Exploring Physical/Digital Interaction in Exhibits at NMSI

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Authorship

This IQP was completed through the efforts of the team as a whole. Though individuals of the team wrote specific pieces of this paper, every member of the team vetted every section of the paper in the final revision.

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Abstract

Incorporating exhibits that combine physical and digital interactions to aid in object interpretation is a priority for museums, but the study of their effectiveness is still a nascent area of research. This group has designed and evaluated two iterations of a prototype exhibit for the Science Museum, London incorporating physical/digital interactions via an abstract model of a rotary phone. Using visitor observation and interviews, the group developed design principles and recommendations for the Science Museum to develop future physical/digital interactives.

Executive Summary

The purpose of this joint project with the Science Museum, London was twofold. First, to design, develop and test two iterations of a prototype exhibit combining physical and digital interactions to engage visitors with and interpret a specific object; and second, to ultimately find a set of design principles that can be applied to development of these kinds of exhibits to engage visitors and convey content about the object.

A physical interaction involves physical manipulation of an object or a model of that object to gain intuitive insight into the purpose and use of the object. Physical interactions can be very powerful tools, giving visitors a solid feel for the object and offer a level of understanding that no amount of text or labels can reproduce. Digital interactions, on the other hand, do not offer the same level of intimate knowledge that physical interactions offer. They can, however, provide a great wealth of knowledge through the use of computer screens and text. These kinds of interactions can display content dynamically in time with the interaction, so that content can be targeted to highlight certain actions during the activity.

Combining these two kinds of interactions to highlight their strengths has great potential for increased comprehension of content by visitors. A combination physical/digital interaction will be able to offer an intuitive feel and understanding for an object, as well as a wealth of information dynamically presented to highlight the current portion of the physical interaction. In this way, physical/digital exhibits can be thought of as digital interpretations of physical interactions.

The project group chose to design and develop a prototype exhibit to model an interaction with, enhance understanding of, and highlight the Strowger Desk Telephone (ca. 1905). This project would both serve as a prototype for this

particular exhibit, and to test viability of physical/digital exhibits at large. As such, there were both physical and digital aspects of the exhibit. The physical portion of the exhibit was an abstract model of the Strowger telephone, including an authentic 1970s rotary dial and a mock receiver. The intent was to model an actual interaction with the Strowger telephone and enhance understanding of the process of dialling by giving visitors an opportunity to physically use a rotary dial. The digital portion of the exhibit was a computer screen. This screen contained instructions to guide visitors through the interaction, as well as the majority of the content in the exhibit. This content highlighted the technical and mechanical aspects of dialling, as well as the importance and necessity of the existence of the rotary dial. The activity was split into two main interactions: Play mode and Call mode. In Play mode, a digital prompt instructed visitors to physically dial a digit, after which an animation played and facts about the mechanisms of the rotary dial were displayed on the screen. In Call mode, an on screen prompt instructed visitors to dial a five-digit number, and a corresponding video conveying content plays (about the mechanisms of the dial, or the importance of the dial).

To evaluate the effectiveness of the prototype exhibit, the project group developed a set of learning outcomes and evaluation goals for the exhibit, and, from these, formulated interview questions to gauge whether the exhibit was usable, and whether or not the main content messages were being conveyed effectively. The results of this first evaluation informed a second iteration of the prototype exhibit, which was again tested and evaluated in the same manner.

Through these evaluations, the prototype exhibit was found to have successes and failures, both of which very useful in highlighting the potentials of physical/digital exhibits, as well as barriers to their implementation. Physical/digital exhibits can be valuable to digitally interpret a physical interaction; the prototype exhibit proved quite able to digitally convey content and enhance understanding of a physical interaction. However, the primary barrier to the implementation of these kinds of exhibits is distraction from the actual object. It has been found that physical/digital

exhibits distract heavily from the actual object they intend to highlight and explain, and care must be taken to ensure that focus is on the object as well as the exhibit. The goal of a physical/digital exhibit is to enhance understanding of an object, and if the focus is entirely on the exhibit then this goal will not be met. This report makes recommendations for future iterations of these kinds of exhibits, but also recommends that more research be performed to determine exactly how to circumvent this barrier.

To suppress barriers to engagement with the actual object, a physical/digital exhibit should be abstract. The physical model should not be a replica of the object, but a general model that has the same properties as the object. The digital interpretation should avoid making textual references directly to the object, instead using descriptive terms when referring to the object (for example, "The first rotary telephone," or "An early automatic desk telephone," instead of directly naming the phone as "Strowger"). Also, there must be a clear delineation in the interaction between instructions and information. When presented with both simultaneously, visitors tend to follow instructions correctly, but do not remember content. Instructions and information need to be separated to ensure that visitors absorb content. Finally, the object needs to be highlighted as much as possible to ensure that the physical/digital exhibit does not distract. While the group has not conclusively determined the most effective way to direct attention to the object, this report outlines suggestions for future tests (lighting the object in the case to direct attention, or indicating on the computer screen that the visitor should look at the object, for example).

In summary, combination physical/digital exhibits have the potential to enhance understanding of an object through digital interpretation of a physical interaction, but face the primary barrier of distracting the visitor from the object. This report makes recommendations to avoid these obstacles, but suggests that more research be conducted to determine if these suggestions are indeed the best course of action.

Introduction

Over time, museums have found various ways of presenting the objects in their collections. Originally, museums presented the object as it was, thinking that the visitor could learn simply through seeing the object in a case and reading an accompanying label. In order to foster greater engagement with their objects, modern museums added physical interactions to provide the visitor with a more tangible experience. By doing this, museums found that learning through a physical interaction is more intuitive and engaging than simply reading labels, but does not provide the same depth of information. To remedy this, museums started using digital interactions to interpret their objects. This revealed that digital interactions provide a greater depth of information than physical interactions, and can dynamically present information based on the context of the current interaction. However, digital interactions do not allow the same level of intuitive understanding of the object.

Since each method of interaction has its strengths, it stands to reason that making an interaction that combines the intuitive, tangible learning of physical interaction; the depth of information and freedom of choice of digital interactions; and the authenticity of an object would be beneficial. However, this has yet to be done successfully.

The overarching purpose of this project was to work with the Science Museum in London to develop a set of design principles that can be applied to the development of future exhibits that combine physical and digital interactions to highlight a specific object. To construct this framework of design principles, this project required testing and refining of a prototype exhibit that utilizes digital interpretation of physical interaction. From evaluation of this prototype exhibit, the effectiveness of the framework could be measured. These evaluations and

conclusions were given to the Science Museum to aid in their overall development of future physical/digital exhibits.

Literature Review

The Early Museums

The original public museum was a product of life in the eighteenth century (Hein, 1998). Amongst increased global competition, various governments began building institutions for self-directed learning to better educate their citizens. These early museums were primarily intended to educate the public, but also served as a vehicle through which the government could show off its wealth (Hein, 1998). A museum would often have a new wing or gallery built each time its governing nation conquered another territory. As time progressed into the mid-nineteenth century, the public need for museums increased. During this time, governments took on more and more responsibility for the basic tenets of social development (social services, education etc.) (Hein 1998). Exhibitions in museums, for example, were often staged alongside campaigns for public health awareness, or to display new innovations in technology and science.

As many children at this time were working 10-12 hour days in factories, and any schooling beyond a few years was not yet required, museums served as a primary source of education for many people in the industrial age. There were pitfalls to this, as Hein notes:

> "All the approaches to education still used today, as well as many of the controversies surrounding them, were first introduced by pioneering staff members a century ago: didactic labels of varying length and complexity, lectures and other events for the public, special courses and programs for school groups, deliberately didactic exhibitions, and in-house and outreach programs for general and specific audiences."
>
> (Hein 1998, 4)

Nineteenth century museums quickly became torn between elitism and education, as Hein (1998) also comments. What was intended to be an educational tool for the whole of society had become a very elitist and egalitarian institution. Proponents of the argument that museums of the nineteenth century were too exclusive often cite limiting factors intended to keep out the "masses". These factors included specific dress codes, for example (Hein, 1998).

A Lack of Curriculum

Public schools became more popular in developing nations during industrialization. While museums had previously been viewed as a valid source of one's education, they became more of a supplement to public schooling as schooling became more commonplace. As more and more children enrolled, school systems quickly developed an accountability system (tests, a standard curriculum, public forums for the discussion of schools and education, etc.) to gauge the progress of both students and the school system itself (Hein, 1998). Museums, however, despite being equally public institutions, did not develop similar approaches for assessments of progress. There was no universal method for determining the effectiveness of the museum experience for a visitor, and indeed many museums still hold on to the attitude that the response of the audience is irrelevant (Hein, 1998).

The late twentieth century saw the notion of "informal education" (education lacking a rigid curriculum) in museums revisited. The methods by which education is defined have been reviewed and updated for a modern world. Hein comments that

> "Learning is now seen as an active participation of the learner with the environment. This conception of learning has elevated experience (as distinct from codified information contained in books) to a more important place in the effort to educate."

(Hein 1998, 6)

The dynamics of education are shifting as educators themselves learn more about pedagogy and developmental psychology. There has been a shift towards the cultural aspect of objects in museums, as "focus shifts from the written word to learners' active participation through interaction with objects" (Hein, 1998). Critics maintain, however, that education is about "learning facts" and that experiential learning is both detrimental and unnecessary. Regardless of the stance on the learning process, museums still exist as a forum for public self-education, and more recently as preservers of culture.

Learning in Museums

Accountability in Museums

The study of learning styles has been developing since the early twentieth century as public education became more popular in the late industrial age (Hein, 1998). While only a few years of schooling were required for young children, it set the stage for growth in the field of learning. With more and more students attending public schools, a system of accountability quickly arose. Administrators of school systems created curricula, standardized testing to gauge student's progress, and more importantly, a system to ensure that the schools themselves were performing their duties adequately. Museums did not develop this robust level of accountability (Hein, 1998). As a result, public education quickly became split between the *formal education* of schools, and the *informal education* found in museums.

Without a concrete system for accountability, education in museums deteriorated (Hein 1998). Instead of performing tests to determine what a visitor would like to learn from an exhibit, and measuring the effectiveness of the exhibit, the curators of museums would determine what information a visitor should be learning. The late 1960s, however, saw renewed interested in learning in museums (Hein, 1998), and

exhibit designers were faced with the challenge of developing exhibits that enhanced the learning experience.

Challenges of Teaching in Museums

Encouraging learning in a museum setting is difficult. A public school largely teaches formally, with a rigorously outlined curriculum, a well-defined student/teacher relationship, and an accountability system to track the progress of the education system as a whole. However, museums are unable to educate in this structured manner largely due to the nature of the museum experience. They face three major difficulties in adhering to a rigid system of education as in public schools.

First, visitors simply do not visit museums often enough to engage in a formal learning process. Hein (1998) notes that even more "advanced visitors" only visit a few times a year. This presents a major challenge to exhibit designers, who need to rely on a foundation of knowledge that already exists in some form, or they must be able to convey it in a quick and intuitive manner.

Second, visitors often take time to become acclimated to the museum experience. Just as a student's first day of school requires adjustment, a "novice" visitor will take time to understand just how to learn in a museum at all (Hein 1998, Housen 1992). It can take dozens of visits before a visitor becomes receptive to the experience. Thus, a well-developed museum exhibit must be able to cater to the majority of visitors that are novices in museum learning.

The third challenge is actually creating a stimulating, engaging experience. Hein (1998) comments that, while experiential learning is an excellent method of learning in a museum, experiences that do not challenge or stimulate a visitor may not have any educational value. Therefore, an exhibit must be more than simply

interactive; "in order to be educative, experiences must not only be 'hands-on' but also 'minds-on'" Hein (1998, 2) to be truly educational.

Evidence for Learning

How to develop an interactive, educative exhibit is an active area of research. Modern museums recognize the need for an accountability system to gauge the effectiveness of exhibits. Gammon (2003) defines learning as "adapting our mental models to accommodate new experiences and new information." With this definition, the skeleton of an accountability system begins to emerge.

As mentioned earlier, a key difficulty that museums face is exactly how to measure and analyze the learning experience. Surveys and evaluations (discussed more fully in the Evaluation Techniques section) aim to tackle this problem by targeting key areas of the experience (Gammon, 2003):

1. Did the visitor express an intense interest in the exhibit?
2. How many times did the visitor repeat the activity?
3. Did the visitor linger at the exhibit longer than the amount of time required to complete the activity (e.g. to read a label)?
4. Is the visitor able to convey the overall theme and motivation behind the exhibit?
5. Can the visitor relate this experience to his or her own life and prior knowledge?

Studying visitor responses to these questions helps to provide insight into the effectiveness of an exhibit, and to determine whether or not an activity is educative. Through research (discussed more fully in the Case Studies section), museum professionals have found that an interesting, well-organized exhibit with some form of interactivity and object interpretation will provide the best environment for learning in a museum.

Interpreting Objects

Why Have Objects in Museums?

The way in which visitors interact with and interpret objects in a gallery is crucial to the success of an exhibit. Empirical evidence shows that visitors are interested primarily in social and intellectual stimulation when visiting a museum (Teixeira, 2009). So, a successful exhibit will be "minds-on", and be stimulating enough to encourage a social interaction between the visitors observing and interacting with the exhibit.

To understand exactly how to create an effective exhibit, one must first analyze the reason visitors attend a museum in the first place. The appeal of a museum is that objects within offer a unique experience that cannot be found anywhere else. For example, an exhibit may contain an object that was the first of its kind, or the last surviving authentic artifact from an historic event. Teixeira (2009) summarizes this unique experience by suggesting five reasons for a museum visit:

1. *Resolution and density of information* – the complete details of an object lie only in the actual object itself
2. *Authenticity of objects* – museum objects are typically 'the real thing' and were once actually used by real people
3. *Scale of objects* – objects in museums are their actual scale, and often incite strong reactions or feelings when visitors note the size of an object compared with its cultural impact
4. *Value of objects* – museum objects are typically unique, and thus extremely valuable, and simply being near these objects is intriguing to visitors
5. *Nostalgia* – objects from a visitor's personal past can evoke feelings of nostalgia and memories from their life

Evidently, a person visits a museum to interact with and see an authentic, unique object. This type of interaction is summed up in the brilliant display of a burned out

Greyhound bus from the civil rights movement in the Birmingham Civil Rights Institute in Birmingham, Alabama (USA). Teixeira (2009) describes an extremely powerful experience created by the striking display of a precise replica of a Greyhound bus that was burned out and bombed during the time. The object was to scale, and a faithful reproduction of the original bus. So, visitors were able to walk around and take in the scope of the object, and make a powerful connection with the culture of the time:

> "In this case, the burned-out bus engendered reflection on the meaning of what they were looking at, imagining other times or places and potentially recalling memories. In fact in this situation it didn't matter that the object wasn't 'the real one' because of the power of the story it illustrated. "
>
> (Teixeira 2009, 5)

Objects in a gallery do more than simply intrigue visitors and encourage museum visits, they also provide context for prior knowledge or notions a visitor may have about a particular event in history. Seeing the burned out Greyhound bus gave powerful meaning and emotional context to the period, and transformed facts from a history book into real events in the minds of the students that were visiting the museum.

Intrinsically Interesting Objects

Visitors like seeing iconic objects that they can recognize (Firkin and Rayner, 2003), and also objects with which they can interact (Gammon, 2003). Pieces in an art gallery, for example, are interesting in their own right and can speak for themselves. Many scientific artifacts by contrast, were not designed to be enjoyed by museum visitors, and thus create challenges and obstacles to encouraging interaction.

To overcome these obstacles, an exhibit designer should try to include objects that are "intrinsically interesting" (Teixeira 2009). These are objects that are interactive,

famous with visitors, beautiful or shocking, large in size, or nostalgic. A perfect example of this is the Apollo 11 capsule included in the Making of the Modern World gallery at the Science Museum, London. This object was authentic, large, culturally significant, and allowed visitors to interact with the original artifact by walking through it. The capsule was the most successful piece in the entire gallery (Siems and Gammon, 2001).

When interaction with the object itself is impossible (the original artifact is too valuable or delicate, for example), a faithful replica should be used. Visitors enjoy multisensory interaction with objects that they can touch, feel, hear, or even smell (Teixeira, 2009). This is a major departure from the "traditional" museum experience of the late nineteenth century and early twentieth century. In fact, current research (Teixeira 2009, Gammon 2003) indicates that visitors abhor exhibits that:

- Contain static or dead objects
- Objects that are behind glass and untouchable
- Exhibits with predominantly text based interpretation

Research also shows that visitors often ignore labels, and do not learn well from a passive museum experience. Hein (1998) suggests that a constructivist approach to object interaction is ideal, and that an exhibit that encourages investigation will be more educative overall. Multisensory interaction through the use of new media is an interesting new solution to this problem.

Using New Media to Encourage Interaction

Using new media in an exhibit is an innovative concept that has become more ingrained with the advancement of modern technology. Teixeira (2009) states "visitors to museums, and in particular to the Science Museum, have come to expect elements of interactivity to aid interaction." Particularly with younger visitors (teenagers and children), touch-screens offering quizzes and games can significantly

increase the educative value of an exhibit. Teixeira sums up this argument by saying:

> "The summative evaluation of the British Galleries at the Victoria & Albert Museum (Morris Hargreaves McIntyre 2003) showed that the inclusion of interactives – ranging from computer interactives, to multisensory interaction with objects (e.g. touching) and hands-on activities – in juxtaposition with historical objects was very popular with visitors. The interactives were found to significantly enhance their visit to the British Galleries and to develop visitors' knowledge and confidence. Contrary to prior fears that visitors might concentrate on the interactives rather than on the real objects, visitors clearly used the interactives as a tool to enhance their appreciation and understanding and to deepen their engagement with the real objects on display. Visitors liked that the interactives effectively provided the contextualisation they needed, gave information and insight on the objects and their context, animated the objects and brought the past to life."
>
> (Teixeira 2009, 19)

Multisensory interaction is important, but must be used carefully. As shown by Siems and Gammon (2001) and Hein (1998), visitors are uncomfortable with isolation, and exhibits catering to a group are more effective. Touch-screens for example, present the challenge that only one visitor at a time may use them. An exhibit using a touch-screen will need to be particularly intriguing for another visitor to wait in line for their turn. Thus, an exhibit designer must consider the social interactions among visitors (using loud speakers to allow several visitors to listen to audio, for example) when relying heavily on these new media interactions.

Incorporation of media into museum exhibits has been shown to improve the overall visitor experience, but must be regarded with skepticism and care. vom

Lehn and Heath (2005) point out that when given a portable PDA to act as a digital tour guide, museum visitors tended to pay more attention to the device itself than the actual artwork in the museum. Visitors would stand in a central location in front of a piece of art, and stare intently at the screen of their PDA. When the video onscreen pointed to a specific piece of the artwork, the visitor would briefly look up at the painting, and then quickly back down at the PDA so as not to miss any information. The PDA had effectively displaced the objects of the museum as the focal point.

In a similar case, visitors at the Victoria and Albert museum watching a short video would only briefly look up at the actual exhibit, and then refocus on the video (vom Lehn and Heath, 2005). While this is not necessarily a poor interaction, there is a fine line between the exhibit itself and the media designed to enhance that exhibit. The video tended to create difficulty when a pair of visitors would try to interact with the exhibit, for example. One visitor would watch the video and dictate the information to a visitor looking at the object. This caused some miscommunication and frustration as the interests of the visitor viewing the object did not always follow the same structure as the interactive film.

