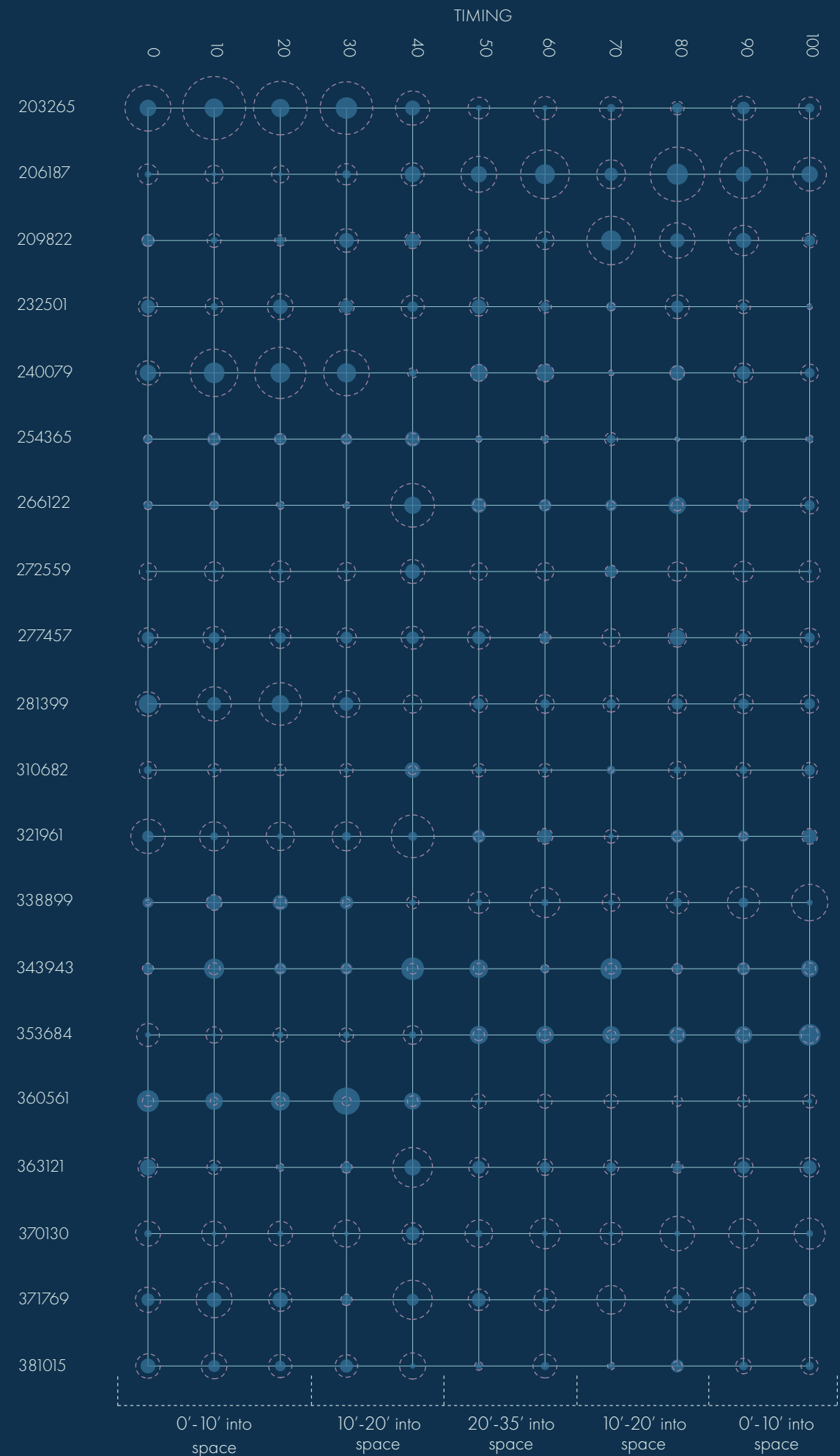Peak Interest

Elevation

Conclusions:

The eight façade looks at the structural detail of the digital space- this system is a standard aluminum mullion. This façade gave positive valence levels, with only 1 participant having a negative valence. Peaks for this system were spread out throughout the experiment time and distance scale. Overall, the average valence and arousal levels of the participant stayed level with the baselines.

When looking at the peak differential, the peaks were mild- with participants looking to be within 5-10 points of the baseline levels. Comparing these values as percentages, the peaks look exponentially larger- with the largest being just under 400% of the baseline. Overall, this façade promotes positive emotion, and was something that the participant recognized almost immediately. This system can/should be utilized in everyday settings.

1	15
0	4

EEG Readings Data

0	6
7	7

Survey Results

LOCATION

PARTICIPANTS

TIMING

PARTICIPANTS

Excitement
Interest

DIFFERENTIATION

-7 0 7 14 21 28 35 42 49 56 63

PARTICIPANTS

203265
206187
209822
232501
240079
254365
266122
272559
277457
281399
310682
321961
338899
343943
353684
360561
363121
370130
371769
381015

- Base Excitement
- Ave. Excitement
- Peak Excitement
- Base Interest
- Ave. Interest
- Peak Interest

PERCENTAGE CHANGE

-70 0 70 140 210 280 350 420 490 560 630

PARTICIPANTS

203265
206187
209822
232501
240079
254365
266122
272559
277457
281399
310682
321961
338899
343943
353684
360561
363121
370130
371769
381015

- Base Excitement
- Ave. Excitement
- Peak Excitement
- Base Interest
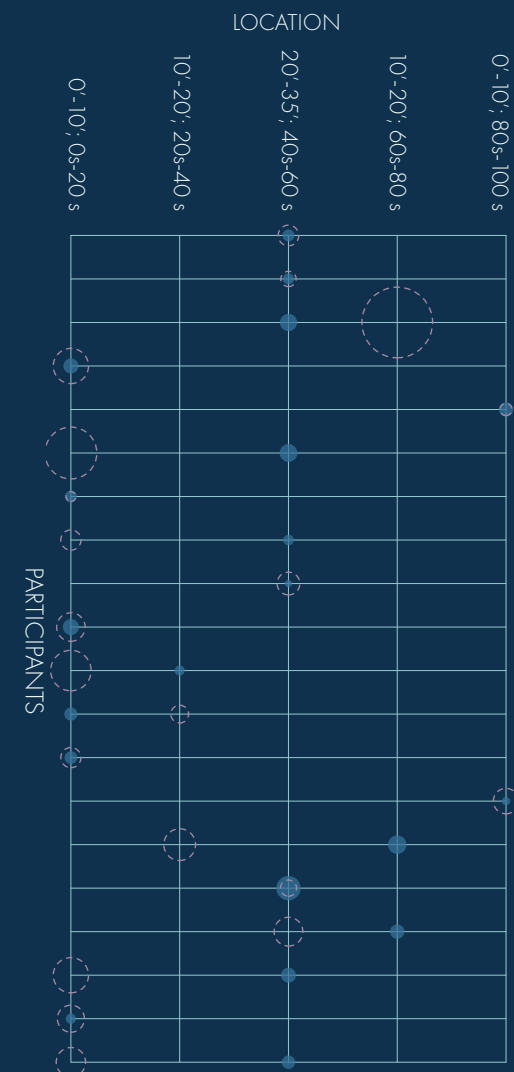- Ave. Interest
- Peak Interest

