TANGIBLE VISUALIZATION TOOLKIT

for making group planning decisions

Thesis Presented by Yi Yang to The Department of Arts, Media and Design in Partial Fulfillment of the Requirements for the Degree of Master of Fine Arts

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Tangible Visualization Toolkit for making group planning decisions

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Physical visualizations exist from the very beginning of human history. Now that we are making all program “paperless” or “digital”, there still are some scenarios will benefit more from physical objects due to their tangibility and their capacity to be grasped and reshaped. The intention of my work is to propose a new visual encoding that maps information to a physical form in order to enhance the efficiency of group planning. I am exploring building up a culturally neutral language that is visually formed so that people from different backgrounds can share basic understanding easily and simultaneously. My initial experiment is a prototype of a set of physical objects. It contains a magnetic base, a set of information sheets, a vacant transparent sheet, a few markers, and some colored magnetic tokens. By assembling the tokens and changing the data simultaneously, users can easily exchange their decisions and share immediate thoughts with other participants. In other words, I intend to design a visual toolkit as a language to help people engaging more with information and better communicate to other people. Instead of just talking about conflicts and picturing them independently in minds, I am proposing to put them in visual forms so we can point at and in tangible form so we can grasp it and make changes immediately. I hope this project will not only benefit group planning process but also provide a novel way to visualize real life problems by users themselves and help them make better decisions. My primary contribution is a visualization toolkit design, I also provide an informal user study in order to find usability problems with my prototype.
Successfully completing a Master’s degree program is never a solitary endeavor. I would never have completed this long, incredible journey without the many wonderful people in my life that supported me in so many ways.

I want to express my heartfelt gratitude and appreciation to the following people: my family and friends for their support, encouragement and understanding.

I also want to share my thankfulness towards my dedicated instructors, particularly Miso Kim for her invaluable mentorship, practical advices and afternoon tea times, Pedro Cruz for his unwavering support and thoughtful discussions; all my great professors at CAMD for their teaching and wisdom; all my kindness classmates for their companying and support.

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INTRODUCTION

Every now and then, we try to achieve agreement with other people. This process is often called as “group decision-making” or “collaborative decision-making”.

Group decision-making is a situation faced when individuals collectively make a choice from the alternatives before them. The examples could range from “what to eat for lunch” to “where to travel for a vacation”. In the former situation, we may want to eat together, but one of us prefers Italian food, while the other doesn’t want to spend too much or listen to opera while eating.

In fact, the whole world is built up on achieving agreements towards goals. In many cases, using different languages may easily end up with misunderstandings hence disagreements. Speaking of language, verbal language is what people often referring to. However, in this case the language that I am referring to is a broader sense of language, that is, the communication context of information. Even when we talk with the same verbal language and in the same contextual environment, sometimes the words have different meanings to different people. On the other hand, a visual representation or a physical object that people can point at or even touch is less misunderstanding in conversational environments.
“Conversation is a requisite for agreeing on goals, as well as for agreeing upon, and coordinating, our actions.”

Hugh Dubberly

Figure 4  Conversation to Collaborate
Agreeing on goals and coordinating actions to achieve them.

Could be an illustration of conversation leading to collaboration and goal agreement.
That is why I am exploring building up a culturally neutral language that is visually formed so that people from different backgrounds can share basic understanding easily and simultaneously. In other words, I intend to design a visual toolkit as a language to help people engaging more with information and better communicate to other people. Instead of just talking about conflicts and picturing them independently in minds, I am proposing to put them in visual forms so we can point at and in tangible form so we can grasp it and make changes immediately.

Why Physical?

The origin of data visualization dates back to 5500 BC according to an eminent archaeologist Denise Schmandt-Besserat. The tool that was used to externalize information is clay token system. It not only support visual thinking but also enhance people’s cognition.

What’s more? Nowadays, physical visualizations can outperform their on-screen counterparts has been proven in data retrieval tasks in research paper “Evaluating the efficiency of physical visualizations”.

Figure 2. Clay tokens date back to 5500 BC, photo by Denise Schmandt-Besserat
“Whereas words consist of immaterial sounds, the tokens were concrete, solid, tangible artifacts, which could be handled, arranged and rearranged at will.

For instance, the tokens could be ordered in special columns according to types of merchandise, entries and expenditures; donors or recipients. The token system thus encouraged manipulating data by abstracting all possible variables. No doubt patterning, the presentation of data in a particular configuration, was developed to highlight special items.”

Denise Schmandt-Besserat
Therefore, this thesis will invest in following questions:
1. What are the components of a tangible visualization toolkit? 2. How can tangibility help in group planning situation? 3. What are the advantages of tangibility in this context?

To answer these research questions, I will explain what I acquired by looking into different aspects of physical visualization, and discuss features of tangibility that work well with physical objects.