Analyzing these problems, vom Lehn and Heath created a short list of "design sensitivities" to consider when creating an exhibit with digital interaction:

1. Portable technology that is not tied to an individual user, but designed to facilitate sharing between multiple visitors may be preferential.
2. Display technology may be used that allows for multi-party participation and facilities overhearing and co-participation.
3. Screens that deliver information to be viewed or read should allow multiple people to view it from different angles.
4. The structure of the content may encourage visitors to view the exhibit at certain points and thus facilitate the interweaving of information from the device with the exhibit itself.

5. The content may be designed to simulate comments and discussion about the original exhibit

(vom Lehn and Heath 2005, 15-16)

These design sensitivities cater largely toward the social aspect of a museum visit. These all aim to avoid a sense of isolation, and effectively convey information to a group of visitors, as opposed to just a single visitor. Also, the technology involved (PDA, screens, movies, audio, etc.) must not be so overwhelming that it steals focus from the exhibit. These technologies should be incorporated to enhance the visitor experience, not alter the meaning of an exhibit.

Exhibit design historically has been something not considered largely important. Traditionally, curators would display a static object behind glass with an unappealing, didactic label. New research shows that interaction with intrinsically appealing objects heavily increases the educative value of an experience (Siems and Gammon, 2001), and that interaction via new media can encourage visitors to learn and interact with objects that may appear less interesting on the surface. These new technologies must be used carefully though, and a thorough understanding of how they affect the overall museum experience must be considered during implementation (vom Lehn and Heath, 2005).

Evaluation Procedures

Evaluation in Museums

Audience research is now considered an integral part of exhibit design. The London Science Museum, for example, has an entire department dedicated to this kind of research. The role of this "Audience Research and Advocacy Group" group at the Museum is to provide research and advice on how visitors learn, so that barriers are removed and learning maximized for target audiences. This group conducts evaluation for important objects, conducts research on the needs, wants, and expectations of potential visitors, and provides briefing documents and training for

Museum staff about these topics. Over the past decade or so, they have developed many formulae for evaluation of visitor response to exhibits, and thus have quite a few methods to gauge the overall effectiveness of an exhibit.

Types of Evaluations

Evaluation is conducted in order to ensure that information regarding the needs, behaviors, and expectations of the audience are being identified and addressed. An evaluation is not responsible for exhibit content per se, but will help the museum identify the proper pathways to a meaningful and inspiring exhibit. Evaluation typically falls under three categories: front-end evaluation, formative evaluation and summative evaluation.

A *front-end evaluation* is the first investigation conducted, and is done at the earliest stages of the project to assess the needs, prior knowledge and attitudes of the target audience. Following front-end evaluation, a *formative evaluation* is conducted to analyze and improve the effectiveness of certain elements of the project (interactives, labels, etc.) This type of evaluation can take many forms (e.g. focus groups and surveys) and will outline the general way in which the audience interacts with the exhibit. This will be extremely beneficial to our project, and will constitute the bulk of the work performed during our time at the Museum. Data from this research will identify potential problems with the design, and help to produce an exhibit that is both effective and educative. The last evaluation to take place is a *summative evaluation*, or a comprehensive analysis of the project. Summative evaluation aims to identify the extent to which the project has met its original objectives, and to identify causes for successes or failures to further the field of audience research.

Conclusion

Historically, audience response to an exhibit has been ignored. New research suggests that interaction with new media is an effective way to engage and educate

museum visitors. However, this is a significant challenge. There is very little literature available at this time that covers effective methods for developing physical/digital interactions that highlight an object. The sponsors wanted to use this project to find out if there was a way to fill this hole in current literature. They encouraged us to consider past experiments with physical/digital exhibits when designing and testing our prototype, which we will cover later in this report.

Methodology

Goals and Objectives

The goal of this project was to assist the Science Museum with the development of an exhibit prototype that would allow visitors to have a meaningful and engaging experience with an object through digital interpretation that responds to the physical manipulation of a model. The four main objectives were: (1) to select a device from the gallery that will provide a meaningful experience; (2) to design an effective exhibit prototype; (3) to evaluate the effectiveness of the exhibit prototype through formative evaluation, and alter the design as necessary; and, (4) to formulate recommendations and best practices for the development of future interactive exhibits at the Science Museum.

In order to allow sufficient time to conduct thorough formative evaluation at the Science Museum, our project team designed and built an early version of the exhibit prototype prior to leaving for London. Through analysis of empirical evidence acquired by previous exhibit evaluations we determined that a meaningful exhibit should create a sense of immersion, wonder, and nostalgia (Gammon 2001, Teixeira 2009). We then arrived systematically at our decision to work with a rotary phone, and to design an exhibit around an experience with this particular object. The team also had to determine how to incorporate physical/digital interaction into the design of the exhibit. The realization of this exhibit required computer programming, computer animation, and the use of audio recordings. Flowcharts of the interaction of the prototypes and the circuit diagram for the prototype are located in appendices K, L, and P, respectively.

The third objective entails substantial formative evaluation of our prototype exhibit. We met with the staff of the museum to determine if any immediate changes needed to be made to the prototype we brought with us to London. We then created, using

the guidance of the museum staff and our research, prototype 1 (P1). During deployment of P1 our group conducted observations and interviews with visitors to the museum. Analysis of this data yielded insight into the successes and failures of P1 and highlighted any further augmentations that needed to be made for the next iteration of the prototype, P2. We then conducted the same types of observations and interviews and analysis for P2, which led us to conclusions and recommendations for P3 as well as physical/digital interaction as a whole.

Our overall goal was to be able to leave the Science Museum with not only a prototype exhibit for their new gallery, but also with valuable research and insight into the design process of physical/digital exhibits.

Objective 1: Object Selection

The first objective was to determine which object our team would like to work with for our project. The Science Museum presented us with a brief, as seen in appendix V, at the start of the project containing several objects considered for the upcoming "Making of Modern Communication" gallery. Our group had to select a final object from this list using the following three sources of design criteria:

- Findings from preliminary research
- Requirements of the Science Museum
- Engineering criteria (cost, ease of development, safety, etc.)

Preliminary Research

Previous evaluation (see Literature Review) revealed that a meaningful experience comes from an exhibit that incites an emotional response as well an intellectual response and that the exhibit should create a sense of immersion for the visitor (Gammon, 2003). A successful exhibit will allow a visitor to truly engage with the object by giving them a glimpse into the world of the object on display and educating the visitor as to the functions of the object. These conclusions were

drawn from analysis of interactions and learning styles in museums, as well as various case studies and evaluations discussed more fully in the Literature Review section.

Science Museum Requirements

The brief presented to us by the Science Museum contained several requirements for the selection and design of our prototype. Firstly, we were to choose the object with the greatest potential for innovative interpretation. Our group had to identify what type of content would benefit from interactions, how these interactions would bring the object to life, and how interaction with the object would help educate visitors about the object itself. The museum also required that interaction with the object should be entirely self-contained. This means that any feedback from the object needed to be incorporated directly into the interaction so that the exhibit does not require museum staff to explain concepts to visitors while they use the object.

The Science Museum wanted an interaction that was effective and educative as well. By "effective" the Science Museum meant that the exhibit should be able to easily convey the information about the object the exhibit represents. Being a science museum, our sponsors required that interactions with the object educated visitors about the actual science and behind the use and functions of the object. A visitor who interacts with our activity should gain knowledge about how the object actually functions, as well as the context of the object (its impact on society at the time, the technological complexities of the object, etc.) and its impact on early 20th century technology.

Finally, the museum encouraged us to consider the manner in which the visitor receives feedback from interaction with the object in the exhibit. The Science Museum did not specifically require that the feedback be presented by the object itself, but did state that feedback should be intuitively obvious, as visitors can

sometimes find it difficult to understand the use of an interaction in a busy exhibition space.

Engineering Criteria

Finally, a set of engineering criteria was factored into the object selection and design process. Our group had a relatively short timetable (less than seven weeks) to actually construct the initial version of the exhibit, and we had to alter the exhibit once we were in London. Thus, the exhibit needed be fairly simple to design and quick to assemble. Also, the exhibit had to be reasonably inexpensive to build. It also had to be reasonably sized to allow easy shipment to London. We tried to avoid any objects that would be overly complicated to build (anything beyond simple rewiring of an object and basic computer programming), and tried to create an interaction that minimized the use of unnecessary external input devices (auxiliary keypads, touch screens etc.). Also, a simply constructed exhibit will be easier for the Science Museum to support, should the exhibit require maintenance at any point in the future. The prototype was turned over to the Science Museum at the conclusion of this study, and a simple design was easier to pass along than a complex prototype.

Final Device Selection

Based on these criteria, we developed comparison charts to choose which object to work with. Using a pairwise comparison chart, and also a numerical evaluation chart (Appendix R, Tables 1, 2), we empirically determined that a rotary phone would be the best object to work with for this particular project, as seen in figure 1. From a strictly engineering perspective, a rotary phone was easy for us to obtain and work with, didn't present any immediate safety concerns for the visitors, and was easily manipulatable (we could easily modify the phone to display the inner workings, for example).

Figure 1: Original Prototype Phone

The rotary phone was an extremely attractive device from a design standpoint, as well. Our project group needed to be able to build this exhibit rather quickly and inexpensively. Working with a rotary phone afforded us both speed and efficiency in terms of design. Additionally, we felt that we would be able to use our existing knowledge of this device, as well as the insight gained from our literature review and museum experts to create an exhibit that will result in a Life Enhancing Experience (a term the museum uses to describe an experience that engages a visitor and does not merely educate them but also puts that knowledge in a larger, more human context) for a visitor.

Our team decided that the rotary phone was popular enough to be fairly recognizable by the target audience, and we believed it would create a sense of nostalgia, which would attract visitors. Our hope was to exploit that sense of nostalgia to create an exhibit that visitors would be excited to use, or to teach their children how to use a rotary dial. This kind of interaction lends itself extremely well to the self-directed learning ubiquitous in modern museums. Also, the exhibit was designed to be "open" enough so the primary user of the object would be able to interact with both the object and the members of their group (to avoid a feeling of isolation). These key variables are all identified in the research literature as requirements to promote effective exhibits and interactions.

Objective 2: Device Design

When making our prototypes we had to create a set of **design principles** from what we had gathered in the Literature Review and through our talks with our sponsors. These design principles influenced our decisions when designing each iteration of the prototype. we then employed an initial version of these principles into both the P1 and P2 designs and considered them when forming our future recommendations for the Science Museum. The design principles then changed in response to any

significant findings or conclusions revealed in testing. The final version of our design principles were as follows:

For All Exhibits:

1. The objectives of the interactive should be clear to the visitor.
2. The interactive should enhance understanding of the actual object.
3. The interactive should be engaging and entertaining.
4. The interactive should be intuitive to use, requiring little to no instruction.

Specifically for Physical/Digital Exhibits:

1. The interactive should digitally interpret a physical interaction.
2. The interactive should augment understanding of the object without overshadowing it.
3. References to the object in the interactive should be abstract.
4. Ideally, every interaction should result in feedback.

These design principles are explained in more detail in Appendix W. The actual application of these principles to the group's preliminary exhibit design is discussed in more detail in the next chapter (Initial Design).

Figure 2: The Strowger Phone

Objective 3: Formative Evaluation

In order to judge how effectively our prototype highlighted the Strowger phone, as seen in figure 2, by combining the physical and digital experiences,

we needed to test each iteration of our prototype with museum visitors. For both P1 and P2, we created a series of observations and interview questions (Appendices D, E, F, G). We then recruited visitors that fit our target audience from the museum floor and had them try our activity. After we had finished observing and interviewing enough members of our target audience, we synthesized our findings into reports. These reports covered our observations, any implications these observations might have, and then provided reasoned recommendations that responded to these observations. We then synthesized the findings from these two reports to form our overall conclusions about how to effectively make a physical/digital interactive that leads visitors to engage with an object.

Objective 4: Recommendations

Finally, two sets of recommendations had to be made to the Science Museum. First, a design for Prototype 3 (P3) had to be made. The Science Museum normally puts its exhibits through three iterations of prototype testing before moving them into a more complete state, but there was only time during the project to conduct two rounds of iteration and testing. Thus, a set of recommendations and a flow chart, as seen in Appendix M, for P3 have been provided to the Science Museum, allowing them to conduct this third round of testing should they need to. The design for P3 is explained in more detail in the Prototype 3 (P3) chapter of this report.

The final objective of this project was to create an overarching set of recommendations based on all of the findings made during this project. The Science Museum can apply our recommendations and conclusions to future physical/digital exhibits. In large part, these recommendations consist of the design principles that were created through initial research, and were then altered in response to findings during testing. The implications of and reasons for these design principles were also crucial pieces of the recommendations made to the Science Museum. The recommendations are addressed in full detail in the Conclusions and Recommendations chapter of this report.

Initial Design

Our exhibit relies heavily on audio and visual feedback to the visitor. Not only was this decision based on suggestions given to us by our sponsors, but it has also been shown to create a much more immersive and interesting exhibit (Gammon 2003). We initially planned to use animations displayed onscreen, as well as audio played from both a representation of a phone receiver and an external speaker to create an immersive experience for the visitor that will educate them about the rotary phone on display.

As shown in Table 3 (Appendix R), we wanted to be sure to address six key areas:

1. What technology will control the interaction?
2. What is the best way to output audio?
3. How can we make this intuitive to use?
4. How can we ensure durability of the object?
5. How will the object educate visitors?
6. Is this object safe to use in a museum environment?

Table 3 (Appendix R) is a morphological chart outlining our thought process during these preliminary stages of design.

As shown in the Bill of Materials, a list of all the materials used in making the prototype (Appendix T), we worked primarily with a rotary phone purchased online, and an Arduino circuit board. Table 4 (Appendix R) outlines the general configuration of the initial version of the exhibit as a whole. As shown in Table 4, we had planned that a rotary phone would be dialled and the phone would send electrical signals to the Arduino circuit board. The Arduino would then translate these signals into numbers to be fed as input to a computer program. The program

would then select a video file and display it on the screen and play it through the speakers. The general outline of the intended interaction for the initial version of the prototype was:

1. The visitor approaches the exhibit.
2. The visitor hears the phone ringing, and picks up the phone.
3. Noticing the animations, the visitor dials a number:
    a. If the number is in the list, proceed to 4.
    b. If the number is not, an "operator" will direct the visitor to try one of the numbers listed nearby.
4. A short video clip corresponding to the number dialled will play for the visitor to enjoy (Appendix H).
5. The screen will reset to the beginning, and the "operator" will instruct the visitor to either:
    a. Choose to watch another, more advanced animation about the same topic.
    b. Hang up, and redial a different number to choose another animation.

Near the phone, we intended to have a label indicating certain numbers for the visitor to dial—a phonebook (Appendix U), as seen in figure 3. These numbers were to be short (four digits) and have a brief description (three to seven words) of the video clip to which they are attributed. Empirical evidence indicates that visitors tend not to read labels (Hein, 1998, Gammon, 2001), which is why we had chosen to

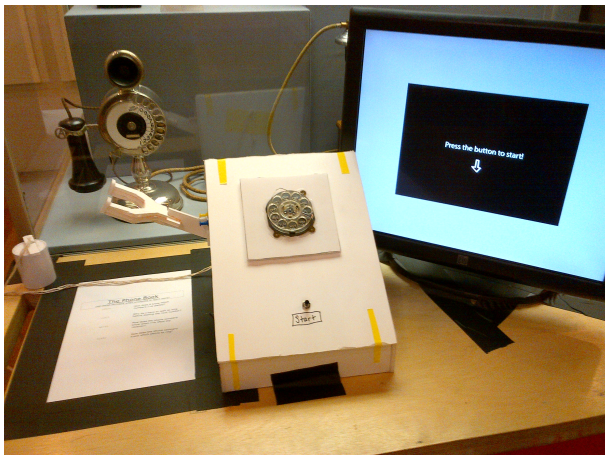

Figure 3: The arrangement of Prototype 1

program a safety net (Step 2b in the above list) into the interactions.
As far as the actual programming was concerned, the Arduino circuit board was programmed using its own native language (Appendix Q). The circuit board is always in a receptive state, and was ready to receive numbers as soon as a visitor picks up the handset of the rotary phone. Once the visitor dials a number, the Arduino will not allow any further pulses to be sent through to avoid any interruption of the video file that is playing. The video would continue to play in its entirety even if the visitor chooses to hang up the handset partway through.

We required the use of a computer to read input from the Arduino, as well as to play the video files. The program on the computer was written in Processing (an open source language designed for visual arts). We chose this language because it manages QuickTime file extensions (.mov) quite well, which allows us to use the H.264 codec when compressing our audio/visual files. H.264 was desirable because it allowed us to generate high quality audio and video while only using a small amount of storage space, creating a more portable system.

The initial version of the computer-side program displays an idling animation (discussed below) when waiting for input. Upon receiving input from the Arduino, the program checks the four-digit number against a database of video files stored on the computer. If the video file was found, it would play on the screen and through the speakers for the visitor to enjoy. If no match was found, an "operator" would urge the visitor to read the phonebook and try dialling a number from that list. Following the conclusion of the video file, the program would revert to the idle state, and play the original idling animation. At this time, the visitor could dial a new number if they'd like, or hang up the handset and leave the exhibit. The code for the two prototypes is located in Appendices I and J.

A major barrier to the implementation of this exhibit was the visitor's lack of prior knowledge about rotary phones. If a visitor has never seen a rotary phone before and does not know how to operate one, the entire experience would be lost. We

hoped to avoid this pitfall with a cleverly designed animation displayed on the screen when the phone is not in use. This "idling animation" (mentioned earlier) would have shown a video clip of how to operate the phone, looping repeatedly until a visitor dials a number to start a video file.

The video files themselves were intended to educate the user on the history of the phone, the inner workings of the phone, and the cultural impact the phone had (see Appendix H for more details). We had found in our research that the human stories behind a device (such as a phone operator discussing their duties, or a wealthy person excitedly calling to boast about being the first in town with a phone) are more compelling to the visitor than the technicalities of the physical operation of the device (TWResearch 2009). As such, we planned to not only create videos to educate the visitor about the technological workings of the phone, but also create some with the intent of providing insight into the impact the rotary phone had on society at the turn of the century.

The video files were created in Adobe Flash. We planned to then record voice-overs to tell the story of the video, along with any sound effects that could increase immersion (the bustle of operators at a phone switch, for example), which would then be compiled with the animation using Adobe Premiere. Finally, we exported these videos into QuickTime as mentioned above, to be easily called by the aforementioned program.

Prototype 1 (P1)

Prototype 1 (P1) Design

After discussions with the sponsors, checking the design principles, and making adjustments for meeting the testing deadlines, the initial design was adjusted. The original idea did not match up to the design principles or the standards of the museum (for example, the activity only provided feedback to the visitor if they followed a specific interaction path whereas an ideal activity would provide feedback for every single interaction). More importantly, the initial design could not provide a suitable basis for testing that would provide meaningful findings and would be useful to the museum in their research of how to make physical/digital interactives work.