Elevation

Conclusions:
The ninth façade looks at the structural detail of the digital space- this system is a cable net system. This façade was found to be within the positive valence side of the circle- overall positive emotion was felt in this space, except for 1 participant. 50% of the participants experienced their peak valence levels at the beginning of the test and at the furthest point from the façade. The arousal level peaks were mainly reached at the closest point to the façade. Overall, the average valence and arousal levels of the participants were elevated- 45% of participants doubled their baselines.
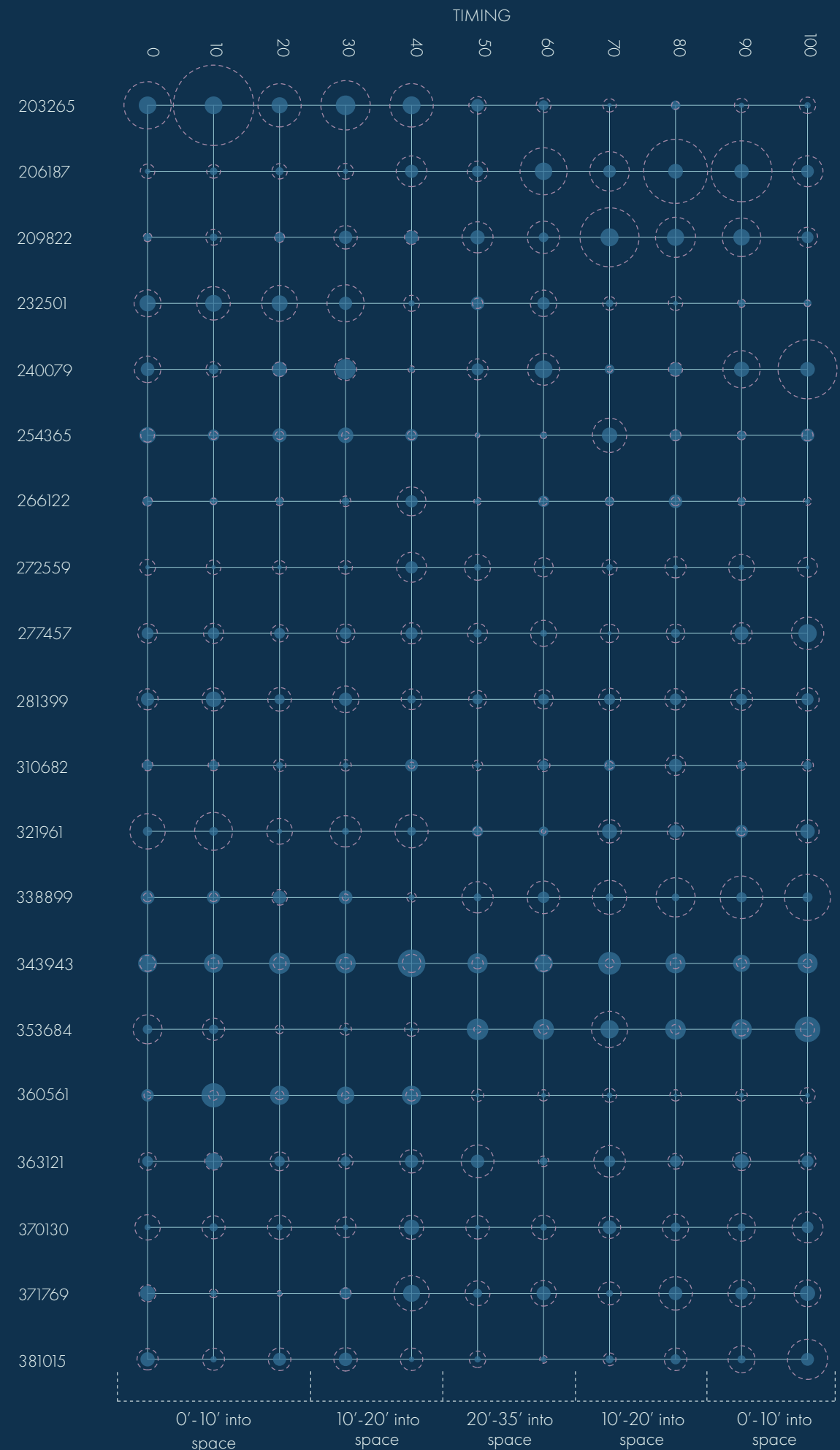
When looking at the peak differential and percentage change, there is only one participant whose results appear greater than the others- all other results seem less drastic of changes.
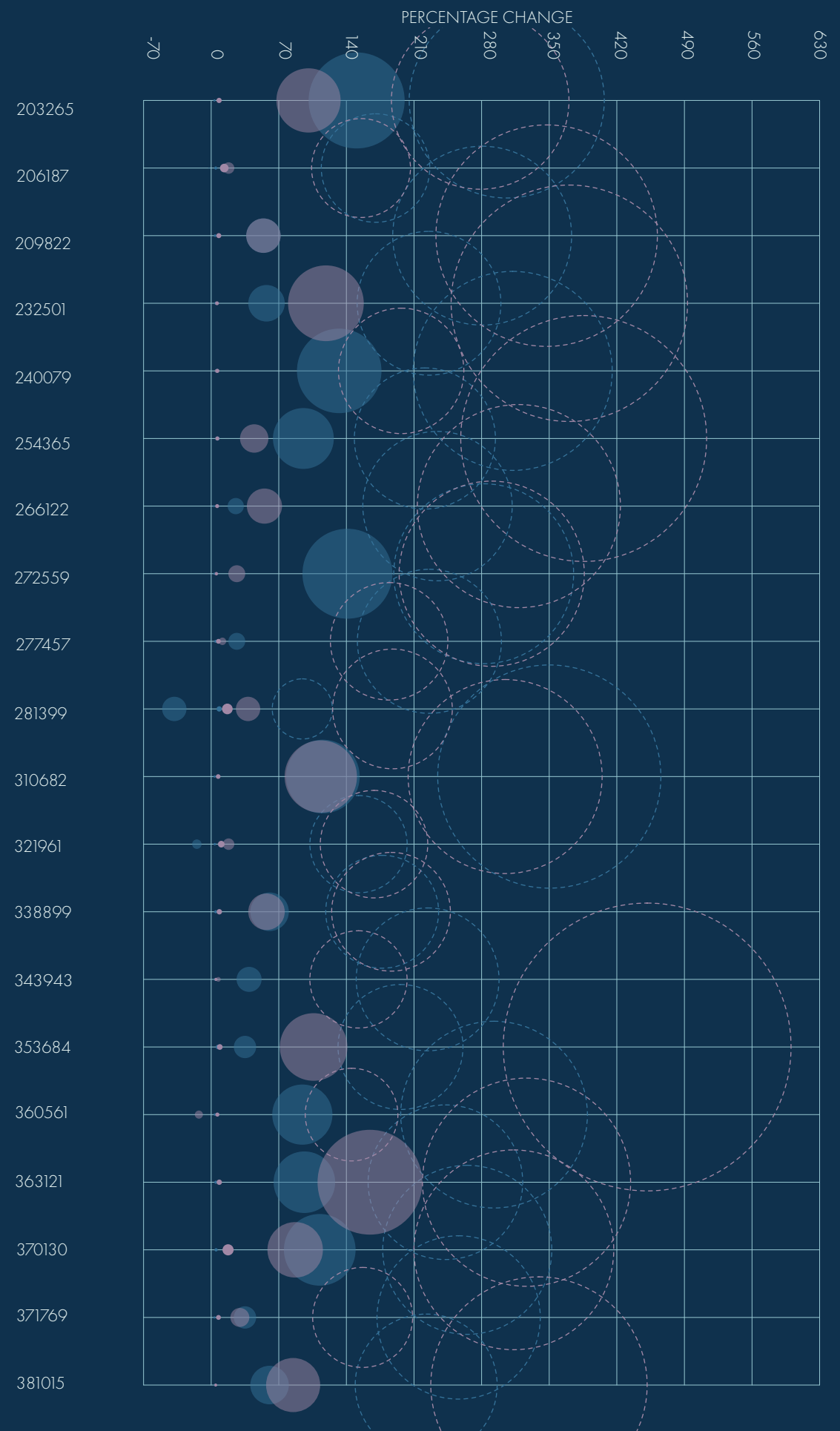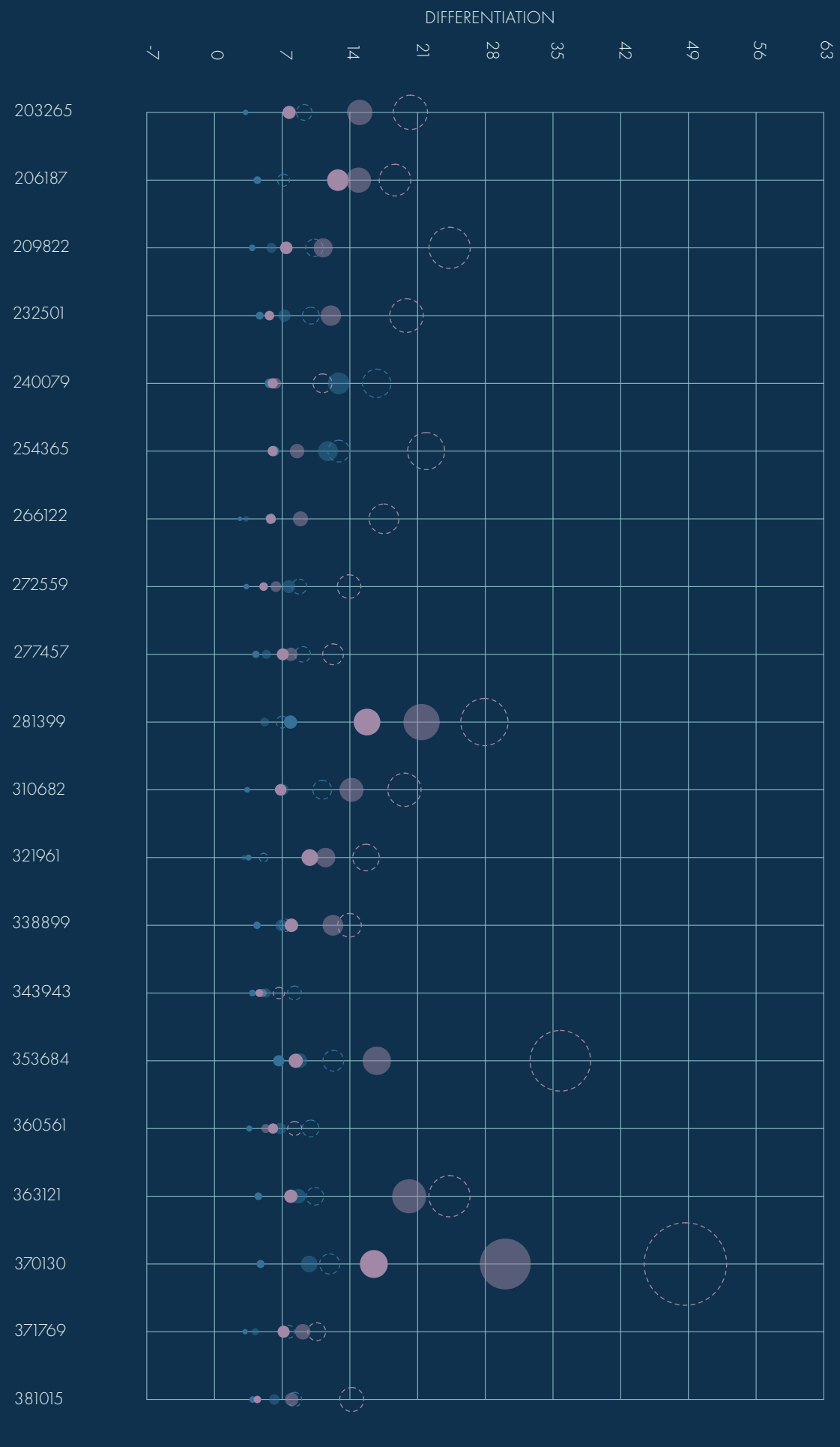
Overall, this space promotes positive emotions- though less extreme than most facades in this study. This system can/should be utilized in the everyday setting.

1	16
0	3

EEG Readings Data

3	7
7	3

Survey Results

LOCATION

PARTICIPANTS

TIMING

PARTICIPANTS

● Excitement
○ Interest

DIFFERENTIATION

-7 0 7 14 21 28 35 42 49 56 63

PARTICIPANTS

203265
206187
209822
232501
240079
254365
266122
272559
277457
281399
310682
321961
338899
343943
353684
360561
363121
370130
371769
381015

PERCENTAGE CHANGE

-70 0 70 140 210 280 350 420 490 560 630

PARTICIPANTS

203265
206187
209822
232501
240079
254365
266122
272559
277457
281399
310682
321961
338899
343943
353684
360561
363121
370130
371769
381015

- Base Excitement
- Ave. Excitement
- Peak Excitement
- Base Interest
- Ave. Interest
- Peak Interest

Elevation

Conclusions:
The tenth façade at the visibility of an image-for this system, the participant should begin to be able to recognize an image, though they may not recognize what the image is. This façade had mixed reactions- though still fell within the positive valence side of the circle. The majority of peaks of both arousal and valence happened at the beginning of the test, when the participant was furthest from the wall. Overall, the average arousal levels were mild and stayed relatively level with the baseline. The fluctuations happened within the average valence levels- most participants ranged from 25-35% change in their valence levels, which could easily change which side of the circle they fell on.
When looking at the peak differential, there are a few participants who had more extreme reactions, but generally participants had mild changes. This shows better within the percentage change graph where one participant had a peak over 600% of the baseline.
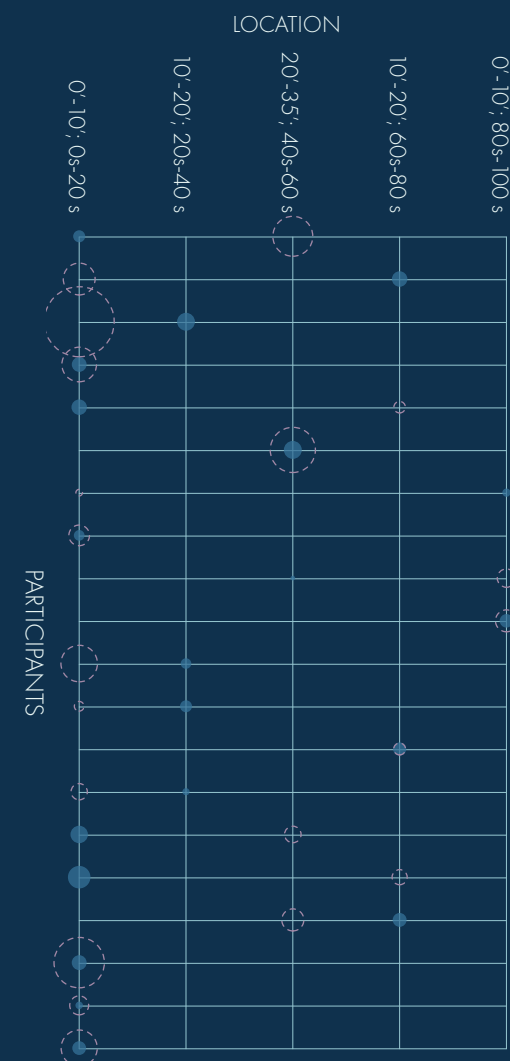Overall, this space promotes generally positive emotions for the user, but one note to make, is that verbally this façade was viewed in a negative light. The participants couldn't quite distinguish the image, so their bias was filling in the image and putting it in a negative connotation. Would not recommend for everyday setting- though would work as a solar shading device.
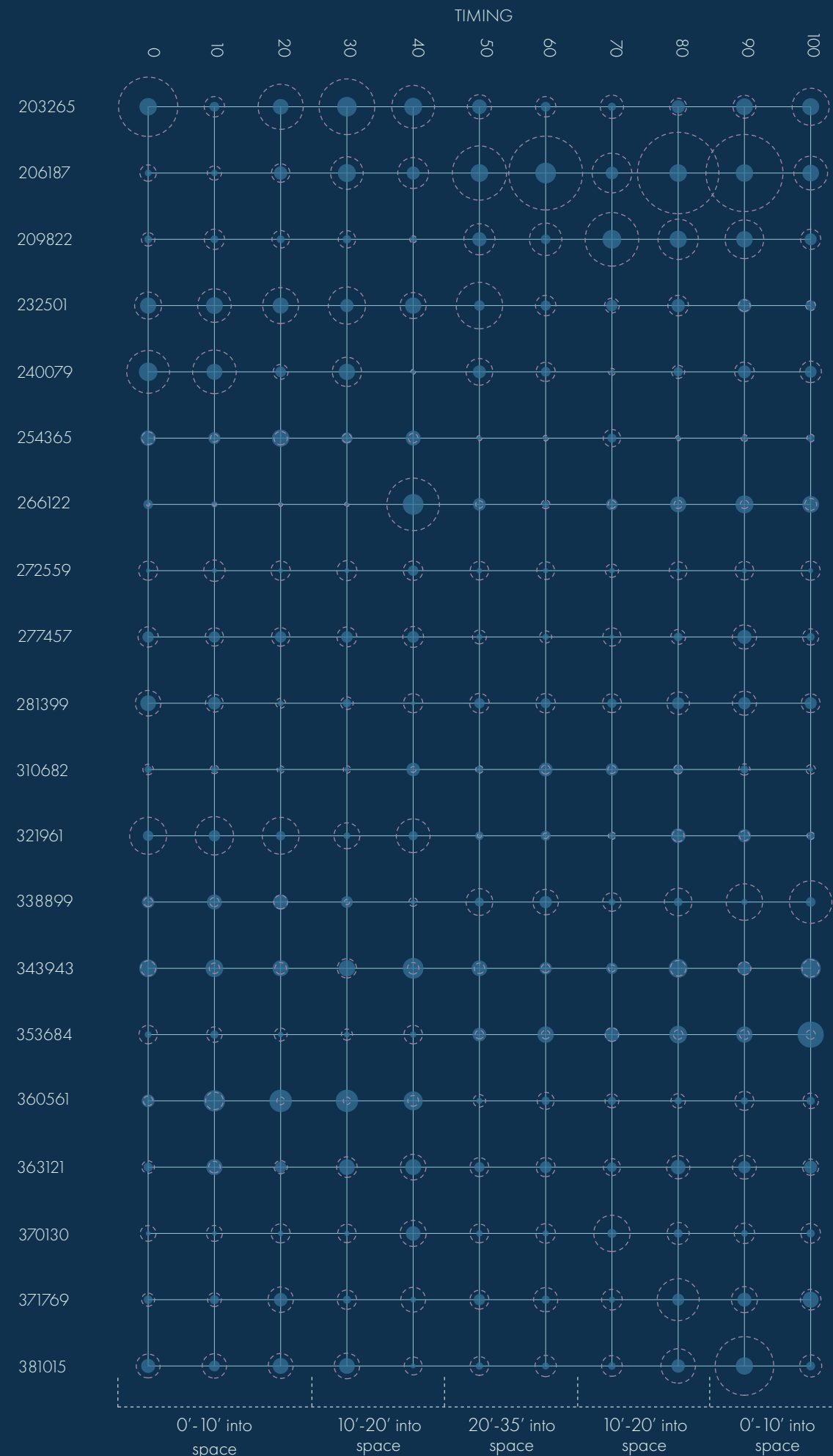
| 4 | 12 |
| 2 | 2 |

