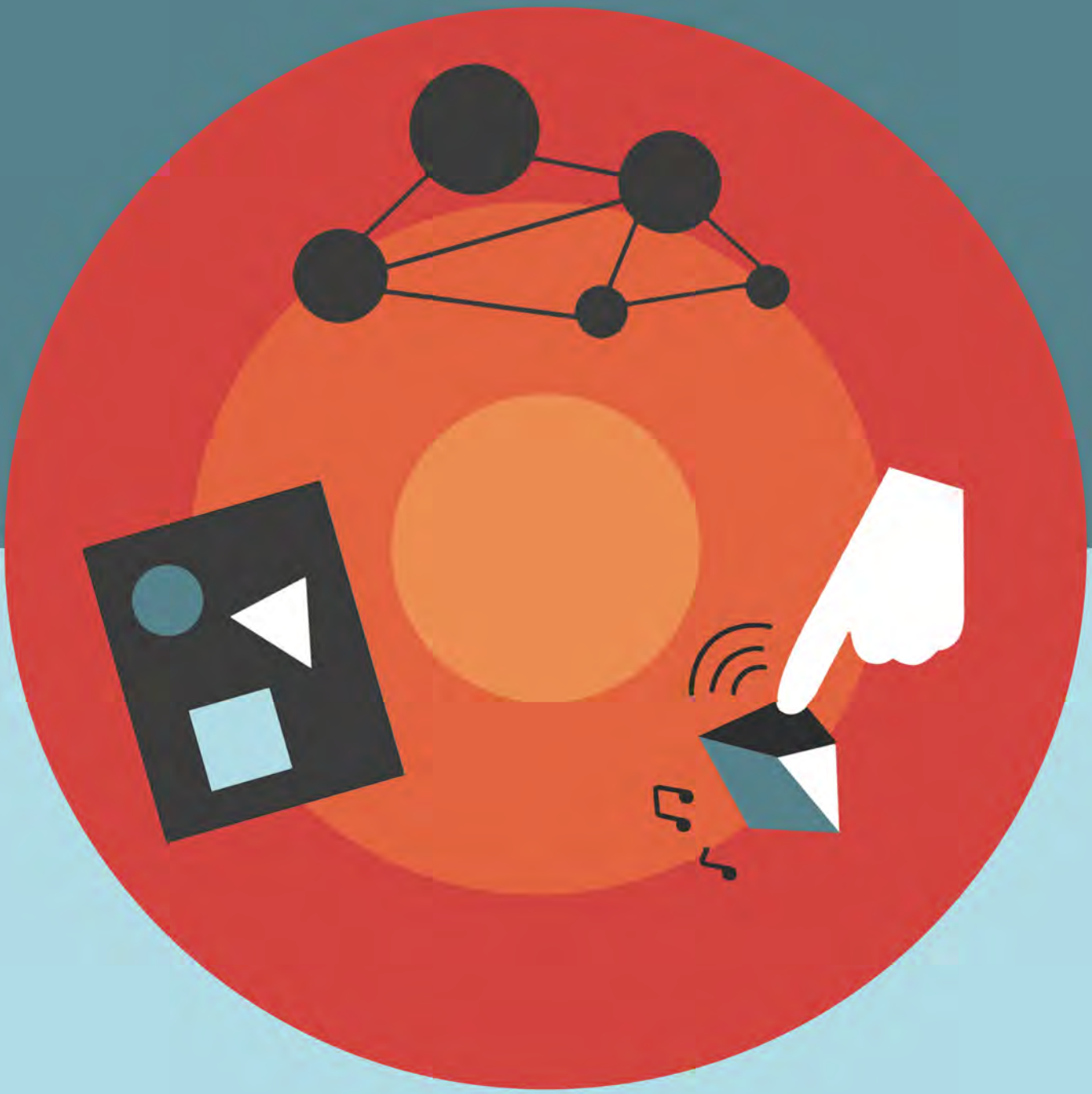
A STUDY IN THE DESIGN OF NOVEL

TANGIBLE, NARRATIVE AND INFOGRAPHIC

MEANS FOR MUSEUM DISSEMINATION



A Master Thesis
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Abstract:

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Abstract

This thesis presents an investigation in the research disciplines of narrative exhibition design, tangible user interfaces and infographic design to explore the possibility to design novel means of narrative, tangible and information light dissemination in the museum. Based on a research review deign considerations was identified to form a design concept to guide the development of novel means to create tangible, narrative and information light dissemination in the museum, with the benefit of creating engaging experiences for the visitors. To evaluate the design concept a novel prototypical interface was build and a case study was conducted at the Danish Storm P. museum. Although the evaluation presented ambivalent result the thesis shows promising directions for further research in all of the include research disciplines and shows confidence in the direction of design displayed by the developed design concept to create a new direction for creating novel mean of dissemination in the museum.

Preface & Acknowledgements

This report presents the documentation of the Master´s Thesis in Medialogy (Interaction specialization) made by Maja Østergaard Nielsen. The thesis was written in the course of the spring semester 2016.

I would like to thank my supervisor Luis Emilio Bruni for support and guidance throughout the Medialogy master program. Furthermore, I could like to thank the Storm P. Museum for their support and cooperation.

References are cited with APA 6th edition, and a full reference list can be found near the end of the report.

The attached DVD contains:

- Source code of the media - technological product.
- Documentation of the product in form of pictures and video.
- A/V- production presenting the master thesis.

Supervisor:
Luis Emilio Bruni

Length of the report:
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Chapter 1 - Introduction

A central aspect of dissemination in museum exhibitions has always been storytelling as narratives are essential to human understanding and meaning making. In the museum, narratives are used to frame the exhibits to provide context and relevance for the visitors and to assist interpretation and comprehension. Stories play the role of connecting the exhibits to the personal human experiences of the visitors. While the importance of narrative exhibition design and storytelling is still a main component in museum dissemination, the means and dissemination strategies have changed with the introduction of digital technology.

Over the last few years, museum exhibitions have changed in form and function with the adoption of digital technology. Digital technology has become a fully integrated part of our lives and has great influence on the way we communicate, socialize and understand the world. Time has proven that the introduction of digital technology attracts more people to the museum and that physical and digital realities can coexist and even complement each other. Digital Technology has become a great tool for meeting the needs of museums visitors and opening up the museums to a wider audience. The visitors of today are expecting to be actively involved in the construction of the stories that the museum generates and to be a part of the museum experience. Digital technology has the ability to support the museum in doing this, by making engaging experiences. Thus the use of digital technology and the development of new digital strategies at museums over the last few years - have been expanding. The initiatives have been many and diverse. To sum up the most resent and dominant examples, the annual *AC/E Digital Culture Report: New Technologies in the Museum* gather the most innovative and widely used technologies currently exhibited in the museum world. The report highlights the use of mobile technology and tablets as the main digital technologies in the museums with the integration of camera, microphones, light sensors, GPS, and accelerometers which offers the possibility for a wider use of technologies like augmented reality, 3D technology or QR codes (Celaya, 2015).

Although these technologies can be found in almost every museum, there are some grey areas in the coexistence of the physical and digital reality of the museum. Especially smaller museums with lesser resources might have difficulties in bridging the gap between the two realities, as digital technology can be both very time consuming and expensive to develop and

implement. Because of this, the advances in the adoption of digital technology in the museum is more limited in the smaller museums and traditional dissemination means like signs, labels, exhibit catalogues and guided tours are still an integral part of most museums because of its familiar form and low cost. Furthermore, the incorporation of digital technology into the museum exhibitions can also be too overwhelming. The museum risks going overboard with information sharing through digital layers by incorporating expensive and extensive digital dissemination means, like AR and 3D rendered animations, to digitalize every aspect of the physical exhibition in the attempt to provide the visitor with as much information as possible. Both instances are problematic. The problem with the traditional use of signs and text panels are explained by Flavia Sparacino (Sparacino, 2004). She states that although these means have the advantage of guiding the audience and communicating information about the exhibits in the exhibition, they also display great disadvantages. Signs, panels and text labels can be very interruptive of the pace of the visitor's experience, as the audience has to direct their attention from simply observing to contemplating in order to read and understand the text, which interferes with the initial sensory experience of the exhibits (Sparacino, 2004). In addition, guided tours disrupt the visitor's freedom to choose their own path through the experience, taking away their choice of what they want to see and for how long. Exhibition catalogues are usually very informative, however they can be cumbersome to carry around, and also disrupt the pace of the experience. On the other hand, overuse of digital technology risk taking away the natural sensory experience of the exhibition. The digital layer creates a greater distance between the visitor and the physical exhibition as a core feature of any digital artifact is essentially the lack of materiality (Hornecker E. a., Integrating material and digital: a new way for cultural heritage, 2013). The exhibits risks losing its materiality, authenticity or "aura" which cannot be transferred to the digital. Emotion, affect and sensation are essential parts of the museum experience, yet many museums still favor information over material and learning over personal experience. Thus the production of digital displays might inhibit or preclude such affective responses in the experience. (Hornecker E. a., 2013).

Digital technology can by certainly enrich the visitors experience but also risk diverting attention, thus preventing contemplation and reflection. The museum needs to find new ways of using digital technology in the disseminating of the museums exhibits, without overpowering the sensory and authentic experience. Therefore, sensory experiences of materiality and physicality should be brought into focus. In the field of human computer interaction (HCI) some attempts to

bring back the materiality and physicality to the museum have already been made with the use of tangible interaction in form of tangible user interfaces (TUIs), as these interfaces have potential to help bridge the gap between the physical and digital world (Dudley, 2012).

Not only the physical aspect of the digital display technology can be problematic but also the delivery of either digital or physical content in the exhibition. Most people know the feeling of being filled up by impressions and tired after a museum visit. Information overload is a big issue in the digital age as the digital technologies have opened up endless opportunities for acquiring information, and we are bombarded with information though all our digital channels, all day. The problem of information overload is a big concern for the museum, as one of their main tasks is the dissemination of knowledge and information. The problem with information overload in the museum is substantiated by author Stephen Bitgood in his article *"Museum Fatigue: A Critical Review"* (Bitgood, 2009). The author explains how information overload in the museum forces the visitors to make decision about whether or not to retain information about a topic. The visitors are confronted with a high number of exhibits an exhibit information and must, do to time pressure, make quick decisions about whether to view more details about a particular exhibit or simply move on to the next (Bitgood, 2009). This information overload may inhibit the visitors in processing the input from the exhibition because too much information and to many exhibits are presented at once. In consequence the visitors acquire only a superficial understanding for the exhibits (Bitgood, 2009). The problem of information overload has also been recognized by the world outside the museum, and as a result ways of presenting information have changed. Especially in marketing and editorial research, digital technology has brought a new understanding of how to catch consumers attention and make information easy and enjoyable for the public. Methods of data visualization and infographics used with great success to mediate information and narratives to create engaging dissemination and storytelling. Perhaps the museums could also benefit from this realization and seize the opportunity to concentrate and optimize their presentation of information and content, to make their exhibitions easier digestible and enjoyable for their visitor's busy minds.

Based on these reflections and above - mentioned problematic areas the thesis presents an investigation of the possibility to design novel dissemination means by combining the compelling features of infographics with the design of tangible user interfaces to facilitate narrative

dissemination, in order to create engaging experiences for the museum visitors. The aim of this thesis is thus to develop a design concept as a framework for designing novel means of narrative, tangible and information light dissemination in the museum. To evaluate the design concept a novel prototypical interface was build and a case study was conducted at the Danish Storm P. museum. The research review of the disciplines of narrative exhibition design, tangible user interfaces and infographics will be presented in the following chapter.

Chapter 2 - Research Review

This chapter presents the research review made for this thesis to investigate the disciplines of narrative exhibition design, tangible user interfaces and infographics. From the research review a set of design considerations will be identified to form an overall design concept that will guide the design of novel means of museum dissemination, to create engaging experiences for the museum visitors.

2.1 Narrative Exhibition Design

Narratives have always been a part of the museum environment to assist visitor interpretation and meaning making of museum exhibits. Narratives are also used by the museum visitors themselves to express their own personal interpretation and meaning making of the exhibits to each other, conveying their own concerns, interests and knowledge. Stories are therefore very important to the museum, since they create personal human experiences that connects to the museum exhibits. This is important for the museum to keep its position as a relevant cultural institution, which facilitates learning and knowledgeable experiences. The question is, why do narratives and storytelling have the ability to engage people in a manner that make them indispensable to the museum? Authors Macleod, Houston & Hale present a possible answer in their book "Museum Making: Narratives, Architectures, Exhibitions" from 2012 (Macleod, 2012). The authors reason that narratives and storytelling capture something that is quite fundamental about the experience of being human, and highlights the philosopher Daniel Dennett´s famous definition of the human self as a *"center of narrative gravity"*. Philosopher Marya Schechtman presents a survey of the recent thinking based on Daniel Dennett´s definition about the nature of the self. She distinguishes between two ways of understanding the narrative self, one where the narrative is an inherent structure of the self and one where the narratives are naturally produced by the self, both creating and picking out narratives from an ongoing flow of perceptual experiences. This implies that humans have a natural narrative capacity that helps us make sense of the world we live in. Our understanding of ourselves and the world around us are thus structured around stories. The influence of narrative is acknowledged and accepted by the museum world and narratives in the museum space have been developed as a

common language for exhibition making as a means to create emphatic links between the visitors and the exhibits. Narratives can in this way function as a binder for temporal, spatial and cultural gaps within the museum (Macleod, 2012).

Having established the importance of narratives as a part of any museum exhibition design, is important to understand the basic principles of exhibition design. Author David Dean describes the field of museum exhibition design in his book "Museum Exhibition: Theory and Practice" form 1996. The book includes a set of factors that should always be considered when designing exhibitions. The author emphasizes the importance of exhibition design by declaring the exhibition environment as the primary medium of communication with the museum visitors (Dean, 1996). He explains that exhibition design can vary a lot depending on the intent and purpose decided by the exhibition maker. Exhibitions can range in the spectrum of being very object-oriented to very concept-oriented. This has been illustrated by authors Varhaar and Meeter in their book "*Project Model Exhibitions"* (Verhaar, 1989), see Figure 1.

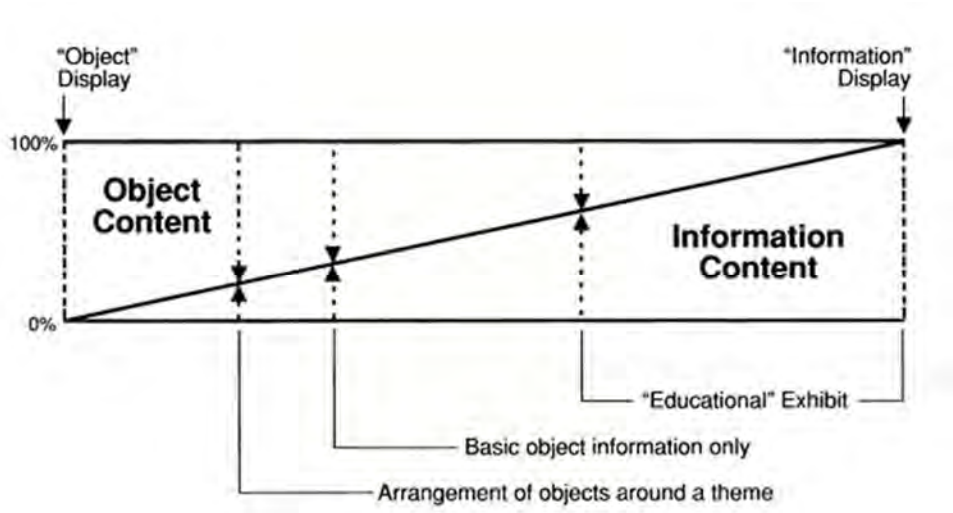


Figure 1: Project Model of Exhibitions by Varhaar and Meeter.

At the left end of the figure is the "Object Display", this resembles a presentation of the objects or exhibits purely, without no interpretative information involved. At the other end is the

"Information Display", where the object is either not present or has minimal importance. The diagonal line illustrates if the exhibition is more towards the object- or concept-oriented design. In the object-oriented exhibition, educational information is limited and relationships and interpreted meanings are not examined to any significant degree. In a concept-oriented approach, the focus is more on messaging and transferring information rather than the collection itself. In the middle ground, we find thematic exhibitions. Thematic exhibitions lean more towards the object-oriented end of the scale and use a collection arranged around a theme with basic information provided, such as labels and headings. Closer to the concept-oriented approach are educational exhibitions, which incorporate 60 percent information and 40 percent exhibits. The decision on which approach to choose is based on the intented purpose of the exhibition and there is no sharp line between when an exhibition is object- or concept-oriented, nor is any of the combinations right or wrong. The choice simply depends on the specific exhibition the museum is aiming for (Dean, 1996).

Dean further explains the basic elements that go into designing the exhibition, he states "*Designing museum exhibitions is the art and science of arranging visual, spatial and material elements of an environment into a composition that the visitors move through*" (Dean, 1996). In this respect, some elements are universal to all visual arts such as value, color, texture, balance, line and shape. These elements will be investigated further in chapter 3.3. The visual elements described by Dean lay the foundation for a successful exhibition composition. When an exhibition works well, it is usually comfortable for the eye. If a design fails both in look and function, people will react negatively even if the content is interesting and beautiful. In addition to the visual design, the element of human factors should be taken into account when designing museum exhibitions. Human factors are factors such as size, movement, and perception abilities. In general, people feel most comfortable in spaces that allows them freedom to move and which are neither too confined nor too exposed. Regarding the perception of touch, people have an innate urge to touch things, both for sensory and experimental purposes. What you see will be reinforced in memory when people get the opportunity to touch it (Dean, 1996). Another important factor to recognize when designing for humans is the viewing height. Most people will spend more time looking at a specific object if it is placed at a comfortable eye level, for adults this is around the height of 1.6 m. These are the most important factors to exhibition design presented by Dean, but he also mentions factors like personal space as well as sitting and leaning behavior, which should also be considered (Dean, 1996).

The exhibition design factors presented by David Dean will be taken into account as requirements for the development of the design of the novel interface prototype made for this thesis to assist a more successful integration into the chosen exhibition space. The purpose and intent of the chosen exhibition will be identified according to the *"Project Model of Exhibitions"* and the design factors such as visual appearance and viewing height will be taken into account when designing and implementing the interface prototype in the exhibition.

2.1.1 Museum Narratives

The previous section established a basic understanding of the importance of narratives and exhibition design. The next step is to investigate how one can successfully construct these narratives in the museum exhibition. A number of theories have been used to explain the construction of narratives in museum settings, some of the most dominating of which are described by authors Paul Mulholland et. al (Mulholland, 2015). The authors focus on structuralist theories, which make a distinction between narrative and story. In the structuralist view, the narrative can be characterized as the telling of the story. The narrative consists of both the story (i.e. what is told) and the discourse (the means by which it is told). The events of the story are seen as key constitutes of the fabula or story as well as existents like setting and characters of the story. To understand the construction of narratives in museums, the authors emphasize the relevance of narrative inquiry as an important theory to narrative construction. Narrative inquiry focuses on the interpretation of the past and communicating the interpretation of the past in narrative form, which is well in line with the purpose of museum dissemination. Narrative inquiry is a process with four main stages:

- Firstly, relevant story events are identified from the topic of interest and organized into a chronological order, mainly of historical periods of time.
- Secondly that chronicle is divided into separate interests of for instance particular themes, characters or types of events.
- Third, plot relations are imposed between the different events, which infer causal relationships between the chronicle events.

- Lastly the narrative is produced communicating a specific viewpoint on that period of time.

In this manner, narrative inquiry not only constitutes a factual telling of events, but also commits to terms of how the events are related and organized according to each other (Mulholland, 2015).

Events are perceived by Mulholland et al. and many others as the key elements of a story. Authors Bruni and Baceviciute (Bruni, 2014), describe, based on the work of Marie-Laure Ryan (Ryan, 2006), how events are the raw material of which stories are constructed. Ryan departs from the viewpoint that is most common among narratologists, where the story is a single or sequence of events while the narrative discourse is the way the events are represented. She argues that the narrative discourse (leaning to form) is defined in terms of its ability to represent that, which constitutes the story. In contrast, the story (leaning to substance) can instead be defined in autonomous terms from the discourse. Meaning that stories are not the same as a series of events, but that the events are in fact the raw material the stories are made of. Others mentioned by Mulholland et al is authors Francesco Mele and Antonio Sorgente (Mele & Sorgente, 2012), who describe an approach of how to formally represent events of a story. Complex events, termed as causal events are used to represent causal relations between events constituting the cause and other events constituting the effect. The events which act as the cause or effect can either be physical or mental. Cause and effect can thus express plot relations between story events in museum stories (Mele & Sorgente, 2012).