We adjusted our initial design accordingly before we started our first round of testing. First, we took our initial idea of dialling phone numbers to bring up content videos and made that into its own mode, which we refer to as "Call Mode". We then created a separate mode of interaction that we called "Play Mode". This mode was created for two reasons. First, we realized that visitors could interact with our exhibit in ways that did not follow our ideal path. We did not want to tell these visitors that they were wrong. Instead we made Play Mode to provide visitors with a complete path through our content regardless of their initial action. Second, this mode was intended to introduce our visitors to the concept of dialling digits on the rotary dial while simultaneously presenting some "fun facts" and a visual representation of how a dial works electronically. We needed to ensure that visitors would know how to dial the phone, so this mode had on-screen instructions. The fun facts were added to present information to the visitors as they learned to dial and to ensure that they were getting feedback from each action that they performed. Finally, we showed a number of sparks traveling around the screen that corresponded to the digit the user last dialled to represent how the dial sends

electrical pulses and determines what digit was dialled. Screenshots of this section are included in appendix H.

Next, we enhanced and clarified Call mode. In our initial design, visitors would simply dial a phone number and then watch the video. This does not provide the visitor with enough feedback nor does it explain the process of calling at all. To address both of these issues we came up with a way to represent the automatic telephone exchanges that were used to connect a phone call during the time the Strowger phone was in use. As the visitor dialled each digit of the phone number, a spark would move from the on-screen phone along a wire to a vertical, disconnected bit of wire. When the spark arrived, the wire would rotate to a horizontal state, representing one step of the call now being connected. This would happen for each of the 5 digits in the phone number. When the fifth digit was dialled and the entire line of wires was connected, the content video would then play. This ensured that the visitor received more feedback and some content before the videos started.

Next, we had to address the issue of our exhibit lacking context. Without context, the visitor had no reason to think that this object was important. To provide some context, both historical and as to why the object was important, we added an introductory video to the interaction that would play after the visitor made their first action on the interactive. In our initial version, this first action was going to be an infrared (IR) sensor picking up on a visitor approaching the exhibit. Since visitors were not going to approach the exhibit naturally during testing, the IR sensor was replaced by a start button. The visitor would press this button to begin the introductory video and the activity as a whole. Although this was not an ideal solution because the start button restricted the way visitors could start the activity (i.e. the visitor had to press the start button before anything else could happen), it was an effective way to start the activity for the testing purposes of P1. Again, Screenshots of the interaction are located in appendix H.

A few last changes were made to P1 because certain things were not essential to achieve the goals we had set for the initial design before testing. First off, we chose not to include sound effects in this version of the prototype. At this point, we felt it was more important to test that visitors were able to use the activity without difficulty and the instructions were clear. Similarly, we did not include full content videos in Call Mode for P1. However, we still wanted to provide feedback to visitors so we made placeholder images that told the visitor what content would be there in its place. Finally, integrating the phonebook into the on-screen instructions was of low priority for this round of testing. Instead, we simply put everything that would be on the phonebook on a sheet of paper that we placed next to the phone and pointed to in the on-screen instructions.

P1 Evaluation Strategy

This evaluation strategy guided evaluation of the first prototype of the exhibit.

Background to the Research and Development Project

The Rotary Phone Digital/Physical Prototype Exhibit is a prototype exhibit intended for use in the upcoming Making of Modern Communication gallery (2014). Our aim is to increase awareness about certain complexities of the phone (the technical aspects of the rotary dial, the science behind the microphone, the intricacy of early networks, etc.).

This prototype employs a digital interpretation of a physical interaction to demonstrate certain features of the Strowger Telephone. Not only will this prototype test usability concepts for this exhibit, but also for combination digital/physical exhibits throughout the Museum.

It was tested next to the actual object (Strowger Telephone) in the existing Telecommunications Gallery on the 1st floor.

Purpose of the Evaluation

The Worcester Polytechnic Institute Project Team will be using this P1 evaluation to determine the usability of this exhibit, analyze whether or not the main points are being conveyed, and try to determine specifically what type of content the visitors are interested in seeing.

The aims of this prototype evaluation are:

- **Usability**
    - Do visitors understand how to operate the dial?
    - Are they able to navigate through the interactive and follow the on screen instructions?
    - Do they use the receiver when appropriate?
- **Motivation**
    - Do visitors find the interaction boring?
- **Interpretation**
    - Do visitors understand the purpose of the interaction?
    - Can they recognize that the exhibit refers to the Strowger phone?
    - What do they think this exhibit is about?

The objectives of the evaluation are:

- To determine if the prototype is intuitive and easy to use
    - Do they understand how/when to use the dial?
    - Do they understand how/when to use the receiver?
- To explore barriers that hinder visitor engagement
    - Is the exhibit confusing/difficult to use? If so, where/when/how?
    - How does is the pacing?
    - Is the current content appropriate?
    - What content would visitors like to see added?
    - How do they react to the phone book label next to the prototype?

        - Do they use it properly?
- To gauge whether visitors are picking up on the main messages and content for the exhibit
    - Did the visitor understand that this exhibit was demonstrating features of the Strowger phone?
    - Did they understand the concept of pulse dialling, and how to use a rotary dial?
    - Do they have an appreciation for the complexity of the Strowger phone?
        - Dialling required electrical pulses
        - Lifting the receiver sends a different kind of electric pulse to open a phone line
        - An extremely complex network was required to handle phone call

Target Audience

1. Independent Adults
2. Families with children 11+ yrs

Time Table of Work

Start P1 Evaluation: Wednesday, March 28th

End of Evaluation: Saturday, April 1st

1. Observation and Interview of Independent Adults, and Families to be conducted during this time

Methodology

We will use qualitative methods to determine the overall usability of the exhibit, as well as more in depth information about how the visitor responds to the content.

- Interviewees will be asked to use the exhibit under observation, during which time we will observe and record their behaviour. Following this, visitors will be interviewed.
- Audience Distribution (30 Total)
    - 15 Independent Adults
    - 15 Families (with children aged 11+)

P1 Report

Executive Summary

This activity employs a digital interpretation of a physical interaction to demonstrate and highlight certain features of a Strowger telephone (in particular the mechanism of dialling). The exhibit was made up of an abstract physical model of a telephone (using an authentic rotary dial, and a fabricated receiver), and a computer screen (as shown in the above photo). The activity was split into two main interactions: Play mode and Call mode. In Play mode, an on screen prompt instructs visitors to dial a digit then an animation plays and facts about the mechanisms of the rotary dial are displayed. In Call mode, an on screen prompt instructs visitors to dial a five-digit number, and a corresponding video conveying content plays (about the mechanisms of the dial, or the importance of the dial).

In this **first prototype,** it was found that many visitors did not notice the actual object, and focused too heavily on interacting with the exhibit (playing with the dial, watching the screen, etc.). This means that there is not enough focus on the object itself, and that attention needs to be shifted from the interactive to the object.

The exhibit itself was quite usable: most visitors were observed to physically use the dial, receiver and phonebook with little difficulty. The physical model of the phone is fine, and should not be changed.

Visitors were observed to struggle with the content presented in Play mode. Evaluation showed that Call mode was much more successful at delivering content, implying that the clear, structured goals and objectives in Call mode increase visitor comprehension of the content.

Key Findings

Not enough visitors noticed the object, or made a connection between the activity and the object.

- Less than half of visitors knew the exhibit was about the Strowger phone when interviewed. Many visitors recognized the word "Strowger" from the activity, but did comprehend the meaning of the word. Visitors stated that they were afraid [to] miss something important" (IA, M, 26-30) by looking away from the screen and did not notice the phone during the interaction.
    - The failure to recognize the object is a failure of the exhibit, as the success of many of the Learning Outcomes hinge on recognition of the object.

Visitors followed the explicit instruction to "dial 5 digits" in Call mode, but misinterpreted the ambiguous instruction to "dial a number" in Play mode.

- Call mode had the very explicit instruction to dial five digits, while Play mode has the much more ambiguous instruction to dial any number. As a result, visitors were observed to sometimes dial many numbers instead of just one, and miss the content entirely. Also, after being presented with a fact during Play mode, the instruction to continue dialling was again unclear. A sizable minority needed to be verbally prompted to continue dialling due largely to

the lack of clear instructions and motivation. As a result of these barriers in Play mode, less than half of visitors absorbed the content presented about the technical aspects of dialling (only 12/30 visitors interviewed grasped the concept of pulse dialling).

- Visitors that do not correctly progress through Play mode will miss the majority of the content relating to the technical aspects of dialling.

The content in Call mode was conveyed more effectively than the content in Play mode.

- The majority of visitors interviewed (22/30) thought the exhibit was about the history of phones, and roughly half the visitors interviewed mentioned "exchanges" or "connections" explicitly (the content presented in Call mode). Conversely, less than half of visitors interviewed (12/30) grasped the concept of pulse dialling (the content presented in Play mode). This is caused by the unfocused interactions in Play mode: Visitors are given a vague instruction to "dial a number" and then dial either one digit or several digits, sometimes missing the content entirely.
  - Play mode needs more explicit instructions to aid in conveying content.

Almost all visitors were able to physically operate the dial successfully, and understood when/how to use the receiver and phonebook.

- The only visitors that had difficulty operating the dial were children that had not encountered a dial previously. In these cases, their parents were observed providing scaffolding for the interaction, and instructed their children how to dial properly.
  - The physical model of the phone was successful, and should not be changed.

Key Recommendations

As mot enough visitors noticed the object, or made a connection between the activity and the object, the phone needs to be highlighted more throughout the interaction and references to the object need to be more abstract. This can be achieved by:

- Make more references to the object.
- Highlight the object more.
- Replace the word "Strowger" with phrases such as "one of the early automatic dial telephones" to increase abstraction.

As visitors followed the explicit instruction to "dial 5 digits" in Call mode, but misinterpreted the ambiguous instruction to "dial a number" in Play mode, Play mode needs to be made more usable so visitors can better absorb the content presented. This can be achieved by:

- Instruct visitors to dial again more clearly, with text instead of an animation.
- Use a more explicit instruction to "dial one digit" in Play mode as in Call mode.
- Call mode worked well, and the instructions should be left the same.

As the content in Call mode was conveyed more effectively than the content in Play mode, the instructions in Play mode need to be much more specific so that visitors understand when to dial and when to look at the screen. This can be achieved by:

- Instruct visitors to "dial one digit" specifically.
- Add sound to Play mode to draw attention away from the dial when appropriate.
- The content in Call mode should be developed further, as it seems to be absorbed well by visitors.

- Include animations (or slideshows, depending on time) for the available videos.

As almost all visitors were able to physically operate the dial successfully, and understood when/how to use the receiver and phonebook, the physical portions of the activity do not need to be changed.

- The physical model of the phone should be kept the same in future versions.

Introduction

The Rotary Phone Digital/Physical Prototype Exhibit is intended for use in the upcoming Making of Modern Communication gallery due for opening in 2014. Our aim with this exhibit is to increase awareness about certain complexities of the internal mechanics of the phone (the technical aspects of the rotary dial, the intricacy of early networks, etc.), and convey the significance of the Strowger phone.

This prototype explores digital interpretation of a physical interaction to demonstrate certain aspects of the object on display (the Strowger phone in this case). This P1 exhibit allowed us to test usability of the activity, as well as some of the content that was included. This also provided us the ability to test viability of combination digital/physical exhibits at the Science Museum.

The interactive exhibit was tested next to the actual object (Strowger Telephone) in the existing Telecommunications Gallery on the 1st floor.

Aims and Objectives

The aims of this prototype evaluation are:

- **Usability**

        - Do visitors understand how to operate the dial?
        - Are they able to navigate through the interactive and follow the on screen instructions?
        - Do they use the receiver when appropriate?
- **Motivation**
    - Do visitors find the interaction boring?
- **Interpretation**
    - Do visitors understand the purpose of the interaction?
    - Can they recognize that the exhibit refers to the Strowger phone?
    - What do they think this exhibit is about?

The objectives of the evaluation are:

- To determine if the prototype is intuitive and easy to use
    - Do they understand how/when to use the dial?
    - Do they understand how/when to use the receiver?
- To explore barriers that hinder visitor engagement
    - Is the exhibit confusing/difficult to use? If so, where/when/how?
    - How does is the pacing?
    - Is the current content appropriate?
    - What content would visitors like to see added?
    - How do they react to the phone book label next to the prototype?
        - Do they use it properly?
- To gauge whether visitors are picking up on the main messages and content for the exhibit
    - Did the visitor understand that this exhibit was demonstrating features of the Strowger phone?
    - Did they understand the concept of pulse dialling, and how to use a rotary dial?
    - Do they have an appreciation for the complexity of the Strowger phone?

- Dialling required electrical pulses
- Lifting the receiver sends a different kind of electric pulse to open a phone line
- An extremely complex network was required to handle phone calls

The intended Learning Outcomes of this exhibit are:

- Skills
  - Be able to discuss how a dial telephone works and was used.
- Attitudes and Values
  - Appreciation of the difference between phones then and now.
- Enjoyment, Inspiration, Curiosity
  - Encourage curiosity about the introduction of the dial telephone/mechanism.
  - Inspire visitors to examine the actual object more closely.
- Knowledge and Understanding
  - Appreciation for the importance of the dial on the Strowger phone in relation to its introduction, how it works, and how it's used.
  - Learn that early networks used automatic exchanges, which required a rotary dial.
  - Understand specific technical aspects of using a rotary dial:
    - Learn that the rotary dial on the Strowger phone sends electric pulses to indicate which digit has just been dialled.
    - Learn that the physical dial completes a circuit when it is released that emits electrical pulses.

Findings

Noticing the object

Not enough visitors noticed the object, or made a connection between the activity and the object. Less than half of visitors knew the exhibit was about the

Strowger phone when interviewed. Many visitors recognized the word "Strowger" from the activity, but did comprehend the meaning of the word. Prior to being shown the phone, visitors expressed that they knew the exhibit was about "Strowger" but did not show that they had a concrete idea of what this word actually meant. Visitors were essentially parroting back the word "Strowger" from where it appeared in the exhibit on screen. This means that the textual references to the object (saying "the Strowger phone was…", "the dial on the Strowger…" etc.) were not successful, and by specifically naming the object, deeper thinking about the object's significance and purpose is discouraged. Also, while the physical model of the phone encouraged visitors to use the real object as a reference, the interactions themselves discouraged actually taking time and looking at the object. Visitors stated that they were "concentrating on the screen" (Family, F, 11), "afraid [to] miss something important" (IA, M, 26-30) by looking away from the screen, or that they "never got a chance to look around" (IA, M, 60) and did not notice the phone during the interaction. The failure to recognize the object is a failure of the exhibit, as the success of many of the Learning Outcomes hinge on recognition of the object.

Recommendations:

The exhibit needs very badly to reference the object more often.

- Visual images of the object
- Descriptions of the object
- Visual indication of its location in the gallery
- Avoid explicitly saying "Strowger" and make textual references to the object abstract to encourage more inquisition on the part of the visitor

Usability

The majority of visitors could physically use the dial. Almost all visitors were observed to interpret the initial instructions to dial correctly, and were able to dial. The exceptions to this were three children who had not seen a dial before; these

children tried to grip the outside of the dial with all of their fingers. This was due both to children's lack of experience with older rotary dials, and a lack of clear instructions in the activity. In all cases, parents helped their children through the experience and the children were able to successfully dial after a few practice tries. This implies that the instructions to dial were clear, but that children may not have the existing knowledge to operate rotary dial properly.

Recommendations:

The instruction to dial was clear, but activity should instruct users of the proper method of dialling also.

- Use an animation of a hand dialling to clearly indicate the proper method of dialling.
- The model phone worked well and the dial was physically usable.
- The instructions to dial were successful and should not be changed.

Almost all visitors successfully used the receiver. 12/15 IA's and 13/15 Families lifted the receiver when prompted, and nearly everyone mentioned the on screen instructions to lift the receiver when interviewed, suggesting that the instructions were quite clear. However, a minority had difficulty reading the instructions, complaining that "the colour scheme was unreadable". If visitors do not lift the receiver, they cannot access call mode and will miss a large portion of the activity.

Recommendations:

Visitors need to be able to understand the prompt to lift the receiver.

- Change the colour scheme from white text on a grey background, which is difficult to read.

A large number of visitors held the receiver during the entirety of Call mode, despite the fact that there was no sound. Typically, visitors would pick up the receiver (either by intuition or instruction from the interactive), and hold it up to

their ear. At this time the testers informed them that there was no sound, but that the finished version would include sound. Most visitors decided to hold on to the receiver at this point (either up to their ear or in their hand at their side), accepting that it would be used at some point in future prototypes. Visitors often mentioned that "it was natural" (IA, M, 20 – 30), or "that's just how you use a phone" (Family, M, 9), meaning that the exhibit succeeded on some level at recreating the experience of using an old telephone.

Recommendations:

The exhibit was successful at recreating the experience of using an old telephone, so the receiver and dial should be kept.

- Add a speaker to the receiver.
    - Add a "dial confirmation noise" when visitors dial a number.
    - Add a ringing noise to match the existing ringing animation.
    - Add sound to content videos.

All visitors successfully used the phonebook once aware of its presence. 14/15 IA's, and 14/15 Families noticed the phonebook (those that didn't were prompted by the testers). At least one of the visitors who did not notice the phonebook was a victim of the programming glitch, and thus it cannot be conclusively said whether or not the phonebook would have been properly noticed and used. All visitors interviewed said that the phonebook was easy to use, and were clear on when to use it. This implies that the structure of the interaction was quite good, as visitors seemed to notice the phonebook when they were instructed to on the screen. Visitors that use the phonebook properly will be able to access the content in Call mode.

Recommendations:

- The phonebook tested better than expected, but is not a final solution as it was intended to be a digital interaction. The phonebook will be worked into the on screen prompts during Call mode in P2.

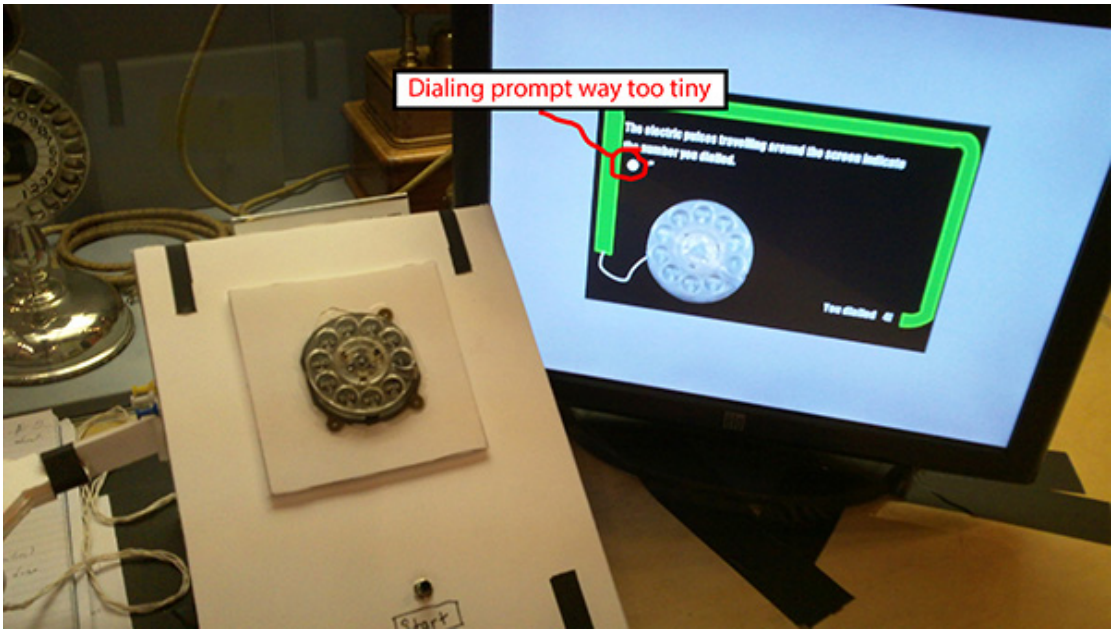

Figure 4: "Dial Again" prompt was too small

Instructions and Usability in Call mode vs. Play mode

Visitors followed the explicit instruction to "dial 5 digits" in Call mode, but misinterpreted the ambiguous instruction to "dial a number" in Play mode. Call mode had the very explicit instruction to dial five digits. Visitors were observed to perform this action, and immediately look back at the screen for further instruction.