EEG Readings Data

| 15 | 4 |
| 1 | 0 |

Survey Results

LOCATION

PARTICIPANTS

TIMING

PARTICIPANTS

Excitement
Interest

DIFFERENTIATION

-7 0 7 14 21 28 35 42 49 56 63

PARTICIPANTS

203265
206187
209822
232501
240079
254365
266122
272559
277457
281399
310682
321961
338899
343943
353684
360561
363121
370130
371769
381015

PERCENTAGE CHANGE

-70 0 70 140 210 280 350 420 490 560 630

PARTICIPANTS

203265
206187
209822
232501
240079
254365
266122
272559
277457
281399
310682
321961
338899
343943
353684
360561
363121
370130
371769
381015

Base Excitement
Ave. Excitement
Peak Excitement
Base Interest
Ave. Interest
Peak Interest

Base Excitement
Ave. Excitement
Peak Excitement
Base Interest
Ave. Interest
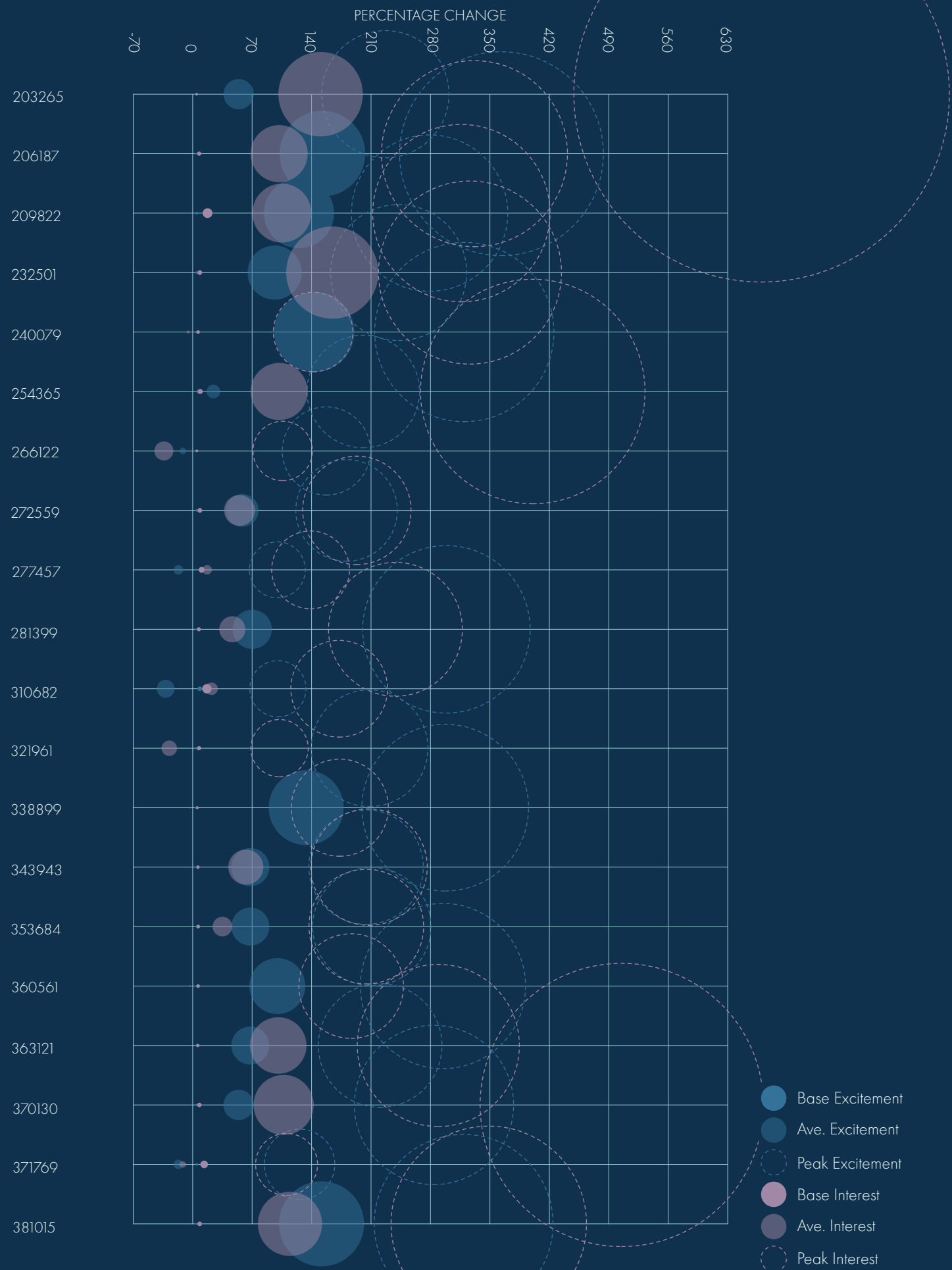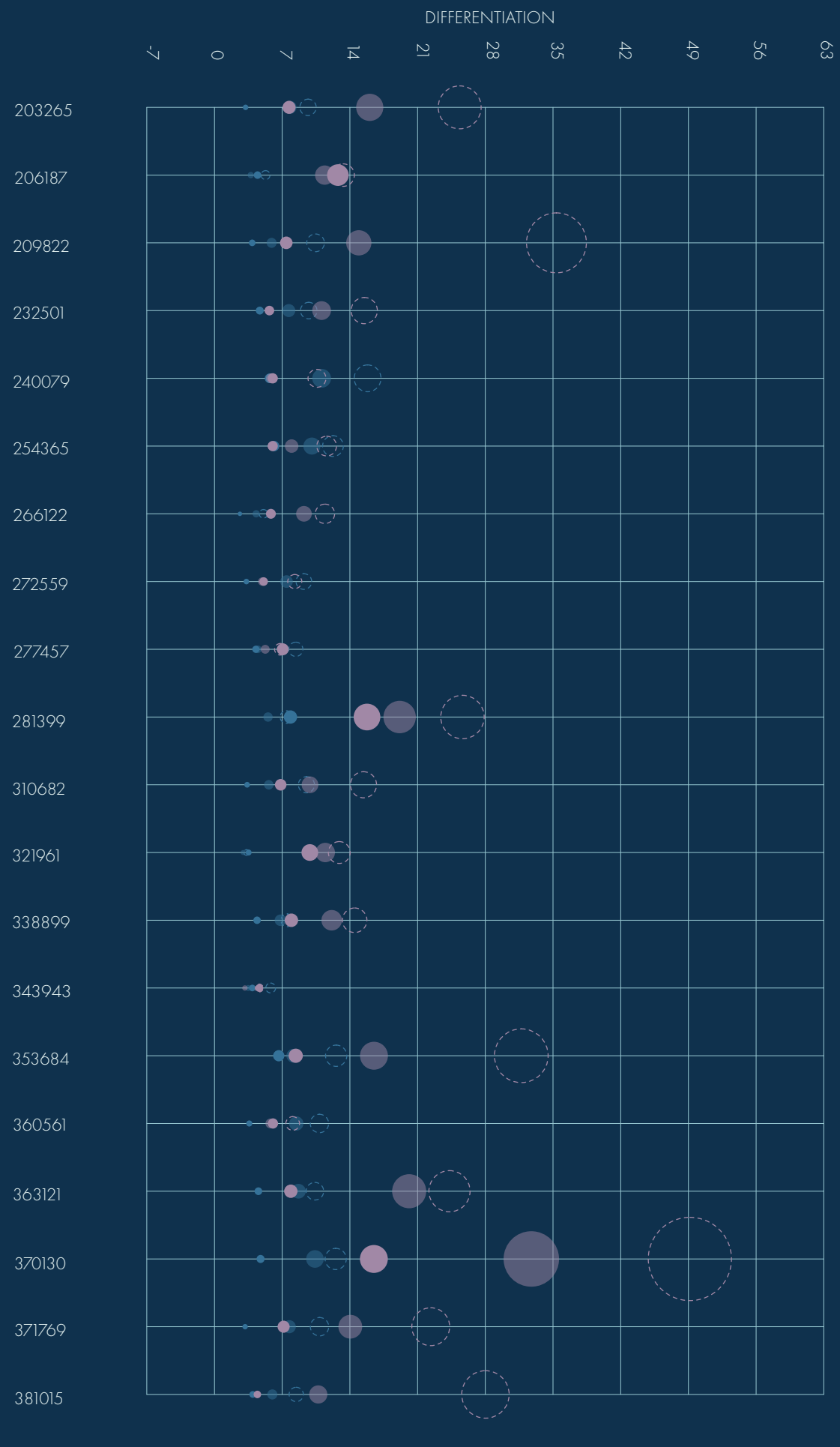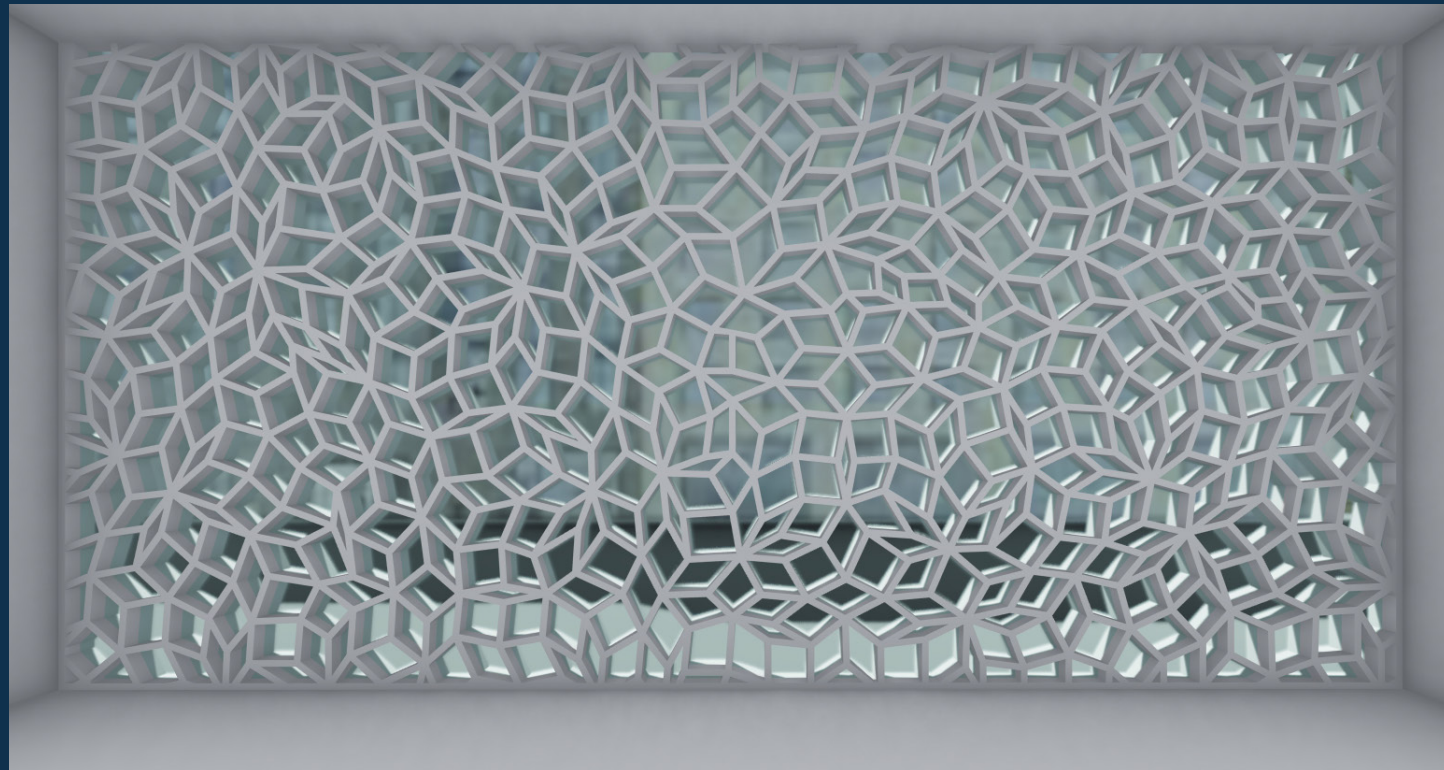Peak Interest

Elevation

Conclusions:

The eleventh façade looks at the predictability of the pattern- this pattern of this system is at a ½ scale and should not be able to be identified locally or globally. This façade was found to be within the positive valence side of the circle. Peaks for both valence and arousal were dispersed through the test time as well as the distance from the façade. Overall, the average arousal and valence levels of the participants were elevated- but less than 25% of the participants doubled their baseline levels. When looking at the peak differentials, the peaks are mild- with no participants jumping higher than 8 points from their average. The percentage chart is also mild- there are no exponentially large jumps from average to peak.

Overall , this façade promotes positive emotion for the user- though again it is an overwhelming and complex structure. Can be utilized in the everyday setting, but there are better systems and process that could achieve this aesthetic.