The type of narratives found in museums can vary a lot in scale and form. Authors Mulholland et al. distinguished between big and little narratives. The "big" narrative is considered as the overall narrative of for instance a period of time or an artist's life and work, disseminated by the museum. The *"small"* narratives are the first personal accounts from the *"big"* narrative, e.g. a period of time in history or personal responses offered by the visitors. The *"big"* narrative can be on a scale of the whole exhibition and the exhibition itself can be thought of as a form of narrative. The narrative structure of a museum exhibition often depends on whether the exhibition is based on the permanent collection or a thematic exhibition; both are usually on a scale of a "big" narrative. Permanent collections are often organized in narratives according to features such as artist, artistic movement, or chronology. Thematic exhibitions are more likely to be organized according to themes defined by the museum curator. Smaller narratives are created by the visitors

themselves to link elements of the exhibition to their own personal experience. The museum can thereby assist the production of "small" narratives to make more personal connection to the exhibits in the exhibition, by for instance introducing a fictional character of the given time period of the exhibition, describing a day in the life of the representing character. This way the museum not only conveys narratives, but also supports the visitors in producing their own narratives (Mulholland, 2015).

Some examples of how technology has been used to facilitate museum narratives is also presented by Mulholland et al. The terms "big" and "small" narratives can be used to distinguish the kind of narratives augmented by technology in a museum setting. Considering "big" narratives, technology has been used in forms that suggest routs or tours through a museum exhibition space, also to assist the users own production of trails through the exhibition. The authors highlights an AI model for virtual tour guiding, based on a knowledgebase of story sections, connecting a number of artifacts within the exhibition made by authors Mei Yii Lim and Ruth Aylett in 2007 (Lim, 2007). Another project was made by authors Kevin Walker in 2006 to investigate the use of mobile technology by allowing visitors to create, edit and share their own trails through the exhibition. The visitors could make voice recordings and capture images and write texts about the exhibits and their experience to create their own coherent narrative of the experience at the museum (Walker, 2006).

In terms of "small" museum narratives, technology has also been used to provide first person narratives and to engage visitors in contributing to the experience. Authors Luigina Ciolfi and Marc McLoughlin explain how the use of QR codes can augment a living history museum to associate personal memories with the exhibits in the exhibitions space. The memories helped the visitors understand the context better, for example how a particular object was used in a specific period of time (Ciolfi, 2012). In another article by Charles Callaway et al., the authors describe a mobile system that can deliver narratives related to an exhibit to each member of a group visiting an exhibition together. The narrative provided to each group member has a different incomplete account form a particular perspective, which encourages the visitors to piece the whole narrative together using each other's active involvement (Callaway, 2012). Other systems using digital technology have been developed to allow visitors to use the elements of narratives, such as events, to chart their own path through historical information. Most of them takes the form of web based

applications. Examples mentioned by Mulholland et al. are the Reasonator (Reasonator, 2016) and Histropedia (Histropedia, 2016). These tools have the common feature of being able to gather data from different sources and present them as a series of events that can be navigated through and viewed in different forms, such as timelines. The Authors argue that this form of data treatment from a narrative inquiry perspective can be seen as giving access to the raw materials from which stories and narratives can be constructed.

Based on the above, Paul Mulholland together with Annika Wolff and Trevor Collins (Wolff, 2012) present examples of how ideas from narrative theory can be used to create links between narratives and museum exhibits to create museum narratives that support visitor interpretation and narrative meaning making for more personal experiences. The authors provide a framework for creating narratively meaningful links between additional exhibition content that is not available in the physical space of the museum exhibition and to allow the visitors to explore underlying stories and plots between different exhibits. The authors describe the construction of these museum narratives based on their development of the curatorial web interface Storyspace. In their report *"Storyspace a Story-driven Approach for Creating Museum Narratives"* from 2012, they describe a narrative framework for creating museum narratives by explaining the narrative component of the Storyspace software (Wolff, 2012).

The Storyspace software was developed as a curatorial tool to help curators make interesting narratives about the physical exhibits in the museum space. In the storyspace software, the curator adds content and information about the exhibit, storyspace then assists the curator in constructing stories, plots and narratives. The authors argue that curatorial narratives found in museum exhibitions are founded on the same principles as other forms of narratives, such a dramatic plot based approaches found in many genres like fictional books or films. The authors based their software on a structuralist view on narratives, meaning that all events of a story are separate from the telling of the story namely the narrative. In line with Ryan's perspective they claim that the events of the story are distinct from the telling of it and the plot is the feature that relates and organize the events according to each other, based on a specific perspective. The plot determines the purpose of the events and chooses only those that advance the plot. The intensity of the narrative can be controlled by the selected plot structure to give a different telling of a story (Wolff, 2012).

The most basic form of narratives has no plot, but base relationships between events on other factors such as chronology. The plot introduces the opportunity to add drama to the narrative, and can be used to manipulate the dramatic impact by choosing when to introduce conflict and when to resolve it. The authors note that when constructing narratives from visual content, the coherence is improved by identifying themes from content selections. This can also improve the subtext to a narrative presentation (Wolff, 2012).

The stories in the exhibition make the exhibits interesting and infer meaning to them. The impact of the story intensifies by the linking to more exhibits or stories. According to Peponis (Peponis, 2003), the narratives in museums are used to refer to the arrangement of exhibits and their associated information into a sequence that provides more complex insights into the exhibits than what comes from the objects alone. This is important for the museum, as more insights and understanding of the information connected to the exhibits, will give it more relevance for the visitors.

Museum narratives, as mentioned earlier in this section, can be divided into "big" and "small" narratives. The "small" narratives originating from the visitors personal experiences and the museum support of their personal experience related to the exhibits. As the impact of these "small" narratives are increased by their connection to other exhibits and stories, the museum should strive to create these connections and links. However, as exhibits might be separated by physical space, notes and signs might be used to indicate linking between the exhibits, but unless the visitor is willing to go back and fourth between items, some are inevitably bound to be 'out of sequence' of the intended narrative. Thus the exhibition needs another way to connect them. Digital hypertexts can create the link between objects by displaying digital information, which refers to other texts and so on. Hypertext[1] can provide contextual information about the museum objects from the museum database and link them by a hypertext architecture. The content can include both text, video and pictures. Hypertext is used by Wolf et al. in the Storyspace software

[1] Hypertext is an arrangement of the information in a computer database that allows a user to get information and to go from one document to another by clicking on highlighted words or pictures (Hypertext, 2016).

to create narrative architectures. Besides linking objects to each other, Wolf et al. encountered another challenge: how to turn all the information and content about the exhibits into coherent and meaningful user experiences, reflected by greater narratives. The authors argue for the use of events to describe the sequencing of exhibit content and information. They also emphasize the importance of plot representation as event sequencing alone only allows for certain types of narratives, such as chronicles that simply lists events according to time. As mentioned before, the plot introduces drama and tension as it imposes a specific viewpoint and reading of the story, to make the story more interesting and relevant. Wolff et al. explain their framework for narrative construction built for the Storyspace software (Wolff, 2012):

The software interface is divided into four layers:

1. **The story layer**. This layer consists of the events of the story including features such as facts and visualizations of both story events and plots.

2. **The plot layer**. This layer describes the relationship between events that are identified as the events that move the story forward.

3. **The narrative layer**. This layer is used to organize the events and plots according to each other for the presentation of the narrative.

4. **The heritage objects layer**. All the information about the exhibited objects are gathered in this layer, like images, links and texts.

The author or curator can then create a curatorial story form all the layers. The structure of the interface resembles a curatorial dossier[2].

Curatorial story

[2] A dossier is defined as a group of papers that contain detailed information about someone or something (Dossier, 2016).

The curatorial story contains a set of events based on two sources form the “dossier” in the Storyspace interface. The stories related to the heritage objects (exhibits) and 2. the events from these stories which relate to more objects, a subset of objects, in the exhibition. Facts relating the exhibits stories can be defined as describing important properties of the curatorial story such as time, location or theme.

Plot employment

The next step in the construction of the narrative is the employment of a plot. A plot is divided into plot descriptions in the interface, with each plot description defining a relationship between some events within the story. There are three different plot types to choose from: *influenced-by, reacted-against* and *related-to*.

Narrative organization

Finally, the narrative must be organized. This is an important step as it can affect both the coherence and dramatic impact of the story. The curator can alter the effect of the narrative by changing the principles used for organizing its elements. The narrative is outputted to the visitors as an ordered set of story events and related exhibits. The ordering is determined by the preference of the curator, it can be created both from facets, a plot or a combination of the two.

The facets of an exhibit can be used to order and organize the story events. The events related to the selected facets are grouped according to their value for that facet. In this case, the coherence of the narrative output is manipulated though the choice of facet ordering. This is useful for grouping exhibits into categories. A facet could for example be either theme, time, location, or artist.

When choosing to organize the narrative from plot instead of facets, this conveys a specific interpretation of story events. Narrative presentation of plot can alter the effect that it has on the audience and introduce drama, for instance by using the dramatic arc first formulated by Aristotle. The dramatic arc is built on the narration of a rising action, a crisis that reaches climax where upon the tension falls, before the narrative is brought to its conclusion (Aristotle, 1996). Following a dramatic arc, the effect of the narrative can be altered by changing the order of the plot elements,

e.g. presenting the end of the story in the beginning or going backwards or forward in time. The Storyspace interface provides three different ways to create narrative from plot, the choice depends on the desired effect. If the plot is an *influenced-by* type of plot, the plot contains two elements, an *influencing-events* element and an *influenced-events* element, like a cause and effect. If the narrative is ordered by *plot description*, the events are ordered according to their inclusion in the plot description. Each individual plot description is viewed as a separate entity. The ordering of the individual plot descriptions is determined by the curator. In terms of the dramatic arc, the tension is minimized by completing a plot description right after it is introduced, e.g. in an influenced-by plot, all causes of influence are introduced and the outcome is immediately presented. Before moving on to the next plot description, see Figure 2.

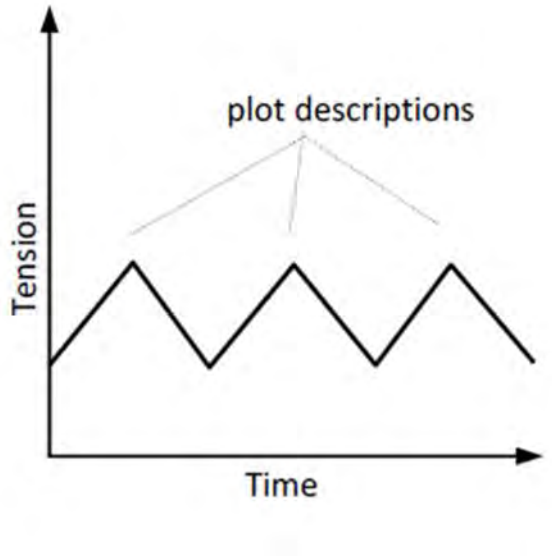


Figure 2: Minimizing tension in a plot-based narrative.

Secondly the narrative can be ordered by *plot elements*. The ordering by elements can maximize the tension of the story by leaving the plot description unresolved for as long as possible. If the *influencing-event* is introduced before the *influenced-event*, this creates suspense because the audience must await the outcome. This plot type is very common in gallery settings, where

influencing plots are often explained by wall panels (text panels) and objects of the exhibition then display the evidence of the stated influence, see Figure 3.

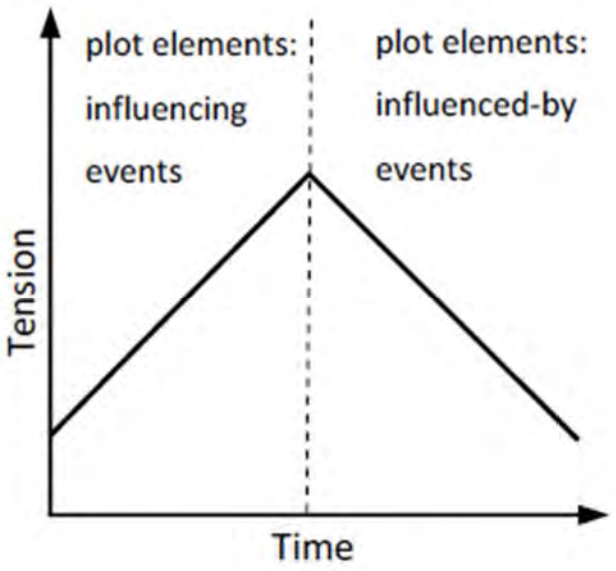


Figure 3: Maximizing tension in a plot-based narrative.

Thirdly the ordering can happen according to *plot type*. The curator specifies which plot type they want to display first, e.g. first show all examples *related-to* then all examples *influenced-by*. The nature of the plot relationship affects the dramatic arc. *Related-to* relations are less dramatic than *influenced-by* relations. This can be used by the curator to increase and decrease tension. A narrative of this organization type might be used to show how certain plot types tend to repeat, see Figure 4.

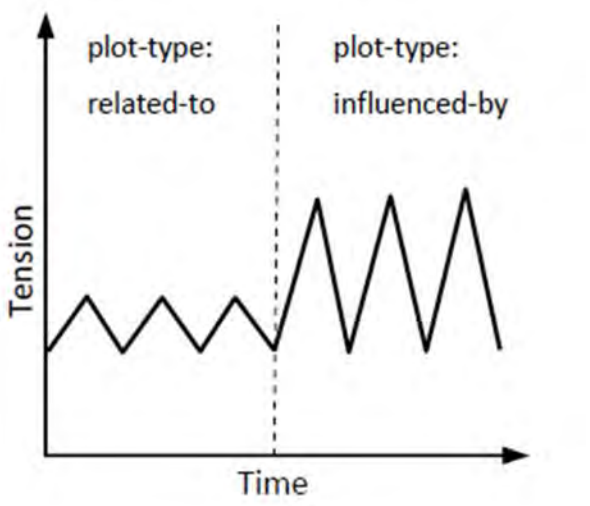


Figure 4: Escalating the tension in a plot-based narrative.

A common way to organize narratives in museums is to order the overarching plot according to facets e.g. an artist's life and work, exploring how their experience have influenced their career and artworks. Smaller parts of the exhibition are then more likely to be organized around smaller thematic categories, events first ordered according to chosen facets with associate plot structures being secondary. This is suitable when plot structure branch out a lot. Most exhibitions then follow a grand narrative with some thematic organization and within these themes smaller vernacular narratives are made, to help the visitors see the bigger narrative and make the experience more personal.

The Storyspace framework presents a way to structure and construct narratives in exhibitions by creating narrative links between exhibits and adds the notion of plot to introduce drama into the give exhibition. Together with the notion of small and big narratives the framework will be utilized to form the base of a design concept for making a novel dissemination mean for the museum exhibition. The design concept will be presented and elaborated upon in section 2.4 Conclusion & design concept.

2.2 Tangible Interaction

Having found a framework for the narrative construction of stories about the exhibits within a museum, these narratives need a medium to unfold within. As presented in the introduction, many of the most popular digital technologies used in museums today are screen based. This is not in itself a problem, but in the development of digital technology as a means of dissemination in the museum, many applications lack in both materiality and physicality. The physical world we meet is analog and our human senses are used to navigate in this analog world. Thus, for an experience to be fully perceived and understood, as many of our senses as possible should be evoked. This can be a challenge with digital technology, although many applications show a great display of strong both visual and audible stimuli, it is in its essence lacking of both materiality and physical content. This is also highlighted by Hornecker et al. in their report *"Integrating Material and digital: A New Way for Cultural Heritage"*, the authors describe how digital layers have a tendency to put a greater distance between the visitor and the exhibits of an exhibition (Hornecker E. a., 2013). Physical objects and environments are a central part of the museum and a big part of the visitor's experience. With this acknowledgement, the research field of tangible user interfaces (TUIs) has advanced to account for the incorporation of more physical experiences in the museum. The goal of TUIs is to bridge the gap between the digital and physical to create more sensory experiences for the user by incorporating design for the use of the human touch modality. This section will thus investigate the use of tangible interaction and tangible user interface design in the context of museums, to gather design requirement for the design of a tangible user interface component as a part of a combined concept design for narrative dissemination in the museum.

2.2.1 Tangible Interaction

According to Eva Hornecker (Hornecker E. , 2016), the use of the notion "Tangible User Interfaces" was first proposed by Hiroshi Ishii and a group of researchers at the MIT Media Lab in 1997 (Ishii, 1997). In the start of the first developments of TUIs they were envisioned as an alternative to graphical displays that could bring more of the interaction richness that people have with physical devices back to the interaction with digital content. The idea was to let tangible objects represent digital content, which could then be manipulated through physical interaction

(Hornecker E. , 2016). One of the first projects to use these tangibles was made by the MIT´s Tangible Media Group and took form as a map that could be manipulated by placing iconic representations of buildings on the map and moving them around. This resulted in the development of Urp, a physical urban planning tool (Underkoffler, 1999). This research has led to an investigation of how digital behavior and form can be coupled together to let users interact in a richer way with digital products. *The Marble Answering Machine* is an early example of this development and the term "tangible interaction" originates from this context. *The Marble Answering Machine* was a student project made by Durrell Bishop. The machine's incoming voice messages were represented by physical marbles. The user would grasp the marble and drop it into an indentation in the machine to play back the message. The marbles could also be placed in an augmented telephone to dial the caller automatically. The project was a great example of making digital information tangible (Ishii, 1997).

A further merging of physical and digital design has been seen with the emergence of "Physical Computing". Physical computing involves the process of fast prototyping with electronics and is defined as *"the design of interactive objects, which are controlled by software, and that people interact with via sensors and actuators "* (Hornecker E. , 2016). Physical computing sparked the field of research in embodied interactions, where installations employ interactive spaces that are sensorized to track a user's behavior in that space. In these types of environments, whole body movements are often used as interaction parameters. Whole body interaction is thinking of tangible interaction on another level – instead of interacting directly with an object the user interacts with a large space, where they move around and use the whole body as an input (Hornecker E. , 2016).

Tangible Interaction as a term has thus come to embrace all of the developments in the field but as outlined by Hornecker, the field of tangible interaction prioritizes as principles of the design:

- Tangibility and materiality
- Physical embodiment of data
- Bodily Interaction
- Embeddedness in real spaces and contexts

The authors argue that the original definition of tangible user interfaces was too exclusive as many interesting developments and systems from production design and the arts where not acknowledged, and therefore the term *tangible interaction* where purposed to cover these disciplines as well. The term *tangible interaction* places the focus on the design of the interaction in the center of attention and makes designers actually wonder how the users are actually going to interact with the system. However, as the term *tangible interaction* has opened up to a broader view of the field it also leaves some more blurred lines of what is actually considered *tangible interaction*. Thus for the sake of this thesis, the focus will be on tangibility and materiality, as these concepts are the primary concern of tangible interaction as described by Hornecker and also falls in line with the focus of this thesis. The next chapter will thus concentrate on the design principles concerned with tangible user interfaces with a focus on materiality and not go into the area of embodied interaction.

2.2.2 TUI design principles

In the context of museums, the science museums seem to be the ones most experienced with using TUIs in their exhibitions. Michael S. Horn et al. describe the design considerations around the use of TUIs in science museums. Based on their research at the Boston Museum of science, the authors present five general design considerations for tangible user interfaces in museum settings. The design considerations are informed by the recent literature in practical design for exhibition developers. The authors focus especially on the unrestricted nature of the museum, meaning that the visitors are free to choose when and where to spend their time in the exhibition. Because of the visitors' freedom to choose, an effective interface must be both inviting and easy to understand. The authors also emphasize that the interface should be able to hold the visitor's attention throughout the whole interaction process. At the same time, designers should be aware of development and maintenance costs, as the museum in general has to be economical with its resources (Horn, 2008). Based on these realizations, the authors provide five design considerations for the design of tangible user interfaces in museum settings:

- Inviting – the interface must catch the attention of the visitors and invite them to interact.

- Apprehendable – it should be easy to understand how to use the interface. Can also be described as immediate apprehendability meaning people with no prior knowledge should immediately understand the purpose, scope and properties of the interface.
- Engaging – an interactive interface should strive to hold the visitors' attention throughout the whole exploration process.
- Supportive of Group Interaction - museums are usually visited by groups and as such the interface should facilitate group interaction with both active and passive visitors.
- Inexpensive and reliable – Very often museums don't have many recourses, thus keeping the development and maintenance cost low is a priority.