Play mode has the much more ambiguous instruction to dial any number. As a result, visitors were observed to sometimes dial many numbers instead of just one, and miss
the content entirely. Also, after being presented with a fact during Play mode, the instruction to continue dialling was again unclear. A sizable minority needed to be verbally prompted to continue dialling due largely to the lack of clear instructions and motivation. As a result of these barriers in Play mode, less than half of visitors absorbed the content presented about the technical aspects of dialling (only 12/30 visitors interviewed grasped the concept of pulse dialling). Visitors that do not

correctly progress through Play mode will miss the majority of the content relating to the technical aspects of dialling.

Recommendations:

Play mode needs to be made more usable so that visitors can absorb the content presented there.

- Instruct visitors to dial again more clearly, with text instead of an animation.
- Use a more explicit instruction to "dial one digit" in Play mode as in Call mode.
- Call mode worked well, and the instructions should be left the same.

Play mode may have too much on screen at once, and visitors may miss important bits because they may not be sure what they should be looking at.

One visitor in particular mentioned during the interview that he "didn't want to look away from the screen" and was "afraid [he'd] miss something important" (IA, M, 26-30). While only one visitor explicitly mentioned this, it was observed with several others during testing. This may point to a major design flaw in the structure of Play mode. Play mode has quite a bit happening on the screen, and it may be overwhelming. The activity should introduce the various pieces of the digital interaction on the screen (the green pipeline around the border, content, the instruction to dial again) gradually as opposed to all at once to avoid confusion. Without a clear activity objective, visitors will not be sure what they should be doing or where they should be looking and will not absorb content.

Recommendations:

The digital interactions in Play mode may be overwhelming, as visitors are appearing confused and are missing content.

- Introduce aspects of Play mode more slowly, as the screen was too busy:
    - First introduce the concept of dialling
    - Next introduce the pipeline image to show pulse dialling
    - Finally introduce text on the screen
- Use clear instructions to ensure visitors only dial one digit at a time.

Conveying Content

The content in Call mode was conveyed more effectively than the content in Play mode. The majority of visitors interviewed (22/30) thought the exhibit was about the history of phones, and roughly half the visitors interviewed mentioned "exchanges" or "connections" explicitly (the content presented in Call mode). Particularly, when interviewed, some visitors claimed the exhibit was about "how [the] phone connects to the relay system" (IA, M, 50-60), or "about old phones or how exchanges work" (F, M, 12). Conversely, less than half of visitors interviewed (12/30) grasped the concept of pulse dialling, implying that this interaction was much less successful at conveying content. This is caused by the unfocused interactions in Play mode. Visitors are given a vague instruction to "dial a number" and then dial either one digit or several digits. Visitors were observed to sometimes focus entirely on the dial, and missed the content presented in Play mode.

Recommendations:

The instructions in Play mode need to be much more specific so that visitors understand when to dial and when to look at the screen.

- Instruct visitors to "dial one digit" specifically.
- Add sound to Play mode to draw attention away from the dial when appropriate.

The content in Call mode should be developed further, as it seems to be absorbed well by visitors.

- Include animations (or slideshows, depending on time) for the available videos.

The introduction video was ineffective. Almost all visitors were observed to successfully start the exhibit. However, despite visitors appearing to read the introduction video, no one interviewed mentioned any content from the introduction video. This content is not built upon or mentioned at any other point during the activity, and is likely the cause of this finding. The purpose of the introduction video is to provide context for the activity, and content should be removed from this video.

Recommendations:

Content included in the introduction video was not conveyed effectively.

- Use the introduction video to provide context and motivation for the exhibit, not content.
- Abstractly reference the phone (use a silhouette of the phone for visualization, and mention the phone as "the first rotary dial automatic telephone) to encourage object reference.

Behavioural differences between IA's and Families

Families interacted and communicated as a group. Parents were often observed narrating content on the screen while their children would play with the dial. While the parents were reading, the child would stop dialling to listen to the content, increasing comprehension for the group. Also, parents were observed to assist their children with physically using the rotary dial, providing the scaffolding for their children who directly interacted with the exhibit. These group interactions show the exhibit has potential to promote intergenerational communication and learning. If the group communicates about the content, it is more likely that the content will be comprehended.

Recommendations:

Encourage this kind of group communication in IA's, and in other parts of the interaction.

- It was excellent that Play mode encouraged this kind of communication; ensure that any changes to the structure of the interaction still allow for communication.
- Sound effects in the receiver may prompt the primary user of the activity to communicate the sounds in the receiver to the rest of the group, further encouraging communication.

Children viewed the screen as the primary point of interaction, while IA's viewed the dial as the primary point. Children were observed to look at the screen much more frequently than adults, almost always turning the dial, and immediately looking back at the screen. Conversely, IA's were observed to focus much more on the dial, and less on the screen. This helped to highlight a major problem with Play mode: visitors focusing too much on either the dial or the screen. Children were observed to shift attention back and forth between the dial and the screen quite well whereas adults were observed to focus too much on one or the other. The consequence of this is that the interaction does not flow smoothly, and the visitor may miss important content or instructions.

Recommendations:

Visitors need to shift attention back and forth between the screen and the dial.

- Clearly define instructions so visitors feel comfortable looking away from the screen and at the dial to perform the instructions.
- Indicate on screen times to look at the dial or the object so visitors feel comfortable shifting their attention.
- Physical/Digital exhibits need clear indications as to where and when attention should be focused.

Visitors in both groups would sometimes ignore the "lift receiver" prompt and dial a few more times before actually lifting the receiver. It was observed on occasion that visitors would see the prompt to lift the receiver at the end of Play mode, ignore it, and keep dialling. This can be the result of a number of things: First, Families with more than one child wanted to allow all of the children a turn. Second, some visitors simply enjoyed dialling and were not interested in doing anything else. And finally, some Families had to instruct their children how to dial (which often took more than 3 dials). Visitors should be given the opportunity to play more if they should choose to do so, but if the receiver is not lifted the content in Call mode cannot be accessed.

Recommendations:

Visitors should be allowed to play, but visitors can't miss out on Call mode content.

- Increase the length of Play mode to allow for more dialling, with the intent that by the time the receiver prompt appears they will be content to move on in the activity.
- Add more general content to Play mode in case the visitors do not make it into Call mode to ensure they can still get the main messages of the activity.

Were the Learning Outcomes achieved?

Visitors were able to physically interact with the dial, and understand how to operate a rotary dial. Many visitors mentioned the history of phones and that it was interesting to see "how phones used to work" (Families, F, 12). To this extent, some of the Learning Outcomes were achieved. However, the content included in this prototype was not very robust, and testing was more focused on actual usability as opposed to whether or not visitors were absorbing content.

Not enough visitors noticed the looked past the interactive to the actual artefact, and neither did visitors grasp the concepts of pulse dialling. These Learning Outcomes were not achieved.

Methodology

We used qualitative methods to determine the overall usability of the exhibit, as well as more in depth information about how the visitor responded to the content.

On Thursday March 29th, Friday March 30th, and Saturday April 1st, interviewees were asked to use the exhibit under observation, during which time we observed and recorded their behaviour (where their eyes were, if they were reading, on which parts of the interactive they focused, group communication, etc.). Following this, visitors were interviewed. Most Families were interviewed during the busy Saturday, and all of the IA's were interviewed on Thursday and Friday.

Audience Distribution

- 15 Independent Adults
    - 6 alone, 9 couples, total of 24 individuals
- 15 Families (with children aged 11+)
    - Average group size 3, 42 total individuals

Prototype 2 (P2)

Prototype 2 (P2) Design

The most important changes for the team to make to the second version of the prototype were to find ways to encourage more visitors to engage with the actual Strowger phone. To this end, images of the phone were included on the screen during the interaction with the goal of giving the visitor a clear reference as to what the exhibit was actually about. The team also removed any use of the word 'Strowger' from the activity because visitors focused on the word itself without knowing what it actually referred to. Content videos were created to replace the placeholder slides from the previous iteration of the prototype. These videos were made long enough to give visitors enough time to look at the picture on screen, read the text, and look at the object all before the next section of content appeared.

As previously mentioned, the team knew that the start button was not an optimal design element due to the fact that it forced visitors to press it in order to start the activity. Therefore, the team replaced the start button from P1 with the option to either move the rotary dial or lift the receiver to start the activity. Moving the dial would lead to Play Mode, while lifting the receiver would take the visitor to Call Mode. A short video providing context about the phone played prior to the start of the mode no matter which action the visitor took.

The team restructured Play Mode for P2 because during P1 testing visitors did not seem to be absorbing the content presented in that section of the activity. More explicit instructions were added to Play Mode that would help visitors to focus on the screen at the appropriate times and read the "fun facts" that were displayed on the screen. The on screen elements of P2's Play Mode were also introduced more gradually, as opposed to P1 presenting all the screen elements to the visitor straight away.

Call Mode remained mostly the same as P1, except for the fact that the phonebook was digitized so that visitors would not be distracted by a physical phonebook too early in the activity. The phonebook now only appeared on screen when it was needed. The placeholder videos from P1 were also expanded into slideshows that presented visitors with some content.

The team also added some sound effects to the activity, both in Play Mode and Call Mode, which played from a speaker that the team placed in the receiver as well as an external speaker. The receiver was also painted black to match the Bakelite on the original Strowger phone. Both of these steps were intended to make the activity more immersive (i.e. give visitors a closer experience to using an actual Strowger phone).

P2 Evaluation Strategy

This evaluation, as in P1, guided our evaluation of our second Prototype.

Background to the Research and Development Project:

The Rotary Phone Digital/Physical Prototype Exhibit is a prototype exhibit intended for use in the upcoming Making of Modern Communication gallery (2014). Our aim is to increase awareness about certain complexities of the phone (the technical aspects of the rotary dial, the intricacy of early networks, etc.).

This prototype employs a digital interpretation of a physical interaction to demonstrate certain features of the Strowger Telephone. Not only will this prototype test usability concepts for this particular exhibit, but also for combination digital/physical exhibits throughout the Museum.

It is going to be tested next to the actual object (Strowger Telephone) in the existing Telecommunications Gallery on the 1st floor.

Purpose of the Evaluation:

The Worcester Polytechnic Institute Project Team will be using this P2 evaluation to test usability of changes made to the P1 design, analyze whether or not the content presented conveys the main concepts of the interactive, and to determine whether or not a structured interaction is the best way to convey content as opposed to unstructured interaction.

The aims of this prototype evaluation are:

- **Usability**
    - Are visitors able to navigate through the interactive and follow the on screen instructions?
    - Can visitors use the digitized version of the phonebook?
    - Do visitors know how to start the interaction?
- **Motivation**
    - Do visitors seem engaged?
    - Are visitors interested enough to look for available content?
    - Does interacting with the exhibit and finding out about the real object provide an enjoyable experience?
- **Interpretation**
    - Do visitors understand the purpose of the interaction is to explain the importance of the Strowger phone and the technical aspects of the dial itself?
    - Can they recognize that the exhibit refers to the Strowger phone?
    - Do visitors understand the main content of the activity?

The objectives of the evaluation are:

- To determine if the interactive is intuitive and easy to use
    - Do visitors start the interaction successfully?

- Is the pacing appropriate as in does it allow the visitor to look at the object and to receive all the information provided by the activity?
  - Interview about pacing of content delivery
  - Observe pacing of transition between digital/physical
- Is the digital phonebook easy to use?

- To gauge whether visitors are picking up on the main messages and content for the exhibit
  - Did visitors notice the exhibit was about the Strowger phone and the introduction of the dial?
  - Did visitors grasp the connection between rotary dials and automatic exchanges?
  - Do the visitors know about the technical aspects of the dial, the early working of exchanges, basic pulse theory, and the physical dial?
  - Do they appreciate the difference between rotary phone and modern ones?
- To determine if a more structured interaction in Play Mode flows better
  - Did the visitors absorb content about pulse dialling?
  - Did they dial when prompted?
  - Did they dial the correct number of digits at the correct time whether it is one at a time in Play Mode or 5 random or guided digits in the Call Mode?
- To see if a successful interaction with the actual object can be realized
  - Determine if visitors notice the content provided
  - Observe if visitors notice object at "good times"
  - Did adding structure to the Play Mode help convey content better.
  - Observe if/when visitors look/interact with object.

Target Audience:

1. Independent Adults
2. Families with children 11+ years of age

Time Table of Work

Start P2 Evaluation: Saturday, April 14th, 2012

End of Evaluation: Tuesday, April 17th, 2012

2. Observation and Interview of Independent Adults, and Families to be conducted during this time

Methodology

We will use qualitative methods to determine the overall usability of the exhibit, as well as more in depth information about how the visitor responds to the content.

- Interviewees will be asked to use the exhibit under observation, during which time we will observe and record their behaviour. Following this, visitors will be interviewed.
- Audience Distribution (30 individuals or groups Total)
    - 15 Independent Adults
    - 15 Families (with children aged 11+)

P2 Report

Executive Summary

Figure 5: Prototype 2

This activity employs a digital interpretation of a physical interaction to demonstrate and highlight certain features of a Strowger telephone (in particular the mechanism of dialling). The exhibit was made up of an abstract physical model of a telephone (using an authentic rotary dial, and a fabricated receiver), and a computer screen (as shown in the above photo). The activity was split into two main interactions: Play mode and Call mode. In Play mode, an on screen prompt instructs visitors to dial a digit then an animation plays and facts about the mechanisms of the rotary dial are displayed. In Call mode, an on screen prompt instructs visitors to dial a five-digit number, and a corresponding video conveying content plays (about the mechanisms of the dial, or the importance of the dial).

In this **second prototype**, many visitors did not notice the actual object, and focused too heavily on interacting with the interactive exhibit (playing with the dial, watching the screen, etc.). This means that there is not enough focus on the object itself, and that attention needs to be shifted from the interactive to the object. Despite this barrier, visitors appeared to be grasping some of the content presented (mechanism of dialling, importance of the dial with respect to automatic exchanges,

technical aspects of dialling), as well as better understanding of the purpose and use of a rotary dial.

Key Findings

Less than half of visitors (12/26 of the groups) noticed the actual phone, on display behind the exhibit, during the activity.

- During observations of the activity the digital element overshadowed the actual object, and as a result more than half of visitors did not actually notice the object in the case during the activity. Interviews confirmed this. Of the 12 that did notice the object, nearly all were observed to notice the object when an image of the phone was displayed on the screen at some point in the activity.
    - This implies the digital interaction is overshadowing the actual object.

Most visitors had a basic understanding of the content, but only about half of visitors grasped content about the mechanisms of dialling and almost no visitors got the main content messages about the importance of the dial.

- Slightly less than half of visitors (11/26) began to broadly grasp content about the mechanisms of dialling, but almost no visitors (1/26) appreciated the importance of the dial in relation to automatic exchanges. When interviewed about the overall theme of the exhibit, visitors responded with discussions about the mechanics of dialling: "As you dialled it was making circuits to join selectors" (IA, M, 20-30), for example. Only one visitor made the connection to automatic exchanges and grasped the importance of the introduction of the dial, however.
    - This means the importance of the dial is not being highlighted enough and visitors do not comprehend content at a deep level.

Play mode encouraged good engagement with both physically using the dial and interacting with instructions on screen, but most visitors did not fully grasp content about the mechanisms of dialling.

- Visitors were observed to read on screen instructions and carry out instructions by physically dialling when prompted. However, when interviewed visitors did not seem to fully grasp the content presented in Play mode.
    - This suggests that the explicit instructions to dial were clear, but also that presenting visitors with instructions and information simultaneously can prevent comprehension of content.

6/13 Independent Adults and 3/13 Families were observed to be confused by the phonebook (did not notice it on the screen and needed to be prompted, asked us for help, etc.).

- Visitors were observed to read the instruction to dial from the phonebook, and then have trouble locating the phonebook on the screen. During interviews, visitors confirmed that they had trouble finding the phonebook, and also understanding its purpose and use.
    - This shows the phonebook is confusing, and preventing visitors from accessing vital content in Call mode.

Key Recommendation

As less than half of visitors (12/26) noticed the actual phone on display during the activity, it would be wise to highlight the object more in proceeding prototypes. This could be achieved by:

1. Use lighting in the case to light the phone and attract attention at various appropriate points in the activity.
2. Use arrows on screen to direct attention to the object in the case behind the exhibit.
3. Show an image of the entire case, with the object itself highlighted specifically to draw focus in from the case as a whole to the specific object.

As about half of visitors only had a basic understanding of the content, the mechanisms of dialling need to be better explained and highlighted, and visitors need to be aware of the importance of the dial and understand the reason for its existence. This could be achieved by:

1. Clearly discuss the mechanics of dialling in Play mode:
    a. Include more specific content about how pulses are generated.
    b. Briefly discuss the purpose of the dial in relation to automatic exchanges.
2. Include content that specifically highlights the importance of the dial.
    a. Highlight the difference between human operators and automatic exchanges.
    b. Explicitly mention that the dial is necessary to use automatic exchanges.

Play mode encouraged good engagement with both physically using the dial and interacting with instructions on screen, but failed to engage visitors with the content. The explicit instruction to dial one digit at a time worked, but content needs to be separated from this instruction. This could be achieved by:

1. Leave the explicit instruction to dial a single digit the same for P3, as it was successful in improving Play mode.
2. Separate the content from the call to action:
    i. Present the content after the visitor dials a digit.
    ii. Present the instruction to dial again after the content has been displayed to allow the visitor time to read it.
3. Apply this explicit instruction to the introductory video to encourage visitors to dial a single digit at the start of the activity so that visitors do not dial during the video and skip it.

As 6/13 IA's and 3/13 Families were observed to be confused by the phonebook (did not notice it on the screen and needed to be prompted, asked us for help, etc.). The phone numbers to dial and the names of the videos need

to be presented in a clear, readable and concise manner, and the phonebook itself needs to be more delineated from the rest of the on screen graphics.

This could be achieved by:

1. Arrows need to point directly to the text to better indicate the location of the phonebook.
2. Put a border around the edge of the phonebook to differentiate it from the rest of the screen.
3. The text needs to be clear to increase readability.
4. Arrange the phone numbers and video titles side by side to more clearly indicate that the number is intended to be dialled and the test is relates to the video corresponding to that number.
5. Avoid having a call to action on screen at the same time as information:
    a. Display the instruction to dial from the phonebook
    b. Then introduce the actual phonebook with a pop-up or a fade in

Introduction

The Rotary Phone Digital/Physical Prototype Exhibit is intended for use in the upcoming Making of Modern Communication gallery due for opening in 2014. Our aim with this exhibit is to increase awareness about certain complexities of the internal mechanics of the phone (the technical aspects of the rotary dial, the intricacy of early networks, etc.), and convey the significance of the Strowger phone.