1	15
1	3

EEG Readings Data

9	7
2	2

Survey Results

LOCATION

PARTICIPANTS

TIMING

PARTICIPANTS

203265
206187
209822
232501
240079
254365
266122
272559
277457
281399
310682
321961
338899
343943
353684
360561
363121
370130
371769
381015

0'-10' into space   10'-20' into space   20'-35' into space   10'-20' into space   0'-10' into space

Excitement
Interest

DIFFERENTIATION

-7　0　7　14　21　28　35　42　49　56　63

PARTICIPANTS

203265
206187
209822
232501
240079
254365
266122
272559
277457
281399
310682
321961
338899
343943
353684
360561
363121
370130
371769
381015

Base Excitement
Ave. Excitement
Peak Excitement
Base Interest
Ave. Interest
Peak Interest

PERCENTAGE CHANGE

-70　0　70　140　210　280　350　420　490　560　630

PARTICIPANTS

203265
206187
209822
232501
240079
254365
266122
272559
277457
281399
310682
321961
338899
343943
353684
360561
363121
370130
371769
381015

Base Excitement
Ave. Excitement
Peak Excitement
Base Interest
Ave. Interest
Peak Interest

Elevation

Conclusions:

The twelfth façade looks at predictability of the pattern- the pattern of this system should not be able to be identified locally but can be seen globally. This façade was found to be on the positive valence side of the circle, but had 25% of participants fall in the negative valence side. Peaks for valence happened throughout the experiment, while arousal levels peaked mainly at the point furthest from the façade. Overall, the average arousal levels stayed close to baseline, 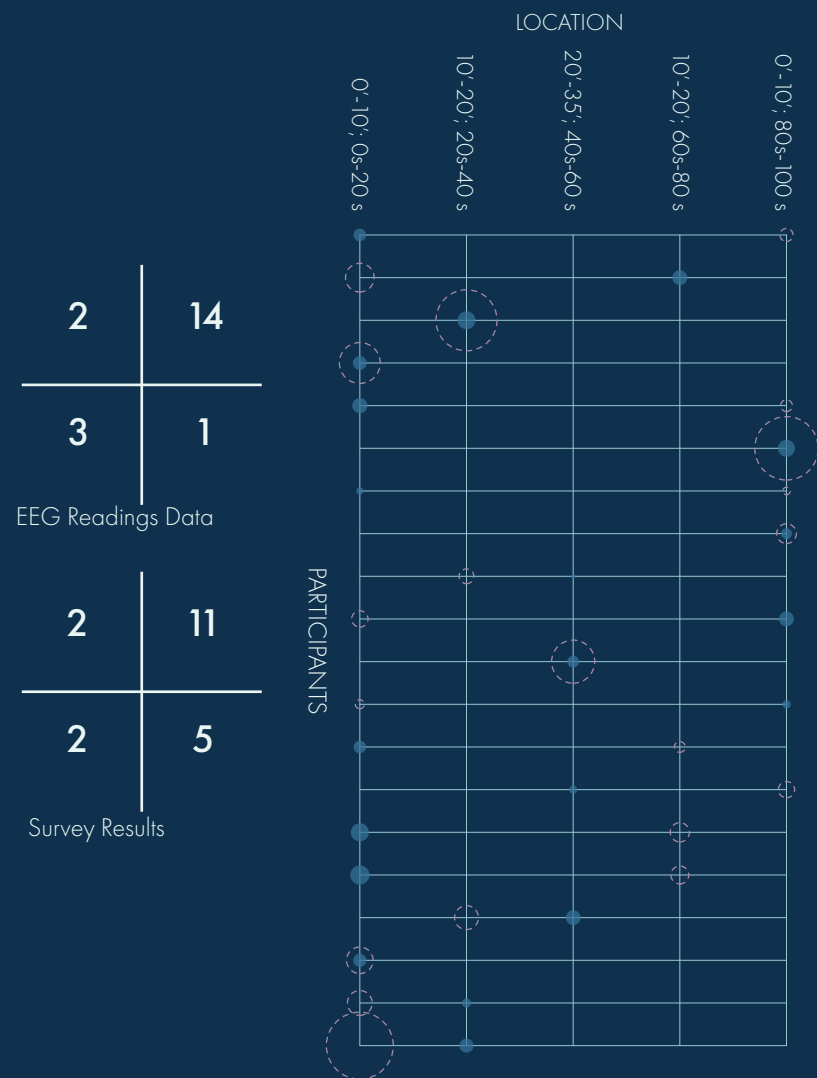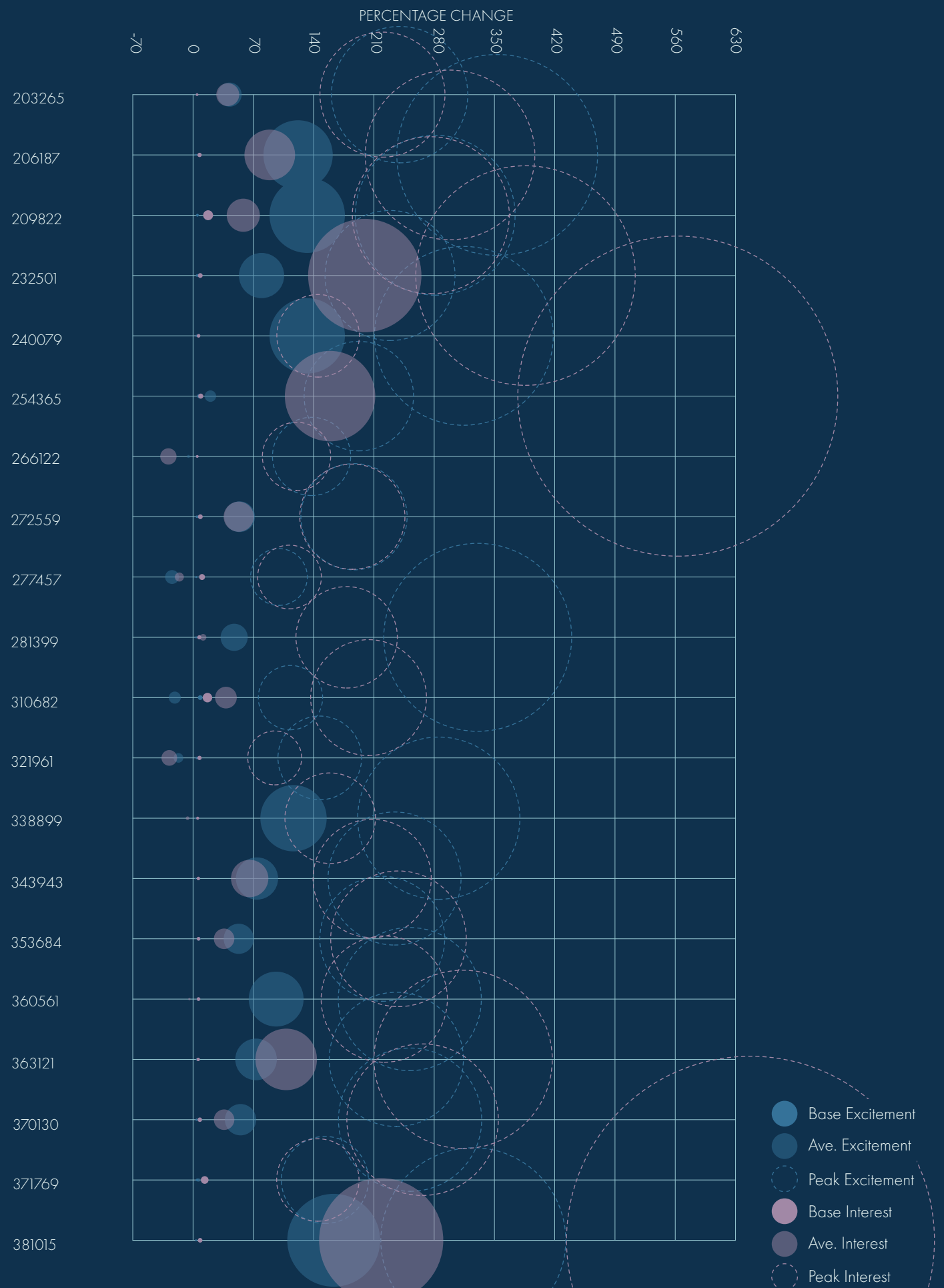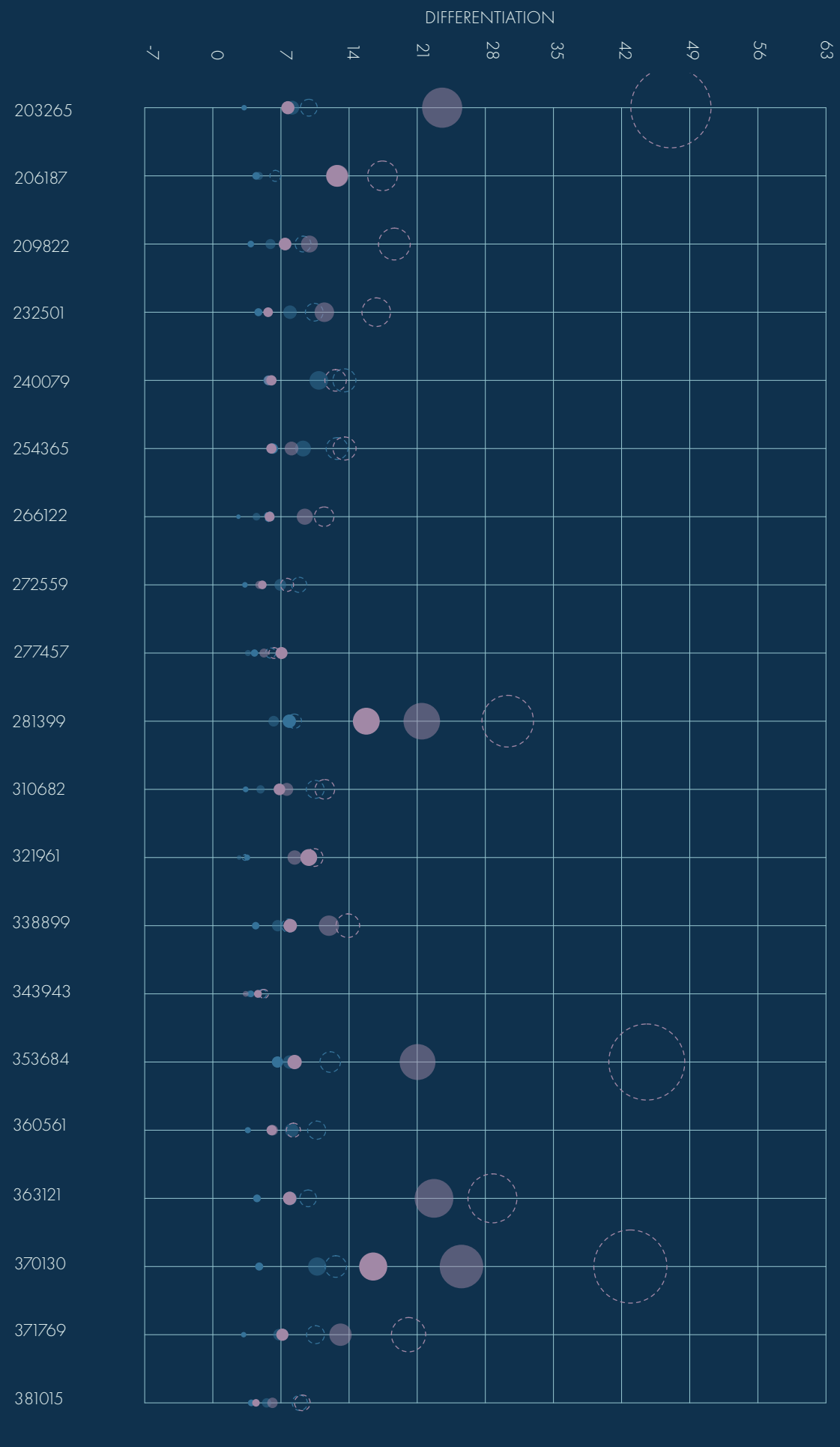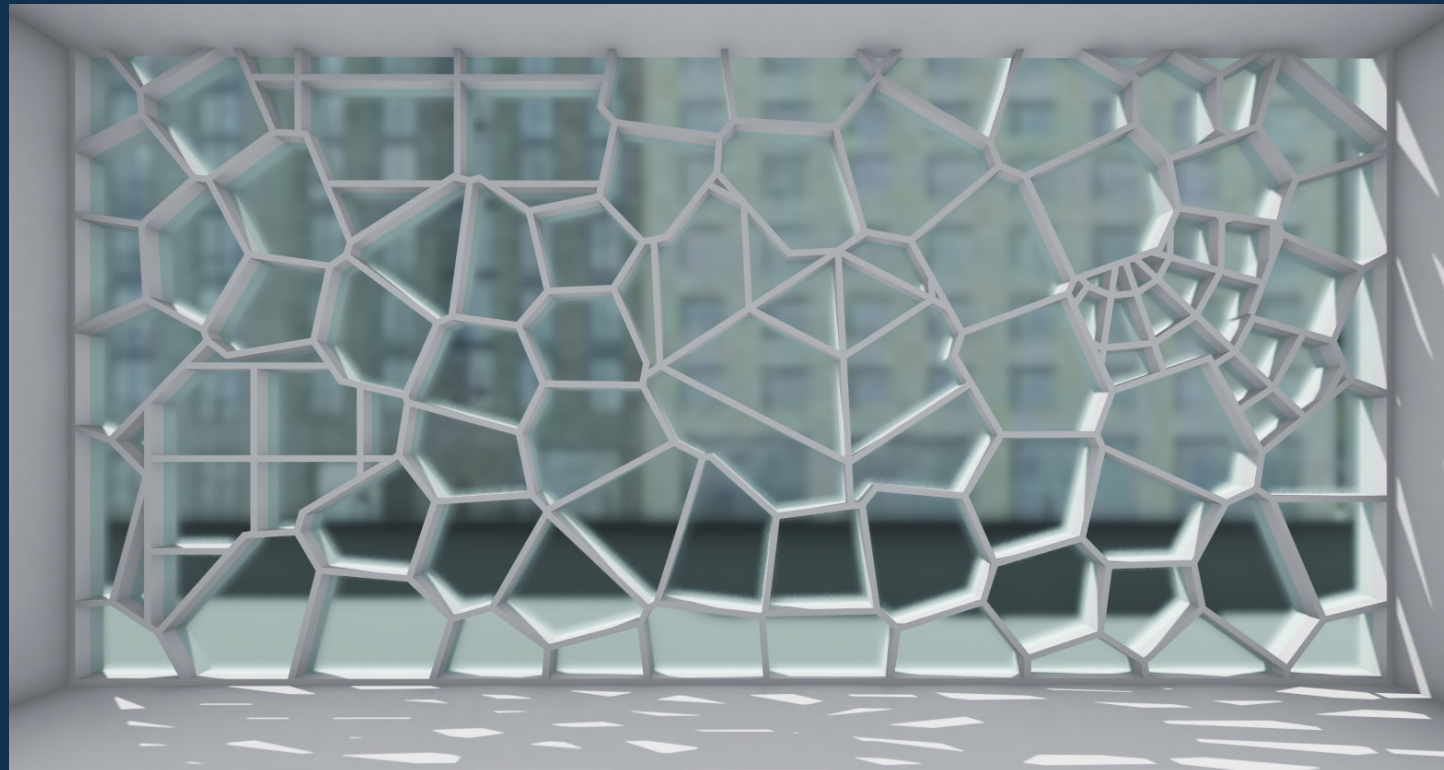while the valence levels fluctuated. When looking at the peak differential, there were 4 participants who had large peaks in the valence levels. However, if you look at the percentage change, you will see that only two participants had a relatively large change with both being over 500% of the baseline. Overall, this façade promotes positive emotions, but should be used in a specific context that allows for this more "chaotic" pattern to function on its own. This system could be utilized in everyday settings- but should be used sparingly.