My initial experiment is a prototype of a set of physical objects. It contains a magnetic base, a set of information sheets, a vacant transparent sheet, a few markers, and some colored magnetic tokens.

My first case study sets the context in group travel planning. I prepared information sheets, printed by transparent papers each containing a certain travel information, such as sites, subway lines, etc. Different tokens represent different attributes of a certain kind of information. The vacant sheet is used to draw the travel routes on. By assembling the tokens and changing the data simultaneously, users can easily exchange their decisions and share immediate thoughts with other participants.
The contribution of this work is to propose a new visual encoding that maps information to a physical form in order to enhance the efficiency of group planning. I hope this project will not only benefit group planning process but also provide a novel way to visualize real life problems by users themselves and help them make better decisions.

Besides the visualization toolkit design, I also provide an informal user study in order to find usability problems with my prototype. This user study was accomplished by 6 participants, and lasted about 15 minutes. My expectations before the test were varied from my observations during the process. I acquired many useful insights both from the observations and the feedback from the participants.
Thesis Structure

This thesis has seven chapters. The chapter 1 is “Related Works”. In this chapter, I introduce the newest development and cutting-edge technologies in physical visualization area. By revisiting the selected existing works, we will have a general idea of what is physical visualization and what are the benefits of it. There will also be some relevant case studies of using token system to solve real life problems.

Chapter 2 is “Conceptual Framing”. In this chapter, I discuss the concept of group planning and how tangibility can facilitate this process. I also depict the process of conversations and how they will effect greatly on successful group decision making.

Chapter 3 is “Initial Experiment”. For this section, I explain how I adopt ideas from conceptual framing into real form that can realize my ideas. And I also produce my prototype of my exploration and justify my visual encodings.

Chapter 4 is “Case Study”. Having detailed context tested on the prototype and informal user study to find the problem with the product, I assume that tangible visualization has its benefits on group planning situation.

Chapter 5 is “Discussions”. In this chapter, I address my achievements and limitations of the results. Reaffirm the proposal and explain possible directions for future work.
1. RELATED WORKS

The structure of this chapter is as following: first, I will introduce different types of physical visualizations; then introduce current approaches in state of the arts, and finally complete this chapter by outlining further inspirations for my work.

1.1 Physical Visualizations

Physical visualizations (or data physicalizations) are data-driven physical artifacts. They are the physical counterparts of data visualizations. Such artifacts may involve the use of computers, either to fabricate them or to actuate them.4

1.1.1 Data Sculptures

Whereas there are no clear definition for data sculpture, it generally refers to artistic physical visualization. According to Zhao and Vande Moere, data sculpture is:

“A data-based physical artifact, possessing both artistic and functional qualities, that aims to augment a nearby audience’s understanding of data insights and any socially relevant issues that underlie it.”5

Contemporary methods such as laser cutters and 3D printers are generally used to facilitate this process.6

5. Zhao, Vande Moere, 2008
6. Vande Moere, 2009
“Traditional visualization map data to pixels or ink, whereas physical visualizations map data to physical form.”

“A data physicalization (or simply physicalization) is a physical artifact whose geometry or material properties encode data.”

7. Jansen, 2013
Case Studies

Mount Fear

A London artist, Abigail Reynolds, who created a cardboard artifact called Mount Fear that representing the crime data in East London between 2002 to 2003. In Mount Fear, the height of the mountain is encoded with the rate of the crime. And the geo-spatial location shows where the incidents took place.

According to her blog: “Visualizing the frequency and position of crimes in East London, Mount Fear’s troubled terrain of peaks and troughs gives massive physical form to hard numerical data. Central to the work is the dramatic contrast between the sedate forms of the cardboard vista and that of the violence that the mountainous forms represent; areas with the highest recorded violent crimes have the highest peaks.”

This data physicalization is using physicality as a perceptual metaphor to enhance people’s understanding and raise their awareness of the crime rate by putting the “fear” in front of them.

Figure 3, 4: data sculpture constructed by corrugated cardboards representing crime data in East London
Tōhoku Japanese Earthquake Sculpture

This data sculpture was created by a British artist Luke Jerram. Measuring by 30cm x 20cm, it was made to contemplate the 2011 Tōhoku earthquake in Japan.

To create the sculpture, a seismogram of the earthquake was rotated using computer aided design and then printed in 3 dimensions using rapid prototyping technology. Exploring how data is read and can be represented and interpreted, the artwork is visualizing the total 9 minutes earthquake by a physical timeline with the radius representing the damages.