This prototype explores digital interpretation of a physical interaction to demonstrate certain aspects of the object on display (the Strowger phone in this case). This P2 exhibit allowed us to test visitor comprehension of content, as well as some of the usability that was altered from P1. This also provided us the ability to further test viability of combination digital/physical exhibits at the Science Museum.

The interactive exhibit was tested next to the actual object (Strowger Telephone) in the existing Telecommunications Gallery on the 1st floor.

Aims and Objectives

The aims of this prototype evaluation are:

- **Usability**
    - Are visitors able to navigate through the interactive and follow the on screen instructions?
    - Can visitors use the digitized version of the phonebook?
    - Do visitors know how to start the interaction?
- **Motivation**
    - Do visitors seem engaged?
    - Are visitors interested enough to look for available content?
    - Does interacting with the exhibit and finding out about the real object provide an enjoyable experience?
- **Interpretation**
    - Do visitors understand the purpose of the interaction is to explain the importance of the Strowger phone and the technical aspects of the dial itself?
    - Can they recognize that the exhibit refers to the Strowger phone?
    - Do visitors understand the main content of the activity?

The objectives of the evaluation are:

- To determine if the interactive is intuitive and easy to use
    - Do visitors start the interaction successfully?
    - Is the pacing appropriate as in does it allow the visitor to look at the object and to receive all the information provided by the activity?
        - Interview about pacing of content delivery
        - Observe pacing of transition between digital/physical
    - Is the digital phonebook easy to use?

- To gauge whether visitors are picking up on the main messages and content for the exhibit
    - Did visitors notice the exhibit was about the Strowger phone and the introduction of the dial?
    - Did visitors grasp the connection between rotary dials and automatic exchanges?
    - Do the visitors know about the technical aspects of the dial, the early working of exchanges, basic pulse theory, and the physical dial?
    - Do they appreciate the difference between rotary phone and modern ones?
- To determine if a more structured interaction in Play Mode is more successful than that of P1 (both in terms of usability and content comprehension).
    - Did the visitors absorb content about the mechanical aspects of dialling?
    - Did they dial when prompted?
    - Did they dial the correct number of digits at the correct time whether it is one at a time in Play Mode or 5 random or guided digits in the Call Mode?
- To see if a successful interaction with the actual object can be realised
    - Determine if visitors notice the object in the case
    - Observe if visitors notice object at "good times" during the activity
        - For example, when an image of the object is present on screen, or during a pause on a content video
    - Observe if/when visitors look/interact with object.

The intended Learning Outcomes of this exhibit are:

- Skills
    - Be able to discuss how a dial telephone works and was used.
- Attitudes and Values

- Appreciation of the difference between phones then and now.

- Enjoyment, Inspiration, Curiosity
  - Encourage curiosity about the introduction of the dial telephone/mechanism.
  - Inspire visitors to examine the actual object more closely.
- Knowledge and Understanding
  - Appreciation for the importance of the dial on the Strowger phone in relation to its introduction, how it works, and how it's used.
  - Learn that early networks used automatic exchanges, which required a rotary dial.
  - Understand specific technical aspects of using a rotary dial:
    - Learn that the rotary dial on the Strowger phone sends electric pulses to indicate which digit has just been dialled.
    - Learn that the physical dial completes a circuit when it is released that emits electrical pulses.

Findings

Noticing the Object

Less than half of visitors (12/26) noticed the actual phone, on display behind the exhibit, during the activity. The activity appeared to overshadow the actual object, and as a result just over half of visitors did not actually notice the object in the case during the activity.

When interviewed, visitors mentioned that they were "focusing too much on the activity" (IA, M, 20-30), or "focused on these two," (IA, M, 20-30) motioning to the dial and screen. Three Families also stated during the interview that they were "focused on the screen" (Family, F, 15), (Family, F, 16), and (Family, M, 13). Visitors were regularly observed to focus only on the screen and dial (12/13 IA's and 12/13 Families were observed to look at the screen or dial during the introduction video, and 12/13 IA's and 12/13 Families in Play mode), and not look at the object itself

during this part of the activity. With more than half of visitors not actually noticing the object during the activity, the activity failed to highlight the object, and visitors did not have full engagement with the object.

One visitor specifically was observed to look at the Strowger phone during the introduction video, and when interviewed claimed he did not notice the actual object and "saw it on the screen but not in the case," and that he was "too focused on the screen" (IA, M, 30-40), despite having actually looked at the object earlier in the activity. This is another strong sign that the activity is overshadowing the actual object.

Recommendations:

As less than half of visitors (12/26) noticed the actual phone on display during the activity, it would be wise to highlight the object more in proceeding prototypes. This could be achieved by:

1. Use lighting in the case to light the phone and attract attention at various appropriate points in the activity.
2. Use arrows on screen to direct attention to the object in the case behind the exhibit.
3. Show an image of the entire case, with the object itself highlighted specifically to draw focus in from the case as a whole to the specific object.

The 5/26 visitors that noticed the phone during the activity were observed to notice it in the case when an image of the phone was on screen. Images of the phone were used on screen at various parts of the interaction, but there was no discernable pattern to when visitors noticed the phone. These images were both full photographs of the object, and zoomed in images of a Strowger phone's dial. When interviewed, these visitors cited an on screen reference to the phone as the reason they noticed the phone in the case: "The pictures of it" (Family, M, 10), "There was a picture at the beginning" (Family, F, 16)**,** "During the 'How do I dial' video" (IA, M,

30-40). This means the use of actual images of the phone on screen during the activity was helpful in recognizing the object, at least for these five visitors.

Recommendations:

Visual images of the object helped visitors to recognize the object.

1. Continue using visual images in P3, as it was mildly successful in helping visitors recognize the object.
    a. When highlighting specific pieces of the object (dial, receiver, etc) use authentic photographs of the object.
    b. Use full images of the object on screen when possible.
2. Draw attention to the images on screen, and mention explicitly that these pictures reference an object in the case.
3. Use visual references to the actual phone as frequently as possible (e.g. don't use an image of a generic dial; use an image of the dial from the Strowger phone).

Visitors did not fully grasp the main messages and content for the exhibit.

Slightly less than half of visitors (11/26) began to understand the mechanisms of dialling from the available content of the activity. When interviewed about the overall theme of the exhibit, it appeared that some visitors were somewhat familiar with the concept that a rotary dial sends pulses to an exchange to indicate which number has been dialled. For example, some visitors said: "well it's about how a phone works, the dial produces pulses for each digit which travels down the line to the exchange and connects you to another phone" (IA, M, 60+), or "what happens when you don't let the dial turn all the way back" (Family, F, 15),

This was the primary content presented in Play mode, and was reinforced by the videos in Call mode. However, visitors missed content present in both Play and Call mode that talks specifically about the mechanics of dialling (for example, that metallic levers create a circuit to generate a pulse). This implies that visitors are

absorbing content from throughout the activity about the mechanisms of dialling, but that this content is not being conveyed at a deep enough level.

Recommendations:

The mechanisms of dialling need to be better explained and highlighted.

1. Clearly discuss the mechanics of dialling in Play mode:
    a. Include more specific content about how pulses are generated.
    b. Briefly discuss the purpose of the dial in relation to automatic exchanges.

Visitors did not appreciate the importance of the dial in relation to automatic exchanges. Only one visitor explicitly mentioned the importance of the dial: "This [phone] was the first one with a dial; it changed how we communicate" (IA, M, 30-40). However, 25/26 visitors missed one of the fundamental goals of the exhibit, which was to highlight the importance of the rotary dial.

Recommendations:

Visitors need to be aware of the importance of the dial, and understand the reason for its existence.

1. Include content that specifically highlights the importance of the dial.
    a. Highlight the difference between human operators and automatic exchanges.
    b. Explicitly mention that the dial is necessary to use automatic exchanges.

Many visitors (18/26) appreciated the difference of phones then and now. This means that the activity highlights some differences between modern phones and rotary phones and, through use of the rotary dial, visitors gain an appreciation of how different it was to physically dial on a rotary phone. When asked what the activity was about, visitors would respond with "[It's about the] evolution of old phones to current phones" (IA, M, 20 – 30), or "how [this one] works versus a cell

phone" (IA, M, 20 – 30). One visitor remarked that it was good to remind people "there was something before buttons" (IA, M, 20 – 30). This shows a rudimentary level of comprehension of the material, but also that visitors are still missing more detailed concepts of the mechanisms of dialling.

Recommendations

Visitors need to continue to comprehend and retain this content.

1. The physical use of the dial was crucial to achieving this, and a physical dial should still be employed.
2. Make the information memorable enough to be recalled later by the visitor.
3. The continued use of black-and-white period photographs will better highlight the historical context of the dial.

Usability and Comprehension of Content in Call Mode and Play Mode

Play Mode

Play mode encouraged good engagement with both physically using the dial and interacting with instructions on screen, but visitors did not fully grasp the content embedded in this section of the activity. Visitors were observed to read the on screen instructions and carry them out by physically dialling when appropriate. However, when interviewed visitors did not seem to fully grasp the content presented in Play mode.

All visitors were observed to dial more than once, with 5/13 IA's and 4/13 Families explicitly citing the on screen instructions as the reason they dialled more than once, implying that the call to action to "dial again" on screen was clear. Also, 11/13 IA's and 9/13 Families dialled only when prompted on screen, one digit at a time. Those that did not, (2/13 IA's and 4/13 Families) dialled many digits repeatedly during Play mode, as opposed to dialling one digit at a time. These visitors only very seldom looked up at the screen, and thus missed the instructions to dial only once.

This suggests that the explicit instruction to "dial one digit" was clear and the use of the word "digit" was successful in actually getting visitors to dial only one digit at a time. Also, the on screen prompt to "dial another digit" was clear and understood as a call to action by visitors that were actually interacting with the screen.

The content in this mode was absorbed by visitors, but not very deeply. As stated earlier, slightly less than half of visitors discussed the mechanics of dialling, while only one visitor mentioned the importance of the dial during the interview. This implies that the content in Play mode was not conveyed deeply. While visitors could discuss how a telephone works and was used, visitors did not fully understand the concept that a rotary dial on the Strowger phone sends electric pulses to indicate which digit has been dialled. The lack of comprehension here may be due to the fact that information and instructions are present on the screen at the same time – content about the mechanics of the dial appear at the same time as an instruction to dial again. The implications of this finding are that the instructions are clear and understandable, but that visitors miss content due to being presented with instructions and information simultaneously.

Recommendations:

The explicit instruction to dial one digit at a time worked and was clear, but content needs to be separated from this instruction.

1. Leave this the same for P3, as it was successful in improving Play mode.
2. Separate the content from the call to action:
    i. Present the content after the visitor dials a digit.
    ii. Present the instruction to dial again after the content has been displayed to allow the visitor time to read it.
3. Apply this explicit instruction to the introductory video to generate a similar effect.

Play mode is in danger of becoming repetitive, which is reducing engagement for a few visitors. While only one visitor explicitly stated that this was a problem, a

few other visitors (3/13 IA's, 3/13 Families) appeared unengaged during Play mode, indicating Play mode may be in danger of become repetitive or uninteresting.
One visitor was noticeably irritated during play mode, and complained that he "had to dial too many times" (IA, M, 60+), and another complaining that the "section at the beginning seemed repetitive" (IA, M, 20 – 30). Conversely, Play mode was long enough to allow enough time for children to learn how to dial properly. It was observed in two Families tested that parents provided scaffolding for children that were dialling for the first time (Family, M, 12), (Family, F, 16). A shortened Play mode may not provide enough time for this communication and scaffolding to occur. This needs to be tested more thoroughly, but is definitely something worth noting.

Recommendations:

The visitor needs to be engaged in all of Play mode.

1. Reduce the number of dials in Play mode before shifting to Call mode.

Call Mode

The content presented in the "Why do I have to wait so long before dialling the next number?" video was absorbed well by visitors. Of the 22 visitors (11/13 IA's and 11/13 Families) that watched the "Why do I have to wait so long before dialling another number?" video, 13 visitors commented that this particular video taught them something interesting, and could relay what that information was, in their own words. For example, one Family stated in an interview that the video was about "If you stop [the dial] before it spins round it sends a different number" (Family, M, 11). This video contained an interesting and memorable fact about dialling presented in an approachable manner. This was evident in the response of visitors when asked if they found anything new or surprising:

- "[I] didn't know it dialled when you let go" (IA, F, 30-40)
- "[You must] allow the dial to spin back" (Family, M, 14)
- "You need to finish dialling"(Family, M, 12)

From this video, visitors were able to grasp the concept that the physical dial completes a circuit when it is released that sends electric pulses, which was a Learning Outcome of P2.

Recommendations:

This video was successful at conveying content.

1. The content from this video should be left the same for P3, as it was comprehended and memorable for visitors.

Usability

Almost all visitors (25/26) correctly started the activity by dialling, rather than by picking up the receiver. Only one visitor (IA, M, 20-30) lifted the receiver first. However, he was then observed to dial immediately after. No visitors interviewed claimed to have trouble with actually starting the activity. This means that either the instructions to dial were clear, or that the act of dialling a rotary dial is intuitive and easy to grasp, allowing visitors to begin the activity.

Recommendations:

This worked well.

1. Leave this the same in P3, as it was a successful start to the activity.

6/13 IA's and 3/13 Families were observed to be confused by the phonebook (did not notice it on the screen and needed to be prompted, asked us for help, etc.). All 9 of these visitors cited the phonebook as a source of confusion when interviewed. For example, one of these visitors mentioned that they "didn't know how to use the phonebook" (IA, M, 30-40), and another said they "didn't know where it was" (Family, M, 12). Visitors were also observed to be confused (did not know how to use the phonebook, for example) when given the instruction to dial a number from the phonebook, and sometimes (4/13 IA's and 1/13 Families) asked for assistance in dialling. The on screen arrow directing visitors to the phonebook pointed to the left off screen, instead of at the phonebook on screen. This confused

at least one visitor that was searching for a physical phonebook off screen ("I was looking for an actual Yellow Pages" (Family, M, 12)) and was changed after the first day of testing (see figure 1). The arrow was angled upwards to more clearly point to the phonebook on the screen. Following this change, 3/13 IA's and 1/9 Families across the second two days of testing mentioned the phonebook as a source of confusion when interviewed.

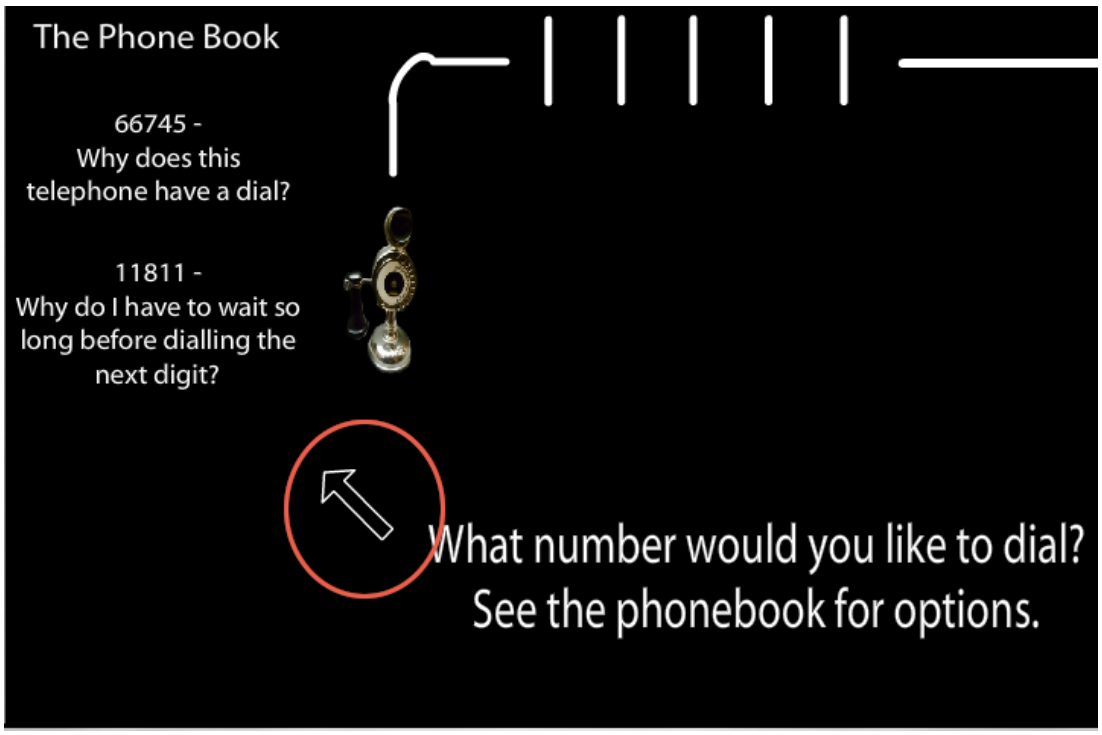

Figure 6: The Phonebook with turned arrow

The arrangement of the text was also confusing, and the phonebook itself was not obvious enough. As a result, visitors were confused about the concept of the phonebook (its actual location, how to use it, what its purpose was, etc.) By not using this phonebook correctly (if visitors) do not properly dial the numbers in the phonebook), visitors will not be able to access the content contained within the videos in Call mode, and will miss a large portion of the activity.

<u>Recommendations:</u>

The phone numbers to dial and the names of the videos need to be presented in a clear, readable and concise manner, and the phonebook itself needs to be more delineated from the rest of the on screen graphics.

1. Arrows need to point directly to the text to better indicate the location of the phonebook.
2. Put a border around the edge of the phonebook to differentiate it from the rest of the screen.
3. The text needs to be clear to increase readability.
4. Arrange the phone numbers and video titles side by side to more clearly indicate that the number is intended to be dialled and the test is relates to the video corresponding to that number.

Almost a third of visitors missed the introductory video because they dialled repeatedly at the start of the activity, causing the video to end and move the visitors to Play mode. 3/13 IA's and 6/13 Families were observed to dial through the introductory video. This means that their attention was not shifting well between physical dial and digital screen as it was in Play mode; the focus was entirely on the dial instead of balanced between the dial and the screen. The consequences of this were that visitors missed/didn't watch the introduction video, and were not given context for the activity. This context would introduce visitors to the importance of the Strowger phone, and provide history about why a rotary dial was needed at all. Once visitors started looking at the screen and reading instructions, however, the balance was much better throughout the activity, suggesting that the on screen instructions were clearer once Play mode began. Visitors that missed the introduction video missed an important opportunity to appreciate the necessity and importance of the rotary dial.

<u>Recommendations:</u>

Visitors need to view the introductory video to provide context for the activity.

1. A more explicit instruction of "dial one digit" worked very well in Play mode, and should be applied here.

Visitor reaction to the use of sound effects in the activity was mixed. 7/26 visitors stated in interviews that they wanted more sound, in the activity, while a few complained that the sound was irritating. The majority of visitors did not comment on the sound at all.