2	14
3	1

EEG Readings Data

2	11
2	5

Survey Results

-7 0 7 14 21 28 35 42 49 56 63

PARTICIPANTS

203265
206187
209822
232501
240079
254365
266122
272559
277457
281399
310682
321961
338899
343943
353684
360561
363121
370130
371769
381015

-70 0 70 140 210 280 350 420 490 560 630

PARTICIPANTS

203265
206187
209822
232501
240079
254365
266122
272559
277457
281399
310682
321961
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Base Excitement
Ave. Excitement
Peak Excitement
Base Interest
Ave. Interest
Peak Interest

Base Excitement
Ave. Excitement
Peak Excitement
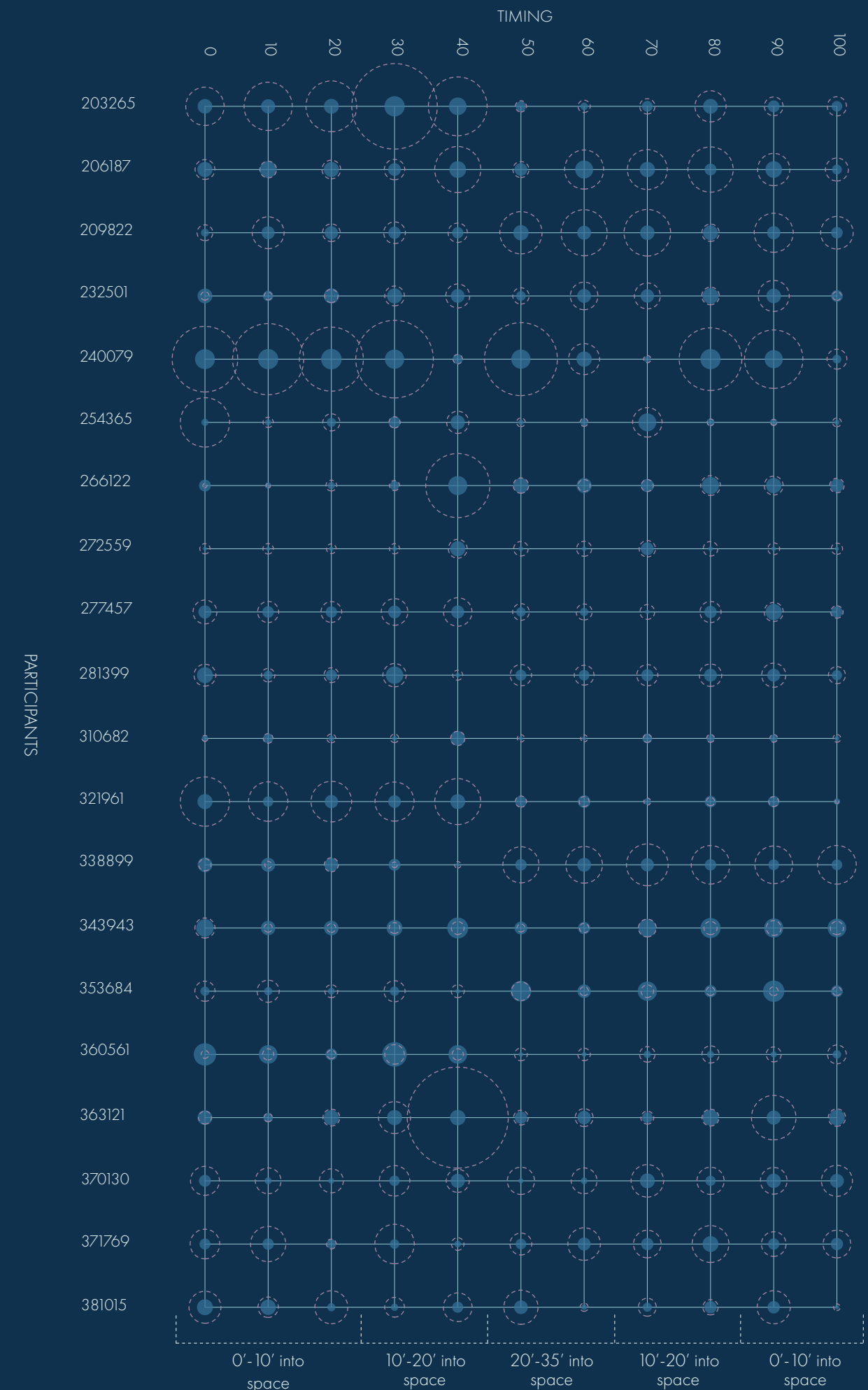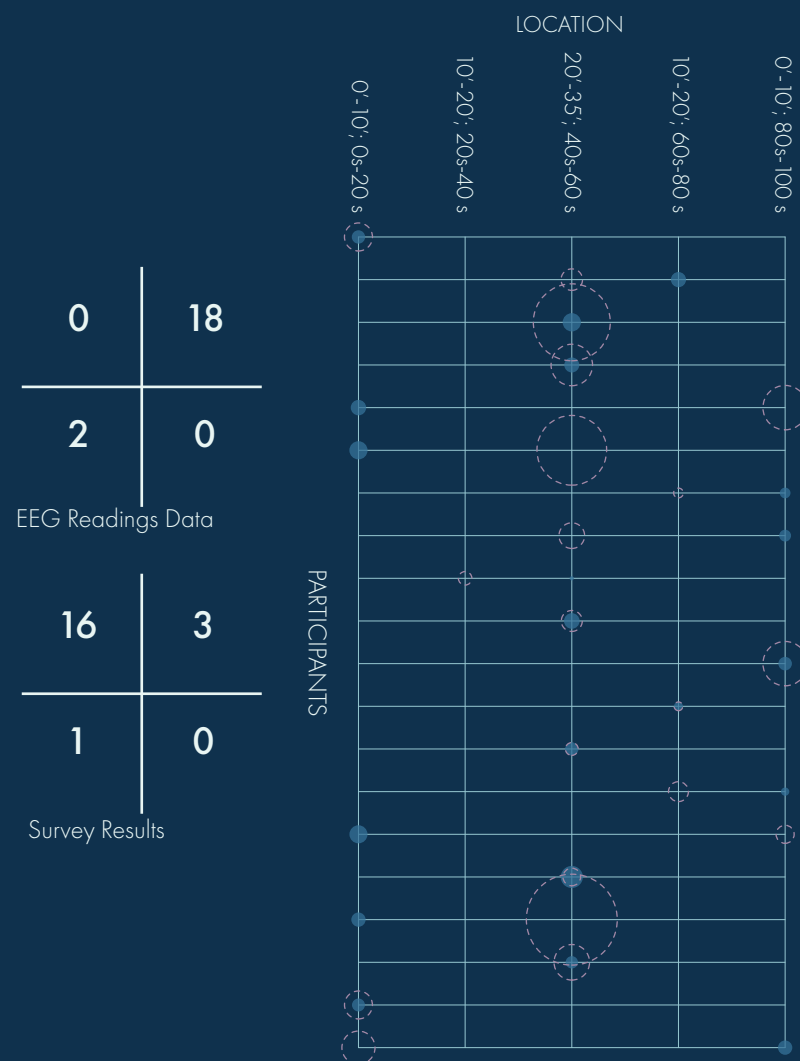Base Interest
Ave. Interest
Peak Interest

Elevation

Conclusions:

The thirteenth façade looks at the predictability of the pattern- this is an organic, patchwork system that should not be identifiable locally or globally. This façade was found to be within the positive valence side of the circle- and has the most participants within the 1st quadrant. One note, though participants fell within the positive side, they were saying they fell within the negative valence side of the circle. Peaks for both valence and arousal happened mainly at the closest point to the façade. Overall, the average arousal and valence levels were elevated greatly- almost all participants doubled their baseline levels.
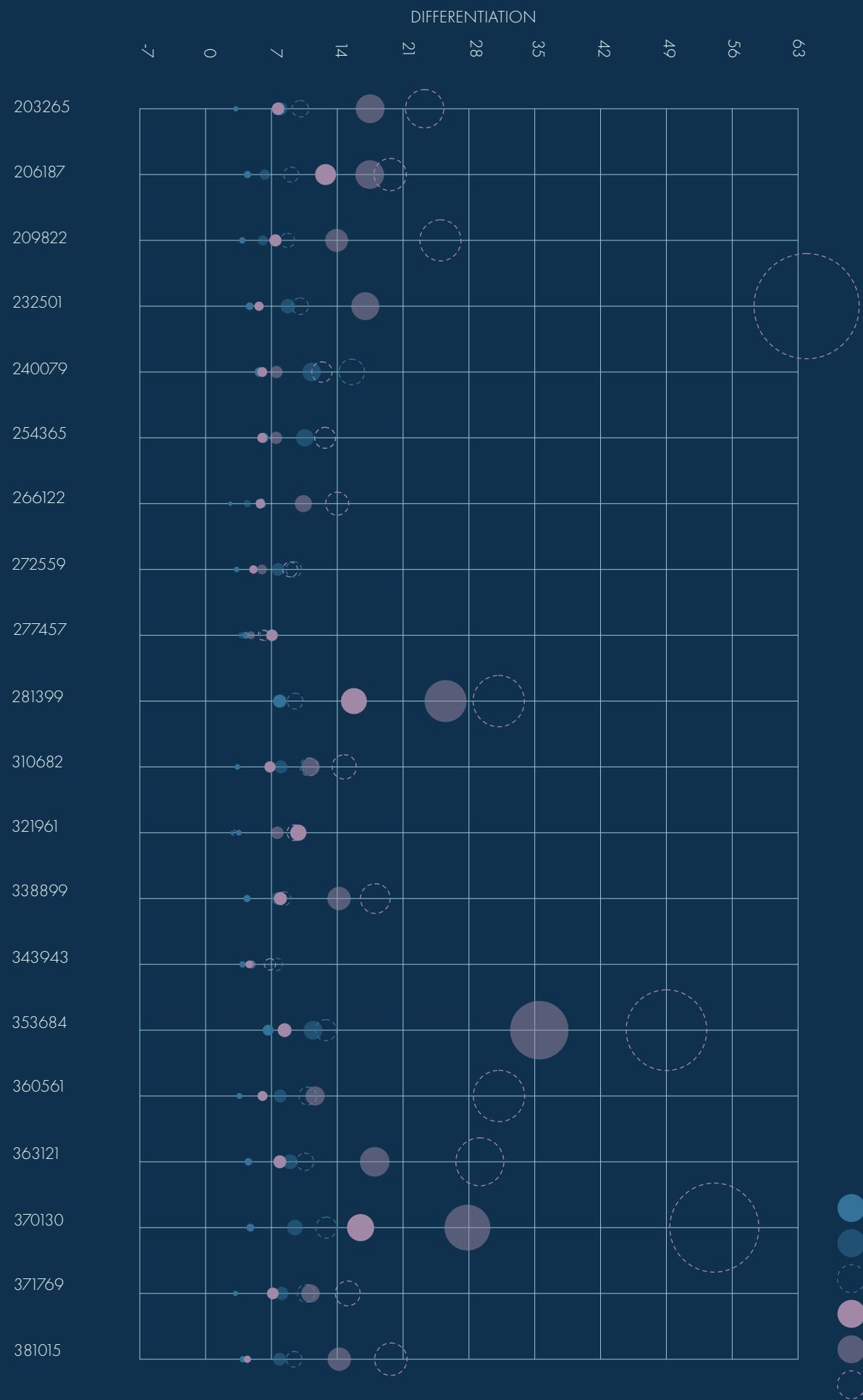
When looking at the peak differential, there are 25% of participants that had large peaks. This translates into the percentage change, where again there are 25% of participants with large peaks- though these were not the same four participants between the two charts.