By visualizing the catastrophic natural disaster with aesthetically pleasing methods, it actually shape people’s perception and help them reflecting from the tragedy itself.
According to Vande Moere:

“Often, the data mapping metaphor employed by a data sculpture may not be immediately understandable, but is instead meant to be discovered through reflecting on the nature of how the data is embodied in a physical form. It is often the act of reflecting itself that brings forward unforeseen associations, which can then be considered the ‘data insights’ that are communicated by the ‘visualization’.”

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Vande Moere, 2008
1. 1. 2 Hybrid Virtual/Physical Visualization

To explain the “hybrid” in visualization context, there are a few concepts discussed as following:

1. What Is Tangibility

**tangible**

1. a : capable of being perceived especially by the sense of touch : palpable

   b : substantially real : material

2. capable of being precisely identified or realized by the mind

3. capable of being appraised at an actual or approximate value

Tangibility is the attribute of being easily detectable with the senses. As far as I am concerned, the attributes of tangibility included but are not limited to color, texture, stickiness, weight and magnetism. In my initial experiment, I chose to explore tangibility’s features through color, size, weight and magnetism.
2. Tangible User Interface\textsuperscript{13}

A tangible user interface (TUI) is a user interface in which a person interacts with digital information through the physical environment. The initial name was Graspable User Interface, which is no longer used. The purpose of TUI development is to empower collaboration, learning, and design by giving physical forms to digital information, thus taking advantage of human abilities of grasp and manipulate physical objects and materials.

\textsuperscript{13} Ishii, 2008

Figure 7. Conceptual model of tangible user interface, a graphic of Hiroshi’s.
Hybrid physical visualizations usually combine virtual with physical elements.\textsuperscript{14} There are quite a few examples in this area that propose to prove the concept of taking the advantages of physicality and on-screen performance.

\textsuperscript{14} Janson, 2013

Case Study

\textbf{Illuminating Clay}\textsuperscript{15}

Illuminating clay is a 3D tangible interface developed for landscape analysis by MIT tangible media group in 2002.

This novel system is created for the real-time computational analysis of a landscape model created by clay. Users can alter the shape of the model while laser scanner is projecting the real-time changing geometry of the landscape. A depth image of the model serves as an input to a library of landscape analysis functions. The results of this analysis are projected back into the workspace and registered with the surfaces of the model.

This system is exploring the capabilities of tangible models as well as real-time computational simulations simultaneously.\textsuperscript{16} It combines virtual with physical elements.

\textsuperscript{15} Piper, 2002

\textsuperscript{16} Ishii, 2012
Figure 8. A diagram produced from Hiroshi’s paper showing the tactics of how Illuminating Clay functions.

Figure 9. A user is manipulating the shape of the clay while observing the real-time analysis on screen.
1.1.3 Manipulable Physical Visualizations

The most frequent and understandable examples of manipulable physical visualizations are visualizations made by legos. The capability of the components such as legos enhance the interactivity of the visualization. By manipulating the visualization itself, users can either find the insights of certain dataset, or simply willing to spend more time to explore the dataset. As far as I am concerned, the effectiveness as well as playfulness are both crucial to this type of physical visualization.

Case Study

LEGO Problem Resolution Tracking System

General Motors created a three-dimensional visualization system using LEGO® building blocks to track step-by-step progress on vehicle repairs.

The system was created to be more organized and efficient. At GM, the process could reduce by 33 percent the time needed to implement a change that would prevent future warranty repairs.

3D Visualization builds on GM's Problem Resolution Tracking System. If a transmission case breaks on a durability test vehicle, a problem resolution report documents the problem, and its corresponding LEGO block goes on a LEGO board. The block color identifies the area on the vehicle and the block size denotes severity; the bigger the block, the bigger the problem. Each block has an identification number and date of discovery, and the board shows its progress from root cause to solution to outcome. 3D Visualization is applicable to any process that has volume and aging.
To sum up, real life data is not always simply presented in tables. Nor it is always efficient to represent data using 2D visualizations especially within multidimensional or geospatial data.

That is why I want to explore the capability of physicalization and provide a new way to visualize data, help people understand their data and at the end enhance conversation and achieve agreements with other people.

“By visually representing a problem it is easier to see the whole scope of it and where the opportunities lie. Besides, unlike a line of data in a spread sheet, seeing a problem as a block on a board is a strong motivator for finding a solution to get it off the board,” said Jamie Pickett, GM senior manager of current program quality.
2D, 3D and On-Screen Visualization

3D visualization

data

on-screen visualization

2D visualization
1.2 State of the Art

As I have mentioned above, the development of technologies such as 3D printing and laser cutting enlarge the experimentation of physicalization especially on data sculptures. In present days, the advancement on virtual reality (VR) and augmented reality (AR) also lead to more interest in hybrid physical visualizations.

Case Study

Tactile Matrix\textsuperscript{18}

The Tactile Matrix is an illuminated, tangible-interactive and machine-readable system designed by MIT CityScope and applied to many research projects.