The authors point out that tangible interfaces have been cited as being well suited for museums, but that there can be potential problems with the cost and reliability of these interfaces. Therefore, designers must make careful considerations about the tradeoff between the type of desired interaction, reliability and cost of technology needed to support the interactions. The tradeoff is between the coupling of the digital and physical world in the tangible system. How close the physical actions are to the digital responses is called the *Isomorph effect* (Hornecker, 2006). In systems with weak isomorph effect, the digital response to the physical manipulation is remote in time and/or space, but the advantage might be robustness, low cost and durability (Horn, 2008). The tradeoff between a strong and weak isomorph effect in a system design should be carefully considered by the designer, and will together with the basic design considerations presented by Horn et al. be taken into account in the design and implementation phase of this project. The design considerations presented by Horn et al. was also used by the authors as an evaluation method to determine the effectiveness of their tangible interface made for the Boston science museum:

- Inviting – so visitors who notice the exhibit decide to interact with it?
- Apprehendable – can visitors quickly learn how the exhibit works?
- Engaging – how long does the exhibit hold visitors 'attention?
- Supportive of group interactions – are visitors able to interact with the exhibit in groups? Does the exhibit support simultaneous active participants? Does the exhibit support both active participants and passive observers?
- Inexpensive and Reliable – was the exhibit relatively inexpensive to develop? What kinds of and how much maintenance does the exhibit require? (Horn, 2008)

The *inviting* quality of the interface was measured by keeping track of the number of visitors who noticed the interface (glanced or looked at it), which then also interacted or touched it. The *apprehendability* of the interface was evaluated by noting whether or not the visitors where able to understand how it worked and use it in the intended manner. To measure *engagement* the duration of each interaction session was recorded, when dealing with groups, the session time was measured from the time the first member started interacting to the last member stopped interacting. To measure the extend of which the interface was *supportive of group interaction,* the number of active and passive visitors for each session was noted. The evaluation method was developed from the design considerations described above, to answer the evaluation questions. The design considerations presented by Horn et al. will thus also be used to evaluate the success and effectiveness of the tangible interface prototype developed for this thesis.

2.2.3 Material Design

As stated by Hornecker, and presented in section 3.2.1, the field of TUIs overlaps with the field of production design, as this area deals with the matter of material and the design of material user experiences. The production design book, "*Materials and Design – the art and science of material selection in production design"* (Ashby, 2014), gives a great insight into the process of designing material objects and explains the use of materials in design. Michael F. Ashby and Kara Johnson emphasize that the world we live in is essentially material, it is materials that give substance to everything we can see and touch. They explain that objects can have meanings and express more abstract ideas through symbolism. Designers strive to produce designs that can blend the technical with the aesthetic through materials, combining practical utility with emotional delight (Ashby, 2014). Elvin Karana, Owain Pedglay and Valentina Rognoli also prescribe to the importance of material design and describe how to design material experiences in their book *"Materials Experience: Fundamentals of Materials and Design"*. The authors explain how material experiences can come in many kinds and types, some are pleasant and some are unpleasant. Generally, experiences can be categorized in to tree types, *aesthetic experience, experience of meaning* and *emotional experiences*. Where the *aesthetic experience* strive to delight our senses the *emotional experience* can arise from a goal to attain e.g. a happy or a sad response and the *experience of meaning* is about attributing characteristics to objects, such as feminine, soft, usable

etc. These three types of experiences usually all occur in a single experience , so it can be hard to distinguish them from each other as they also affect each other's quality. There are however some underlying processes that can be conceptually separated. The authors argue that in the context of material experiences the experience of meaning is the most relevant (Karana, 2013).

Material Aesthetics

The authors define the term 'aesthetic' as "*pleasure attained form sensory perception"* from the definition of Hekkert (Karana, 2013). Materials can thus be aesthetically pleasing. As humans we are interested in making sense of the world and sensory experiences help us identify things and navigate in our environment. For that reason, we have learned to aesthetically appreciate the features, patterns or cues around us that facilitate these functions. Humans prefer objects that are both maximally novel while being as familiar as possible. This can be achieved by using well-known shapes, but with the adaption of a new material to that shape. However, what is regarded as novel depends on a person's previous experience with a given product or material. One material may be very novel for a specific context, for example crock used in an interactive device. Correspondingly, if you have a very novel shape it is from a aesthetic point a view best to stick to familiar materials for the category of that product (Karana, 2013).

Emotions to materials

Materials can also evoke emotions; people can be fascinated by the strength of a material or be disappointed about a material surface that scratches easily. Surprise can also be evoked by materials, they can be surprisingly light or heavy, smooth or rough, warm or cold. When this surprise occurs and the unexpected is better than anticipated it produces positive emotions like relief, amusement or happiness (Karana, 2013).

Meanings of materials

Meanings can be ascribed to materials and products. E.g. the glass is fragile, the seat is comfortable, the sneakers are cool. It is often very difficult to separate the meaning that are attributed to materials from the meaning of the product itself. Are the sneaker cool because of the material or despite of the material? Product and material meanings are rooted in the human sensory

perception. In reality materials do not possess meanings, in the same matter as with emotions and aesthetic responses, the meaning of materials arise in interaction and are sensitive to context, any material can inherent any meaning in a particular context. There are however patterns and regularities that is considered material-meaning relationships. E.g. materials appear professional when it is smooth and dark and it is used in an office context. Such material-meaning associations are almost universal (Karana, 2013).

Universal meanings can occur when figurative qualities are attributed to materials. To understand our place in the world, humans can associate meanings to materials through a universal understanding of the world we live in. E.g. warm temperatures are considered more present than cold ones. Humans therefore tend to use metaphors to describe the world around us based on this universal understanding, e.g. if a person is described as warm it means that the person is pleasant, inviting or open. This indicates, the materials could also be perceived in the same manner, for instance, wood is literally warm to touch and therefore is considered inviting and pleasant to touch, whereas other materials as steel and stone are more cold to touch and for that reason is considered more distant. Stone and steel are relatively heavy, and for that reason they give the impression of being of high quality. Light materials are, on the other hand, often considered to be cheap. When materials are rough, humans tend to perceive them as being more natural than smooth materials, and transparent materials are likely to be seen as fragile. Lastly, soft materials are mainly considered to be organic or alive and hard materials are considered to be dead. The authors argue that these material-meaning associations are by their sensorimotor nature very robust and not that sensitive to cultural and individual differences. However, if the materials have a shorter story of presence in humans lives, compared to wood or steel for instance, they have not yet become routed in the sensorimotor experience and thus have to be learned, like meanings such as cool, toylike or modern. These meanings becomes associated with materials through a kind of associative process, which the authors describe as learned meanings (Karana, 2013).

When materials are used often in a certain context, they become associated with particular meanings that are dominant in that context. These meanings can, over time, be perceived as intrinsic characteristics of the given material. An example is the perception of ceramics as being of high quality, because the material has a certain weight and rigidity, but also because of its frequent use in expensive and long lasting dinnerware, which reinforces the attribution of this

meaning to the material. The authors emphasizes Paul Hekkert and Matthijs van Dijk´s (Hekkert, 2011) belief that materials and user-project relationships are part of a larger context of all kinds of factors, such as technological possibilities, social patterns and cultural expressions. These contextual factors all have an effect on how people perceive and respond to a given product and material. The contextual factors of people's interaction with a given material is mediated by the concern of the user in terms of *goals***,** "what we want", *standards* "How we believe things ought to be", and *taste* "what we like." Many material- meanings associations are learned within societies based mainly on frequent use of materials in a particular context, in its functionality, its ease of formability, such that there will naturally be association differences based on culture and context (Karana, 2013).

These considerations regarding materials give an indication of how to choose materials for a given design and will be used in the design considerations regarding the TUI made for this thesis. The different processes of material experiences*, material aesthetics, emotions to materials* and *material meanings* will be considered when designing the materiality on the TUI for this thesis and will be part of the design concept presented in section 2.4 Conclusion & design concept.

2.2.4 Tangible interface technology

Searching for inspiration in projects with features connected to the design considerations presented by Horn and Karana et al. and with focus on it to be inexpensive and reliable meaning that the technology should be both cheap and quick to make but still reliable in functionality (Horn, 2008). The field of low fidelity prototyping of TUIs was found to encompass many of these requirements. Projects like Sketch-a-TUI presented by author Alexander Withoff et. al. and describe in their report "*Sketch-a-TUI: Low Cost Prototyping of Tangible Interactions Using Cardboard and Conductive Ink*" shows how to develop TUIs that accounts for the expenses and time it would normally take to make tangibles. The authors argue that the process of making tangible interfaces normally require at substantial amount of time and effort, even with a high expertise in electronics. To make a low cost and less resource requiring solution they have developed a low fidelity prototype solution, which is both efficient in time and low cost. The solution is very simple consisting of cardboard forms and lines drawn with conductive ink, to make the tangibles into small capacitive touch screens. Coupled with routine programming the tangibles can be quickly

developed in to lo-fi prototypes made to test various designs (Wiethoff, 2012). The low fidelity prototyping method developed by the authors is called Sketch - A – TUI, and lets people rapidity construct lo-fi paper objects that are recognized by capacitive surfaces, see Figure 5.

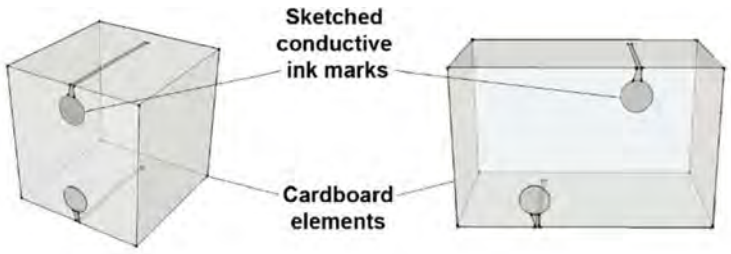


Figure 5: The Sketch-a-TUI interface elements (Wiethoff, 2012).

The tracking of the paper objects is based on capacitive touch screens, where the capacitive surface recognizes changes in the capacitive field above the surface of the screen. This is possible either through passive conductors or active electronics embedded in the interface. But instead of dealing with the complex development of the electronics that goes into the development of capacitive touch screens, the authors let non-professionals create capacitive objects by simply drawing lines on the objects with conductive ink. When a person touches the objects on its touch points on the top of the object, the conductive ink transmits the body´s capacitive load form the tip of the tangible object towards the bottom that has contact to a surface screen. The screen surface then detects the object. Sketch-A-TUI provides various of paper templates to create 3D shapes, like cubes, pyramids and cylinders which can be used as tangible interface objects. An example of a Sketch-A-TUI interface can be seen on Figure 6.

Figure 6: User making a Sketch-A-TUI tangible interface object (Wiethoff, 2012).

The use of conductive ink to make creative and low cost solution have also been used in the field of production design, for editorial purposes. The design and retail agency Dalziel&Pow made an interactive tangible interface for the annual retail design expo in London in 2015. To stand out the company made use of conductive ink to create an interactive exhibition stand, making a touch screen out of wooden walls with painted illustrations, conductive ink and projection mapping. The conductive ink served as a flexible touch sensor as it could be painted write onto the wood, the painted sensors where then connected to a ototo board (a touch to sound converter), which then connected the output to some speakers place behind the wooden walls. The illustrations on the wooden interface was brought to life by the projected visuals form the projection mapping. The expo was a great success and facilitate an interactive, engaging experience for the audience (Dalziel&Pow, 2015). A video illustrating the success of the interface can be seen in this video link: https://vimeo.com/121878247

Another project made by Dalziel&Pow was an interactive sound poster made for the Zippy kids ware store in Portugal. The interactive sound poster was made much like the design form the retail expo. A wooden plate with screen printed characters where brought to life by the use of conductive ink, that created an array of sensing points on the poster which could tigger different sound effects when the kids touched the graphics (Burns, 2015), Figure 7. A video illustrating the functionality of the poster and other tangible interfaces made for the Zippy kids ware store, can also be seen on this video link: https://vimeo.com/135269038

Figure 7: The Zippy sound poster interface.

From the concepts of low fidelity prototyping and inspired by the design from the retail expo and other branding concepts, like the interactive sound poster made by innovative design team Dalziel&Pow, I will look into the possibility of using conductive ink as sensor technology to make a tangible interface to facilitate physical infographics for museum exhibitions. The hardware used in the Dalziel &Pow´s retail design expo is the combination of using conductive ink on plywood, the capacitive touch board Ototo (a touch to sound converter). The use of conductive ink was presented by Bare Conductive, an interactive technology company specialized in making sensing tools for engineers, designers and makers (Conductive, Bare Conductive, 2016). The company present a lot of knowledge and design requirement and considerations for using conductive ink as sensing technology, and will be the main source of information about the technological requirements for this thesis.

Conductive Ink

Conductive ink or electric paint is an electrically conductive paint, which can be used to cold solder and repair breaks in circuits but more interestingly it be used to paint wireless sensors. It can be

applied to both paper, plastic, textiles, wood, plaster, conductive is intended for circuits with low DC voltage at low currents. The properties of the glass and many other materials. This allows for the integration of electrical properties into traditionally inert mediums such as screen printing, painting or other visual arts techniques. The paint from bare paint from the Bare Conductive website is presented below (Conductive, Bare Conductive, 2016):

Color: Black

Viscosity: Highly viscous and shear sensitive

Density: 1.16 g/ml

Surface Resistivity: 55 Ω/Sq 50 microns or 32 Ω/Sq when using a brush

Vehicle: Water-based

Use by: 6 months after opening

Drying Temperature: Electric Paint should be allowed to dry at room temperature for 5 – 15 minutes. Drying time can be reduced by placing Electric Paint under a warm lamp or another low intensity heat source.

The electric paint has different resistance depending on the size and form of the area it covers.

The resistance in a sample of conductive material is defined by the dimensions of the sample. The resistance is inversely proportional to cross sectional area, i.e. a set length and depth, a wider sample will have less resistance than a thin one. Thus the resistance can be defined by the ratio length and depth. The resistance can be calculated by the equation: Resistance = 19.77 (ratio) + 12 for any proportion over 1. See Figure 8.

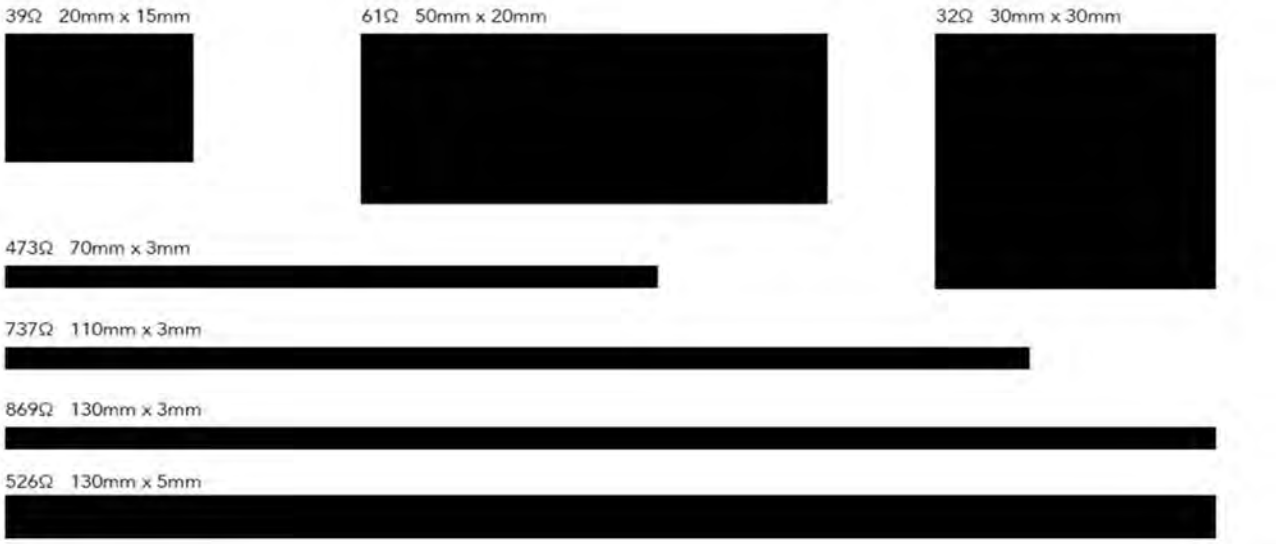


Figure 8: Resistance depending on size (Conductive, Bare Conductive, 2016).

When using the electric paint as sensors some basic rules apply. The size of the trigger such as a hand or finger should be relatively large in comparison to the sensor area. This is especially important when designing large proximity sensors, whereas designing touch sensors the rule doesn't always apply. To go about this rule, the sensing area can be hatched instead of filling up the whole shape. Then the conductive matter is low in comparison to the trigger and the sensing area is still large. So when covering a larger area, it is a good idea to brake to sensor up in lines, but it is a good idea to bridge the lines to allow the sensor to work even if the line is broken at some point. Creating different graphics with the same amount of paint doesn't change the performance of the sensor so it allows for visual experimentation.

The conductive paint doesn't require metal connection or heat to order to attach or solder. This means that components can be cold soldered unto nontraditional materials such as paper, cardboard or plastic. The paint can also be used to paint simple circuits.

Shape

Painted sensors can take almost any shape you want, the difference between a square and a circular sensor with the same fill and size is insignificant. The important factors to remember are the

thickness of the paint and the *length* of track leading to the sensor, the *fill* pattern and the sensor *size*.

Trace length

When making painted traces from the sensor to the touch board the trace should normally are between 5 to 30 cm and with a width between 3 to 15 mm. If the trace needs to be longer than 1m other materials such as copper wire could help extend the trace.

Fill pattern

When designing the sensor, the ratio of the conductive sensor area needs to be considered in respect to the size of the triggering object (e.g. hand or finger). If the sensor is meant to detect the presence of a hand, the outer limit of the sensor should be larger than a hand. The sensitivity of the area can be increased by reducing the area of the conductive surface by hatching the fill. A sensor with complete fill will be less conductive as the same size sensor with a hatching fill. This especially improves the performance of the sensor and potential range of proximity detection. See examples of fill patterns on figure 9.

Size

The size of the painted sensor area is important to consider in respect to the purpose of the sensor. Small sensor areas, like the size of a fingerprint works best when making touch sensitive buttons, while large sensors works better as proximity sensors. Large sensors (1m x 1m) which are filled in with a full covering of electric paint can have a slower response time, compared to the same area filled with a hatching pattern. Example of different fill patterns can be seen on Figure 9.

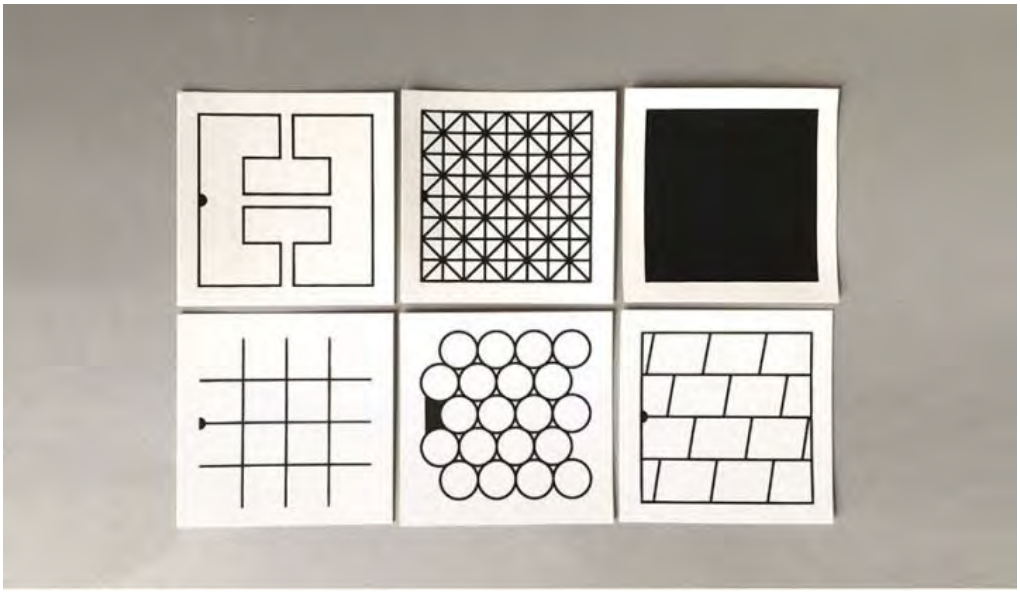


Figure 9: Examples of different fill patterns (Conductive, Bare Conductive, 2016).

Touch Board

To produce an output from the ink painted sensors it can be connected to any microcomputer or controller such as the Arduino or Raspberry Pi. Bare Conductive however provides an Arduino based and compatible device, the Touch Board which makes physical interfacing even more simple and convenient. The Touch Board is an Arduino compatible microcontroller with robust distance and capacitive touch sensing, MP3 Player and MIDI functionality. The board is preprogrammed as an MP3 player but the code can be changed to trigger any kind of output, such as sound, movement or light.

The Touch Board is despite its name actually doing proximity sensing via capacitive sensing. If the threshold is set relatively high the board rejects proximity events and only respond to touches. The Touch Board is supported by a lot of documentation and tutorials by the Bare Conductive community and there exits various code snippets to help build and debug solutions. For instance, Bare conductive provide a Processing sketch for visualizing the data passed through the Touch Board in order to access the raw proximity of the data captured by the board and the display of touch and release events. This is very useful for debugging installations.