Overall, this space promotes a positive valence and high arousal- but I believe this is due to the randomness that the system has. It kept the participant engaged as all participants continued to look around and didn't settle their gaze in one particular spot. This system should be used sparingly in everyday settings.
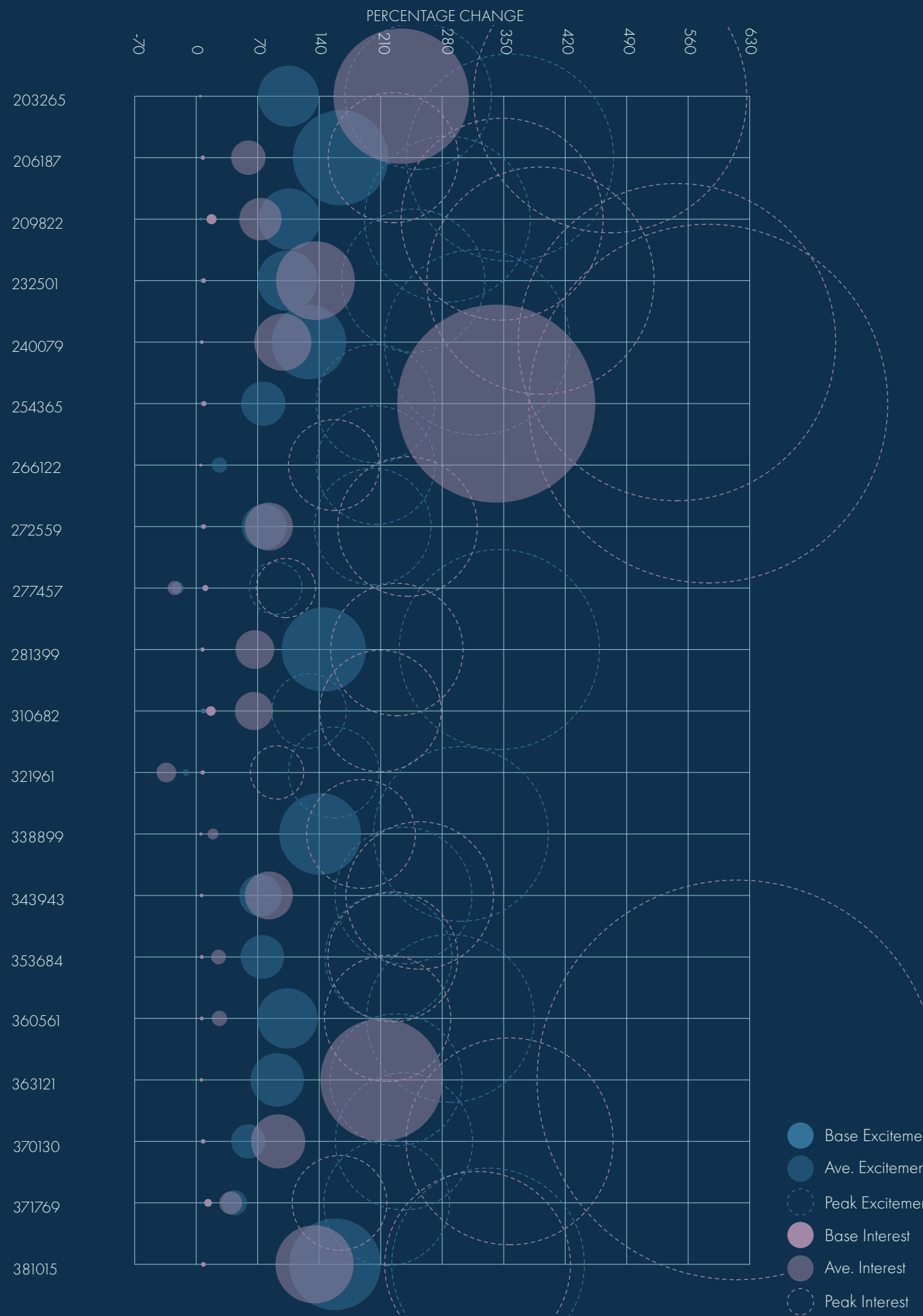
0	18
2	0

EEG Readings Data

16	3
1	0

Survey Results

LOCATION

PARTICIPANTS

0'-10'; 0s-20 s
10'-20'; 20s-40 s
20'-35'; 40s-60 s
10'-20'; 60s-80 s
0'-10'; 80s-100 s

PARTICIPANTS

	0	10	20	30	40	50	60	70	80	90	100
203265											
206187											
209822											
232501											
240079											
254365											
266122											
272559											
277457											
281399											
310682											
321961											
338899											
343943											
353684											
360561											
363121											
370130											
371769											
381015											

0'-10' into space	10'-20' into space	20'-35' into space	10'-20' into space	0'-10' into space

● Excitement
◌ Interest

DIFFERENTIATION

-7 0 7 14 21 28 35 42 49 56 63

PARTICIPANTS

203265
206187
209822
232501
240079
254365
266122
272559
277457
281399
310682
321961
338899
343943
353684
360561
363121
370130
371769
381015

Base Excitement
Ave. Excitement
Peak Excitement
Base Interest
Ave. Interest
Peak Interest

PERCENTAGE CHANGE

-70 0 70 140 210 280 350 420 490 560 630

PARTICIPANTS

203265
206187
209822
232501
240079
254365
266122
272559
277457
281399
310682
321961
338899
343943
353684
360561
363121
370130
371769
381015

Base Excitement
Ave. Excitement
Peak Excitement
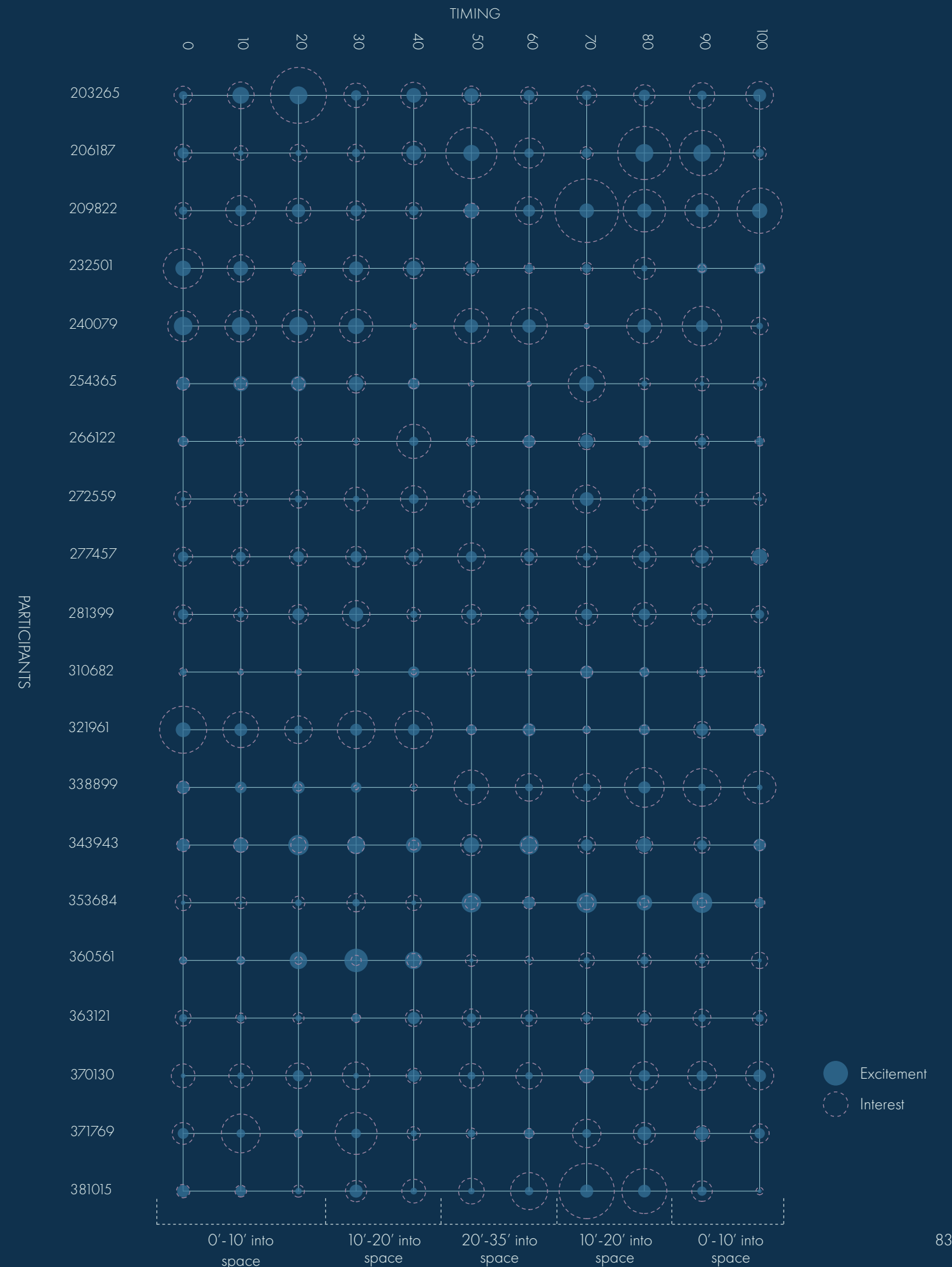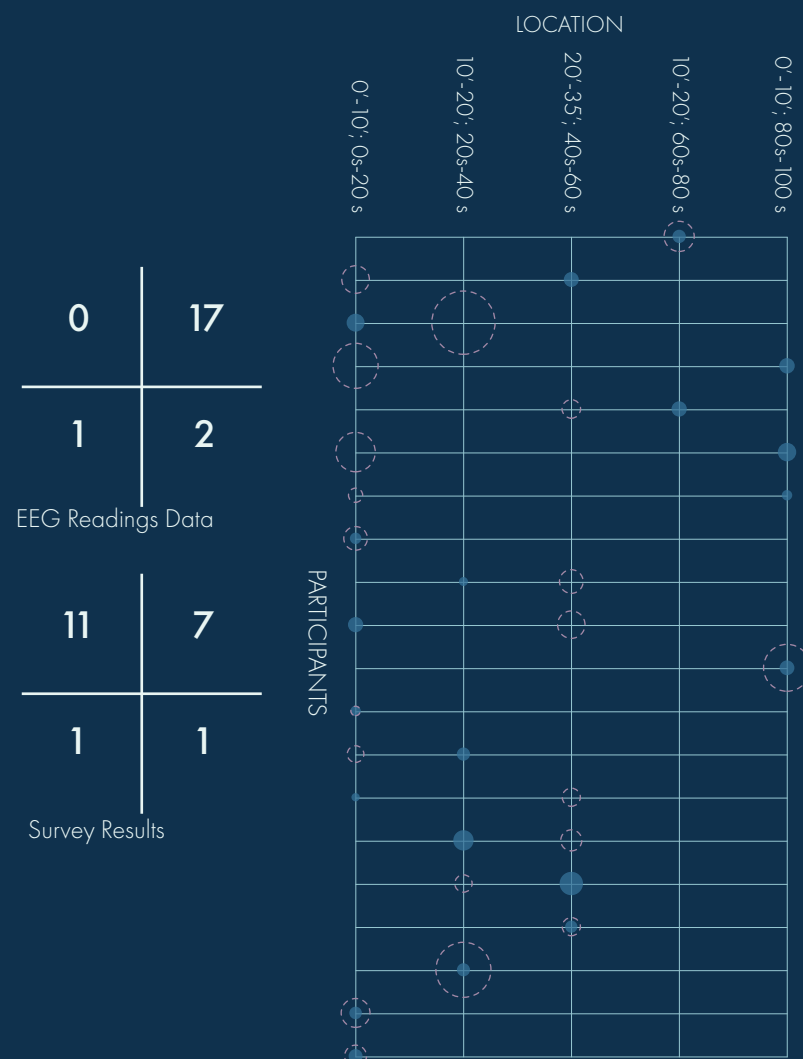Base Interest
Ave. Interest
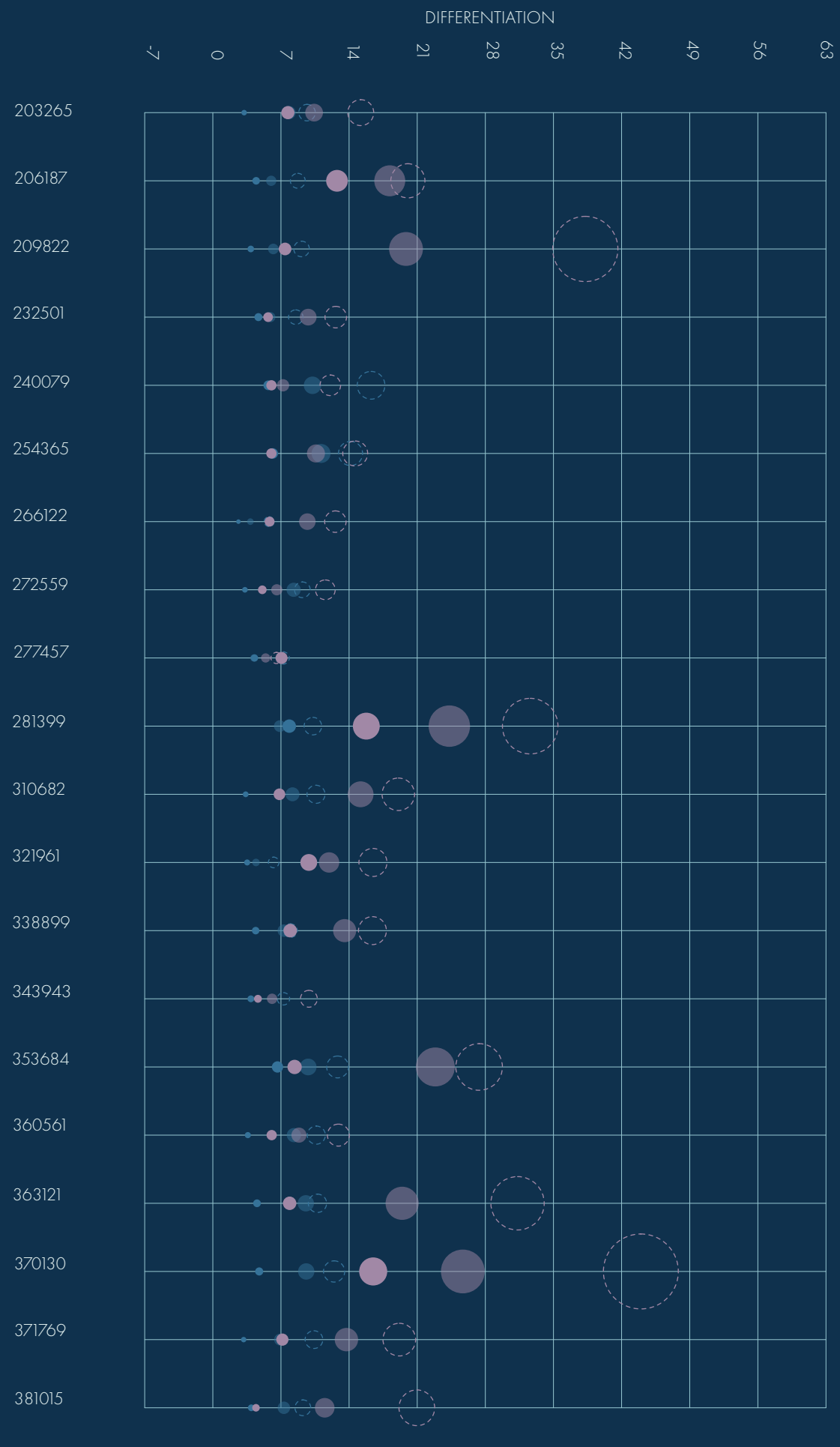Peak Interest