This tangible interactive matrix system provide the users with the abilities to manipulate with the machine-readable lego blocks. By placing and rotating the blocks, the matrix performs real-time computation and projection-mapping.

This system is designed to make complex systems intuitive and more approachable for users. It also provides an interactive narrative device to make matrix-based mathematical methods more accessible for non-experts.

\textsuperscript{18} Winder, 2014.
Emoto Installation

The emoto data art sculpture was part of London 2012 Festival and was presented at the Cultural Olympiad closing celebration.

The emoto project set out to characterize the emotional response to the Olympic Games London 2012. Over 12 million tweets, which were collected during the project runtime, are now preserved in a unique data sculpture, serving as an aggregate archive of the collective response to the games.

The installation is made up of 19 milled plates, each representing one day. The hills and valleys of the landscapes represents the ups and downs of the games as experienced by audiences world-wide.

In addition, individual stories are projected onto the data sculpture. Viewers of the exhibit can choose different projected overlays which illustrate how individual stories related to the Games were commented online over the course of the 19 days.
1.3 Inspirations

Besides all these examples above, there are many precedences on either related or irrelevant contexts that invoke my thinking of data physicalization and my own project. Here are some of the instances that effect most upon my reflections.

By asking the participants to create, update and explain their own information visualizations using only tangible building blocks, this research provides observations, discussions of participants’ actions.20

Colors and sizes are used to differentiate one’s emotional status through stacked circle patch visualizations.
This was an experimental project looking at more analogue approaches to infographic design. Differently expanded spong was considered to be a nice way to show water requirements on a map. It ties the medium of the graphic directly to what it represented.21

Stadtistik deals with urban statistics in the ten largest German cities. The intention of this work is to enable the viewer to objectively evaluate and characterize the cities of themselves. By changing the front page, which is printed on an additional piece of translucent paper, a quick comparison could be make between two cities.22
Using ordinary materials like chalk, string, stickers and balloons, this hand made visualization toolkit experiment with various visualization techniques, from area charts to bubble graphs to Venn diagrams.  

23. Duarte, 2010

(top left) Figure 19. Handmade visualization toolkit design with ordinary materials.
(top right) Figure 20. Internet users 2000-2010.
(middle) Figure 21. Internet users by country in 2010.

23. Duarte, 2010

(bottom) Figure 22. Spam vs. real email: 90 out of every 100 emails are spam.
2. CONCEPTUAL FRAMING

With all these examples about data physicalization above, we have seen plenty great projects on how tangible objects can be efficient in tracking data and engaging more with users. While I find the greatest attractiveness for physical visualization, especially for dynamic physical visualization, is the capability to be handled, arranged and rearranged as will.

The data could be immediate input to the system and the outcome could also be perceived not only visually but also tangibly. Generally, I am interested in how tangible objects can visualize a process of planning and help users to understand each other better and have some shared facts to communicate during negotiation.

2.1 Group Planning

In order to address these questions, I intend to look into the concept of group planning. Based on my own experience of group planning and negotiating towards agreements, the problem that leads to a disagreement is barely a “yes” or “no” question that can be answered simply.

For example, if you agree to travel with other people, there is more likely you will agree to visit place A if you have 30 minutes and the usual visiting time for place A is exactly around that length, or you will be more willing to visit place B if it is closer to the place that you plan to visit
before this one. There are many attributes effect on people’s decision making, we usually view them as contexts.

Group planning typically involves one or more of the following stages: vision, goals, objectives and actions. Group decision-making (also known as collaborative decision-making) is a situation faced when individuals collectively make a choice from the alternatives before them. The decision is then no longer attributable to any single individual who is a member of the group. This is because all the individuals and social group processes such as social influence contribute to the outcome. The decisions made by groups are often different from those made by individuals. According to the idea of synergy, decisions made collectively tend to be more effective than decisions made by a single individual.

Factors that impact other social group behaviors also affect group decisions. For example, groups high in cohesion, in combination with other antecedent conditions (e.g. ideological homogeneity and insulation from dissenting opinions) have been noted to have a negative effect on group decision-making and hence on group effectiveness. Moreover, when individuals make decisions as part of a group, there is a tendency to exhibit a bias towards discussing shared information (i.e. shared information bias), as opposed to unshared information.

Besides the conceptual tactics of group planning, we can not underestimate the one major factor’s role on achieving a successful group decision-making. Conversation as a key component that participate throughout the whole planning process is also been well studied by many design theory professionals.
What is conversation?

According to Hugh Dubberly, conversation enables participants to: learn, coordinate, and collaborate. In his design theory research paper “What is conversation? How can we design for effective conversation?” 26, he provides us with three conceptual models of these three stages of conversation.