The Touch Board has 12 electrodes which can be extended by the electric paint or other conductive materials to make touch and distance sensitive sensors. The board comes with a microSD card which can contain MP3 files to be played directly from the board by connecting a speaker. The Touch board can be programmed just like an Arduino through the Arduino IDE. It IDE (Integrated Development also contains an Arduino Leonardo pin layout to support Arduino shields, a build in LiPO battery charger. Connecting any conductive material like the electric paint to the board turns it into a reliable distance or touch sensor. The board auto calibrates and compensates for tan impressive range of sensor sizes. See the Touch Board on Figure 10.

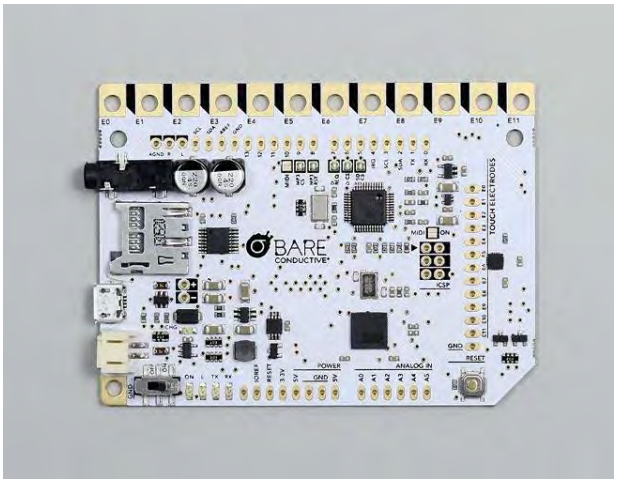


Figure 10: The Bare Conductive Touch Board.

A connection to the Touch Board can be established fairly easy by the use of standard fitting like alligator clips and small bolts or use of conductive thread through the electrode holes. The touch board can also be connected to the sensors through painting directly onto the board. The fact that the touch Board have edge plated electrodes means that a connection to the board can be made from any point around each electrode (Conductive, Bare Conductive, 2016).

Arduino IDE

To write code to the Touch Board it can be interfaced with the Arduino Software IDE (Integrated Development Environment) which let you write code and upload it to the board. The software functions on multiple platforms and the coding environment is written in Java and based on

Processing and other open source software. The Arduino IDE software contains a text editor for code writing, a message area, a text console a toolbar with common functions and a series of menus. It connects to the Arduino, Genuino or Touch Board hardware to communicate with them and upload programs. The programs written for the Arduino IDE are called sketches. The sketches are written in the text editor and are saved as file extensions.ino. The message area delivers feedback while saving and exporting and displays errors. The console displays text output, including error messages and other information. Other libraries can be included in a sketch to provide extra functionality. The Arduino IDE can be used with the Touch Board from Bare Conductive to alter the pre-installed code. The Touch board simply needs to be connected to the computer using a micro USB cable, run the installer and select the touch board from the right port (Conductive, Bare Conductive, 2016).

The technical requirements from the Bare Conductive documentation will be utilized in the development and implementation part of this thesis to provide guidance in the use of conductive ink as the main technology of the developed tangible user interface prototype.

2.3 Infographic Design

In addition to the physical mean of TUIs for facilitating narratives in the museum, the narrative information also need to be disseminated to the visitors. Based on the reflections from the introduction Infographics are a promising medium for dissemination as it can prevent information overload as a possible minimizatione of museum fatigue and as narrative disseminator. Thus this section will investigate the potential of infographic design as a narrative disseminator and gather some design considerations to include in the design concept to guide the design of a novel dissemination mean for the museum.

The medium of infographic has actually been around for a long time, William Playfair was one of the first statisticians to publish traditional visual chart types, such as the line graph, pie chart and bar chart as an alternative way of representing statistical information (Yau, 2013). In 1786 he published his first bar charts depicting Norway and Denmark´s import and export in *The Commercial and Political Atlas,* see Figure 11.

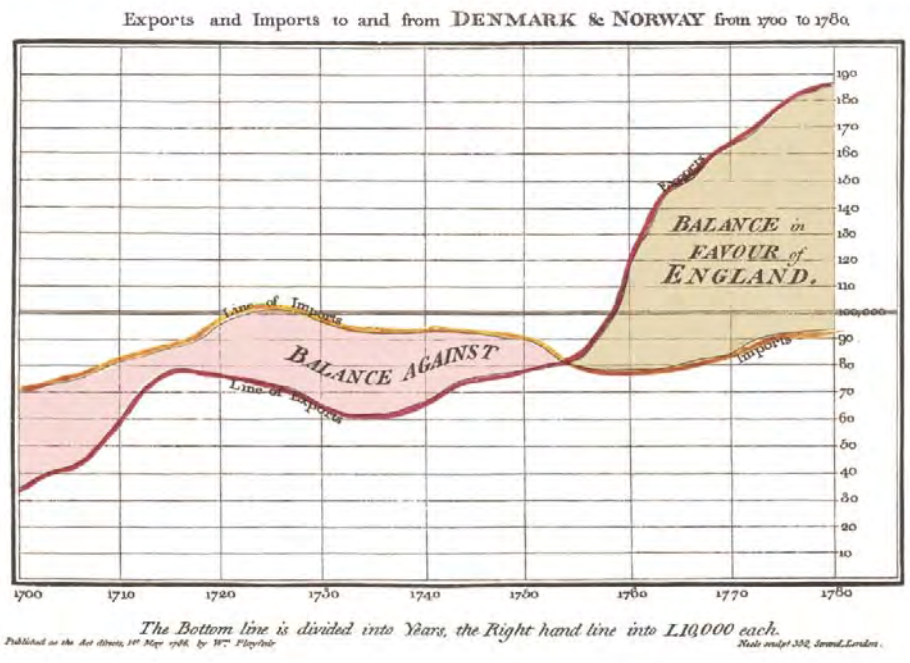


Figure 11: Norway and Denmark's import and export in 1786 (Yau, 2013).

Infographic design have since then evolved through the twentieth century into the form it has today. For many years the medium has been restricted to present statistical data, but nowadays the medium has developed into a storytelling tool as well, as in data journalism, where designers have begun to focus more on an illustrative approach (Lankow, 2012). The creation of information graphics is however difficult to define as it crosses with various disciplines like journalism, computer science, graphic design and statistical analysis. Infographics have been defined more as a medium than a tool *"a way to explore, present and express meaning of data…"* (Yau, 2013). Lankow, Ritchie, & Crooks also describe the term infographics in their book *Infographics: The Power of Visual Storytelling* as a broad term that in its simplest explanation uses visual cues to communicate information (Lankow, 2012). Infographics cannot be described to have a certain amount of data, level of complexity or analysis. There is no line or threshold to determine when something becomes an infographic. A simple sign with a man holding a shovel that lets you understand the construction is ahead or a complex visual analysis of the global economy can all be defined as infographics. In the context of the museum, we are interested in the term of narrative infographics as the dissemination of the museums exhibitions happens through the means of storytelling.

2.3.1 Narrative Infographics & Design principles

Narrative infographics is explained by the authors Lankow, Ritchie, & Crooks as an approach to information design that is used to guide the audience through a selected set of information that tells a story. Narrative infographics is used to communicate value and is designed to deliver a specific message to the audience. The term has thus been defined as visuals which have a predetermined story, a specific take-away message for audiences and audience appeal and aim for information retention (Lankow, 2012).

Then considering how to design these *narrative* infographics, Lankow, Ritchie, and Crooks (Lankow, 2012) argue that there is no correct approach, but that the choice relies on the objective and goal of the design. They argue that different approaches are uttered in the field of information design and that the correct approach depends on the specific objective of the design, with common perspective approaches seen in different fields. For instance, the field of statistic and academic information vary from the field of editorial information design. In the field of statistics, one of the

most known voices in the area is the statistics professor Edward Tufte who is the writer of some of the most acclaimed work in the area of information design. Tufte is of the belief that all unnecessary graphic elements that do not convey information should be discarded in the design of an infographic, and uses the term *chartjunk* to express this principle. This is a typical approach to infographics in the area of academia and for designers with a scientific background. He argues, that any design element, which does not communicate a specific piece of information should be excluded from the design. He believes, that decorative elements and unnecessary lines or labels only distract the viewer and distort the data. He is concerned with the integrity of the graphics and states that *chartjunk* only decreases the value of the infographic. He does, however, recognize that decorative elements can be helpful in editorializing the topic in some cases, but he typically discourages their use.

From another stand point the graphic designer Nigel Holmes take on the opposite perspective on the approach. He supports heavy use of illustration and decoration to embellish information design. He is known for his illustrations of editorial "explanation graphics" in *Time* magazine in which he shows his perspective to support the notion to use illustration and visual metaphors to reinforce the intended topic and make the graphic appealing to the viewer, an example of one of Nigel Holmes exploration graphics on Figure 12. Studies in information design also support his perspective in that decorative elements can aid the retention of information (Lankow, 2012).

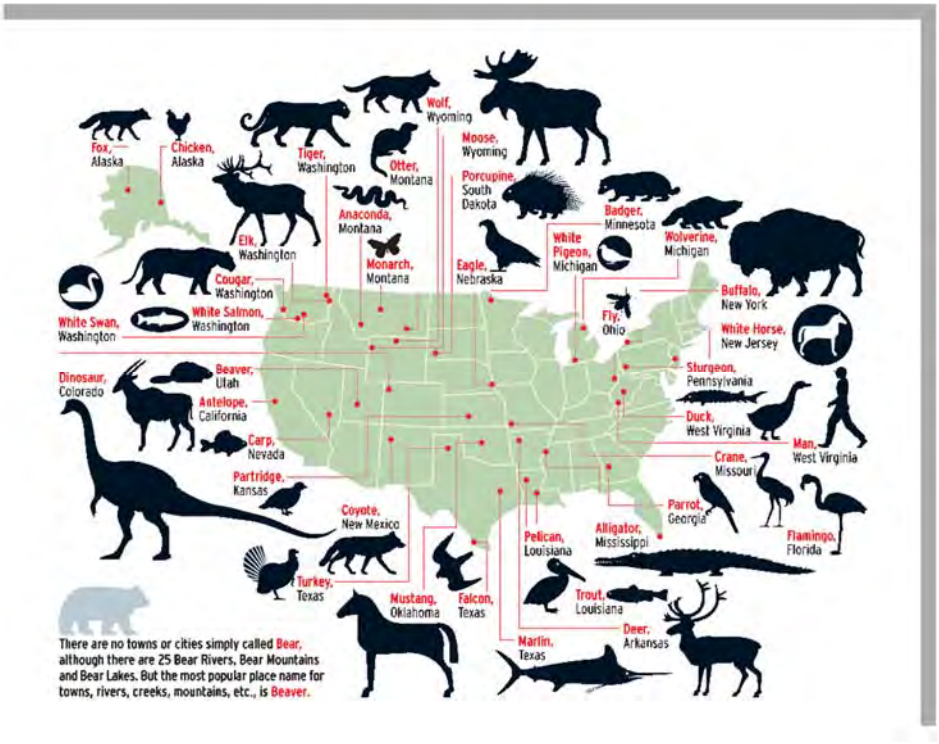


Figure 12: Example of Nigel Holmes "explanation graphics". The example illustrates the different places in USA which are named after an animal (Holmes, 2016).

This enlighten the different objectives of information design, and how the same dataset would be presented very differently depended on the designer's objective and approach. Tufte would aim to show the information in the most natural way to encourage the viewers to analyze the information without bias. Holmes would use the same data and editorialize the message in order to appeal to the viewer while communicating the value and message that he wants the viewer to take away from the design. The different approaches vary in that Tuftes communication is explorative and encourage the viewers to explore and extract their own insights, whereas Holmes approach is narrative and expresses the intended conclusion to the viewer. The differences come from their respective area of work as the objectives of the science and research field are different from those of the publishing world. Thus there is no universal approach to infographic design, each respective industry or individual should develop their own practices depended of the specific goal of the application (Lankow, 2012). In regards to this thesis the approach will lean more towards Holmen

approach seeing that this is narrative and goes in line with the aim to make the information as attractive and engaging as possible.

In addition to objective and goal considerations, the authors Lankow, Ritchie, and Crooks present additional principles of information design based on concepts made by the roman author and architect Vitruvius: Utility, Soundness and Beauty. Utility describes how well the infographic accomplish its objectives and goals. Soundness is measured by the quality of the messaged conveyed by the infographic. Beauty applies to the format and the quality of the aesthetic design itself (Lankow, 2012).

On the basis of these concepts the authors purpose as slightly different categorization to fit the area of infographics. Beauty is now referred to as *appeal*, utility is divided into *comprehension* and *retention,* as the authors believe that these three concepts are the elements of all effective visual communication methods.

Appeal

Appeal is described as the element which should communicate engaging factors to attract an audience voluntary.

Comprehension

The element to communicate and provide knowledge effectively which can facilitate an clear understanding of the presented information.

Retention

Communication that should impact memorable knowledge in the user.

The importance of *appeal* is connected to the exploding amount of information which is processed by each of us every day. As a result, it is getting more and more difficult to attract people's attention since they are bombarded with visual stimuli throughout their day. It is therefore a formidable task to make a design stand out to catch attention. Without the element of aesthetic appeal, it is almost impossible to get peoples interest, so for every information designer this should be a "must have" feature in the design. It is not enough to make the content visual it should also be visually

interesting. This can be achieved though iconography, illustrative metaphors or decorative framing mechanisms, however it is important always to remember the objective to avoid *chartjunk* so to master the balance between appeal and clarity.

In comprehending the information presented, the way it is presented is essential. Although research and discussions of different learning styles and studies of how humans comprehend information have pointed to different learning styles, as people can be both visual, auditory and kinesthetic learner, today most displays relay on visual stimuli for presenting information. The value of using visual communication instead of just words are truly significant. As author Colin Ware states in his book *Information Visualization: Perception for Design*:

> "*The human visual system is a pattern seeker of enormous power and subtlety. The eye and the visual cortex of the brain form a massive parallel processor that provides the highest bandwidth channel into human cognitive centers. At higher levels of processing, perception and cognition are closely interrelated, which is why the words understanding and seeing are synonymous."* (Ware, 2012)

He states that humans are able to *comprehend* more information through our visual system that through all our other senses combined. This is also underlined by the common saying: *"A picture says more than a thousand words"*. The reason for this is mainly because visualizations contain preattentive attributes, which is perceived very quickly by our eyes and processed with impressive accuracy by our brain. An example of preattentive attributes are color change which makes recognition almost instant. All visualizations contain these attributes and the right use of them is key to good visual communication. The natural function of the eye and its connection to the brain is a great mean when we want to communicate information quickly or with a short attention span. Combining aesthetic appeal with these preattentive attributes thus creates a very strong way to disseminate information. With this said the authors also emphasize that words and text can sometime be beneficial to use, for instance when conveying procedural information, logical conditions and abstract concepts where visual elements are best with special structures, location and detail. Words have the benefit of universal familiarity where visual elements are often more isolated to specific social and cultural settings. The strongest visualizations are thus

supported by description and narrative in form of words, especially in editorial applications. It helps to bring personality and clarity in to an infographic.

Another benefit of using infographics in communication is its ability to help viewers *retain* information as graphics have the ability to extend the reach of our memory systems. This happens because visualizations instantly and constantly draw upon non-visual information that is stored in our long-term memory (Ware, 2012). The human brain can recall familiar symbols, scenes and patterns, which allow for rapid connections to already stored information so we quickly comprehend and remember what we see. The authors draw examples from the literature and state that people are better at remembering information if accompanied with visuals in case of long-term memory (Lankow, 2012). Thereby visualization is capable of creating both more appeal and help people retain messages and understand information. While design style varies a lot and cannot be nicely categorized, there are certain elements of the design which can be utilized to facilitate comprehension, retention and appeal. The authors refer to these elements as illustrative designs:

Visual Metaphor

Visual metaphors can contain information as a framing mechanism that is indicative of a subject matter.

Symbols and Iconography

These elements depend on cultural context, as viewers must have a universal understanding of the ions and symbols used to be effective. If this is obtained these elements can provide great communication shortcuts by using visual elements instead of verbal explanation.

Decorative Framing

Using design elements that appeal to your target audience lets them connect with your infographic on an emotional level, sparking a deeper interest and retention of the information.

The authors also express that it is important to remember that illustrations should complement visualization elements, but never at the expense of misleading the viewer from the content.

2.3.2 Genres of visual narratives

There are 7 basic genres of infographics described by authors Segel and Heer: *Magazine style, Annotated chart, partitioned poster, flow chart, comic strip, slide show and film/video/animation*. The different genres vary in terms of number of fames used, distinct visual scenes, multiplexed in time and/or space that each contains the ordering of their respective visual elements. As an example an image placed in a page of text (magazine style) has only one frame, where as a comic strip may have many frames. Multi-view visualizations (partitioned posters) may suggest only a loose order to its images, while a comic strip tends to follow a strict linear path. The different genres are not mutually exclusive, they can be mixed and used as building blocks to create more complex visual genres (Segel, 2010). The different genres are illustrated on Figure 13.

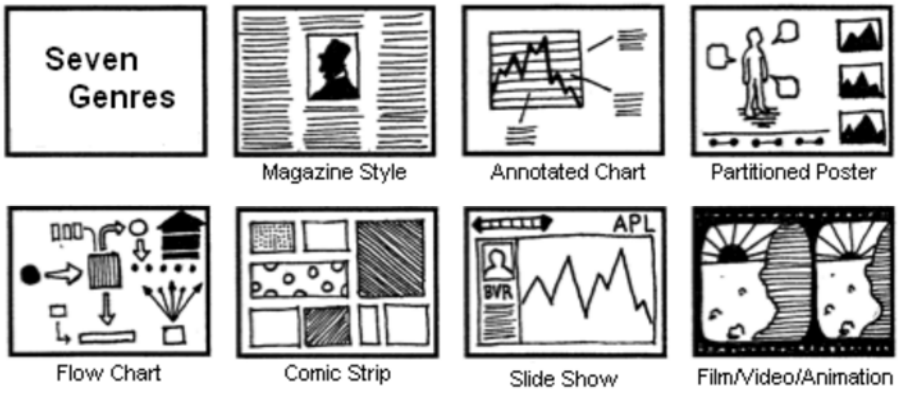


Figure 13: Illustration of the genres of infographic.

Choosing the right genre for your infographic depends on a variety of factors such as the complexity of the data, the complexity of the story, the audience and the intended medium. For instance, business presentations often use Slide Shows, and television commercials use a video format instead of flow charts. The right choice depends on the goal, content and the audience (Segel, 2010).

Based on these genres, both messaging and interactivity can be layered on top of them. Messaging is used through text to provide observations and explanations to accompany images. These text bits often take form as headlines, captions, labels and annotations. In some cases, messaging also includes audio.

Interactivity is used in infographics to allow the audience to manipulate the visualizations. The design of interaction can take many forms depending on the purpose and the genre, some forms use navigation buttons, hover highlights, filtering, drill-down, zooming and time sliders. The appropriate amount of messaging and interactivity in the visualization is a balance of tradeoffs between the two. Messaging might clarify visual elements but produce clutter in the visualization and interactivity might engage the user but distract from the authors intended message. Balancing these tradeoffs requires context specific considerations and judgment.

This highlight the important aspects of carful considerations about author-driven and reader-driven approaches when designing infographic narratives. Together with genre, interaction and messaging considerations, the narrative visualizations are placed within the spectrum of author-driven and reader-driven.

Purely author-driven approaches have a strict linear path through the visualization. It relies heavily on messaging and doesn't include interactivity, often used in film and slideshows. A strong author-driven approach works best when the goal is storytelling or efficient communication. This approach is often used in comics, cinema, business presentations and educational material.

A purely reader-driven approach has no preordering of visual elements and no messaging but a high level of interactivity. Examples are visual analysis tools like Tableau and Spotfire. A reader-driven approach is good at supporting tasks such data diagnostics and pattern discovery. In the development of infographics more examples of narrative visualizations fall somewhere in-between the author – and reader – driven approach, and the balance and flexibility between the two have become a core element in narrative visualizations. This have made ways for visualizations which provide the space for limited interactivity with in a more structured narrative (Segel, 2010).

From an investigation of narrative visualizations made by author Segal and Heer, they identify three narrative structure models as the most widely used structures balancing the reader- and author-driven approaches. The first structure prioritizes the author-driven approach, the second structure promotes a dialogue between the two approaches, while the third structure prioritizes the reader-driven approach.

The Martini Glass Structure

The first structure is called the martini glass structure as its structure resembles a martini glass. It beginnings with an author-driven approach and then opens up to a reader- driven stage, with the stem of the glass representing the single-path author-driven narrative and the widening mouth of the glass representing the available paths made possible for the audience through reader-driven interactivity. With the martini glass as a metaphor the design of narrative structures can be thought of with different digress of authoring and readership, corresponding to different stem types and mouth shapes, shot or long stems, wide or narrow mouth. The overall structures stay intact with the author-driven narrative first followed by the reader-driven interactions, as a way to present the themes and outline of the narrative suggesting the type of information the at reader might explore on his own. The authors Segal and Heer, found this structure to be the most common among the interactive visualizations examined in their research (Segel, 2010).