Elevation

Conclusions:
The fourteenth façade looks at the visibility of an image- for this system, the image is fully legible and should be recognized by the participant. This façade was found to be within the positive valence side of the circle. Peaks for both arousal and valence happened throughout the test. Overall, the both the average arousal and valence were elevated in relation to other facades.

When looking at the peak differential, there were two peaks larger than 7 points from the average. When looking at this through a percentage however, there were more drastic changes in peaks than what the differential chart shows.
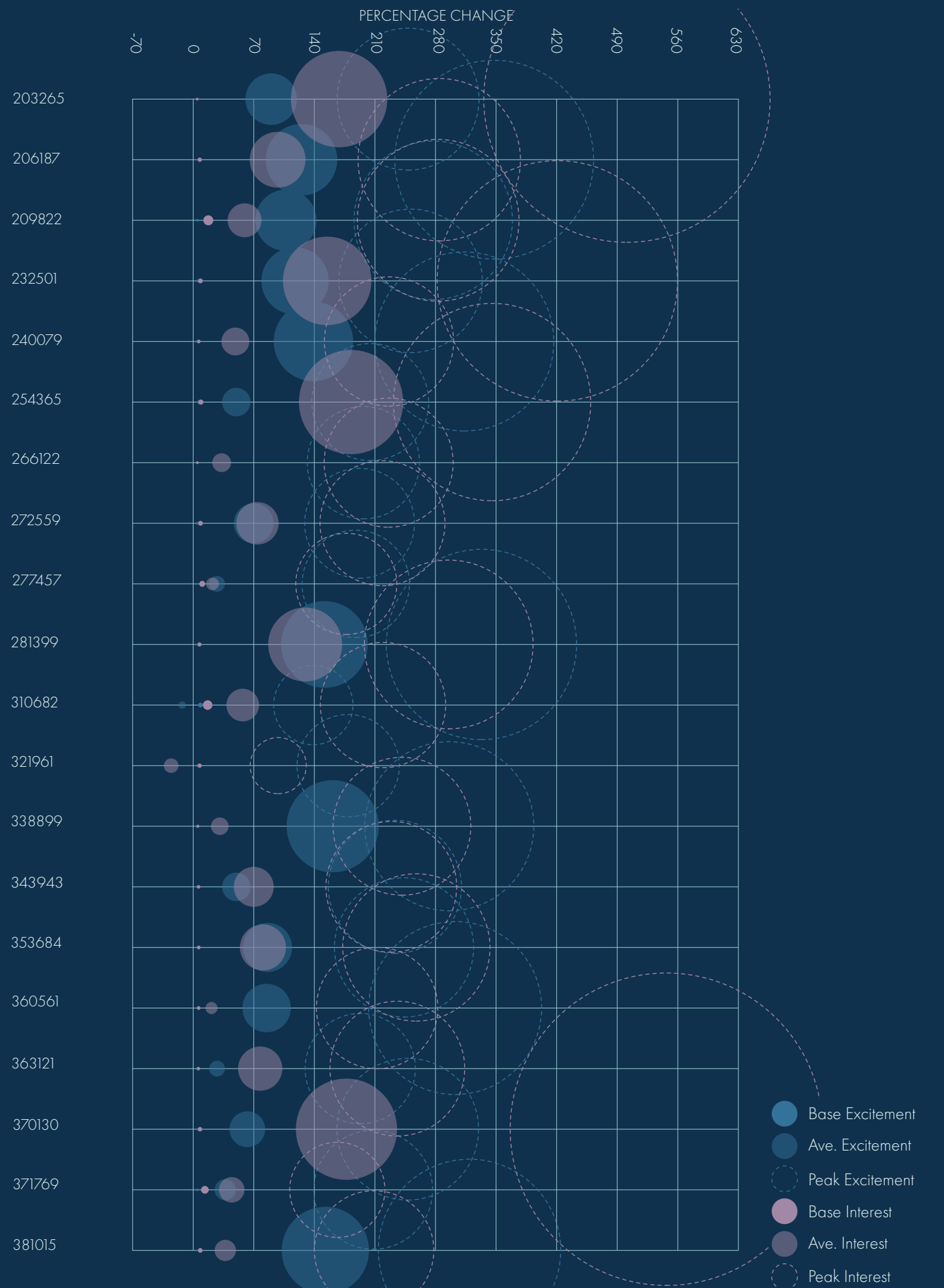
Overall, this façade promotes positive emotions from the user- and can/should be utilized in everyday settings. There is the added bonus that this fritting pattern can be used as a solar shading device as well.

0	17
1	2

EEG Readings Data

11	7
1	1

Survey Results

LOCATION

PARTICIPANTS

0'-10'; 0s-20 s
10'-20'; 20s-40 s
20'-35'; 40s-60 s
10'-20'; 60s-80 s
0'-10'; 80s-100 s

TIMING

0 10 20 30 40 50 60 70 80 90 100

PARTICIPANTS

203265
206187
209822
232501
240079
254365
266122
272559
277457
281399
310682
321961
338899
343943
353684
360561
363121
370130
371769
381015

0'-10' into space
10'-20' into space
20'-35' into space
10'-20' into space
0'-10' into space

Excitement
Interest

DIFFERENTIATION

-7 0 7 14 21 28 35 42 49 56 63

PARTICIPANTS

203265
206187
209822
232501
240079
254365
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272559
277457
281399
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321961
338899
343943
353684
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370130
371769
381015