For the first stage “learn”, he suggests that learning the basic things may seem trivial but they may save time later, and freeing future attention for later less trivial things. To my understanding, this process is for participants to share their language in context and check if they are on the same stage of understanding a particular concept. The second stage is to coordinate. After we have synchronized, now it is the time to coordinate our actions in ways that are mutually beneficial. To be noticed, in this stage, we do need to have shared goals. The scenarios could simply be if you want to visit place A, then can I ask to also visit place B. In this case, conversation is the tool to help participants to reach an agreement to transact. The third stage is to coordinate actions to achieve goals together. The conversation will continue if the mutual goal is not achieved.

Figure 23. Concept model of conversation for agreement.
As we can see from above, the conceptual model of group decision-making is the key to a successful group planning. Nevertheless, the significance of the interpretation of the shared information is also a milestone for the whole picture. Because of the limitations of human memory, comparing something visible with memories of what was seen before is more difficult than comparing things simultaneously visible side by side. The tangible visualization toolkit I am proposing is to facilitate this translation process and help individuals reduce the bias towards shared information.

In many cases, people who fail to achieve their goals or simply end up having discordant disagreements easily because they do not have shared context or they do not learn and share enough information between together. It is the same for other situations that it is the related context has the most critical effect upon the decision making.

2.2 Efficiency of Physical Visualizations

It is now the time to talk about why I think it is promising to have a set of tangible objects to facilitate the process of planning and enhance the understanding of the data itself.
As I mentioned in introduction, there are certain researches that evaluated the performance on physical visualizations, and the results are promising.

In research study “Evaluating the Efficiency of Physical Visualizations”28, researchers took 3D bar charts as an example, compared the efficiency of on-screen 3D bar charts and physical bar charts at users’ information retrieval tasks. Due to its ability to be touched, physical bar charts performs better than its on-screen counterpart.

With all the discussions above, instead of picturing everything in an individual’s mind, I am proposing a new way to visualize concepts through a set of physical objects that enhance not only the understanding among people but in-depth thought of the relationships among data and ourselves.

The diagram I am presenting on the next page (page 37) shows the conceptual ideas of my project. This project is consist of three major components. First, I explored the features of tangibility, such as color, texture, thickness, weight, magnetism, etc.

I also explained my motivation and the framing about how to focus on group decision making.

After that, I came up with a concept model which is set up in the context of group trip planning. The reason I experimented in this scenario has been well considered. First, trip planning is a real-life problem almost everybody has some basic experience about. Second, this process usually comes up with many back-and-forth procedures. Last but not the least, travel is a topic that interests most of the people.
Conceptual Framing

A case study in the context of group trip planning.

Tangibility

Color, texture, thickness, weight, magnetism, etc.

Group Planning

A set of conversations are intended to reach agreements in order to achieve a goal.
3. INITIAL EXPERIMENT

After several approaches, the most meaningful context I would like to explore is group planning, especially in achieving consensus. Implementing the tangibility of physical objects in order to help people to plan together and to move towards consensus is a challenging yet meaningful topic to me.

There are many physical visualization designed for visualizing various contexts. After several attempts, I finally chose to set up my first physical experiment in the context of group trip planning. Due to physical visualizations capacity of manipulating data by visualizing all possible variables, group trip planning seems to be a perfect case study to explore. The possible attributes a trip planning process may include but not limited to geo-spatial locations, visiting time, routes. All these attributes could be well evaluated via tangible token system.

The existing tools and websites for trip planning, such as Google Trips or Triplantica have their advantages in featuring mobile portability or itinerary auto-generation. They also have customization to some extent. However, because of their on-screen based modality, they lack the possibility for a group of people to plan together, and the method of their customization is not always fulfilling users needs. In order to deal with these situations, I intend to bring tangibility in physical objects. I argue that by assembling the variables represented in physical forms and learning through building, thus intuitive process that we always ignore could not only engage users more with data but also help facilitate the group planning situation.
Figure 26. Triplantica leverage the automatic travel itinerary planning mechanism to organize and personalize itinerary.

Figure 27. Google Trips gathers users' travel information from Gmail and Inbox, then organizes it automatically. The entire app is available offline.
The context of this experiment is set in a trip to New York City. By using the physical magnets token to grade expected sites users want to visit, the token system helps them understand and engage more with their trip through the assembling process.

Tokens can be added and attached to each other to create a stacked physical visualization. Thus both the horizontal view and vertical view represent different aspects of data. This assembling process enhance users’ experience and help visitors find their genuinely willings towards a trip. The thoroughly learning process of assembling before one trip may also help framing long-term memories.31

Design Rationale

Unlike other trip planning tools who just randomly generate the itinerary for you, this toolkit helps you making your own decision through both rational and emotional methods.