The Interactive Slideshow

The second structure is called the Slideshow structure as it follows a typical slideshow form. It differs from a normal slideshow by incorporating interaction mid-narrative within each slide. This structure allows the user to explore the particular points in the presentation before moving on to the next stage in the story. In contrary to the martini glass structure, this structure allows for interaction mid-narrative and display a more balanced mix between author-driven and reader-driven approaches. However, many individual slides or parts of the story make use of the martini glass structure, communicating author intended massages first and prompting users to interact with the display afterwards.

This structure works well with both narratives and complex datasets. The structure allows for the author to walk the audience through complex data-dimensions and manipulations step by

step. For complex narratives the structure also allows the author to draw discrete boundaries between different story segments, like when you make cuts between scenes in a film.

The Drill-Down story

The third structure is the drill-down structure which start by presenting a general theme and then allows the user to choose among the particular parts of story or information to reveal additional details and back stories. An example might be a map showing “North Korean Prison Camps”, letting the user explore the individual camps by picking a specific position on the map. This structure is more concerned with the reader-driven approach, letting the user dictate which stories are told and in which order. This approach however still entails a lot of authorship to determine the possible types of interaction, which stories to include and the details included in each story.

2.4 Conclusion & design concept

The conclusion to the chapter above, presents the development of a design concept based on design principles and guidelines found in the research review. The design concept has been created in order to develop a framework of general principles and guidelines to form novel tangible, narrative and information light dissemination means that can provide engaging experiences to museum visitors. Through the review methods and principles of design within the respective disciplines of narrative exhibition design, tangible user interfaces and infographic design, have been identified. The design concept is made to merge the three disciplines in to one concept. The three disciplines all provides means of engaging features and many of the design principles found from the different discipline overlap. Thus, they can be joint into one overall design concept, with the possibility of assisting each other in making novel dissemination means, to facilitate engaging experiences for the museum visitors. Even though the disciplines will overlap and play together in the overall design concept they each target a different problem inherent with museum dissemination, as described in the introduction, and will thus serve different purposes in the overall design:

Narrative exhibition design

The purpose of narrative exhibition design with focus on narrative construction is to organize exhibition information and stories into a narrative about the exhibits in the exhibition, creating internal links between the exhibits to create meaningful and more personable experiences for the visitors.

Tangible user interfaces

The purpose of designing tangible user interfaces is to facilitate physical interaction and active user involvement and to bridge the gap between the digital and physical world to make a more sensory and authentic experience for the visitors.

Infographics

The purpose of infographic design is to create and disseminate easy comprehendible and obtainable information so to reduce information overload and museum fatigue for the museum visitors.

2.4.1 General design considerations

Although the different research disciplines target different purposes, a common goal is found within all of them, namely the goal to create engaging experiences for the museum visitors. This brings me to the first part of the design concept, the design should be *user centered* to keep the visitor in mind and the designer should strive to always think of the design from the user perspective. Throughout the research review it was also evident that one of the first and foremost design principles shared by all of the three disciplines are *goal* considerations. In all of the research disciplines emphasis is put on the influence of goal and intent on the design choices. The designer should always think as to serve the goal and intent of the given exhibition in the best possible way. The last general consideration is defined as *context* dependence, which means that the design will always be context dependent. Considerations of the given exhibition with its accompanying exhibits and exhibit information should thus be the focal point of all of the design choices, which will be closely related to the second general design consideration of goal.

2.4.2 Individual Design Considerations:

In addition to the general design considerations, the research review also provided a list of design principles inherent to the respective disciplines, narrative exhibition design, tangible user interfaces and infographic design. These different parts of the design concept will be presented in the following section as an integrated part of the design concept.

Part 1 - Narrative Exhibition Design

The narrative exhibition design part of the design concept is formed based on the above mentioned focus to create narrative linking between the museum exhibits in order to create more meaningful experiences for the visitors. These design requirements will of cause be informed by the general

design considerations mentioned in the previous section. The design considerations concerning narrative exhibition design have been summarized in to the following design requirements:

- **Object- or concept-oriented**

  The first narrative design consideration is the exhibitions orientation. Is it more object or concept-oriented? If it is object oriented the focus on the design should be on the objects / exhibits themselves without much considerations to the rest of the exhibition: If the exhibition is more concept oriented the design focus should be more on general concepts of the exhibition and less on the individual exhibits.

- **Big or Small narratives**

  The next thing to consider has to do with narrative construction in the exhibition. The designer should decide whether the design should target a big or small narrative. The big narratives operate on a larger scale often considering the whole exhibition and all the exhibits, whereas the small narrative involves a smaller part of the exhibition with only a few exhibits.

- **Composition**

  When considering exhibition design the visual appearance of the design is important to create a harmonic exhibition composition, universal visual elements should be considered such as color, balance, texture, line and shape.

- **Human factors**

  When designing exhibitions human factors should be accounted for in the design. Factors such as size, movement, perception abilities, viewing height, personal space, sitting and leaning behavior are important to note when designing physical exhibitions to accommodate humans.

- **Narrative construction**

In order to make narrative links in the given exhibition the Storyspace framework reviewed in section 2.1.1. serves as the base for designing narrative construction in the exhibition:

- **Information Layers**

  Gather all the information from the exhibition and divide it in to different layers, *story layer, plot layer, narrative layer* and *heritage object layer* (for the sake of this thesis this layer is denoted the *exhibit layer*).

- **Curatorial story**

  Gather relevant stories and events that relates to each other, this is selected form the information layers. Facets can be defined to describe important properties of the story e.g. time, location and themes. Identify plots from the events.

- **Plot employment**

  The plots found from the curatorial story are divided into plot descriptions which specifies relationships between the events of the story. There are three possible plot types - *influenced-by, reacted-against, related to.*

- **Narrative organization**

  The narrative is organized and outputted as an ordered set of story events with relations to the chosen exhibits. The organization of events can be ordered in three ways:

  - **Facet** – the facets are ordered according to importance e.g. time then location then theme. The coherent output are manipulated by the ordering of the facets.

  - **Plot** – ordering by plot provides a specific interpretation of events. There are three ways to order by plot - *plot description, plot elements, plot type.* Ordering by description means that the events are ordered by their inclusion in the plot description, this minimizes narrative tension. Ordering by plot

elements maximize tension by leaving the plot description unresolved for as long as possible. By ordering by plot type the curator chooses which plot type to show first, e.g. *related-to* first and then *influenced-by*. This controls the tension.

- **Plot & Facet** – ordering by both plot and facet lets the overarching plot of the exhibition being ordered by facet first and then by plot structures afterwards.

Part 2 - Tangible User Interfaces

As mentioned above the purpose of the TUI design is to create physical interaction and material sensation for the museum visitors, in order to bridge the gap between the physical and digital world of the museum. The design considerations found from the research review forms the TUI design principles as the second part of the design concept:

- **Inviting**
  The interface must catch the attention of the visitors and invite them to interact.

- **Apprehendable**
  It should be easy to understand how to use the interface. This can also be described as immediate apprehendability, meaning that people with no prior knowledge of the interface should immediately understand the purpose, scope and properties of it.

- **Engaging**
  The interface should strive to hold the visitors' attention throughout the whole exploration process.

- **Supportive of Group Interaction**
  Museums are usually visited by groups and as such the interface should facilitate group interaction with both active and passive visitors.

- **Inexpensive and reliable**

  Very often museums do not have many recourses, thus keeping the development and maintenance cost low is a priority.

- **The Isomorph Effect**

  The tradeoff between the robustness and sturdiness of the interface and the distance from the digital response to the physical manipulation should be carefully considered.

- **Material Experiences**

  The creation of material experiences is an important part of creating tangible interfaces, as both aesthetic, emotion and meanings are contributed to the material design.

  - **Material Aesthetics**

    Humans prefer objects that are both maximally novel while being as familiar as possible, and as such this should be considered in the design and can be achieved by using a well-known shape, but with the adaption of a new material to that shape. However, what is regarded as novel depends on a person's previous experience with a given product or material, the context should therefore also be taken into account in the design decision.

  - **Emotions of Materials**

    Materials can also evoke emotions. People can be fascinated by the strength of a material or be disappointed about a material surface that scratch easily. When a material lives up to or extends our belief about a material it evokes positive feelings which should be strived for in the design.

  - **Material Meanings**

    When deciding which material to use, the designer should consider the universal and learned meanings of materials. For instance, wood are generally considered to be warm and soft materials, which are considered organic, while stone are

considered to be cold, and heavy materials are considered to be expensive. The material meaning is also context dependent and follows the learned meanings of the material, which means that if a material is frequently used in a given context the meaning of the material is colored by that context.

Part 3 - Infographic Design

The purpose of the third part of the design concept, the infographic design, is to disseminate easy obtainable information to the museum visitors and to reduce museum fatigue. Like the TUI design and narrative design considerations, the infographic design choices are also determined by the overall goal and intend of the given exhibition which will also inform the choice of infographic genre and structure choices mentioned in this section. The research review of infographics did however also present a set of design principles that should always be considered in infographic design. These are presented below:

- **Appeal**

  Appeal is described as the element which should communicate engaging factors to attract an audience voluntary. This can be archived through iconography, illustrative metaphors or decorative framing mechanisms. Visual metaphors for instance can contain information as a framing mechanism that is indicative of a subject matter that relates to the visitor.

- **Comprehension**

  The element to communicate and provide knowledge effectively which can facilitate an clear understanding of the presented information. This can be created with symbols and iconography. These elements depend on cultural context, as viewers must have a universal understanding of the ions and symbols used to be effective. If this is obtained these elements can provide great communication shortcuts by using visual elements instead of verbal explanation. To facilitate comprehension, the right use of preattentive attributes, such as pattern or color change in a composition can also assist a faster absorption of information and thus a better comprehension.

- **Retention**

Infographics help viewers retain information as graphics have the ability to extend the reach of our memory systems. For instance, by using decorative framing that appeal to your target audience lets them connect with your infographic on an emotional level, sparking a deeper interest and retention of the information.

- **Genre consideration**

  Genre choices are of course dependent on the goal and intend of the exhibition and the given narrative in mind, as presented in the research review the different genres are *Magazine style, Annotated chart, partitioned poster, flow chart, comic strip, slide show* and *film/video/animation*. The different genres are all good for different purposes and the choice depends again of the goal and intend of the specific exhibition. In accordance to these genres there are different structures which can be used to present the given narrative. These are based on the wish for more author- or reader- driven interactions, and deals with the messaging and interaction structure of the infographic content:

  - **The Martini glass**

    The Martini glass structure starts with the *author-driven* narrative followed by the *reader-driven* interactions. In this way it presents the themes and outline the narrative, suggesting the type of information the at reader might explore on his own.

  - **The Interactive slideshow**

    The Interactive Slideshow structure follows a typical slideshow form. It differs from a normal slideshow by incorporating interaction mid-narrative within each slide. This structure allows the user to explore the particular points in the presentation before moving on to the next stage in the story.

  - **The Drill down story**

    The drill-down structure starts by presenting a general theme and then allows the user to choose among the particular parts of story or information to reveal additional details and back stories

The design concept incorporates both the general design considerations and all of the individual design principles mentioned above. The concept can be further divided into two levels of design, a *macro* level represented by the narrative construction and a *micro* level represented by the infographic and TUI design. On the macro level, the narrative structure created by the narrative construction forms the base of the design and contains the overall links between different exhibits and their respecting part of information and contribution to the overall narrative.

On the *micro* level, the infographics and tangible user interface design operates within the constraints of the narrative structure created by the narrative construction. The design of the tangible interface and infographic content depends heavily on the narrative structure and individual stories and information connected with the different exhibits. Thus the execution of the design will vary a lot form exhibition to exhibition, however the design considerations will be the same and provide a flexible mean to customizing the narrative dissemination to different exhibitions. An illustration of the design concept can be seen on Figure 14.

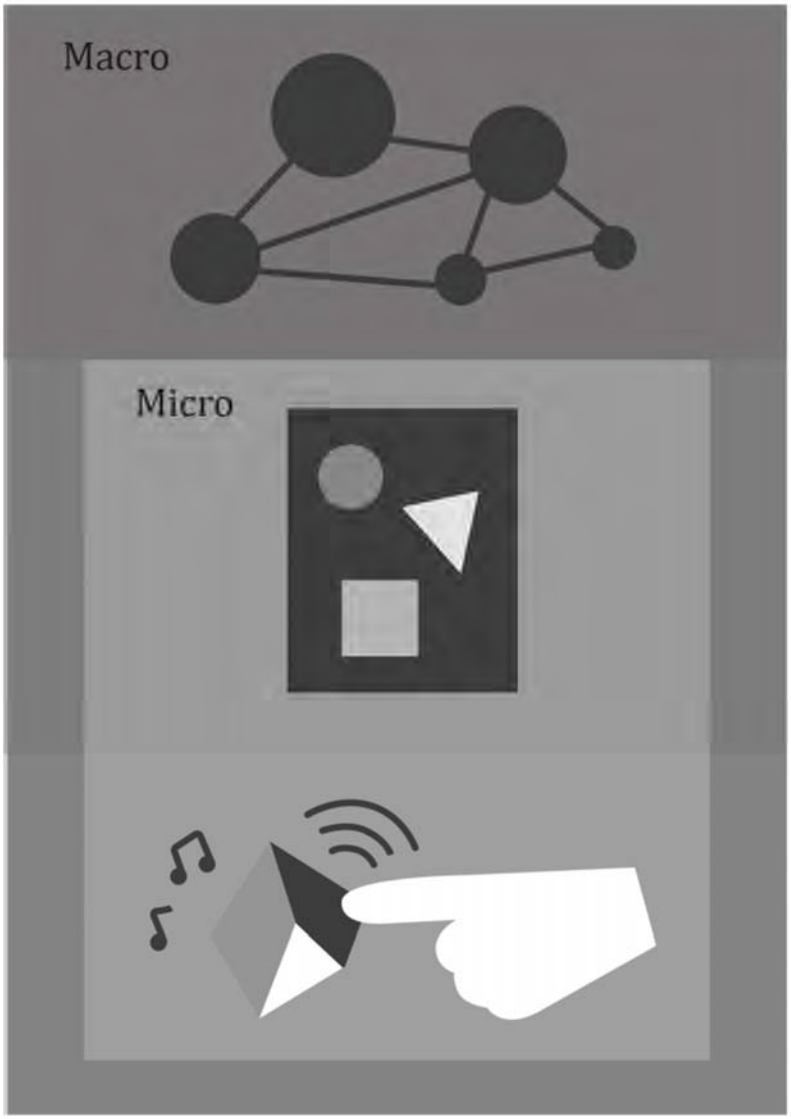


Figure 14: Illustration of the design concept.

Chapter 3 - Case Study

A case study was founded for this project to provide a real world setting for an evaluation of the design concept and the development of a novel interface prototype based on the concept. The case study was based

on the Danish Storm P. Museum's permanent exhibition. The Storm P. Museum is an independent, state supported museum without support association. The museum is responsible for the dissemination of the artist Storm P.s work, his life and the Danish tradition of humor and satire within the art. It is placed in Copenhagen with address in an old police building at the entrance of Frederiksberg have. The small museum building contains the space for both a permanent exhibition with Storm P.s work and historic artifacts from his life as well as a temporary exhibition. The temporary exhibition changes approximately every other month. The museum is a part of *Frederiksbergmuseerne*, which is a gathering of five different museums in the Frederiksberg area. In the end of 2010 the museum got a new museum director, which caused a change in the strategy for the museum. This included a new vision and mission for the museums work. In the museum´s annual report from 2010 the new mission and vision for the museum is described (Frederiksbergmuseerne, 2010):

The Vision

The museums vision is to investigate art, humor and satire and to make an impact on the public with a base in the collection and the museum.

The Mission

The museums mission is based on the museum law, to collect, register, preserve and research and disseminate humor and satire in the art through all times and together with all cultures, with the basis in Storm P.s work and genre related expressions.

The strategy

The museum strategy is concentrated on a user oriented and participatory view of the museum. The museum focuses on their responsibility area of humor and satire, through changing temporary exhibitions.

Dissemination

The museum sees it as their inherent task to expand the museums position as an art historic knowledge resource in the field of humor and satire through an open and welcoming dissemination on many different levels.

The museum does not have a specific digital strategy but since 2011 they have made different initiatives to incorporate digital technology and media as part of the museums dissemination. Some of the initiatives include the launching of a new website, the development of different apps for iPad and the incorporation of interactive installations in the museum's permanent exhibition, using both multi-touch screen technology and Augmented Reality.

Most recently the museum's exhibition has undergone a renovation. The renovation was based on the premise of striving towards a more interesting and engaging dissemination. In this process the museum chose to focus on digitalization as a mean to make the dissemination more interesting. An example is the incorporation of augmented reality developed to be used with the IPad to make the exhibition interactive. Based on user surveys the museum found that the museum visitors wanted to know more about the biographical part of the museum, being the life of Storm P. Thus, the renovation of the exhibition also focused on the dissemination of historical information on Storm P. life and work. The new exhibition thus includes photographs of him and his life as well as a physical copy of his study. The renovation of the exhibition was inspired by the whimsical nature of storm P. and his universe and aimed at letting the design bind the physical and digital dissemination together (Frederiksbergmuseerne, 2010).

The museums profile and aims are closely connected to the aims of this thesis as the museum already focuses on user orientation and participatory experiences for the visitors. The museum also seeks to create engaging dissemination and making design that can merge the digital and physical dissemination, thus the museum is very fitting as a facilitator of the evaluation of the design concept created in this thesis.

3.1 The exhibition

In order to make an evaluation of the design concept the case study focuses on the part of the Storm P. museum´s permanent exhibition called the invention space. This part of the exhibition holds a gathering of the artist's invention drawings. The drawings depict crazy and complicated inventions

all thought up to make the days of human lives easier. The drawings a filled with humor and reflect the artists love for machines and engineering, but also a skeptic view towards the industrial progress happening in his time of living in the early 1900. Figure 15 presents an example of one of the drawings displayed in the invention exhibition space.

Figure 15: An invention for deaf people to hear the doorbell, by Storm P.

Besides a collection of invention drawings displayed on the walls, the exhibition space gives room to a physical ball track for the visitors to play with, a touch table for the visitor to look through the extensive collection of Storm P´s drawings, a magnetic wall with magnets that can be used by the visitors to create their own inventions and a sculpture made as a tribute to the artist himself. The exhibition space can be viewed in Figure 16.

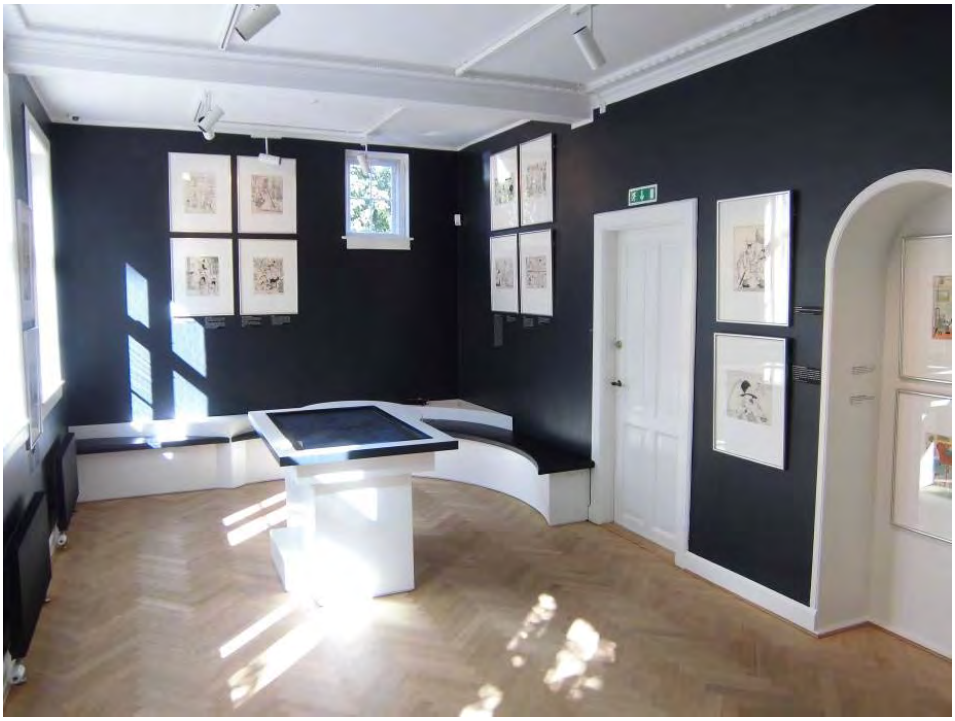


Figure 16: The invention exhibition space.