The sound effects in the activity were observed to increase communication for at least one family: when dialling a number, one of the visitors in the group mentioned "Oh, someone's answering" (Family, M, 12) when they heard the ringing sound in the receiver. During a video describing the automatic exchange, the same visitor mentioned that it "[sounds] like that big thing around the corner" (referencing the automatic exchange in the telecommunications gallery). However, one Family mentioned during the interview that the "sound [was] quite annoying". Additionally, a visitor was observed to be quite startled, and actually jumped when the first sound effect played in the receiver. During the interview, this visitor mentioned that "the noises were surprising" (IA, F, 50-60). This implies that the use of sound effects could be used to encourage curiosity about the object itself, and about the gallery as a whole, but that sounds can take from the activity for visitors if they are too loud or sudden. If a visitor is distracted by sounds, they will not be able to focus on the activity and absorb the content.

As mentioned earlier, during interviews 7/26 visitors mentioned wanting more sound in the activity. One visitor mentioned that it was "difficult to read the text and look at the pictures" (IA, M, 30-40), and added that a narration of the text would have been helpful. Two Families added that "more sound would be interesting" (Family, M, 12), (Family, F, 15), commenting that more sound would lead to a more immersive experience. Visitors did not have a specific recommendation for sounds outside of adding voice-overs or narration for the text when probed further.

<u>Recommendations:</u>

Sounds were helpful in increasing engagement and curiosity, but annoyed or surprised some visitors. Sounds need

1. Sounds need to be checked for volume so to ensure they are not too loud.
2. Sounds need to be used more consistently so that they are not startling.
3. Consider adding more sound for increased immersion:
    a. Adding narrations to the receiver sound during videos.
    b. Adding background noise where appropriate (i.e. sounds of exchanges, sounds of pulse dialling, etc.).

The black receiver caused brief confusion for some visitors. For P2 testing, the receiver was painted black (this was the only change made to the receiver from P1 testing). 1/13 IA's and 2/13 Families were observed to have difficulty locating the receiver, or did not realize what the receiver was (visitors were observed to point to the receiver and ask what it was). When prompted to lift the receiver during the activity, one visitor pointed to the receiver and asked "is this it?" (IA, M, 20-30). A Family interviewed commented that the "receiver was a bit strange" (Family, F, 14) in appearance, and another Family claimed they "didn't know where the receiver was" (Family, F, 13). Visitors that do not locate and lift the receiver will not be able to enter Call mode, and will miss a very large portion of the activity.

<u>Recommendations:</u>

The receiver needs to be more noticeable and obvious

1. Paint the receiver white, this worked previously in P1 testing.

Were the Learning Outcomes achieved?

Very few visitors came to the conclusion that the rotary dial on the Strowger phone sends electric pulses to indicate which digit has just been dialled. This exhibit was missing a content video in Call mode, which was intended to provide this knowledge, and so visitors were prevented from being introduced to this content.

Most visitors that used this exhibit were able to discuss how a dial telephone works and were used. Also, many visitors appreciated the difference between phones and now, and half of the visitors interviewed learned that the physical dial completes a circuit when it is released that emits electrical pulses.

More than half of visitors did not notice the object, and thus the activity failed to highlight the actual object enough. This failed to inspire visitors to examine the actual object more closely. Additionally, only a very small number of visitors gained an appreciation for the importance of the dial on the Strowger phone in relation to its introduction, how it works, and how it's used.

Methodology

We used qualitative methods to determine the overall usability of the exhibit, as well as more in depth information about how the visitor responded to the content.

On Saturday April 14th, Monday April 16th, and Tuesday April 17th, interviewees were asked to use the exhibit under observation, during which time we observed and recorded their behaviour (where their eyes were, if they were reading, on which parts of the interactive they focused, group communication, etc.). Following this, visitors were interviewed. Most Families were interviewed during the busy Saturday, and all of the IA's were interviewed on Thursday and Friday.

Audience Distribution

- 13 Independent Adults
    - 6 alone, 7 couples, total of 20 individuals
- 13 Families (with children aged 11+)
    - Average group size 3, 40 total individuals

Prototype 3 (P3)

This is the collected recommendations for the design of P3 as well as an outline of the interaction journey. The recommendations have been taken from the findings that emerged from testing P2. The actual design is left to the museum to implement since the team does not have time to create a new iteration of the prototype.

Design

Physical design

The physical design of the prototype worked well, and should mostly be kept the same, except for two points.

First, the receiver should be painted white to match the rest of the prototype. Painting the receiver white would also keep the model abstract from the actual Strowger phone, which will encourage the visitor to look at the actual object to see features pointed out in the content. Additionally, some visitors had trouble finding the black receiver in P2. This problem did not happen in P1, which had a white receiver. Other possible solutions to this issue would be to explicitly point out the location of the receiver in the digital interaction, or change the placement of the receiver so it is more obvious.

Second, the current dial should be replaced with a larger one so that it is easier to use than the current dial. While this was not an issue during P1 and P2 testing, a few visitors suggested that a larger dial would be easier for children to use.-

Introductory video

1) The main problem with the introductory video was that some visitors dialled multiple times at the welcome screen and therefore accidentally skipped the introductory video. To remedy this, the welcome screen that plays once the visitor has approached the exhibit should have an explicit instruction to dial one digit, which would take the visitor straight to the introductory video. This instruction worked well in Play mode, and so should be similarly effective here.

2) The introductory video would be a good point during the activity to direct the visitor's attention to the actual object. Therefore, the introductory video should show an image of the entire case with the Strowger phone clearly highlighted.

3) Make it so that once activated nothing can interfere with the intro video and the visitor has to watch it all the way through. The intro video should provide feedback (perhaps in the form of sound effects or some small animation on the screen) when the dial is turned but the intro video must be watched by the visitor. Visitors that miss the intro video will miss the majority of the context for the exhibit and likely have difficulty engaging with the object and/or realizing the main concepts of the exhibit.

Play mode

Play mode allows visitors to dial any digits they wanted, while displaying an animation showing that the rotary dial sends out a number of electric pulses corresponding to the digit the visitor dialled. Every time a visitor dials a digit a fact about how the dial operates appears, as well as an instruction to dial another digit. Once the visitor has dialled four digits they are prompted to pick up the receiver and enter Call mode.

Play mode was successful in encouraging visitors to physically engage with the dial. Visitors were also observed to dial just one digit at a time and lift the receiver when prompted, showing that the instructions in Play mode were also effective and should be kept for P3.

Visitors did not grasp the content at a deep enough level during Play mode, and could only discuss the mechanisms of dialling at a very broad and basic level. This is due to information and instruction being presented simultaneously on screen. In Play mode, visitors are instructed to dial a digit, and then are presented with content and the instruction to dial another digit. Visitors would almost always dial another digit, but would only very rarely actually absorb the content.

One solution to these problems would be to insert a pause between the fun facts appearing in Play mode and the instruction to dial again, or to stagger the text in such a way that the visitor has time to absorb the information before reading another instruction. Another solution would be to only display the dialling instruction once. Visitors also mentioned that Play mode was somewhat repetitive, which can be fixed by reducing the number of times the visitor is asked to dial before the prompt to pick up the receiver appears.

Call mode

- Most visitors did not pick up on the importance of the rotary dial in relation to the automatic exchange. This relationship should be explicitly mentioned, and the differences between automatic exchanges and human operators should be highlighted in the content videos.
- The other problem visitors had with Call mode was that some had difficulty finding the on screen phonebook. The solution to this is to clearly

differentiate the phonebook from the rest of the screen by putting a border around the edge. The content of the phonebook itself can also be improved by placing the phone numbers and the question their videos answer side by side to clearly indicate that the numbers are intended to be dialled and that the text relates to the number.

- In order to make this section more active, the content videos could pause, and the content could periodically be replaced with calls to action, which would demonstrate the content the video is trying to convey, e.g. the video explaining that visitors need to let the dial spin back would pause to ask visitors to try and interrupt the dial and see what happens.

Sound

Overall, visitors responded favourably to the inclusion of sound in the interaction. The most obvious improvements in this regard would be to add more sounds, such as narration during content videos and background noise where appropriate, as using sound consistently prevents visitors from being startled. Volume should also be equal across all the sounds to ensure that they are not too loud.

Interaction Journey

The general flow of interactions is as follows: Initially, an animation welcomes the visitor, and instructs them to "dial a digit." At this point the visitor can choose to either dial as instructed, or lift the receiver. No matter what action the visitor takes, a brief introductory video plays that provides context about the exhibit and discusses the importance of the phone. Once the intro video finishes the visitor is again instructed to dial a digit. This is the beginning of Play mode.

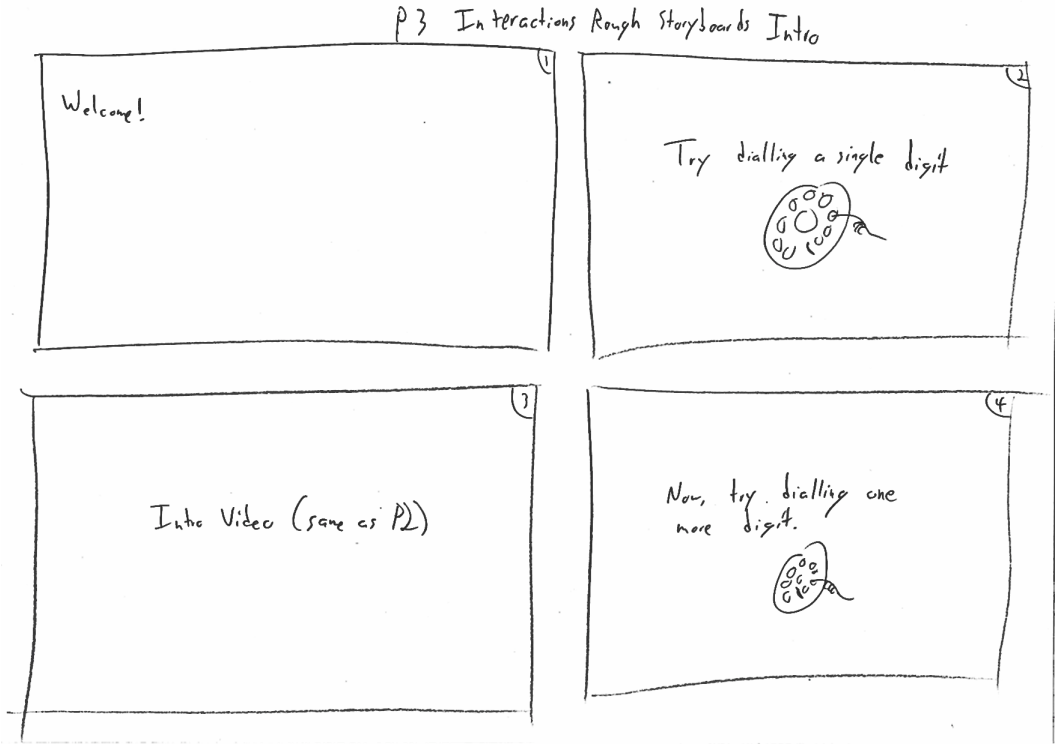

Figure 7: Interaction Rough Storyboard Intro

If the visitor does decide to dial a digit a pipeline going around the outside of the screen appears, as well as a representation of the dial. Once these elements are in place another instruction to dial a digit is displayed on the screen. At this point the visitor can dial any digit they like. This will cause the representation of the dial on the screen to send out a number of pulses equal to the digit the visitor dialled. These pulses travel into the pipeline, which then displays the digit the visitor dialled at the other end. For example, if the user dials '4,' four pulses leave the dial and enter the pipeline, which then displays the number '4' at the other end. This is intended to represent how pulse dialling works. Another thing that happens every time a visitor dials is that a 'fun fact' appears on the screen. These 'fun facts' are meant to inform the visitor about the mechanism of dialling. After a pause to give visitors time to read the facts, another instruction to dial a digit is displayed on the screen.

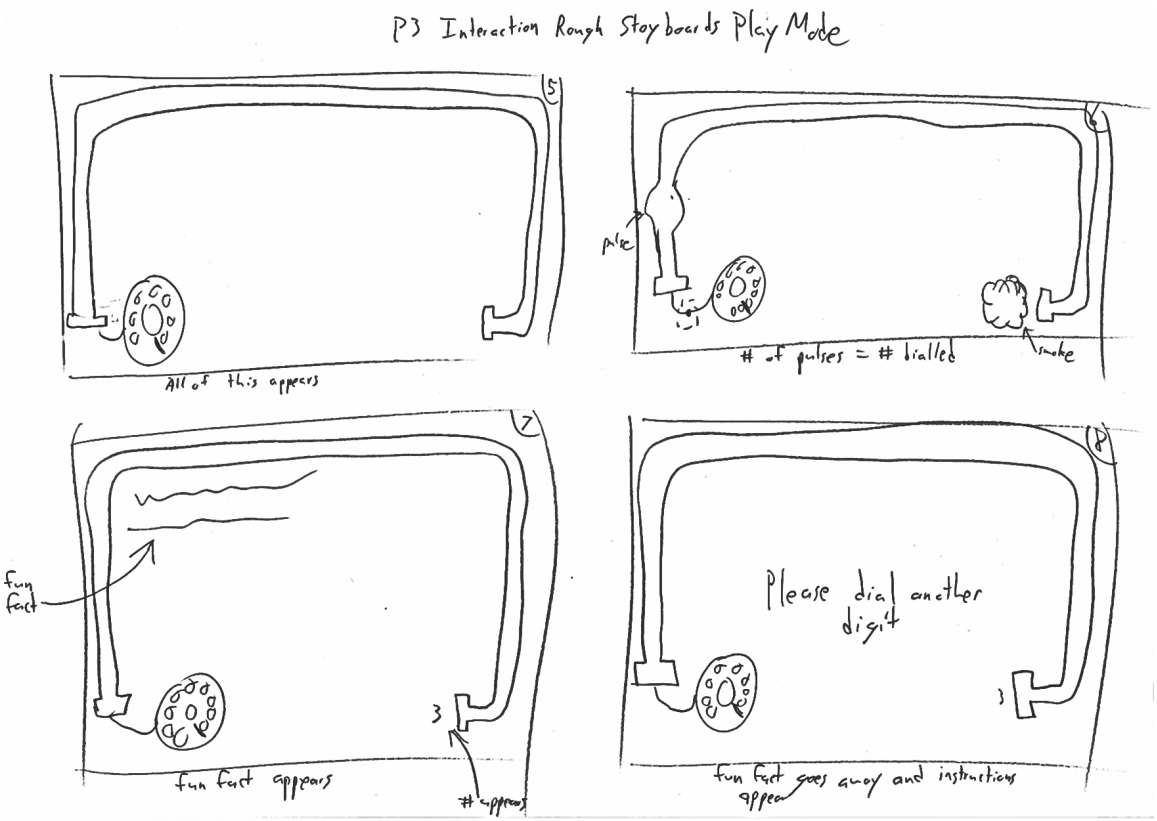

Figure 8: Interaction Rough Storyboard Play Mode

Once the visitor has dialled four digits, a prompt to pick up the receiver appears on the screen, instead of the instruction to dial again. If the visitor picks up the receiver a video plays that explains what happens in the Strowger phone when its receiver is lifted. If the visitor started the interaction by lifting the receiver, the prompt to pick up the receiver does not appear. Instead, the video plays after a pause long enough to allow the visitor to read the current 'fun fact.' Once the video finishes playing the exhibit enters Call mode.

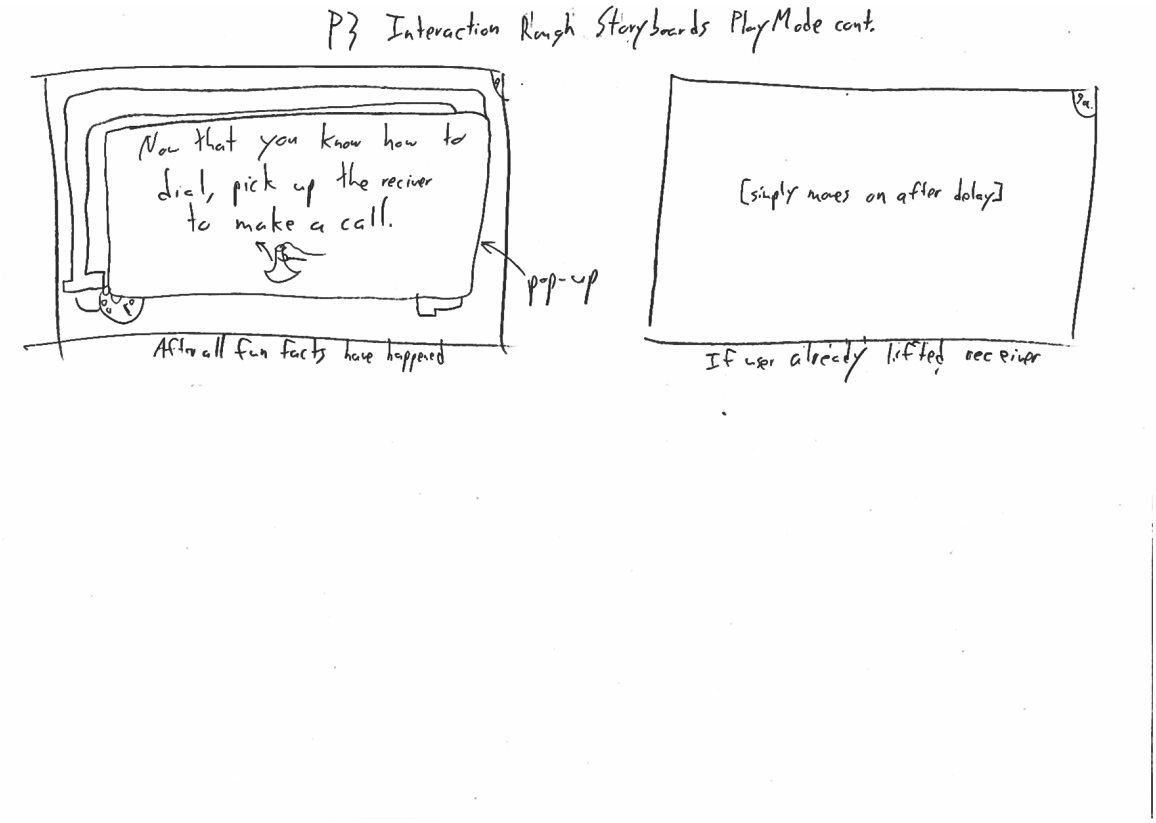

Figure 9: Interaction Rough Storyboard Play Mode Cont.

At the start of Call mode, visitors are instructed to dial any five-digit number. As the visitor dials, an animation plays on the screen representing how an automatic exchange connects their call. They are then shown a video about how automatic exchanges connected phone calls. A phonebook then appears on screen, along with a prompt to choose a number to dial. These numbers are associated with content videos, and are all labelled with a question (for example, "Why does this phone have a dial?").