It’s emotional because the result it shows you based only on your own interests. On the other hand, it’s rational because after you have done all the grading, you can count the scores each site gets, and it will come up with a final score based on all the decisions you have just made. By constantly discussing with an affiliate tool from both visual and manipulative aspects, people can use these results for further reference. And it is also convenient to pull and push back the data just by erasing lines or remove the tokens.

31. Ware, 2008
Visual encodings

The picture above presents effectiveness rankings for the visual channels broken down according to the two expressiveness types of ordered and categorical data. Categorical attributes are variables that belong to different genres. For instance, visiting time, attractiveness and ticket value for a particular visiting site are considered as categorical attributes. Different sites are also considered as categorical attributes and are taking the most effective channels, spatial regions. Therefore, different attribute based on one particular site is designed to take the second effective channel, color hue. In the context of my initial experiment, an attractiveness level of one particular site could be considered as ordered attributes. According to the sizes of different tokens, they are assigned to values from 1, 2 to 3.
How does the toolkit work through steps?

For instance, if a family want to plan for a trip together, they need to:

First, pick up a destination for their trip. Find out what are the specific sites they want to visit. The sites can be places everyone want to visit or just based on personal preferences. We can discuss that later by playing with the toolkit. (In my informal user study, in order to simplify the whole process and deduct redundant scenarios, each participant was asked to pick one site.) The locations can be traced down on the decision sheet. (See figure 30.)

Then, use the transit information sheet to discuss the alternatives of possible routes. Trace them down by colored markers. (See figure 31-32.)

Next, they may want to value each sites by using the tokens to grade from aspects they care about, such as time, price, interest levels, etc. To note that, this process include constantly discussion and conversation so the scores for each attribute is the outcome of negotiation even it may be objective to some extent. (See figure 33-35.)

After that, just add up the scores every sites have, then we can move to next steps: plan for routes, transportation methods, etc.

In every individual step, we may want to use different information sheet that contains precise information so that users can focus only on the current task and avoid distractions from massive information load.
Figure 30. Trace down the sites one wants to visit onto the decision sheet.

Figure 31. Change the information sheet underneath the decision sheet. Trace the possible routes down according to transit information sheet. Use colored lines to differentiate each route.

Figure 32. Take out all the information sheet underneath the decision sheet.

Figure 33. Use magnetic tokens to grade each route separately. Different color encodes different attributes assigned by user.

Figure 34. Through conversations and negotiations, each route gets a stacked visualization. The result is clearly shown onto the physical space.

Figure 35. If users have a second thought or they simply not happy with the result, each step can be repeated conveniently.
4. CASE STUDY

This case study is an informal user study I conducted with my classmates in order to find the usability problems with my prototype. I do not perform any quantitative analysis. My intention of this test is to observe participants’ actions and conversations. After the testing, they also shared their invaluable insights with me.

List of things I prepared:

1. a list of New York City’s top 30 attractive spots and short descriptions
2. an instruction
3. a box of magnets with different color hue and sizes
4. a few markers with different color hue
5. two information sheets of New York
   a) 30 locations on map
   b) subway information
6. a transparant vacant decision sheet
According to Munzner, small datasets may well be appropriate for a user study in the context that methodology is great for finding usability problems with products.\textsuperscript{33}

\textsuperscript{33}Munzner, 2008

Process

This user study set up in the context of group trip planning. There are all together six of my colleagues participate in this study. The age of the participants range from 23-38 years old. There are five female and one male. This process last about 15 minutes.

At the beginning of the trip group planning process, each participant was asked to choose one site to visit from the list of “New York City’s top 30 attractive spots.” In order to start the conversation, this list act as a context to establish the environment for participants. To note that this process could also be visualized and discussed with the tangible tokens. However, in order to reduce the similar process of this test, this step is simplified as thus.

After everyone has picked their preferred site, they were asked to trace the locations down according to the sheet a).

The next step is to put the sheet b) underneath the decision sheet and discuss the possible routes based on the sheet b). Colored markers are used to draw the routes.

After that, participants may use the magnets to evaluate and score the routes.

Observations & Reflections

In general, the whole planning process is filled with conversations and sometimes arguing to my surprise. I was trying to conduct the test at the first place. However, one of my participants pointed out that since I have designed
instructions, it would be more genuine if I just observe their actions and take notes. I took notes of their questions and videoed their behavior while using tokens.

Figure 37. A screen shot taken from the video I recorded during the group planning.