3.2 The Goal

As expressed in the design concept, the goal of the exhibition is the first consideration when planning the design. The goal, of this specific exhibition space in the Storm P. museum is formed by the museums general vision, mission and strategy. The goal is described by the museum as being to create engaging, interesting and participatory experiences for the visitors, with a focus on disseminating biographical knowledge about the life of the artist Storm P. Furthermore, the museum intent to bind the physical and digital dissemination together as part of the goal of the exhibition. These museum goals will be adopted as the goals for the design of the interface prototype presented in section 4.2 Design of the final prototype.

3.3 The visitors

User centered design is an important aspect both for the museum and as part of the design concept made for this thesis. Thus, the usual visitors of the Storm P. museum have been defined to better inform the design for this specific exhibition. The definition is based on a user survey made by the Danish agency for culture in 2014. The survey was carried out to understand who the users of the Storm P. museum are.

The survey showed that the visitors are mostly Danish (94 %). There are representatives of all age groups, and that they are fairly distributed among men and woman, men (34%) and woman (66%). Most of the visitors have a higher educational level. By the help of the Gallup (the Danish institute of analysis) compass, a tool to segment the Danish population, the Danish agency for culture defines which population segments are represented in the museum users. Looking at the different segments represented by the museum visitors, the users are mostly academics, cultural and socially engaged people. They are self-employed or salaried employees that lives in the capital area, with an overrepresentation of people in the age of 20 - 49 with families. They have academic background especially in the humanistic areas. They often work with education, leadership or in the health sector. They are generally socially and community oriented, open to the world, tolerant and humanitarian (Kulturstyrelsen, 2014).

According to the survey the motivation for the visitors to visit the Storm P. museum is mostly caused by seeking knowledge or for hunting experiences. The most of the visitors have relatively little knowledge of the topic of the museum before the visit (47 %), or they have a specific interest in a topic that they have knowledge about beforehand (45%). The knowledge seeking visitors are curious an interested in visiting the museum to gather new knowledge and inspiration. The experience hunters are motivated by the desire to find the newest and best experiences and have an attitude of “been there done that” (Kulturstyrelsen, 2014).

The visitor / user information from the survey will be used to guide the design of the interface prototype together with the understanding of the goals of the invention exhibition space. This way a context has been established for the evaluation of the design concept and an interface

prototype based on the concept. Thus, the next chapter will present the design and implementation of the interface prototype.

Chapter 4 - Design & Implementation

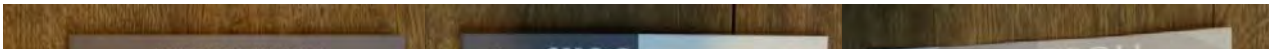
The design and implementation of the developed interface prototype is based on the above mentioned case study of the Storm P. museum. The prototype has been designed in accordance to the design concept from section 3.4 with the design considerations from the fields of narrative exhibition design, tangible user interfaces and infographics. The prototype has been designed specifically to the context of the Storm P. Museum's invention exhibition space. To investigate the different aspects of the design process, some initial design ideas and prototypes was made as a proof of concept, which will be presented in the following section.

4.1 Initial Prototypes

The initial prototypes where made based on the Storm P. museums temporary exhibition with the Norwegian artist Theodor Kittelsen. A collection of his artworks was exhibited at the Storm P. museum in January 2016. The artist is most known for his illustrations of mythical creatures from Norwegian folklore, like the creature "Nøkken" (the Nix) and the Norwegian trolls to which he gave visual form. The Theodor Kittelsen exhibition and artworks was used to investigate and experiment with initial design idea for the final prototype. Three different designs were created from this experimentation process:

First Design:

The first design was made to investigate the use of conductive ink to make an interactive physical copy of one of the artist paintings. The idea was to make a copy of one of the art works from the exhibition, that the museum visitors would actually be allowed to touch, and which at the same time could provide information about the art work. The chosen art work, depicted an illustration of the mythical creature, the Nix, from the Norwegian folklore. The copy of the art work was made interactive by applying conductive ink to the back. The ink was then connected to a micro controller to make the ink function as capacitive sensors. Sound samples, with voice recording of stories about the Nix was uploaded to the micro controller which was connected to a speaker. Interaction points was painted on the front of the art work copy, such that when one of the black



touch point was touched an audio bit was played with stories about the Nix. The prototype design can be seen on Figure 17 and Figure 18.

Figure 18: The back o

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Figure 17: The front of the prototype.

The design proved to be very successful, as the technology was simple and easy to work with. The interaction points were easy to trigger, and gave quick responses. The idea also seemed fun and intuitive, but the concept left little room for authorship and infographic design elements, as the design and visual appearance are restricted to the appearance of the copied art work. Furthermore, the design lacked tangible design elements.

Second Design

The second prototype design was made to investigate the design of tangible user interfaces. The idea for the tangible interface was inspired by Theodor Kittelsens troll illustrations and tock form as a physical troll made out of different layers of materials. The tangible interaction was made by making paper strips that could reveal underlying illustrations, in this case a sun behind the night sky is revesled when sliding a paper strip back and forth. Another feature to the tangible troll was the blinking eye, made by conductive paint connected to a battery and a LED light. A paper button was made connecting the painted circuit so that the LED would light up when the paper was pressed together, connecting the circuit. The interface prototype can be seen on Figure 19.

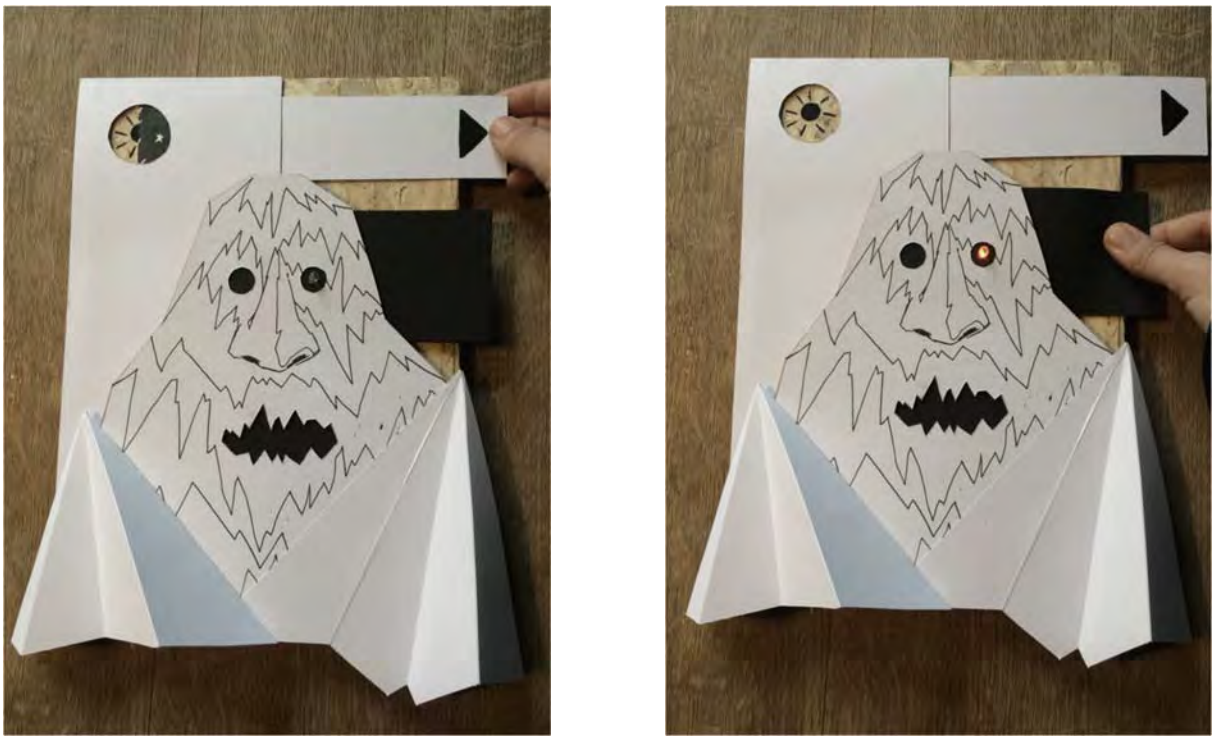

Figure 19: The sun and night sky paper slider functionality of the prototype on the left and the LED light troll eye on the right.

The second prototype combined the technology form the first design with tangible features and made a more sensory and engaging experience. It indeed proved to be much more sensory than the first design and the tangible elements defiantly made the interface more engaging. However, this design lacked the element of narrative, as it did not incorporate any direct elements of information dissemination or storytelling.

Third Design

The last prototype design was developed as an investigation of how infographic design can disseminate information and stories supported by graphical elements. The different designs all display different trolls, the *wasstroll, skogtroll*, and *bergtroll* (water, forest and mountain troll) based on three of Theodor Kittelsens troll illustrations. The graphic is accompanied with small text bits and a timeline is displayed in the bottom of every design to show the year that the different illustrations were made respective to each other. The three infographics can be seen on Figure 20.

Figure 20: The three infographic trolls from the third prototype design.

The last prototype design gave an idea of how the infographic design of the final interface could look like. By using the real art works as reference the infographics would relate to the art works visually and create a connection to the information disseminated by the infographic content. Adding tangible interaction to the infographic content would also allow for the use of sound to assist the dissemination instead of text. For longer stories about the exhibits, audio is a good way of disseminating. Instead of having to move attention to read a large block of text, or seeing a video the visitor can observe the exhibit while listening to the story.

The investigation and initial prototype development showed potential in all of the designs and when combining, the design incorporate all of the elements required by the design concept. Thus, the design investigation and the initial interface prototypes have informed the direction of the design of the final prototype.

4.2 Design of the final prototype

The design of the final prototype was based on the design concept from section 3.4 to make a novel tangible interface prototype that would be able to facilitate narrative museum dissemination in form of easy digestible information. This section explains the specific design choices made for the final prototype.

Having already established an understanding of the Storm P. museums visitors and the goal for the invention exhibition, information about the content of the exhibition and its exhibits where gathered. The purpose was to find possible stories and exhibits, that could be used as the material for the construction of a narrative in the exhibition, which linked some of the exhibits in one joint narrative. Through the information gathering many interesting stories and themes used in the work and life of Storm P. was found. However, in this case as the "curator" I found the stories surrounding Storm P.s friendship with the Danish journalist and race car driver Alfred Nervø and their common endeavor out in the art of building airplanes, to contain the most compelling stories. Thus these stories became the material from which the narrative for the for the final prototype, was constructed. The narrative got the assigned headline *"Flyvervennen" ("The flying friend").* All the events, stories, pictures and exhibits made by Storm P. related to the theme was gathered as material for the narrative construction. Based on the narrative construction framework form the design concept the narrative for the final prototype was made. The prototype was then build based on the concept of tangible user interfaces and infographic content. The design and implementation is described in the following sections.

4.2.1 Narrative construction – Macro

The narrative construction is placed on the macro level of the design concept, and as such it is the first design to consider. The theme of the narrative was found from the events surrounding Storm P. and his friend Alfred Nervø, a journalist and race car driver with whom Storm P. experimented with the art of flying in the years around 1910. From the narrative construction template presented in the design concept the narrative was formed and created to make narrative linking between three of the exhibits in the invention exhibition space. The themes surrounding the events are *technique,*

inventions, imagination, fascination of machines, ambivalence and *scepticism towards the industrial process.*

The narrative design is more *concept-oriented* than *object-oriented* as the focus is on disseminating biographical content, the exhibits (objects) are thus the mean to facilitate the different parts of the narrative. The design focus more on the general concepts and themes displayed in the exhibition space than the exhibits themselves. This specific narrative is centered around a *small* narrative involving only a smaller part of the exhibition with three exhibits. The *small* narrative is however already placed in a *bigger* narrative, which is already present in the museum, the *bigger* narrative is of cause the artist Storm P. himself. The design of the final prototype will however only be concentrated on the *small* narrative in the invention exhibition space to exemplify the design concept. The design principles of *composition* and *human factors* are accounted for in the implementation of the prototype in section 4.3.3 Implementation in the exhibition.

Narrative construction

The narrative construction of "*the flying friend*" narrative was created using the Storyspace framework as presented in the design concept in section 3.4. As described above information material was gathered from the exhibition and divide into different layers, *story layer, plot layer, narrative layer* and *heritage object layer*, to get an overview of all the information and material related to the narrative. Relevant and important events which had a relation to each other was identified**.** Plots where found and divided into plot descriptions which specified relationships between the events.

Narrative organization

The narrative was organized according to plot elements, leaving the plot description unresolved for some time, building tension and resolving it in the end. This way it would follow a dramatic arc and bring more drama into the narrative. The narrative uses an *influenced-by* plot type by first presenting an influencing-event and then presenting the influenced-event, but the related exhibits follows the *related-to* plot type and are related to the narrative events by thematic themes. The story events and plot descriptions are described below:

1. Event:

The Danish pilot Jacob Ellehammer had his first test flight in august 28 in year 1906 at the Danish island Lindholm.

2. Event:

The Danish journalist and race car driver Alfred Nervø & Storm P. experimented with the art of flying in the summer in year 1910, at Kløvermarken near Copenhagen.

3. Event:

Alfred Nervø was the first person to fly over the city of Copenhagen on the third of June, year 1910.

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1. Plot:

Storm P´s good friend Alfred Nervø attended the Danish pilot Jacob Ellehammers first test flight the 28 of august year 1906 and became interested in the art of flying. It was the beginning of an insane idea that Storm P. and Nervø had about Nervø being the first human to fly over Copenhagen's towers and rooftops.

2. Plot:

Storm P. and Nervø then experimented with the art of flying in the summer of 1910. They worked in secrecy in the fields of Amager called *Kløvermarken* to finish building Nervø´s airplane *Wampa*. Storm P. and Nervø went around the city in all secrecy to note where there were towers and chimneys that could be in the way for the flight. The airplane was ready to fly.

3. Plot:

The third of June on a quiet summer night one could hear a sound over the sky of Copenhagen. It was the sound of the airplane Wampa with Nervø behind the wheel. They circled quietly around the town hall and out on the fields of Amager again.

The chosen Exhibits

The chosen exhibits from the invention exhibition where picked according to if they would fit to the concept and theme of the narrative, and the plot descriptions. The chosen exhibits are described below with their respective narrative plots.

Exhibit 1:

The first exhibit chosen is the drawing of a scientist going to mars in a crazy machine. The exhibit can be seen on Figure 21. The text displayed with the exhibit says:

"I 1929 med teksten AMERICAN NEWS. Et Telegram fra Amerika beretter, at en amerikansk Videnskabsmand er ved at konstruere en Maskine, der skal kunne sejls til Mars på Æterbølger – han paastaa, at han vil vende tilbage lige saa let, som han rejste ud – vi tror nu, det gaar meget lettere. (B.T, april 1929)" / "In the 1929 with the text AMARICAN NEWS. A Telegram from America tells about an American scientist who have constructed a machine, that should be able to sail to Mars on ether waves – he claims, that he will return just as easy as when he left – but we think the it´s goanna be a much easier travel"

The first plot description was related to this exhibit and the narrative was formulated in this manner:

”I begyndelsen af 1900-tallet forsøgte flere mennesker over hele verden at lave flyvemaskiner. Den ene maskine var mere ejendommelig end den anden. Nogle af flyvemaskinerne så tossede ud, og de var ikke langt fra at ligne Storm P.’s skøre opfindelser.” / ”In the beginning of the 1900 humans around the world started to build airplanes. One machine would be more crazy than the other. Some of the airplanes looked ridiculous and was not fare from looking like Storm P. crazy inventions.”

”I Amerika fantaserede man enda om at flvye til mars i en maskine.” / ”In America they even fantasized about flying to Mars in a machine.”

”Storm P´s gode ven jounalisten og racerkøren Alfred Nervø overværede den danske pilot Jacob Ellehammers først forsøg på at flyve i en maskine den 28 august 1906 og fik på den måde vagt sin interesse for flyvekunsten.” / ”Storm P.´s good friend the journalist and race car driver Alfred Nervø attended the Danish pilot Jacob Ellehammers first attempt to fly in an airplane, the 28th of August 1906 and this sparked his interest for the art of flying.”

”Storm p og Nervø delt den store fascinationen for teknik og nye opfindelser, og det blev starten på den vanvittig ide om at Nervø skulle være den først til at flyve over Københavns tårne og tage.” / ”Storm P. and Nervø shared the fascination of engineering and new inventions. This became the start of an insane idea about Nervø being the first human to fly over the towers and rooftops of Copenhagen.”

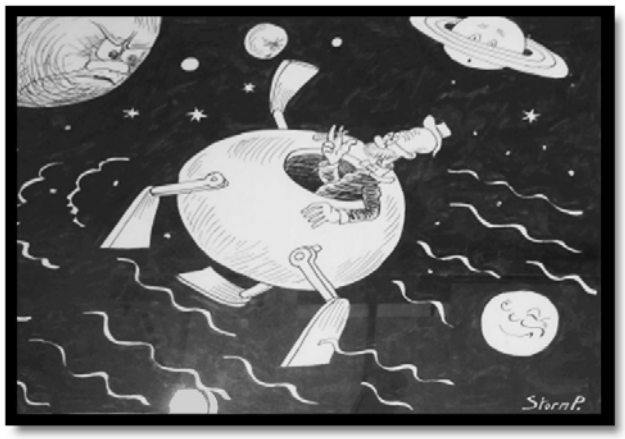

Figure 21: Exhibit no 1.

Exhibit 2:

The second exhibit is a drawing about the possibility to exploit the wind power of the country. The exhibit can be seen on Figure 22 . The accompanying text says:

"Man burde udnytte Vindkraften her til lands hvor det blæseer saa meget – genske vidst løber man den Risiko at Vinden vender sig. (B.T, maj 1940)". / "The wind power should be exploited in this contry where it is so windy – but you do ofcause take the risk that the wind might change direction."

The associated narrative is related to the second plot description and is formulated in this manner:

"Storm P og Alfred Nervø experimenterede i sommeren 1910 med flyvekunsten, hvor de med hemmelighedsfulde miner arbejde på Nervøs fly "Wampa" ude på Amagers kløvermark." / "Storm P and Alfred Nervø did in the summer of 1900 experimented with the art of flying. They worked with secretive mines on Nervø´s airplane "Wampa", out in the fields of klover on Amager."

"I hemmelighed tog Nervø og storm rundt i København og noterede sig hvor der var tårne og skorstene, der kunne komme i vejen for flyveturen. Wampaen var flyve klar!"/ " Storm P. and Nervø went around the city in secret to note which towers and chimneys that might get in the way of the flight. The Wampa was ready to fly! "

"Storm P. tegnede ikke præcise arbejdstegninger af opfindelser der kunne bygges og fungere i virkeligheden. Men opfindelserne virker – i fantasien!" / "Storm P. did not draw exact work drawings of inventions that could be built and function in reality, but the inventions work – with the imagination!"

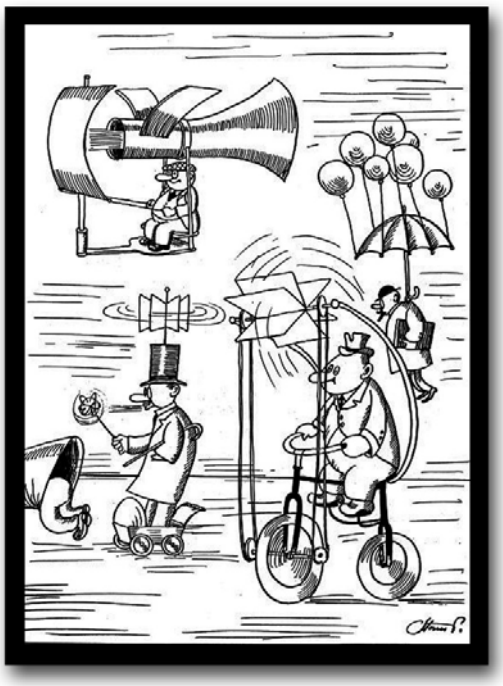

Figure 22: Exhibit no 2.

Exhibit 3:

The third exhibit chosen is a drawing of the makings of some very special bicycles. The exhibit can be seen on Figure 23. The exhibit has the accompanying text:

"Den nederste cykel her vi fremstillet efter opfordring af den franske komponist August Node – udtalt Nod´de – der ønsker at færdes så ubemærket som muligt. Resultatet blev desværre, at Monsieur Node blev den mest omtalte mand i Paris" / *"The bicycle in the buttom have been made by request of the franch music composer August Node, called Nod'de – as he which to travel with out notice. The resualt was unfortunately that Monsieur Node becane the most mentioned man in Paris."*

The associated narrative is related to the third plot description and is formulated like this:

" Den 3 juni 1910 kunne man på en stille sommeraften høre en summen på himlen over København, det var lyden af flyveren Wampa med Alfred Nervø bag roret. De kredsede roligt

rundt omkring rådhustårnet og ud til amagers kløvermark igen. Alfred var således den første til at flyver ind over København". "The 3th of June 1910, one could hear a sound over the sky of Copenhagen. It was teh sound of the aiplane Wampa with Alfred Nervø behind the wheel. They circled quietly around the town hall and back out on the fields of Amager. Alfred was hereby the first human to fly over the sky of Copenhagen. "

"Begivenheden gav genlyd i hele landet og verden - Ligesom monsieur Node blev Nervø den mest omtalte mand i Danmark, Paris og resten af verden"/ " The event resonated in the whole contry and the world – just like monsieur Node, Nervø became the most mentiond man in Denmaark, Paris and the rest of the world."