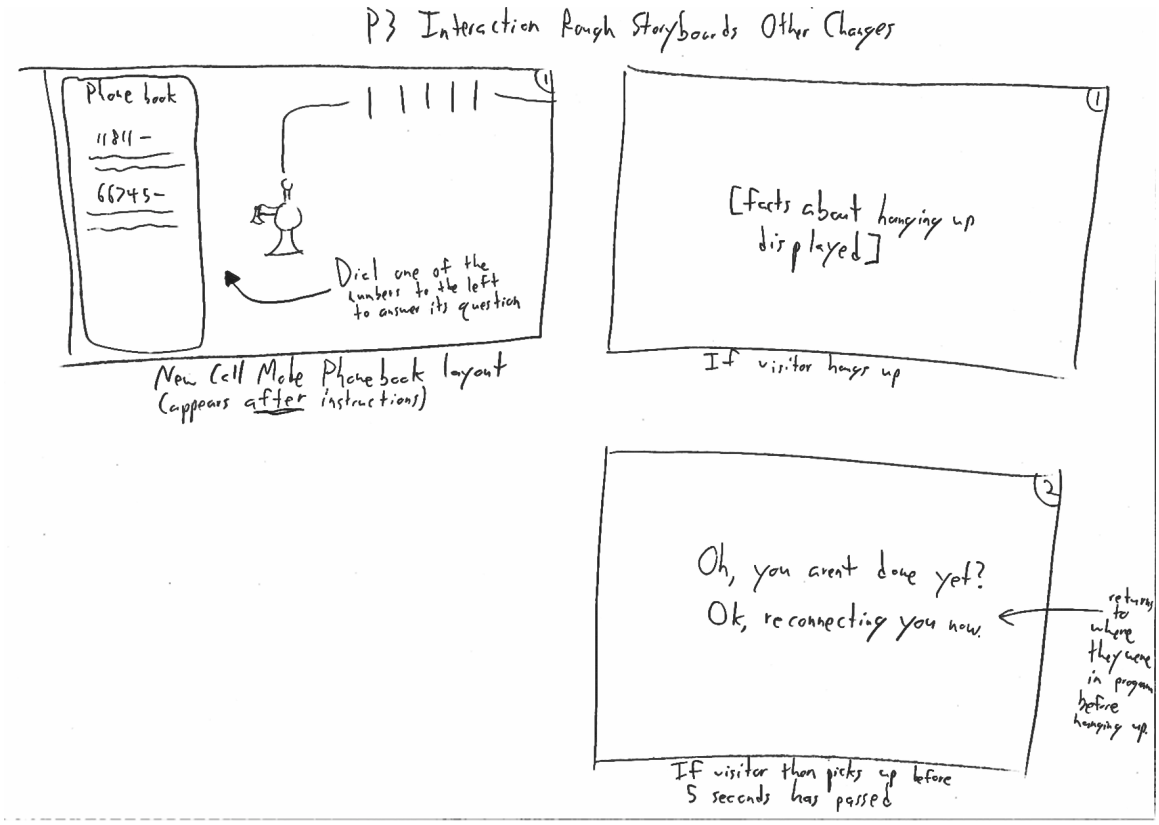

Figure 10: Interaction Rough Storyboard Other Changes

As the visitor dials a number the animation showing the operation of automatic exchanges plays again. Once the number has been completed, either the corresponding video plays, or, if a wrong number was dialled, a message is displayed indicating the video does not exist. The visitor can then choose to dial again, or to end the interaction by hanging up the receiver. The visitor could also choose to hang up the receiver at any point during the interaction.

Hanging up the receiver causes another video to play, detailing what happens in the Strowger phone once its receiver is put back on the hook. If the receiver is picked back up less than five seconds before it was put down, the visitor returns to wherever they were in Call mode before they hung up.

A graphical representation of this interaction journey can be found in Appendix M.

NOTE:

The reason for having the visitor go through Play mode regardless of whether they start by lifting the receiver or dialling is so that every visitor goes through the same interactions and is exposed to the same content. This was chosen by the group as a simple method to force visitors to proceed through the interaction and view all content as intended, but the group is worried that it may be too linear an interaction (not allowing visitors to use the exhibit in the way they wish)

An alternative to this is to have Call mode display the same fun facts as Play mode when the visitor is dialling the first five-digit number. Call mode could also show the animation of the dial sending out pulses. Essentially, if visitors are allowed to miss Play mode then that content needs to be conveyed in Call mode as well. However, there is trouble here as well, as visitors may end up seeing the same content twice.

These are the only two methods that our group was able to come up with for restructuring the interaction. Testing and evaluation will need to be performed before the group can say which the correct path is.

Conclusions and Recommendations

Evaluation of the prototype exhibit has led to conclusions about physical/digital exhibits as a whole. Research has shown that these exhibits have potential to convey content and highlight an object, but that barriers exist to their implementation. Along with the design principles (Appendix W) developed by the group during this project, the group identified and outlined the potential for and major barriers to success of these exhibits.

During testing, visitors showed an increased understanding and appreciation of the mechanical aspects of the dial. This implies that visitors understood the content at a basic level, and shows that physical/digital exhibits can be successful at conveying content and meaning. However, the majority of visitors across both iterations of testing did not notice the object in the case. This implies that the interaction overshadowed the object in the case instead of highlighting it. Also, very few visitors absorbed content about the mechanism of dialling during Play mode of the activity. As discussed in the P2 report, the group believes this was due to the fact that content was digitally presented alongside instructions on screen. The failure of this interaction implies that information and instructions cannot be presented simultaneously, as visitors will not be able to absorb both at the same time.

To address these barriers in future exhibits, this project group recommends restructuring the interaction to ensure that all digital interactions are digital interpretations of physical interactions, that the exhibit makes references to the object within the activity to encourage visitor engagement with the object, using abstraction of both the physical shape of the object, and recommends that instructions and information be kept separate during the activity.

Digital interpretations of physical interactions

A successful physical/digital exhibit will digitally interpret a physical interaction that one might have with the object. This is the most important finding in this document. The

reason for a physical/digital exhibit is to exploit the strengths of digital interactions to provide additional information and context beyond the edges of a physical interaction. This is an important distinction to make. The digital interaction must *interpret* the physical interaction. Similarly, the physical interaction must drive the digital interpretation. At no time should the physical simply be a stepping stone to the digital, but the digital should enhance the physical and create a deeper understanding of the physical interaction, and in turn the object itself. The exhibit must be structured in such a way that the physical interaction leads directly into the information conveyed on screen, and that on screen information should augment understanding of the physical interaction.

Visitors can intuitively learn by doing, and physical/digital exhibits should capitalize on this by using a computer screen to provide contextual information about the physical interaction throughout the course of the activity, and build upon the concepts laid down by the physical interaction. This is a fundamental principle of physical/digital exhibits and it distinguishes them from simply being information kiosks. A physical/digital exhibit should not simply allow access to information by pressing a button, pulling a lever, or spinning a wheel; a successful physical/digital exhibit will provide a digital interpretation of exactly what happens when the button is pressed, the lever is pulled, or the wheel is spun, thereby augmenting understanding of the physical action to a point not possible otherwise.

Focusing on the object

The aim of the sections above was to highlight barriers and discuss methods to avoid them in the hopes of increasing visitor engagement with both the exhibit and the object. While the above sections outline general recommendations that this group believes to be essential to the success of all physical/digital exhibits, it is worth noting explicitly here that the most important method of visitor engagement is highlighting the object as much as possible. Testing showed that roughly half of visitors noticed the Strowger phone during the prototype activity, meaning that much more needs to be done to guide visitor attention to the object in that particular exhibit. Abstraction and separation of

interactions are important, but the object itself must be highlighted as much as possible to ensure visitor engagement.

The recommendations for P3 suggest new methods to attempt to highlight the object, and indeed these methods apply to physical/digital exhibits as a whole. The object needs to be highlighted in the activity itself, through the use of on screen imagery, abstract textual references, and an abstract physical model. More importantly, however, the object needs to be distinguished from other objects in the gallery. Visitors need to know where to look for the object, and how to find it on gallery. This could be done with lighting effects to highlight the object on gallery when it is referenced in the activity, and by directing visitor attention to the object during the activity with explicit instructions on screen ("The actual object is located over there on gallery" with an arrow pointing to the location, for example). More research is needed to determine the best method for highlighting the object, and it may be that those methods differ for each physical/digital exhibit. This group can state conclusively from research outlined in this report, though, that the actual object needs to be highlighted as much as possible during the activity to ensure visitor engagement with the object.

Also, the interaction needs to be structured in such a way to encourage the visitor to engage with the actual object. Abstraction (as mentioned earlier) of the physical is an excellent method to achieve this. By using an abstract physical model, visitors may notice that the actual object (due to an image on screen, or by noticing it in the gallery) is different from the physical model with which they are interacting. A visitor that is able to make this distinction, or considers the real object in this way, is actually engaging with the real object. A successful physical/digital exhibit will be structured in this way, and cause the visitor to think critically about the physical nature of the actual object.

Abstraction

Abstraction (both visual and textual) in an activity is important. An abstract physical model of an object, for example, will require the visitor to use the actual object as a point of reference. Abstraction shifts attention from the activity to the object itself – if all of

the information about the object were contained within the activity, there would be no need for the actual object at all.

Abstraction helps shift visitor attention to the actual object, but must be used carefully. A physical model must be abstract enough to not distract from the object, but not so abstract that a visitor cannot determine what object it represents. The model must be able to mimic the physical interaction (physically dialling in the case of this project) but not serve as a replica of the original object.

For physical abstraction of the Strowger telephone, for example, this group constructed a plain white box with a rotary dial and receiver attached. Visitors knew that it was a model of a telephone because of the dial and receiver, but due to the general nature of the design of the model are still forced to wonder which phone is being represented, as well as the significance of the telephone being represented. The activity itself should then aim to answer these questions, and direct the visitor's attention past the abstract model to the actual object. The physical model should not be an exact replica of the object itself. Were this the case, the visitor would have absolutely no motivation nor reason to ever look past the model to the object.

Similarly, textual references to the object on screen must be careful not to mention the object by name, but must be obvious enough descriptions so that the visitor realizes which object the activity references. Abstraction must convey the significance of the object by hinting at the object.

When making abstract references through text on screen, testing revealed it is best to reference the object by its importance and meaning. During P1 testing, for example, the object was referenced on screen by its name "Strowger". When interviewed, visitors would often mention that the exhibit was about "Strowger" without any indication that they comprehended what the word actually represented. For P2, the group removed any explicit mention of the word "Strowger" from the interaction. Visitors did not mention

"Strowger" during interviews in P2 evaluation, but appeared to have a more solid understanding of the underlying concepts the exhibit hoped to convey.

As opposed to using the actual name of the object, consider the reason the object is important, and use those reasons to refer to the object. Following with the same example, one might refer to the dial telephone as "one of the first dial telephones" or "a dial telephone that changed communication forever" so that visitors still need to use the actual object as a reference point.

It is important to note however that visual images of the object on screen are effective in increasing engagement with the actual object, so long as references are to the actual object, and not the images on screen.

Separation of interactions

Testing revealed that interactions must be clearly defined and clearly delineated. Visitors interacting with an activity are capable of absorbing one piece of information at a time, and so interactions must be carefully planned so that only one piece of information is conveyed. "Interactions" here refers to one of two things: a call to action, or information conveyance. A call to action is an instruction to perform some action ("push a button", "spin the wheel", "dial a digit", etc.). Information conveyance involves delivering some form of content to the visitor. A call to action and information conveyance must never occur at the same time during an activity. Testing revealed that when both of these occur at the same time, the visitor will either absorb information, or follow an instruction; only very rarely did both occur. Frequently visitors would understand the content, but misinterpret the instructions, or miss the content entirely and only perform the instructed action. This observation implies that in order to effectively convey either content or a call to action, they must be kept separate.

A call to action must be very clear, to ensure that it is a singular event with a beginning and end. Continuing the telephone example, if the activity were to require interacting with the rotary dial to view content, visitors should be instructed to "dial a single digit"

instead of to "dial a number". The instruction to dial a number is very vague, and does not have a clear end. While some visitors may dial a single digit as intended, visitors may also interpret that as dialling a full phone number, and still others may just continue dialling indefinitely, completely unaware that content was present at all. The instruction to dial a single digit has a clear end: after dialling that single digit, the visitor will be forced to look at the screen for further instruction. This kind of clear instruction encourages shifting attention between physical and digital, and creates a better environment for delivering content.

Information must be kept separate for a call to action for the very same reason. If information is conveyed during a call to action, the information does not have time to sink in. Visitors will read the information, read the call to action, and then perform the action. The information by then has either been forgotten or become vague in the mind of the visitor. By separating the call to action from information, visitors have time to adjust their minds to a more receptive state, and actually engage in the content being delivered.

Conclusions

Physical/digital exhibits can be very effective means of interacting with and interpreting an object. There is great potential for visitors to gain a deep understanding of an object that cannot be achieved by simply displaying an object in a case, or even through interacting solely physically or solely digitally with representations of that object. A combination of both physical and digital affords a very comprehensive look at an object and can convey a wealth of information and understanding. However, these types of interactions must be structured very carefully: focus must remain on the object itself, and content must be conveyed in such a way that it is allowed to be absorbed by the visitor. Also, the activity must enhance a visitor's understanding of the actual object, not simply be entertaining. Most importantly, the exhibit should not only model an interaction with the real object, but interpret it as well. A successful physical/digital exhibit will both highlight the object, and provide deep understanding of the actual object by interpreting an interaction with it.

A major barrier exists in engaging visitors with the actual object itself. This project group was unable to determine an effective means to shift attention from the physical/digital interaction to the object, but makes suggestions in the P3 Recommendations section that will require further testing before being determined conclusive solutions to this barrier. When done properly, a digital interpretation of a physical interaction with an object allows insight and understanding not possible with any other kind of interaction or exhibit. These exhibits have clearly shown potential to be effective means of object interpretation, but more research is needed before it can be determined conclusively that the set of design goals (outlined in Appendix W) are sure to yield effective physical/digital exhibits.

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Appendices

Appendix A – Interaction Journeys

Contained herein are descriptions of the activities, as well as of the ideal visitor journey through the activity (P1, P2, and P3).

P1 Interaction Journey

The general flow of interactions is as follows: Initially, an animation welcomes the visitor, and instructs them to push the start button to begin. Following this, a brief introductory video is played, providing context for the exhibit and discussing the importance of the phone. At this time, visitors are prompted to try dialling for themselves (this is the beginning of Play mode).

During Play mode, visitors dial a number, and an on screen dial is shown sending pulses around the edge of the screen. Dialling "4" will send four pulses around the screen. This is intended to be representative of pulse dialling. Also during this time, brief "fun facts" are displayed on screen to educate the visitor about the technical aspects of dialling. After three dials, the visitor is prompted to lift the receiver (this starts Call mode).

When lifting the receiver, the visitor is shown a video detailing what happens in the Strowger phone when the receiver is lifted. Following this, visitors are instructed to dial any five digit number. As they dial, an animation the screen representing an automatic exchange connects their call. They are then shown a video about how automatic exchanges connected phone calls. Visitors are then prompted to choose a number from a nearby phonebook to dial. These numbers are associated with content videos, and are all labelled with a question ("How does it know what number I've dialled?" for example).

Upon dialling a number, either the corresponding video is played, or, if a wrong number was dialled, a message is displayed indicating the video does not exist. They can then choose to dial again, or to end the interaction.

P2 Interaction Journey

The general flow of interactions is as follows: Initially, an animation welcomes the visitor, and instructs them to turn the dial to begin. Following this, a brief introductory video is played, providing context for the exhibit and discussing the importance of the phone. At this time, visitors are prompted to try dialling for themselves (this is the beginning of Play mode).

During Play mode, visitors dial a number, and an on screen dial is shown sending pulses around the edge of the screen. For example, dialling "4" will send four pulses around the screen. This is intended to be representative of pulse dialling. Also during this time, brief "fun facts" are displayed on screen to educate the visitor about the mechanism of dialling. After several dials, the visitor is prompted to lift the receiver (this starts Call mode).

When lifting the receiver, the visitor is shown a video detailing what happens in the Strowger phone when the receiver is lifted. Following this, visitors are instructed to dial any five digit number. As they dial, an animation the screen representing an automatic exchange connects their call. They are then shown a video about how automatic exchanges connected phone calls. Visitors are then prompted to choose a number from an onscreen phonebook to dial. These numbers are associated with content videos, and are all labelled with a question ("Why does this phone have a dial?" for example).

Upon dialling a number, either the corresponding video is played, or, if a wrong number was dialled, a message is displayed indicating the video does not exist. They can then choose to dial again, or to end the interaction.

P3 Interaction Journey

The general flow of interactions is as follows: Initially, an animation welcomes the visitor, and instructs them to "dial a digit." At this point the visitor can choose to either dial as instructed, or lift the receiver. No matter what action the visitor takes, a brief introductory video plays that provides context about the exhibit and discusses the importance of the phone. Once the intro video finishes the visitor is again instructed to dial a digit. This is the beginning of Play Mode.

If the visitor does decide to dial a digit a pipeline going around the outside of the screen appears, as well as a representation of the dial. Once these elements are in place another instruction to dial a digit is displayed on the screen. At this point the visitor can dial any digit they like. This will cause the representation of the dial on the screen to send out a number of pulses equal to the digit the visitor dialled. These pulses travel into the pipeline, which then displays the digit the visitor dialled at the other end. For example, if the user dials '4,' four pulses leave the dial and enter the pipeline, which then displays the number '4' at the other end. This is intended to represent how pulse dialling works. Another thing that happens every time a visitor dials is that a 'fun fact' appears on the screen. These 'fun facts' are meant to inform the visitor about the mechanism of dialling. After a pause to give visitors time to read the facts, another instruction to dial a digit is displayed on the screen.

Once the visitor has dialled four digits, a prompt to pick up the receiver appears on the screen, instead of the instruction to dial again. If the visitor picks up the receiver a video plays that explains what happens in the Strowger phone when its receiver is lifted. If the visitor started the interaction by lifting the receiver, the prompt to pick up the receiver does not appear. Instead, the video plays after a pause long enough to allow the visitor to read the current 'fun fact.' Once the video finishes playing the exhibit enters Call Mode.

At the start of Call Mode, visitors are instructed to dial any five-digit number. As the visitor dials, an animation plays on the screen representing how an automatic exchange connects their call. They are then shown a video about how automatic exchanges connected phone calls. A phonebook then appears on screen, along with a prompt to choose a number to dial. These numbers are associated with content videos, and are all labelled with a question (for example, "Why does this phone have a dial?").

As the visitor dials a number the animation showing the operation of automatic exchanges plays again. Once the number has been completed, either the corresponding video plays, or, if a wrong number was dialled, a message is displayed indicating the video does not exist. The visitor can then choose to dial again, or to end the interaction by hanging up the receiver. The visitor could also choose to hang up the receiver at any point during the interaction.

Hanging up the receiver causes another video to play, detailing what happens in the Strowger phone once its receiver is put back on the hook. If the receiver is picked back up less than five seconds before it was put down, the visitor returns to wherever they were in Call Mode before they hung up.

Appendix B - Sponsor Summary, London Science Museum

The Science Museum, London has existed in some form or another for just about 150 years. Its history is rooted in the Crystal Palace built in Hyde Park for the Great Exhibition of 1851. Money from the success of the Crystal Palace allowed its patron to fund the South Kensington Museum, opening in 1857. While this museum is now a part of the Victoria and Albert Museum, the Science Museum became its own entity in 1909.

Initially it took some work to simply promote the idea of a museum dedicated solely to science, but thanks to campaigning from men such as Norman Lockyer the British government eventually asked for and helped develop this very museum. In the early days of the museum, everything operated very similarly to a typical museum of the period. Objects were displayed in static form behind glass, were only explained by labels, and often those explanations were often not comprehensible by the layman. However, the Science Museum intended to change that. As early as 1922, their goal was to put the "ordinary visitor" before experts. One major step towards that was the opening of the Children's Gallery in 1931. This gallery made use of interactive models that the children could play with to better learn about the objects. The museum also attempted to keep up with topics that mattered to their visitors by creating exhibits on current issues.