<table>
<thead>
<tr>
<th>Select spots</th>
<th>Mark on decision sheet</th>
<th>Choose transit routes</th>
<th>Draw on decision sheet</th>
<th>Use tokens for planning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 1: Locate the places your group want to visit using the providing information sheet.</td>
<td>Step 2: Trace the sites down on decision sheet. For instance, each participant could pick one site at the first round.</td>
<td>Step 3: Discuss transit methods between each spots using provided information sheet.</td>
<td>Step 4: Trace the possible routes down using colored markers. Different routes could be compared on the next step.</td>
<td>Step 5: Use tokens’ colors to encode different attributes. Use tokens’ sizes to represent different values. Tokens could be stacked and compared.</td>
</tr>
</tbody>
</table>

Figure 38. The instruction I designed for participants to follow.
The first thing that I noticed is that almost every participant gets excited when they get the list of sightseeings. The decisions they make for themselves to visit usually just about seconds. The reason for that could be that the context I chose, which is New York City, is familiar with many of them for a long time. And they all get even more excited when they think it is the time to play with the tokens. However, they seem to lack some interest with the diagramed instructions. There are only one participant that tried to talk through others to go through the instructions carefully. But at that time, everyone else seems to be attracted by the magnetism. Nevertheless, because at the beginning I have clarified that this test is not a formal target user study. The intention of this study is to find the weak points on my design.

The other thing that occurs to me is that even I have 6 individual participate in the process, the most active participants are usually two or three during most of the planning period. It makes me to reconsider the utility of the tokens. Can I add another dimension to the tokens? So everyone could have their opinions shared even if they do not talk much. The rules that I set at the beginning is that whenever the conversation achieve an agreement, the group use one token to record the process, thus leaving footprints for tracing the whole planning process.

There is another thing that I took notes: I did not provide first stage of the conversation by guiding participants to share they knowledge in order to synchronize everyone’s ideas and exchange context information. Each participants get their own sites list. In my further work, I will provide photo cards and display them on the table for users to start the conversation.
When I designed the process of this study, I had some expectations before the test. For example, the participants are supposed to read the instructions carefully and start the conversations towards agreements. However, due to the lack of conducting the process, the test was not performed as I expected. One of the reasons may be the list of locations were presented in texts rather than in shared visual form. For my next study, I will have some photo cards with informations on the back to replace the location list.

Although this toolkit works well for people that are at the same place, nowadays the meetings we conduct via remote communication tools are also frequent to see. That is why I will look into remote communication technologies such as virtual reality in the future and discover the possibility to integrate my idea and those technologies.

Besides, the mobile ability of this tool is also worth further consideration. There are more digital features could be added into this experiment. For example, the decisions could be detected by mobile devices and carried by users while they are traveling.

On my next steps, I would like to explore the possibility of implementing virtual reality on this tool to enhance users’ experience. Allowing them to put pictures, videos or other experience onto the specific sites accordingly and use virtual reality equipments to review the precious travel experience of their family will be my forward approach. By using this hybrid physical visualization toolkit, people live at remote places can easily plan trips together and collect
their experience in a memorable and meaningful way.

I will also study group planning in other context such as “how to choose a neighborhood in Boston for new coming college students (who plan to leave together)”. Conduct interviews on target user group on further project, find out the domain tasks they want to solve and reframe and amplify my ideas about the functions and fruitions of my design. Further more, I intend to conduct a formal focus group user study. Having target users test my revised prototype, and evaluate my previous works based on their feedbacks.

It also occurs to my attention that there might be some restrictions on the number of participants. Too many users may result in a chaotic situation.

**Conclusion**

The prototype I came up with is trying to help with the scenario of negotiating to agreement. Through the work and research I did on this topic, I hope my intention and objective of implementing physical visualization into conversations are well explained. I think it is meaningful and the invention will not only benefit group planning but also provide a novel form of visualization that construct not by designer’s desire but due to the real life problem-solving process from users. I am also arguing against the idea that visualization is merely about visual processing. It is time we start to think about combining other sensors and being open to enhance the capability of physicalization.
REFERENCES

Dubberly, H. and Pangaro, P., 2009. ON MODELING What is conversation, and how can we design for it?. interactions, 16(4), pp.22-28.


A. Instruction

Select spots

Mark on decision sheet

Choose transit routes

Draw on decision sheet

Use tokens for planning

Step 1: Locate the places your group want to visit using the providing information sheet.

Step 2: Trace the sites down on decision sheet. For instance, each participant could pick one site at the first round.

Step 3: Discuss transit methods between each spots using provided information sheet.

Step 4: Trace the possible routes down using colored markers. Different routes could be compared on the next step.