"Storm P. var begejstret for den nye videnskab og teknik, men han gjorde også grin med udviklingen og satte spørgsmålstegn ved, om alt nyt kun var godt. Var alle de nye opfindelser nu også med til at gøre livet lettere for mennesket? Kunne de larmende og forurenende maskiner til tider egentlig ikke gøre livet mere besværligt?"/ "Storm P. was excited about the new technology and science, but he did also make fun of the evolution. He questioned if the technological progress was only for the better. Did all of the new inventions make the life easier for humans? Or could the noisy and polluting machines sometimes also make the life more difficult?"

Figure 23: Exhibit no 3.

4.2.2 Infographic & TUI design – Micro

On the micro level of the design concept the infographic and TUI design is placed. The design choices on this level is affected by the narrative construction on the macro level and the design choices made in this section thus always refers back to the narrative construction.

Infographic Design

The infographic design was made to disseminate the content of the narrative constructed in the previous section. The narrative and theme of the narrative have great influence on the infographic design and was considered all the way through the infographic design process. The design was made based on the principle from the design concept in section 2.4 Conclusion & design concept. Thus, the elements of *appeal, comprehension* and *retention* where accounted for in the design by using visual metaphors, Symbols, Iconography and decorative framing.

The genre of the infographic design for this specific narrative fits best into *the petitioned poster* genre with a lose structure to the visual elements. In addition, messaging and interaction was applied following *the martini glass* structure with an *interactive slideshow* structure inside it, meaning that the narrative is first presented to the visitor, who are then able to freely interact within the presented narrative. As the narrative is divided into three events with respective plots, there are three different infographic designs, one for each event related to the respective exhibits. The first design and the infographic design choices made are described in the following section as an example of the design process inherent with all of the three infographic designs.

Figure 24. The first infographic design related to the first event and plot description.

The infographic described in this section was designed to disseminate the narrative coherent with the first plot description. The design makes use of *iconography* like the *light bulb* and the *world* icons which can be seen on Figure 24. The light bulb is used to express that Nervø has an "idea", he is enlightened. The world icon is used to illustrate that the building of airplanes in the time of 1900 was happening all around the world.

To link the content visually to the exhibit connected to the plot description, some of the figures on the infographic resembles the figures from the related exhibit. This infographic design relates to exhibit no 1. with the crazy scientist, and therefore have an illustration of the figure form the exhibited drawing in the infographic design. See Figure 25.

Figure 25: To the left, the infographic design of the scientist, to the right the original figure from the exhibit.

The corresponding text in the infographic design is included to help quick *comprehension.* Text can be of great use in infographic design to present general themes and the most important characters and concepts, like in this case the theme "*Flyvekunsten*" *(the art of flying)* and the character of *Alfred Nervø*. Text have been used in this infographic to make the visitors able to get a quick understanding of the overall themes and the general facts, like important dates and years which should also assist the visitor's *retention.*

The illustrations of the infographic elements are made from reference photos of the characters and figures of the narrative, like Nervø and the airplane illustration in the infographic resembles old photos from their time. This is done to make the design more realistic and authentic.

The visual style of the infographic is created to make it compelling to the viewers eyes and to make a coherent visual language throughout the three different infographics. The colors are kept simple and with only one color contrast of red / orange to catch attention as a *preattentive attribute*. Decorative framing has also been used throughout the design to make it more *appealing* to the visitors.

Interaction and messaging

The visual stippled lines in the infographic design are made to suggest an order in which the user should interact with the interface. The structure of the narrative in the infographic is laid out to have a natural order illustrated by the stippled lines with the figures on the line functioning as interaction points. The narrative story bits from the constructed narrative is however constructed to make perfect sense, no matter the order of interaction. Each story bit contributes information to enrich the narrative and the dramatic structure is increased by the number of story bit being heard by the visitor. The interactive pointes are designed illustratively as the most dominant figures in the infographic, in this case the two *flying machine figures* in the night sky, the *airplane* and the character of *Alfred Nervø*.

As this infographic design is developed as an incorporated into a tangible user interface design, the infographic dissemination of the content was designed to be assisted by sound bites which display voice recordings narrative story, the recordings disseminate the narrative story bits from the three plot descriptions presented in section 4.2.1 Narrative construction – Macro. Because of this, the infographic design leave room for the sound and doesn't display the whole narrative as visual content. The infographic design thus plays the role of presenting the narrative and attracting the visitor's attention, assisting a quick comprehension and retention of the narrative by the infographic design elements mentioned above. Furthermore, the design helps links the narrative to the exhibits by visual cues. Below is an illustration of the final three infographic designs, see Figure 26.

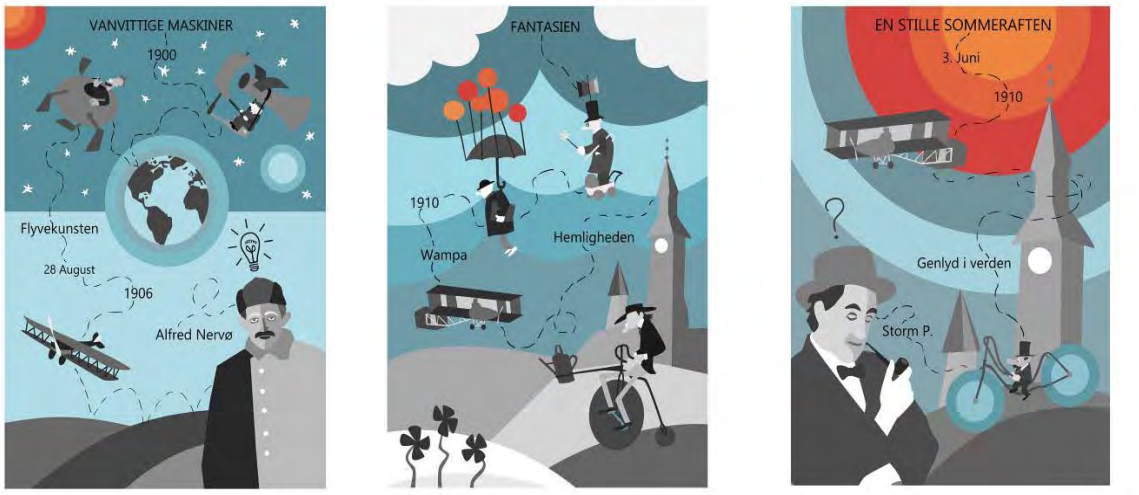

Figure 26: All three of the infographics design.

Tangible user interfaces

The tangible user interface design, as explained above, is overlapping with the infographic design as they assist each other in facilitating the constructed narrative. Especially when designing for the interaction, the two disciplines merge together. Thus the TUI design principles from the design concept are also overlapping with the infographic design.

Inviting

For instance, in the requirement to establish an *inviting* interface that will attract attention, the infographic design assist in meeting this requirement by creating *appeal*. The TUI design however also contribute in invite the visitors to interact by making the physical design stand out. In this case the interface relay on the physical form and especially materials used in the design to attract the visitor and encourage them to interact.

Apprehendable

The apprehendability of the interface are also assisted by the infographics, using the stippled lines and placing the interaction points in a logical reading order. The physical appearance of the interface is designed to have the interaction points on another level form the background to make them stand out as the points to touch, to make the interaction as strait forward as possible for the visitors.

Engaging

All of the design choices are made to contribute to an engaging experience that should be able to hold the visitor's attention throughout the whole exploration process. The infographic design should make the information easy digestible so that the visitor does not become overpowered by information. The tangible interaction contributes to the a more sensual and authentic experience, but the narrative construction is the main facilitator of keeping the visitor's attention, the dramatic structure is the main precursor of driving the visitor to keep exploring and interacting.

Supportive of group interaction

Group interaction are facilitated in the interface by allowing the visitor to listen to the narrative together, and take turns interacting with the interface, which let them participate as both passive and active part of the experience.

Inexpensive and reliable

The maintenance and low cost is achieved by using cheap and easy to handle technology and materials. The technology used for the interface will be described in section 5.3. In the choice of material and physical form of the interface the *isomorph effect* has also been considered. As this thesis only present a prototype, more weight has been put towards creating a low distance from the digital response to the physical manipulation to secure a smooth interaction for the user. The reason being that robustness and sturdiness can always be improved in later development.

Material

The choice of material is an important part of the tangible interface design, as it creates the sensuous experience for the visitor. Both the feel, the look and form of the materials contribute to the experience. Furthermore, the material should connect *aesthetically, emotionally* and *meaningfully* to the narrative and the infographic content.

Aesthetically the materials present the known form from text panels in the museum exhibition, as it is designed to resemble a square canvas placed beside the corresponding exhibits. The novel element is presented by the use of different textures and materials to make the infographic content physical. This should create an aesthetically pleasing construct, with a known shape but the use of new materials in the museum context.

Emotionally the materials are designed to live up to the beliefs about it. If the materials look soft, it is also soft to touch. This way the interface should evoke positive feeling when touched.

In the design process of choosing the right materials for the tangible physical appearance of the interface, universal and learn meaning have been considered. The main materials chosen for the interface was cork, paper and cardboard both because these materials are generally considered to be warm and inviting and because they are also relatively soft materials which make them seem more natural and organic. The choice of material should insinuate some life into the story figures and characters of the infographic content. The choices were also made based on the leaned meaning of the museum setting. The use of cardboard panels and displays are common in an exhibition setting and thus well knows to the visitors. Another reason is that the exhibits in the invention exhibition space are all paper drawing, the use of paper then relates to the materials used in the exhibits by the artist. To make the interface visually interesting the materials chosen have different textures, thickness and are placed in different layers to give some depth to the interface and separate the interactive points from the background. The design of the tangible interface with the integrated infographic content can be seen on Figure 27.

Figure 27: The tangible user interface with the infographic content.

4.3 Implementation

This chapter presents the design of the physical construction of the final prototype and technical implementation of the technology made for the functionality of the interface. Furthermore, it presents the implementation of the prototype in the chosen exhibition at the Storm P. museum.

4.3.1 Physical construction

The physical design of the interface was made using the materials chosen thorough the design process. A hard cardboard box was used as the base of the interface to hide the technology inside

it. The infographic design was then made into a physical design using the different material of paper, cardboard, cork and fabric cut out into the different shapes and figures. Inside the cardboard box two small speaker was put in each side of the bottom. The speakers where connected to the bare conductive Touch Board which was placed inside the box as well. Conductive ink was used to paint capacitive sensor points on the inside of the box corresponding to the physical interaction points made on the front of the interface. The sensors were then connected to the touch board by painting the conductive ink lines right unto the board pins. See Figure 28.

Figure 28: The inside of the interface with the touch board, speakers and conductive ink.

4.3.2 Functionality

The Touch board stores the functionality of the interface, when connected to the Arduino IDE the code handling the functionality can be changed and then uploaded to the board. The touch and distance detection which makes the tangible interaction possible is handled by the MPR121 touch detection library provided by bare conductive github.

Every object has capacitance, when touched the capacitance of the object changes. The MPR121 is a sensor controller incorporated in the Touch Board and functions as a capacitance detection engine. The MPR121 library exemplifies how the capacitive data is processed in the *data stream* code example. The code is used to look for changes in the capacitance of the respective object, and gives back information about when changes in the capacitance happens. The conductive ink serves as electrodes, which channels the changes in capacitance to the Touch Boards pins. This change is detected in the data stream and processed in the code. To detect touch a threshold is set to determine if the detected change in capacitance should be recognized as a touch event. The touch threshold is set to a default value of 40. Setting the threshold lower makes the sensor more likely to trigger and making the sensors function more as proximity or distance sensor. A release threshold is also set to control when the sensor is not touched anymore:

```
32 // this is the touch threshold -
33 // setting it low makes it more like a proximity trigger
34 // default value is 40 for touch
35 const int touchThreshold = 40;
36 // this is the release threshold -
37 //must ALWAYS be smaller than the touch threshold
38 // default value is 20 for touch
39 const int releaseThreshold = 20;
```

The MPR121 uses a I2C communication protocol, a 2-wire serial connection with the address 0x5C. The included *wire* library allows for communication with the I2C device. The next code

snippet shows how the data is send from the Touch Board over the I2C connection, using serial data. The code uses a switch case structure to give feedback about the connection:

```
void setup(){
  Serial.begin(baudRate);
  while(!Serial);

  // 0x5C is the MPR121 I2C address on the Bare Touch Board
  if(!MPR121.begin(0x5C)){
    Serial.println("error setting up MPR121");
    switch(MPR121.getError()){
      case NO_ERROR:
        Serial.println("no error");
        break;
      case ADDRESS_UNKNOWN:
        Serial.println("incorrect address");
        break;
      case READBACK_FAIL:
        Serial.println("readback failure");
        break;
      case OVERCURRENT_FLAG:
        Serial.println("overcurrent on REXT pin");
        break;
      case OUT_OF_RANGE:
        Serial.println("electrode out of range");
        break;
      case NOT_INITED:
        Serial.println("not initialised");
        break;
      default:
        Serial.println("unknown error");
        break;
    }
    while(1);
  }
```

The raw input from the data is then processed and identified. The raw data input runs through several for-loops and if-statements to categorize the data. The loops run though the data from the 12 pins on the Touch Board and categorize it according to touch values, touch thresholds, release thresholds, filtered values and baseline values. The touch and release status is determined by comparing the acquired capacitance data to the baseline value. The capacitance of the baseline is

tracked automatically based on the capacitance background variation. This way the baseline value is compared to the current immediate electrode data to determine if there is a touch or release event. The touch threshold and release threshold mentioned before sets the boundaries for touch and release events to eliminate jitter and noise (Semiconductor, 2013):

```
79 void loop(){
80    readRawInputs();
81 }
82
83 void readRawInputs(){
84     int i;
85
86     if(MPR121.touchStatusChanged()) MPR121.updateTouchData();
87     MPR121.updateBaselineData();
88     MPR121.updateFilteredData();
89
90
91     Serial.print("TOUCH: ");
92     for(i=0; i<13; i++){          // 13 touch values
93       Serial.print(MPR121.getTouchData(i), DEC);
94       if(i<12) Serial.print(" ");
95     }
96     Serial.println();
97
98     Serial.print("TTHS: ");
99     for(i=0; i<13; i++){          // 13 touch thresholds
100      Serial.print(touchThreshold, DEC);
101      if(i<12) Serial.print(" ");
102    }
103    Serial.println();
104
105    Serial.print("RTHS: ");
106    for(i=0; i<13; i++){          // 13 release thresholds
107      Serial.print(releaseThreshold, DEC);
108      if(i<12) Serial.print(" ");
109    }
110    Serial.println();
111
112    Serial.print("FDAT: ");
113    for(i=0; i<13; i++){          // 13 filtered values
114      Serial.print(MPR121.getFilteredData(i), DEC);
115      if(i<12) Serial.print(" ");
116    }
117    Serial.println();
118
```

```
119     Serial.print("BVAL: ");
120     for(i=0; i<13; i++){          // 13 baseline values
121       Serial.print(MPR121.getBaselineData(i), DEC);
122       if(i<12) Serial.print(" ");
123     }
124     Serial.println();
125
126     // the trigger and threshold values refer to the
127     // difference between the filtered data and the
128     // running baseline
129
130     Serial.print("DIFF: ");
131     for(i=0; i<13; i++){          // 13 value pairs
132       Serial.print(MPR121.getBaselineData(i
133       )-MPR121.getFilteredData(i), DEC);
134       if(i<12) Serial.print(" ");
135     }
136     Serial.println();
137
138 }
```

As described above the functionality is uploaded to the touch board through the Arduino IDE and the sound bites containing the recorded narrative story bits are uploaded as midi files to the Touch Board correspondent to each pin connected to the sensors. All of the three interfaces have a Touch Board and speakers inside of them so that they can be placed in different places in the exhibition.

4.3.3 Implementation in the exhibition

The final prototype was implemented in the exhibition by mounting the three interfaces on the walls with double sided tape. The interfaces were placed as close to their related exhibits as possible. The interfaces were hung with respect to the natural viewing high of adult visitors, but still in a height such that children would also be able to use the interfaces. Only one of the interfaces had to be placed at a lower height because of the limited space on the exhibition walls. All of the interfaces was then connected to power plugs to power the touch board and speakers inside the interface. In the implementation process there were some problems with getting the interactive sensor points working on one of the interfaces, but these where fixed during the evaluation.

Chapter 5 - Evaluation

This chapter presents the methodology and evaluation of the final prototype and design concept made for this thesis. The methodology is based on previous experience with evaluating interactive exhibits, as will be presented in the following section. Based on the methodology a summative evaluation protocol has been made and an evaluation conducted at the Storm P museum.

5.1 Methodology for evaluating interactive exhibits

To evaluate the final prototype and the success of the design concept, the user experience with the prototype has been evaluated. The method for making the evaluation is based on an examination of general evaluation means for evaluating interactive exhibits in the museum space. Regarding the evaluation of museum exhibits there are four different types of evaluation. The front-end evaluation which is used to gather visitor needs and requirements for the specific exhibition. Formative evaluation, which is done in the design phase to test iterations and redesigns. Remedial evaluation is preformed when the exhibit is build and done, to improve potential errors in the design and summative evaluation which is done to access the overall finished exhibits (interactive interfaces) (Bitgood, 1994). ̇From an overview of different evaluation studies primarily centered on the work of Eva Hornecker, evaluations of tangible interaction in context of the museums have been summarized by Sune Kastbjerg in his thesis *"Examining museological interaction design in practice"* (Kastbjerg, 2015). The methods highlighted from this literature are observations, interviews and timing and tracking. As these have been identified as the predominate evaluation methods they will serve as the methods of evaluation in this thesis as well.

5.1.1 Observations

Evaluation through observation can be divided in to four elements to consider.

Covert vs. overt

To which extend is the participant aware of being observed? Covert and overt observations can give different results as the user may act differently depending on how aware they are of being

observed. E.g. in a video recording session the participant should be informed that they are being filmed.

Non - Participant vs. participant

To what extend does the observer become a part of the experience being observed? There are not many observational methods that lets the observer become a part of the experience, but an example can be when an observer follows a group of visitors around discussing their interactions at the exhibition. This is generally discouraged because it can easily introduce bias.

Systematic vs. unsystematic

How structured are the observation notes? When doing observations in the museum field notes and video recordings are used as the primary mean of collecting data. When using field notes the quality of the data depends on the researcher ability to stay as objective as possible and thus requires a lot of discipline. In contemporary studies the field notes are generally made with a systematic approach. In these studies, the observer looks for occurrences of specific actions which relates to the focus of the given study.

Natural vs. controlled context

How realistic is the environment in which the observations take place? The ecology of the study is very important to produce real life observations in the given context, in this case the museum – the natural environment of the visitor, instead of lab evaluations.

Self-observations vs. observations of others

How much attention is paid to the researcher's reflexive self-observation in the data gathering? It is difficult for the researcher to stay completely objective throughout the observations. It is therefore an important task for the researcher to be reflexive about his / her own task.

Observations can also be measure quantitatively though measures of timing and tacking.

5.1.2 Timing and tracking

Timing and tracking can provide extra information of attraction power of specific exhibits in the museum space which provides very usable data about the users experience with the different exhibits. Tracking the visitors around or measuring holding power will also contribute additional quantitative data. Holding power can be used as a measure of the visitor's engagement with the exhibit. Naturally the visitor becomes more engaged and learn more when the visitor uses more time with an exhibit. The active time spend with the exhibit can thus be used as an indicator of the attractiveness of an exhibit. In the recent studies review by author Sune Kastbjerg measures of holding time have been used in a variety of studies as a measure of engagement with different exhibits, by comparing average holding time of different exhibits. The measures can also represent how deeply engaged the visitors are (Kastbjerg, 2015).

5.1.3 Interviews

Interviews are used to gather data about the visitor's own perception of the experience. These interviews can be more or less structured. A very structured interview is much like a questionnaire and a very unstructured interview is much like a regular conversation. A semi – structured interview is in between the two, and have a structured focus but the possibility to go more in-depth if the visitor says something interesting, by the use of follow up questions. Typically, an interview guide or framework is made before the actual interview. The most widely used approach is semi-structured interviews after the visitors experience with the exhibit (post – interviews). This provides an insight to the visitors self-perceived experience.