PERCENTAGE CHANGE

-70 0 70 140 210 280 350 420 490 560 630

PARTICIPANTS

Base Excitement
Ave. Excitement
Peak Excitement
Base Interest
Ave. Interest
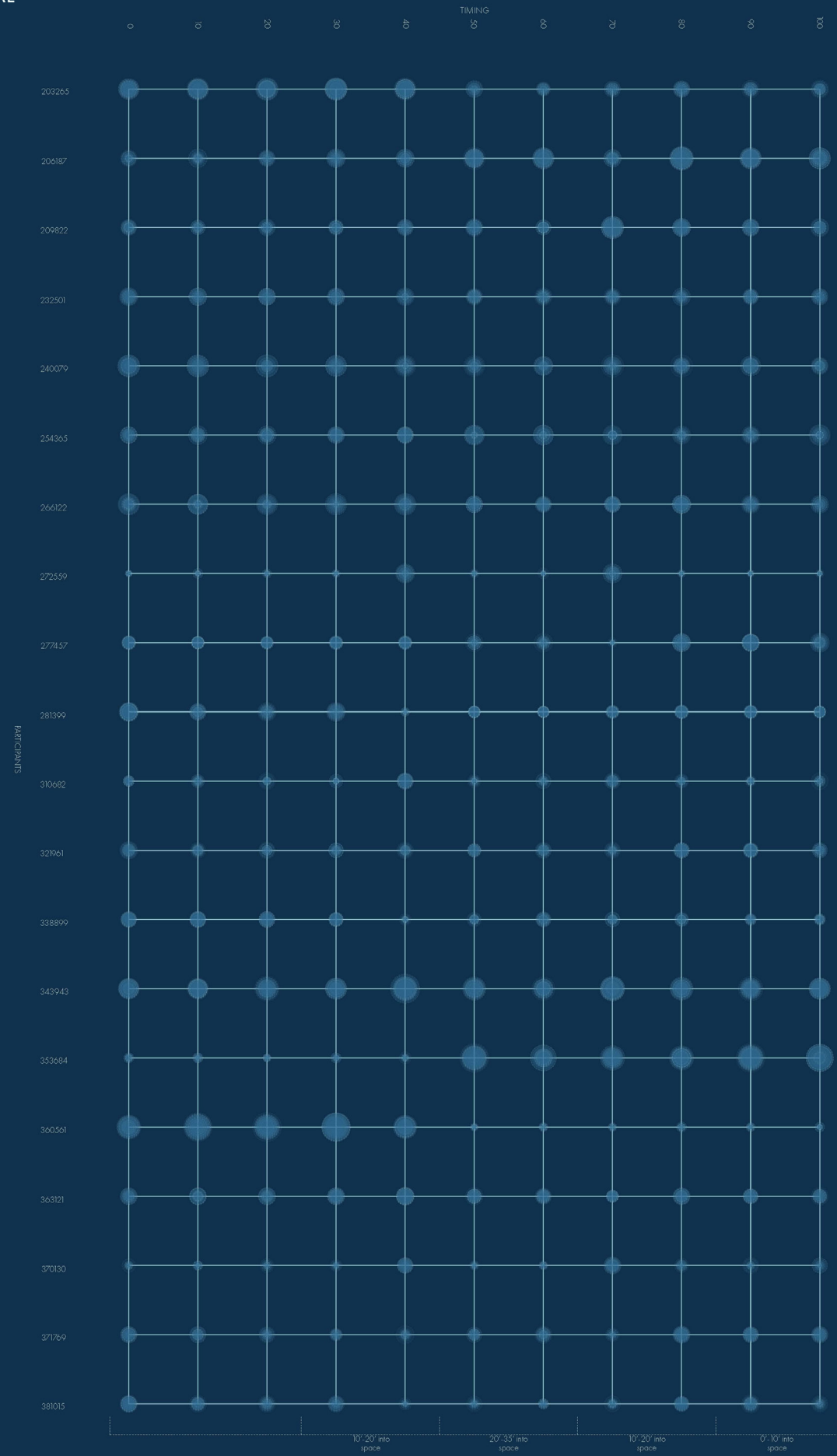Peak Interest
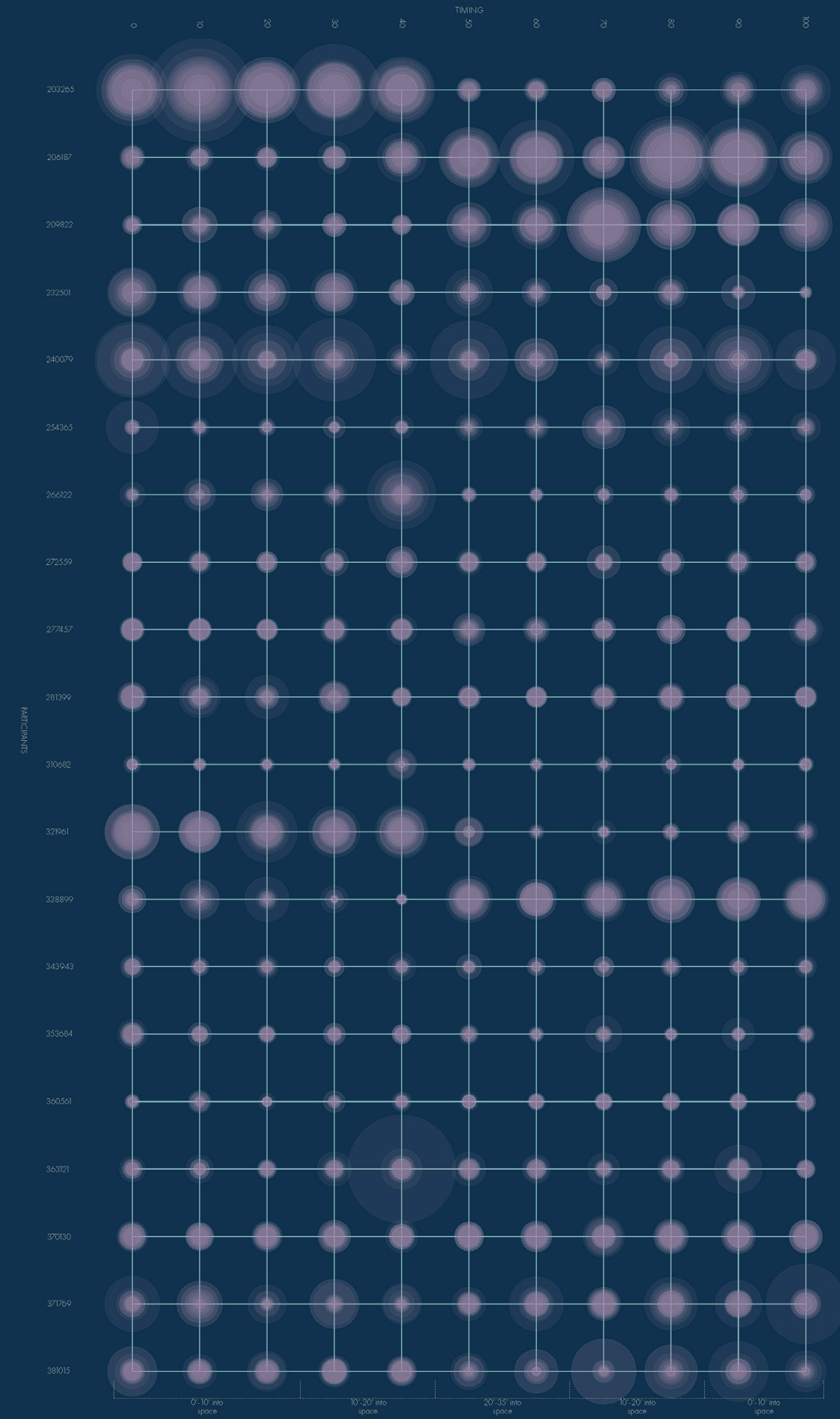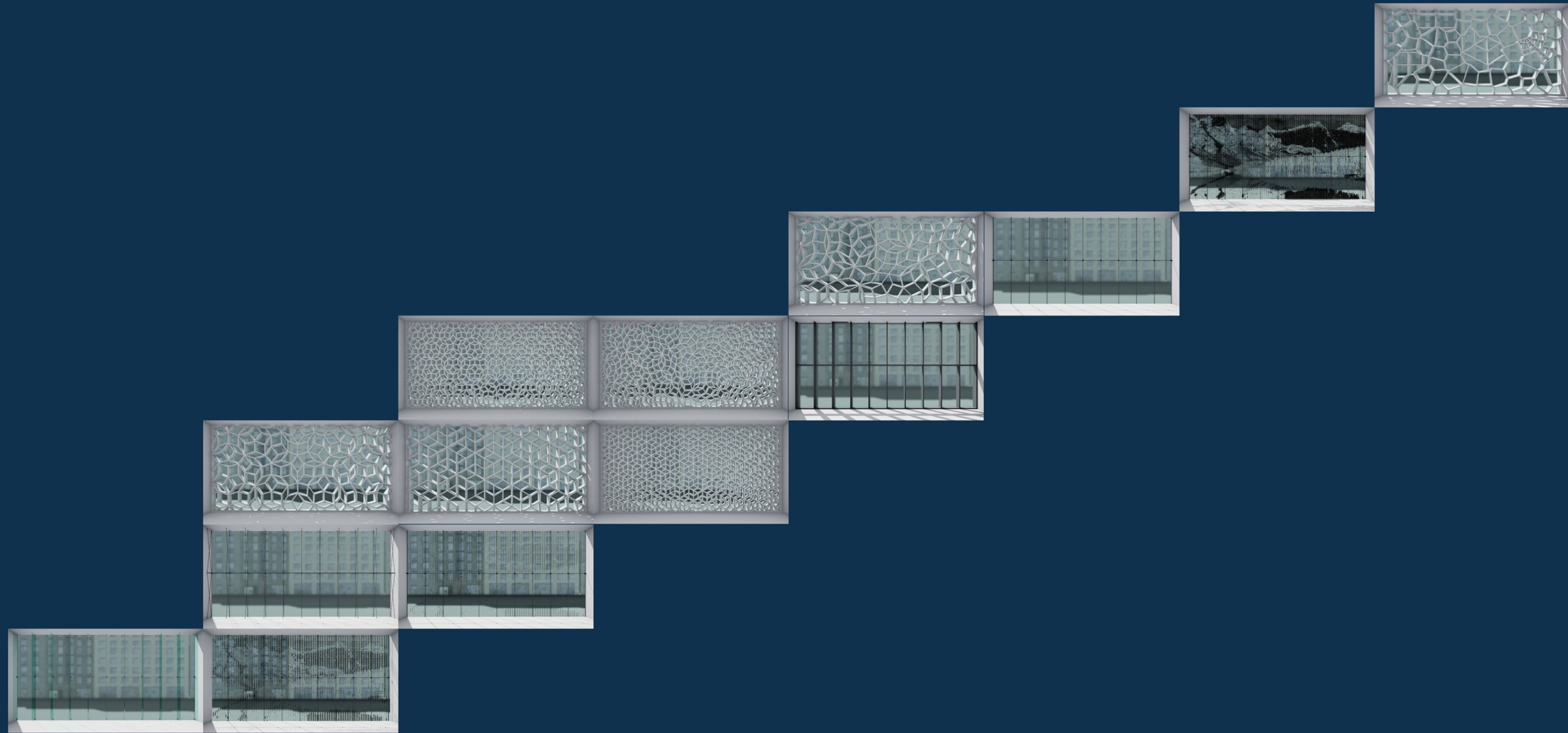
CONCLUSIONS

CONCLUSIONS

Based upon the data collected, and through the analysis process, the facades were placed within the survey circle shown previously in this book. The further away from the bottom left corner, the more positive valence and high arousal the facade had.

FINAL CONCLUSIONS:

Valence changed more drastically overall than arousal.

       I believe that this is the case because arousal is described as the intensity that the participant is feeling. Valence on the other hand is the overall positiveness of the emotion they are feeling. This would explain why valence is higher than arousal- it is harder to change the intensity of an emotion as quickly as the testing times are set up.

The more unpredictable the pattern- the more you attract the user, thus their valence and arousal levels are higher.

       The reverse order of the pattern predictability parameter set goes in the order that the facades fell in based on this hypothesis.

The scale of the pattern- where half or full-made little difference.

       By comparing the two sets of patterns to each other, they overall peaks, and averages were relatively similar. If there were peaks happening in one, they were also happening in the other.

The more unpredictable the pattern- and with a smaller scale- the smaller the overall peak of the participant is.

Level of detail within the virtual reality environment did not make a difference- the user was focusing on other aspects of the façade system.

The less legible the image- the more negative the reaction the image will receive.

       When looking at the three imagery facades, it was found that the first two illegible facades, were placing on the lower end of the grid, while the legible image was at the top.
       Next steps for this façade system is to test a negative image to see if the same reactions happen as did here.

FINAL CONCLUSIONS:

Highest in each quadrant:
       Quad 1: Room 13
   Quad 2: Room 10 or 2
       Quad 3: Room 1
       Quad 4: Room 8

FUTURE STEPS:

       A future parameter to test would be the order of the facades. I ran the groupings where there were two groups of 3. The first set had two facades that were similar, and the third was a "jump" or drastic change. The second set again had two facades that were similar, but the third was less drastic- in this case there was a similarity between the two where the "jump" occurred. In my setup there were jumps between rooms 2 & 3, and 9 & 10. Lead ups occur between 6 & 7, and 13 & 14.

       Moving forward, the testing environments right now are seen in small doses. What happens when the participants are in the space for 5 minutes? 10? 20? The next step for this research is to add a parameter within the testing space that changes the test time in different user groups. Test multiple times, with multiple façade groupings.

       The methodology developed within this thesis is be used as a resource in addition to traditional building practices and research. Facades were studied within a vaccum, but the knowledge and data is there now to be studied further in more detailed VR environments.

AROUSAL

VALENCE
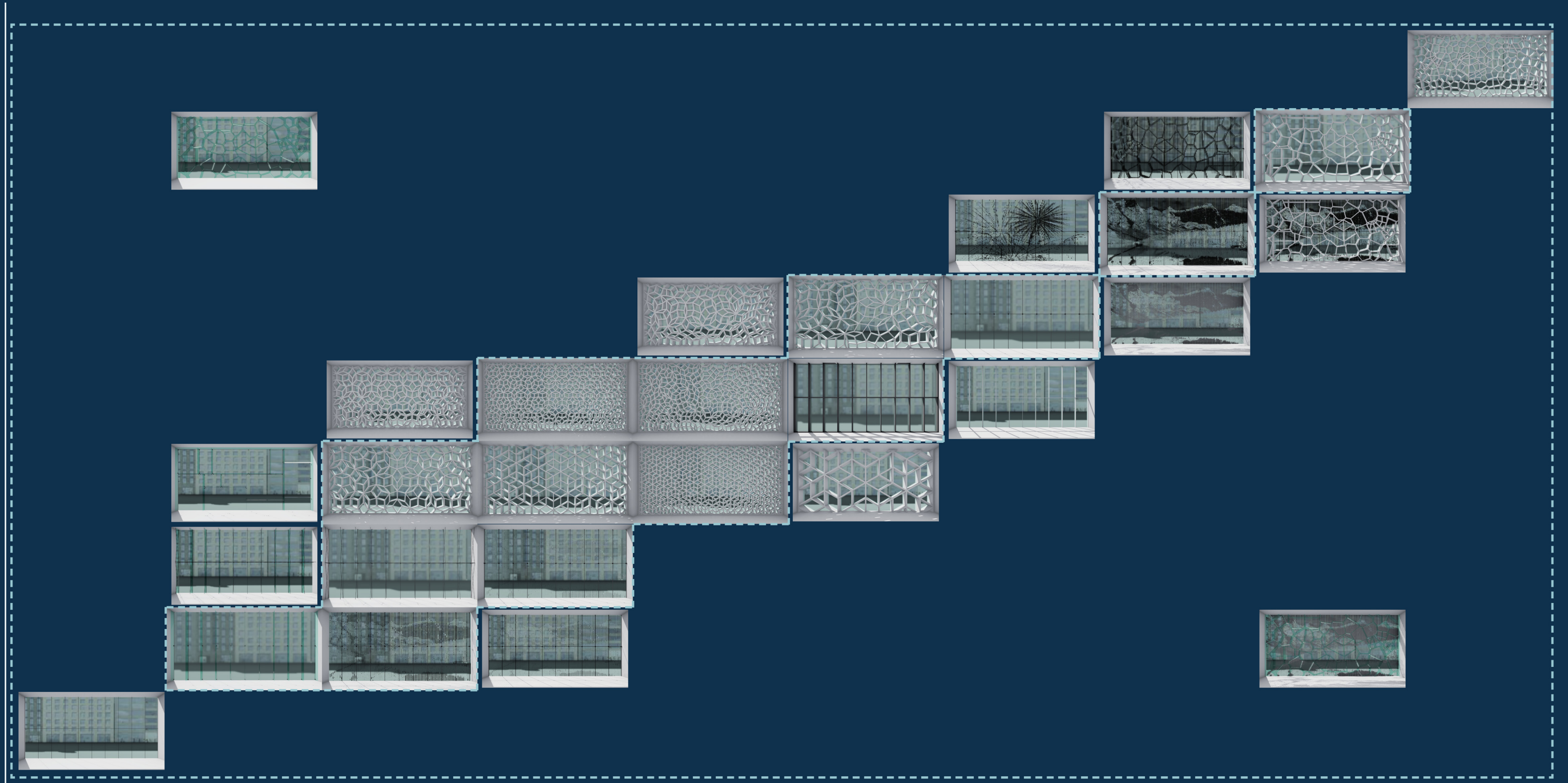
Based upon all data collected- connections can begin to be drawn between the interconnecting facades.
Next steps within the research is to continue populating the grid, and then testing those new populations on
additional testing groups.

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