Step 5: Use tokens’s colors to encode different attributes. Use tokens’ sizes to represent different values. Tokens could be stacked and compared.
B. List of New York's Top 30 Attractions

New York City's Most Popular Attractions

<table>
<thead>
<tr>
<th>No.</th>
<th>Attraction</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Statue of Liberty</td>
<td>Located on Liberty Island at the southern tip of Manhattan, the Statue of Liberty embodies the values of freedom and democracy.</td>
</tr>
<tr>
<td>2.</td>
<td>Empire State Building</td>
<td>Tallest building in the world from 1931 to 1972, the Empire State Building offers panoramic views of the city.</td>
</tr>
<tr>
<td>3.</td>
<td>Brooklyn Bridge</td>
<td>Iconic suspension bridge over the East River, connecting Brooklyn and Manhattan.</td>
</tr>
<tr>
<td>4.</td>
<td>Central Park</td>
<td>The largest urban park in the United States, Central Park offers a myriad of activities from relaxation to sports.</td>
</tr>
<tr>
<td>5.</td>
<td>Times Square</td>
<td>A bustling intersection lined with theaters, shopping, and entertainment venues, symbolizing the energy of the city.</td>
</tr>
<tr>
<td>6.</td>
<td>Flatiron Building</td>
<td>One of the most recognizable landmarks in New York City, the Flatiron Building is a symbol of the city's architectural innovation.</td>
</tr>
<tr>
<td>7.</td>
<td>Wall Street</td>
<td>Known as the financial heart of New York City, Wall Street is the place where the nation's economy is forged.</td>
</tr>
<tr>
<td>8.</td>
<td>Empire State Building</td>
<td>Tallest building in the world from 1931 to 1972, the Empire State Building offers panoramic views of the city.</td>
</tr>
<tr>
<td>9.</td>
<td>Chrysler Building</td>
<td>A modern masterpiece of Art Deco style, the Chrysler Building is a symbol of the city's architectural innovation and creativity.</td>
</tr>
<tr>
<td>10.</td>
<td>The Dakota</td>
<td>One of the most famous addresses in New York City, The Dakota is home to many celebrities and VIPs.</td>
</tr>
<tr>
<td>11.</td>
<td>Wall Street</td>
<td>Known as the financial heart of New York City, Wall Street is the place where the nation's economy is forged.</td>
</tr>
<tr>
<td>12.</td>
<td>Metropolitan Life Insurance Company Building</td>
<td>A historic building on Broadway, the Metropolitan Life Insurance Company Building serves as a reminder of the city's insurance legacy.</td>
</tr>
<tr>
<td>13.</td>
<td>Trump Tower</td>
<td>One of the most iconic buildings in New York City, Trump Tower exemplifies the city's modernism and wealth.</td>
</tr>
<tr>
<td>14.</td>
<td>Rockefeller Center</td>
<td>The modernist masterpiece of the Rockefeller Center exemplifies the city's modernism and wealth.</td>
</tr>
<tr>
<td>15.</td>
<td>Columbus Circle</td>
<td>One of the most iconic buildings in New York City, the Columbus Circle exemplifies the city's modernism and wealth.</td>
</tr>
<tr>
<td>17.</td>
<td>Ellis Island</td>
<td>One of the most iconic buildings in New York City, Ellis Island exemplifies the city's modernism and wealth.</td>
</tr>
<tr>
<td>18.</td>
<td>Madison Square</td>
<td>A popular meeting place in the city, Madison Square exemplifies the city's modernism and wealth.</td>
</tr>
<tr>
<td>19.</td>
<td>Washington Square</td>
<td>One of the most iconic buildings in New York City, Washington Square exemplifies the city's modernism and wealth.</td>
</tr>
<tr>
<td>20.</td>
<td>Metropolitan Museum of Art</td>
<td>One of the most iconic buildings in New York City, the Metropolitan Museum of Art exemplifies the city's modernism and wealth.</td>
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<td>21.</td>
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<td>23.</td>
<td>Metropolitan Museum of Art</td>
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<td>25.</td>
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<td>One of the most iconic buildings in New York City, Washington Square exemplifies the city's modernism and wealth.</td>
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<td>26.</td>
<td>Metropolitan Museum of Art</td>
<td>One of the most iconic buildings in New York City, the Metropolitan Museum of Art exemplifies the city's modernism and wealth.</td>
</tr>
<tr>
<td>27.</td>
<td>New York Public Library</td>
<td>The New York Public Library is one of the most iconic buildings in New York City, symbolizing the city's cultural and intellectual enrichment.</td>
</tr>
<tr>
<td>28.</td>
<td>Bryant Park</td>
<td>A popular park in the heart of New York City, Bryant Park exemplifies the city's modernism and wealth.</td>
</tr>
<tr>
<td>29.</td>
<td>Little Italy</td>
<td>A popular restaurant and nightlife area in the city, Little Italy exemplifies the city's modernism and wealth.</td>
</tr>
<tr>
<td>30.</td>
<td>High Line</td>
<td>A popular area of the city, the High Line exemplifies the city's modernism and wealth.</td>
</tr>
</tbody>
</table>
C. Locations Sheet