The evaluation of the above mentioned evaluation methods of interactive exhibits in a museum context presented by author Sune Kastbjerg, will form the base of the methods chosen for the evaluation of the prototype in this thesis. Summarized from the work of Kastbjerg in the most successful and widely used methods identified as naturalistic covert observations, time and tracking and follow up interviews, the author also emphasize that the summative evaluation gives the most insight to the ultimate success of the exhibit and give insight to the users experience with it. The evaluation in this thesis will thus be built from these approaches.

In order to make an evaluation specific to the context of interactive interfaces in museum exhibitions the author Sune Kastbjerg also present the measure of engagement as a success criteria of the experience. He emphasizes the author Carey Tisdal's four-dimensional construct of engagement as the best measure for interactive museum interfaces. The dimensions are physical, intellectual, social and emotional.

Physical engagement happens when the visitor interacts with the exhibit physically, it is measured by holding time and how they interact, press and stand. Intellectual engagement is the way the visitor understands the message of the interface, how they engage with their minds. Social engagement is defined by the way visitors interact with each other, talking, guiding each other in the experience and communicating about it. The last dimension is the emotional engagement, which occur both during and after the experience, it is the affect which is reflected in the visitor, positive (enjoyment), negative (frustration) (Tisdal, 2004).

Covert observations were chosen to be conducted in the evaluation for this thesis by letting the researcher blend into the crow at the museum and behave as a regular visitor. Field notes were thus being taken and noted down on a mobile phone. Using the mobile phone have the advantage of being considered as a more normal behavior of a visitor in the museum. A sign was posted outside the exhibition to let the visitors know that observation would occur and video recordings were made to support the field notes. Post interviews were conducted with the visitors about the experience with the interfaces. The questions asked in the interview was inspired by the work of Sune Kastbjerg and the protocol form the work with summative evaluation presented in the mentioned thesis, was used as a framework for the created summative protocol made for this thesis as well. The summative evaluation protocol can be seen in Appendix A - Summative Evaluation protocol and the transcribed interviews can be viewed in Appendix B - Transcribed interviews.

5.2 Set up & procedure

14 participant participated in the evaluation, which were conducted in the summer 2016, from the 18th to the 24th of July at the Storm P. Museums. The evaluation was facilitated in the Storm P. museums invention exhibition space. The evaluation ran from 10 in the morning until 16 in the afternoon. The three interface prototypes where placed in three different places on the walls as

close as possible to the connected exhibits in the invention exhibition space. A camera was placed in the window to record the participant's interaction with the interfaces, it was only possible to capture two of the of the interfaces on the recordings as they were placed fare from each other in the room. When a visitor or a group of visitor entered the exhibition space the researcher would observe them and take field notes of the visitors interaction in accordance to the protocol. When the visitor would leave the exhibition space the researcher would approach them a ask them to participate in the small interview asking the questions from the summative evaluation protocol. The researcher would record the interview with a voice recorder.

The evaluation ran smooth though out the week of evaluation, with only a few problems with the sensors of one of the interfaces, which caused it to be more difficult to ticker the sound from touching the interactive touch points, than the other two interfaces as also discussed in section 4.3.2.

Chapter 6 - Results

From the evaluation of the final interface prototype the results showed that there were mostly single participants (60%) interacting with the interface, compared to groups of visitors (40%). See Figure 29.

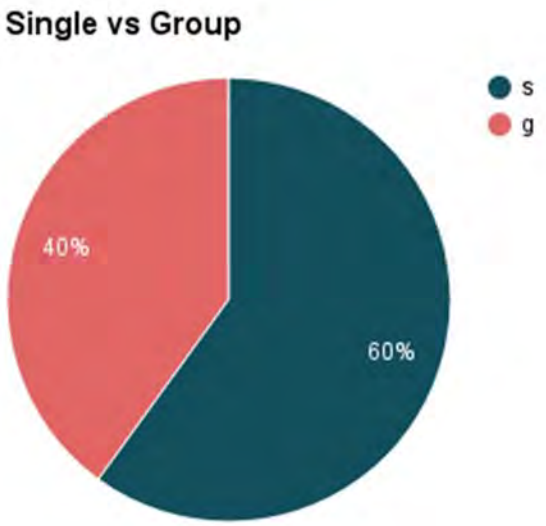

Figure 29: Single vs. group.

The summative evaluation showed that almost all observed participants had the same approach to interacting with the interface. They would stand before the interface, look at it for a short while, press a touch point, listen and press another touch point. The amount of times that the participants pressed the different touch points would wary from 1 to 9 of the touch points. In general participants listened to the whole story bit, before pressing another touch point. Some participants were confused but also curious to how the interface worked and would bang on the sides of the box with their hands in order to activate the sound.

The time it would take from when a visitor stood in front of the interface to activate the sound stories where short, in average 3.2 seconds, and the holding time of the interface was on an average 1.17 minutes with a standard deviation of 0.045.

The results from the post session interview showed that the participants initial thoughts about the interface were in general that they were curios but also a bit puzzled about the interface,

almost all of the participant stated that they immediately though that the interface where able to do something and that they were wondering how it worked. One participant said:

“ Jeg tænkte at de måtte kunne noget, så jeg trykkede på dem og der kom lyd.” / ” I tought, they must be able to do something, so then I pressed on one of them and I hear that there was sound”

Another participant said:

” Vi snakkede om hvordan de mon virkede og prøvede at regne det ud fordi vi kunne se at der gik ledninger ned fra kassen. ” / “We talked about how it worked and tried to figure it out because we would see that a wire was sticking out from it”

When asked about weather is was difficult to figure out how to use the interface the general answer was that it was not difficult. One participant said:

“ Næ, det var ret nemt faktisk. ”/ “ No it was actually fairly easy. “

Another participant said:

“Nej, det virkede meget naturligt” / “ No it seemed very natural. “

Others of the participants had more difficulty with the initial interaction, but after having interacted with one of touch point also found it easy to use the interface. A participant said:

“ Nej, når først man havde fundet ud af den ku sige noget var det nemt, det var bare som om den ene virkede bredere end den anden.” / ”No, when you first found out that the boxes could say something it was easy, it was just like one of them (the interface boxes) funcioned better than the other”.

The answers from the interview are also underlined by the shot interaction time and the video recordings which shows that people are relatively quick to interact with the interface when standing in front of it. The videos can be seen on the accompanying DVD (Master Thesis -> Evaluation Videos).

When asked to rate the interface on a scale from 1 – 10 compared to the interactive touch table placed in the same exhibition space, the average rating was a little above the middle with a rating of 6.

For the intellectual engagement questions about the information presented by the interface the participates were generally good a remembering the answer of the question about the year in which people began building airplanes, three out of five answered correctly on that answer. For the question about who was the first pilot to fly over Copenhagen only one had the right answer out of the five participants asked. For the last question about whether Storm P. was found of engineering, all of the participants answered that he was, but no one mentioned that he might have a sepsis towards the technological development. This indicated that in general the participants had a superficial knowledge of the disseminated information from the interface, but there was no sign of a deeper understanding.

Chapter 7 - Discussion

This chapter presents a discussion of the result form the evaluation and an overall assessment of the success of the developed design concept.

When looking at the results it is evident that the interface was able to draw attention and spark the participants interest as a majority of the participants interacted with the interface. This is also supported by answers from the post interview stating that most of the participant's initial thoughts of the interface were that the interface could do something and that it was easy to understand how to use it. This indicates that the interface was able to meet the requirement of appeal and apprehendability to some extent. The results from the observations showed that the participants generally interacted with the interface as indented form the design. However, some of the participants also had difficulties triggering the sound from the interface, which caused confusion and led to a quicker lose of interest and apprehendability of the interface. This might be due to errors in one of the interface boxes, where the interaction points did not respond as well as with the other interface boxes. Generally, the observation also showed that almost all of the participants did not interact with all of the three interfaces, but on average did only interact with one or two of the interface boxes. The reason to this might be because of the placement of the interfaces, as one of the interfaces was place in a much lower height level than the other interfaces and as such was not as easily available for interaction as the interface boxes placed in the right viewing height. Another factor could also be that the disseminated narrative did not spark the participants interest enough to hold their attention throughout the whole exploration process. However, the majority of participants did press more than one interaction point, and in many cases also interacted with another interface, after having interacted with one interface box. This indicates that the design of the interface was able to hold the visitor's attention though a smaller part of the exploration, this is also supported by the holding time presented in the results. The holding time indicate that the interface was not able to hold the attention of the participants as long as the touch table, it was however able to hold the attention for almost one and a half minute and as the interface is designed for quick and easy comprehendible information this should be enough for the visitors to grasp the disseminated information. The holding time also express how many of the interfaces boxes were included in the interaction of the participants as the interaction patterns showed that they would listen to the whole story bit before moving on to the next interaction point. This is also

substantiated by the results from the post interview, that express the participant's intellectual engagement which indicates that the narrative disseminated in the interface was only comprehended to a certain extend. The participants were able to answer the most of the questions on a superficial level, which indicates that the infographic content might have succeeded in presenting the overall themes and facts, but have failed in communicating the essence and more detailed meaning of the narrative. This suggest that the interface have failed in creating a more personal and meaningful experience for the visitor, but were still able to disseminate some information and knowledge about the biographical history of Storm P.

When reflecting on the result is evident that the novel interface design, displays both successful and less successful elements. The aim of this thesis was to develop a design concept as a framework for designing novel means of narrative, tangible and information light dissemination in the museum, that could create engaging experiences for the visitors. Based on the evaluation, the evaluation of the success of the design concept exhibited by the novel interface prototype is ambivalent. On one hand the visitors did engaged and interacted with the interface within a short exploration process, acquired biographical knowledge about Storm P. and where able to retain the disseminate information on a superficial level. This indicates that the concept design succeeded to some extend in guiding the novel interface design, as the final prototype facilitated both physical interaction and active user involvement. Furthermore, it indicates that the infographic design was successful in creating comprehendible and easy obtainable information. On the other hand, the evaluation also revealed that the interface was not able to hold the visitor's attention throughout the whole exploration process, which means that some of the narrative was lost and the visitor did not get the full picture, linking all of story bits and exhibits together in a joint narrative. Thus, the aim to create internal links between the exhibits were unsuccessful. This also indicates that the narrative construction did not succeed in creating a more personable and meaningful experience for the visitor.

Chapter 8 - Conclusion & Future Perspectives

Throughout the thesis the disciplines of narrative exhibition design, tangible user interfaces and infographic design have been reviewed. Deign considerations have been identified from the research review and a design concept was formed to guide the development of novel means to create tangible, narrative and information light dissemination in the museum, with the benefit of creating engaging experiences for the visitors. An interactive interface prototype was made to evaluate the design concept and a case study was conducted at the Storm P. museum to facilitate the evaluation.

It was found from the result of the evaluation that the design concept exhibited both successful and unsuccessful element. To better understand the reason for these results further exploration should be done both investigating the general design concept and the individual design disciplines individually and together. The thesis however shows promising directions for further research in all of the include research disciplines and show confidence in the direction of design showed by the developed design concept to create a new direction for creating novel mean of dissemination in the museum.

For further development the design concept should undergo a more thorough evaluation to identify the errors caused in the evaluation in this thesis. Furthermore, the design concept should be developed upon to be even more specific about the elements that make up a good design for the disciplines of infographic, tangible and narrative museum dissemination.

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Appendix A - Summative Evaluation protocol

Observe

Interaction patterns, verbal communications about the experience, utterance and emotional expressions.

Time and track

Measure holding time, from when the user starts to interact to when she/he leaves.

Measure of interaction time from when the visitor is ready to interact to, when the user has interacted successfully.

Post session interviews

Approach user, introduce yourself and your purpose, ask questions based on engagement measures.

Questions

Danish

Social Engagement

- Jeg lagde mærke til at du snakkede med X om historie kasserne på væggen inde i opfindelses rummet, hvad snakkede I om?

Physical Engagement

-Hvad gjorde og tænkte du da du så og trykkede på kasserne? Var det svært at finde ud af?

Emotionel Engagement

-I forhold til de andre skærme / installationer på museet, hvordan vil du så score historie kasserne på en skala fra 1 – 10 hvor 10 er bedst?

Intellectual Engagement

Spørg til indholdet og interfacets budskab.

- *Var Storm P. glad for teknik?*
- *Hvornår begyndte man at bygge flyvemaskiner?*
- *Hvem var den første til at flyve over København?*

English

Social Engagement

-I noticed that you were talking with X about the story boxes hanging on the wall inside the invention space. What did you talk about?

Physical Engagement

- What did you do and think when you pressed the surface of the boxes? Was it difficult to figure out how to use them?

Emotional Engagement

-In relation to the other installations at the museum, how would you rate the story boxes on a scale from 1-10 where 10 is the best rating?

Intellectual Engagement

Ask about the content and the message.

- *Was Storm P. found of engineering?*
- *Which year did humans start to build airplanes?*
- *Who was the first human to fly over the sky of Copenhagen?*

Appendix B - Transcribed interviews

Interview 1:

MØN: ” Hej, jeg hedder Maja, jeg er ved at lave mit speciale projekt her på museet så jeg ville høre om jeg ikke må stille dig et par hurtige spørgsmål om udstillingen.”

P1: ” Øhhm, okay.”

MØN: ” Tak, jeg lagde mærke til at du trykkede på kasserne inde i udstillingen. Hvad tænkte du da du så dem?”

P1: ” Jeg tænkte at de måtte kunne noget, så jeg trykkede på dem og der kom lyd.”

MØN: ” Var det svært at finde ud af hvordan det virkede?”

P1: ” Næ, det var ret nemt faktisk. ”

MØN: ” Hvis du skulle bedømme kasserne på en skala fra 1 – 10 i forhold til bordet derinde hvad for en karakter ville du så give, hvis 10 er bedst?”

P1: ” 7 tror jeg ”

MØN: ” Så har jeg lige nogle hurtige spørgsmål om Storm P. Var Storm P. glad for teknik?

P1: ” Ja, han tegnede jo alle de der opfindelser. ”

MØN: ” Hvilket årstal begyndte man at bygge flyvemaskiner? ”

P1: ” 1900 tallet tror jeg.”

MØN: ” Hvem var den første pilot der fløj over København? ”

P1: ” Det ved jeg ikke. ”

MØN: ”Okay det var det, mange tak for hjælpen. ”

Interview 2:

MØN: ” Hej, jeg hedder Maja og jeg laver mit speciale projekt her på museet, er det okay hvis jeg stiller dig et par spørgsmål? det tager ikke så lang tid. ”

P2: ” Ja, det må du da godt. ”

MØN: ” Tak, jeg kunne se at i snakkede om kasserne inde i opfindelsesrummet, hvad snakkede i om? ”

P2: ” Vi snakkede om hvordan de mon virkede og prøvede at regne det ud fordi vi kunne se at der gik ledninger ned fra kassen. ”

MØN: ” Hvad gjorde du da du så kassen? ”

P2: ” Jeg trykkede på den fordi min datter sagde at den nok ku sige noget. ”

MØN: ” Var det svært at finde ud af at bruge det? ”

P2: ” Nej, når først man havde fundet ud af den ku sige noget var det nemt, det var bare som om den ene virkede bredere end den anden. ”

MØN: ” Hvis du nu skulle rate kasserne fra 1 – 10 i forhold til bordet derinde hvad for en karakter vil du så give hvis 10 er bedst? ”

P2: ” 5 tror jeg, fordi den ene kasse ikke virkede så godt. ”

MØN: ” Så her jeg lige et par spørgsmål om Storm P. Var han glad for teknik? ”

P2: ”Ja det var han vel, han lavede jo alle mulige opfindelser og man kan se han var inspireret af teknik, med alle de skøre cykler og flyvemaskiner. ”

MØN: ”Hvornår begyndte man at lave flyvemaskiner? ”

P2: ” åhh det ved jeg ikke rigtig, måske var det 1870, deromkring. ”

MØN: ” Hvem var så den første til at flyve over København? ”

P2: ” Åh det ved jeg altså ikke. ”

MØN: ” Det er helt okay, og det var det. Tak for hjælpen. ”

P2: ” Det var så lidt. ”

Interview 3:

MØN: ” Hej, jeg hedder Maja og jeg er ved at lave mit speciale projekt her på museet. Ville det være i orden hvis jeg lige stiller dig et par spørgsmål? ”

P3: ” Ja det må du godt. ”

MØN: ” Jeg lagde mærke til at du snakkede om kasserne derinde i opfindelsesrummet. Hvad snakkede i om? ”

P3: ” Vi snakkede om hvordan de virker fordi den ene kasse ikke rigtig virkede når vi trykkede på den. ”

MØN: ” Hvad tænkte du da du så den første kasse? ”

P3: ” At man kunne trykke på den. ”

MØN: ” Hvad skete der når du gjorde det? ”

P3: ” Altså der kom sådan en fly lyd. ”

MØN: ”Var det svært at finde ud af hvordan det virkede? ”

P3: ” Ikke ved den første kasse, men nummer to virkede ikke rigtig. ”

MØN: ” Hvis du nu skulle rate kasserne i forhold til bordet derinde, på en skala fra 1 – 10 hor 10 er bedst. ”

P3: ” Altså jeg syntes det var meget sjovt at der kom lyd men det virkede ikke så godt på den anden kasse, så nok 5. ”

MØN: ” Okay, så har jeg lige nogle Storm P. spørgsmål. Var Storm P. glad for teknik tror du? ”

P3: ” Åh det ved jeg ikke, men det vil jeg tro. ”

MØN: ” Hvilket årstal begyndte man at lave flyvemaskiner? ”

P3: ” Det ved jeg ikke, pas. ”

MØN: ” Hvem var den første pilot til at flyve over København? ”

P3: ”Eiijjh, det ved jeg altså heller ikke. ”

MØN: ” Det er helt okay, men tak for din tid og nyd rasten af udstillingen. ”

P3: ” Det var så lidt. ”

Interview 4:

MØN: ” Hej, jeg hedder Maja og jeg laver mit speciale projekt her på museet, er det okay hvis jeg stiller dig et par spørgsmål om udstillingen? ”

P4: ”Ja, det kan jeg godt. ”

MØN: ” Jeg lagde mærke til at du prøvede kasserne derinde. Hvad tænkte du da du så dem? ”

P4: ”humm, jeg tænkte hvad er det for noget, men så så jeg min datter trykke på den så det prøvede jeg også, så spillede den en slags historie om Storm P. ”

MØN: ” Var det svært at finde ud af hvordan det virkede? ”

P4: ” Nej det virkede meget naturligt. ”

MØN: ” Hvis du nu skulle rate kasserne på en skala fra 1 – 10 i forhold til bordet derinde, hvad ville du så give? ”

P4: ” Det må være en 6’er, det var meget sjovt at høre noget historie på den måde. ”

MØN: ” Så har jeg lige lidt fakta spørgsmål om Storm P. Tror du at Storm P. var glad for teknik? ”

P4: ” Ja det må han have været. Der er jo så mange tegninger med opfindelser af alle mulige slags. ”

MØN: ” Hvilket årstal begyndte man at opfinde flyvemaskiner? ”

P4: ” Jeg tror det var omkring 1900 tallet. ”

MØN: ” Hvem var den første pilot til at flyve over København? ”

P4: ” Det var vist ham der, han hed noget med Alfred… Hvad var det han hed? ”

MØN: ”Alfred Nervø?”

P4: ” Ja, det var det. ”

MØN: ” Nå men det var det tak for hjælpen. ”

P4: ” Nå jamen det er i orden. ”

Interview 5:

MØN: ” Hej, jeg hedder Maja og jeg laver mit speciale projekt her på museet, ville det være okay hvis jeg stiller dig et par spørgsmål omkring udstillingen? ”

P5: ” Ja, jamen det må du da godt. ”

MØN: ” Tak, jeg lagde mærke til at du brugte kasserne inde i opfindelsesrummet. Hvad tænkte du da du så dem?”

P5: ” Ja, jeg så skiltet og så prøvede jeg at røre ved dem og hørte at der kom lyd, sådan nogle små historier. ”

MØN: ” Var det svært at bruge kasserne?”

P5: ” Nej der var det ikke, man skulle bare trykke på dem. ”

MØN: ” Hvis du skulle give dem en karakter fra 1 – 10 i forhold til bordet derinde. 10 er bedst. Hvilken karakter ville du give? ”

P5: ” 7 tror jeg. Jeg syntes det var meget sjovt at høre de små historier.

MØN: ” Så har jeg lige et par fakta spørgsmål. Tror du Storm P. var glad for teknik?”

P5: ”Ja. ”

MØN: ”Hvilket årstal begyndte man at lave flyvemaskiner? ”

P5: ”Jeg så der stod 1900 på kassen, så det må være deromkring. ”

MØN: ” Hvem var den første der fløj over København. ”

P5: ” Det ved jeg ikke desværre. ”

MØN: ” Det er helt i orden, det var også mit sidste spørgsmål, tak for din tid. ”

P5: ” Det var så lidt. ”