By 1963 the Science Museum had completed its Centre Block and began opening galleries in it floor by floor. These galleries covered topics such as transportation, time, astronomy, and surveying, all of which began to more widely use modern methods of displaying their content. It was also with these new galleries that the focus of the museum changed more to presenting scientifically significant artifacts in the context of the time and place of their origination. In 1986 the Science Museum opened Launch Pad, a gallery specifically meant for interactive experiences

to educate the visitors. It has proven extremely popular, even moving to a brand new location in 2007.

Political changes came in 1984 when the Science Museum and its sister museums came under the management of their own Board of Trustees under the name of the "National Museum of Science and Industry". Some of the most recent developments at the Science Museum include the opening of a series of exhibitions looking at the future of science and technology and a gallery called "Making the Modern World" opened in 2000.

Today the Science Museum is the most popular museum in the United Kingdom for science-related fields, welcoming over 2.7 million visitors every year. Table 1 shows some statistics about their visitors. Amazingly, the Science Museum only displays a mere 7% of their total collection at any given time (their total collection includes over 300,000 objects, with particular focus on the history of western science, technology and medicine since 1700). The popularity and scale of the Science Museum is part of the reason that engaging, interactive exhibits are so important. The museum spent over £1,000,000 in September 2011 alone on exhibit development and visitor studies.

Of their 2.3 million general visitors in 2010/11:
• 52% are male, 48% are female
• 34% are children aged 0-15, 66% are adults (aged 16+)
• 68% of visitors visit in a family group, 32% are independent adults
• 27% are overseas visitors, 73% are from the UK
• 44% come from London and the South East
• 99% of visitors enjoyed their visit and found it interesting
• 99% said that their visit was good value for money
• 99% say they would recommend the Museum to friends

- 94% would visit again
- 90% say that their visit brought science and technology alive for them
- 89% said they learnt something new during their visit

Ian Blatchford, who began his role as director in November 2010, currently directs the National Museum of Science and Industry (NMSI), the organization that includes the Science Museum. NMSI is run as a charity organization that is technically public, but it does not take its funding from the British government directly in any way. This has only been the case since the Science Museum and the rest reorganized under the NMSI title in 1984.

In our project we will work specifically with both the New Media and the Audience Research and Advocacy departments within the Science Museum. Our contact in New Media is Anne Prugnon, and our contact in Audience Research and Advocacy is Kayte McSweeney. The New Media department is concerned with incorporating modern technology and interactive elements into exhibits. We will be working the Audience Research department in order to judge the effectiveness of our exhibit in informing and educating the visitors on the topic we cover. As Kayte and Anne have told us during our most recent conference call, our exhibit will ultimately end up in a new gallery the Science Museum is opening in 2014 that will focus on communication technology over the ages.

Appendix C – Case Study

Contained herein is a brief summary of a summative evaluation performed of the Making of the Modern World gallery in the Science Museum.

Making of the Modern World Summative Evaluation

Jo Siems and Ben Gammon, 2001

Summary

The Making of the Modern World (MMw) exhibit incorporated hundreds of artifacts that contributed in some way to the development of society over the past two hundred years. A wide variety of objects ranging widely both in time and size were selected to guide visitors on a journey from the industrial age all the way up to modern day. A key piece of this gallery was an Apollo 10 capsule that actually travelled into space (this proved to be the most popular object in the gallery).

Findings

- Key sections of the exhibition were missed by visitors due to a non-linear structure
- Visitors felt the exhibition was aimed at adults rather than children
- Visitors felt the exhibition should contain objects that are more accessible, and there should be more working models
- Visitors felt the objects should be placed in context (including more about the people who built/used them)

Appendix D – P1 Families Observation and Interview Sheet

Contained herein is the Observation/Interview sheet used to collect raw data from Families in P1 testing and evaluation.

Families

Hello, my name is ____. I work with the Museum and am testing out a new exhibit. The exhibit is meant for older kids and adults, so everyone can have a go. We are testing just around the corner in the telecommunications gallery. It won't take more than 10-15 minutes, and your feedback will be really helpful! Would you like to give it a try?

When you get them to the prototype:

"I know this doesn't look amazing and it's certainly not anyway finished but that's why we want you to have a play and then after tell us what you think….."

No. **M / F** **Dwell time:** **Group Structure:** **Date:** **Time:** **Children's Ages:**	
Points to look for:	**Observations:**
First point of interaction: Know how to start? Y/N Button/Dial/Receiver/Touch the screen/Read phonebook Start successfully (push the button)? Y/N After welcome video: Know what to do? Y/N Dial/lift receiver	

Fun facts: Did they know how to dial? Y/N Do they seem confused? Y/N Did they dial only when prompted? Y/N What happens if not? Do they try dialling more than once? Y/N Appearance when facts were on screen: Confused / Bored / Distracted / Amused / Interested / Excited Lift the receiver when prompted? Y/N What happens if not?	Did they read the facts?
Calling: Did they know what to do? Notice the phonebook? Y/N What happens if not? Dial the numbers in the phone book? Y/N What happens if not? Watch the animation? Y/N (if group) Conversation? Y/N Held receiver entire time? Y/N Videos dialled: Hang up at the end? Y/N What happens if not?	When? Behaviour during animations:

Interview Questions – Families

Now that you've had a try, I'd like to ask you all a few questions about what you thought about this thing. Remember, this isn't a test. I'm not trying to see how much you know, I just really want to know what you thought about it. There are no right or wrong answers, and anything you tell us will be very helpful!

1. Now that you've gotten to try, what did you think?
    a. Prompt: What was your overall feeling?

Kid:

Parent:

2. Is there anything that you particularly liked about it?

    a. Probe: What was it about _____ that you really liked?

        i. Can you tell me more about that?

3. Is there anything you didn't like or didn't think worked for you?

    a. Probe: What was it about ____ that didn't work for you?

        i. Can you tell me more about that?

4. Did you find anything confusing during this activity?

    a. Probe: Can you tell me what was confusing?

    b. Probe: Is there anything we can do to make it less confusing?

Kid:

Parent:

5. What do you think this is all about?
    a. Prompt: What is it trying to tell you?

    b. Probe: What makes you say that?

6. This activity is all about the Strowger phone here on display – did you realize this while you were using it? Y/N

Probe:

    a. Yes – Can you tell me what the activity is telling you about the phone itself?

    b. No – Is there a reason you didn't notice the phone here on display?

7. Did you find out anything new or surprising?

    a. Probe: Could you tell me more about that?

8. When you were using this activity, you had to turn and move the dial here (point at dial). What do you think we were trying to show by having you use the dial?

    a. Probe: Can you tell me a bit more about that?

9. The dialling was meant to show you that the Strowger phone generates electric pulses to dial phone numbers. Did you pick up on this?

   Probe:
   a. Yes – Can you tell me what the activity is telling you about that?

   b. No – Is there a reason you didn't notice this?

10. You also had to use the receiver during this activity. How did you know how to use it?

    a. Probe: Where did you get this information from?

    b. Probe: Was there anything confusing or difficult about that?

11. How did you find using the phonebook on the side here (point to phonebook)?

    a. Probe: Where you clear on when to use it?

    b. Probe: Was there anything confusing or difficult about that?

12. After you dialled the number, you had to watch a little animation. What did you think of that?

    a. Probe: What was the video about (what was it trying to tell you)?

13. (at child) Do feel like this activity is right for you?

    a. (if at parents) What age group do you think it would suit best?

       i. Probe: Why do you think that?

b. (at child) Do you feel like you had to already know about phones and dials in order to have fun? Y/N

    i. Probe: Why do you think that?

14. What do you think could be done better?

    a. Probe: How would that be more helpful for you?

15. Anything else you would like to add?

Appendix E – P1 Independent Adults Observation and Interview Sheet

Contained herein is the Observation/Interview sheet used to collect raw data from Independent Adults in P1 testing and evaluation.

Independent Adults

Hello, my name is ____. I work with the Museum and am testing out a very early version of a new activity we are developing. We are testing just around the corner/over here in the telecommunications gallery. It won't take more than 10-15 minutes, and your feedback will be really helpful! Would you like to give it a try?

When you get them to the prototype:

"I know this doesn't look amazing and it's certainly not anyway finished but that's why we want you to have a play and then after tell us what you think….."

No. M / F Dwell time: Group Structure: alone/couple/ group **Ages: 16-20 / 20-30 / 30-40 / 40 -50/ 50 – 60 / 60+ Date: Time:**	
Points to look for:	**Observations:**
First point of interaction: Know how to start? Y/N Button/Dial/Receiver/Touch the screen/Read phonebook Start successfully (push the button)? Y/N After welcome video: Know what to do? Y/N Dial/lift receiver	

Fun facts: Did they know how to dial? Y/N Do they seem confused? Y/N Did they dial only when prompted? Y/N What happens if not? Do they try dialling more than once? Y/N Appearance when facts were on screen: Confused / Bored / Distracted / Amused / Interested / Excited Lift the receiver when prompted? Y/N What happens if not?	Did they read the facts?
Calling: Did they know what to do? Notice the phonebook? Y/N What happens if not? Dial the numbers in the phone book? Y/N What happens if not? Watch the animation? Y/N (if group) Conversation? Y/N Held receiver entire time? Y/N Videos dialled: Hang up at the end? Y/N What happens if not? Know it's finished?	When? Behaviour during animations:

Interview Questions – IA

Now that you've had a try, I'd like to ask you a few questions about what you thought about this thing. Remember, this isn't a test; I'm not trying to see how much you know about the object. I just really want your feedback and opinions. There are no right or wrong answers, and anything you tell us will be very useful!

1. Now that you've gotten to try, what did you think?
   Prompt: What was your overall impression?

2. Is there anything that you particularly liked about it?

   a. Probe: What was it about _____ that you really liked?
      i. Can you tell me more about that?

3. Is there anything you didn't like or didn't think worked for you?

   a. Probe: What was it about ____ that didn't work for you?
      i. Can you tell me more about that?

4. Did you find anything confusing during this activity?

   a. Probe: Can you tell me what was confusing for you?

   b. Probe: Is there anything we could do to make it less confusing?

5. What do you think this activity is all about?
   Prompt: What is it trying to tell you?

a. Probe: What makes you say that?

6. This activity is all about the Strowger phone here on display – did you realize this while you were using it? Y/N

   Probe:

   a. Yes – Can you tell me what the activity is telling you about the phone itself?

   b. No – Is there a reason you didn't notice the phone here on display?

7. Did you find out anything new or surprising?

   a. Probe: Could you tell me more about that?

8. When you were using this activity, you had to turn and move the dial here (point at dial). What do you think we were trying to show by having you use the dial?

   a. Probe: Can you tell me a bit more about that?

9. The dialling was meant to show you that the Strowger phone generates electric pulses to dial phone numbers. Did you pick up on this?

   Probe:

   a. Yes – Can you tell me what the activity is telling you about that?

   b. No – Is there a reason you didn't notice this?

10. You also had to use the receiver during this activity. How did you know how to use it?

    a. Probe: Where did you get this information from?

    b. Probe: Was there anything confusing or difficult about that?

11. How did you find using the phonebook on the side here (point to phonebook)?

    a. Probe: Where you clear when to use it?

    b. Probe: Was there anything confusing or difficult about that?

12. Which questions in the phonebook were you most interested in finding out about?

13. Who do feel this exhibit is most suitable for?

    Probe: Can you me a bit more about that?

    a. Probe: What age group do you think it would suit best?

        i. Why do you think that?

    b. Probe: Do you feel as though you need to have some pre-knowledge about the subject in order to enjoy this activity? Y/N

        i. Why do you think that?

14. What do you think could be done better?

a. Probe: How would that be more helpful for you?

15. Anything else you would like to add?

Appendix F – P2 Families Observation and Interview Sheet

Contained herein is the Observation/Interview sheet used to collect raw data from Families in P2 testing and evaluation.

Families

Recruitment:

Hello, my name is ____. I work with the Museum and am testing out a new exhibit. We are testing just around the corner in the telecommunications gallery. It won't take more than 10-15 minutes, and your feedback will be really helpful! Would you like to give it a try?

When you get them to the prototype:

"Here we are! I know this doesn't look amazing; it's still very early on in testing. That's why we'd like you to have a play and let us know what you think; your input will be very helpful!"

No. **M / F** **Dwell time:** **Group Structure:** **Date:** **Time:** **Children's Ages:**	
Points to look for:	**Observations:**
First point of interaction: Know how to start? Y/N Dial/Receiver/Touch the screen Read intro video? Look at phone during? Appearance during intro video: Confused / Bored / Distracted / Amused / Interested / Excited After intro video: Know what to do? Y/N Dial/receiver	At what times specifically do they look at the phone?

Play mode: Did they know how to dial? Y/N Do they seem confused? Y/N Did they dial only when prompted? Y/N What happens if not? Do they try dialling more than once? Y/N Did they read the facts? Y/N Appearance when facts were on screen: Confused / Bored / Distracted / Amused / Interested / Excited Look at the object during fun facts? Lift the receiver when prompted? Y/N What happens if not?	Comments about balance of attention between physical/digital:
Call mode: Did they know what to do? Dial the numbers in the phone book? Y/N What happens if not? Videos dialled: Read content during animation? Y/N (if group) Conversation? Y/N Reaction to content? Confused / Bored / Distracted / Amused / Interested / Excited Held receiver entire time? Y/N Hang up at the end? Y/N What happens if not? Know it's finished?	Did they go through play mode? Behaviour during animations(look at object?):

Interview Questions – Families

Now that you've had a try, I'd like to ask you all a few questions about what you thought about this thing. Remember, this isn't a test. I'm not trying to see how much you know, I just really want to know what you thought about it. There are no right or wrong answers, and anything you tell us will be very helpful!

1. Now that you've gotten to try, what did you think?

    a. Prompt: What was your overall feeling?

Kid:

Parent:

2. Did you find out anything new or surprising?

    a. Probe: Would you mind telling me a little more about that?

3. Is there anything that you particularly liked about it?

    a. Probe: What was it about ____ that you really liked?

        i. Can you tell me more about that?

4. Is there anything you didn't like or didn't think worked for you?

    a. Probe: What was it about ____ that didn't work for you?

        i. Can you tell me more about that?

5. Did you find anything in this activity confusing or difficult for you?

6. How did you feel about having to look between the screen and the dial?

    a. Probe: Was there anything difficult or confusing about that?

    b. Probe: Do you feel you missed anything by having to go back and forth?

7. What do you think this activity is all about?

    a. Prompt: What is it trying to tell you?

    b. Probe: What makes you say that?

8. One of the main things we wanted to highlight is the Strowger phone here on display – did you realize this while you were using it? Y/N

Probe:

   a. Yes – At what point in the activity did you notice the phone?

   b. No – Is there a reason you didn't notice the phone here on display?

9. What do you think we were trying to say in particular about the phone by presenting information the way we did in this exhibit?

   a. Probe: How do you feel about being able to actually interact with this model phone?

10. When you were using this activity, you had to turn and move the dial here (point at dial). What do you think we were trying to show by having you use the dial?

   a. Probe: Can you tell me a bit more about that?

11. The dialling was meant to show you how the rotary dial works mechanically. Did you pick up on this?

Probe:

a. Yes – Can you tell me what in the activity is telling you about that?

b. No – Is there a reason you didn't notice this?

12. How did you know to dial more than once?

a. Prompt: What caused you dial more than once?

b. Probe: Where did you get this information from?

Exchanges Video

13. What, if anything, do you think we were trying to tell you about early exchanges during this activity?

a. Probe: What makes you say that?

b. Probe: Could you tell me a little more about that?

How Dial Video (11811)

14. You watched a video about how to dial, what do you think the main message of this video was?

    a. Probe: Was there anything confusing in the video?

Why Dial Video (66745)

15. You watched a video about why this phone has a dial. If you had to explain it to a friend, what would you say it was all about?

    a. Probe: Was there anything confusing in the video?

16. Having watched all of this content, what do you think the overall message was that we were trying to get across?

    a. Probe: Can you tell me a little more about that?

17. What do you think could be done better?

    a. Probe: How would that be more helpful for you?

18. Anything else you would like to add?

Appendix G – P2 Independent Adult Observation and Interview Sheet

Contained herein is the Observation/Interview sheet used to collect raw data from Independent Adults in P2 testing and evaluation.

Independent Adults

Recruitment:

Hello, my name is ____. I work with the Museum and am testing out a new exhibit. We are testing just around the corner in the telecommunications gallery. It won't take more than 10-15 minutes, and your feedback will be really helpful! Would you like to give it a try?

When you get them to the prototype:

"Here we are! I know this doesn't look amazing; it's still very early on in testing. That's why we'd like you to have a play and let us know what you think; your input will be very helpful!"

No. M / F Dwell time: Group Structure: alone/couple **Ages: 16-20 / 20-30 / 30-40 / 40 -50/ 50 – 60 / 60+ Date: Time:**	
Points to look for:	**Observations:**
First point of interaction: Know how to start? Y/N Dial/Receiver/Touch the screen Read intro video? Look at phone during? Appearance during intro video: Confused / Bored / Distracted / Amused / Interested / Excited After intro video: Know what to do? Y/N Dial/receiver	At what times specifically do they look at the phone?

Play mode: Did they know how to dial? Y/N Do they seem confused? Y/N Did they dial only when prompted? Y/N What happens if not? Do they try dialling more than once? Y/N Did they read the facts? Y/N Appearance when facts were on screen: Confused / Bored / Distracted / Amused / Interested / Excited Look at the object during fun facts? Lift the receiver when prompted? Y/N What happens if not?	Comments about balance of attention between physical/digital:
Call mode: Did they know what to do? Dial the numbers in the phone book? Y/N What happens if not? Videos dialled: Read content during animation? Y/N (if group) Conversation? Y/N Reaction to content? Confused / Bored / Distracted / Amused / Interested / Excited Held receiver entire time? Y/N Hang up at the end? Y/N What happens if not? Know it's finished?	Did they go through play mode? Behaviour during animations(look at object?):

Interview Questions – IA

Now that you've had a try, I'd like to ask you a few questions about what you thought about this thing. Remember, this isn't a test; I'm not trying to see how much you know, or what you remember. I just really want your feedback and opinions. There are no right or wrong answers, and anything you tell us will be very useful!

1. Now that you've gotten to try, what did you think?
    a. Prompt: What was your overall impression?

2. Did you find out anything new or surprising?

    a. Probe: Would you mind telling me a little more about that?

3. Is there anything that you particularly liked about it?

    a. Probe: What was it about _____ that you really liked?

        i. Can you tell me more about that?

4. Is there anything you didn't like or didn't think worked for you?

    a. Probe: What was it about ____ that didn't work for you?

i. Can you tell me more about that?

5. Did you find anything in this activity confusing or difficult for you?

6. How did you feel about having to look between the screen and the dial?

   a. Probe: Was there anything difficult or confusing about that?

   b. Probe: Do you feel you missed anything by having to go back and forth?

7. What do you think this activity is all about?

   a. Prompt: What is it trying to tell you?

   b. Probe: What makes you say that?

8. One of the main things we wanted to highlight is the Strowger phone here on display – did you realize this while you were using it? Y/N

Probe:

a. Yes – At what point in the activity did you notice the phone?

b. No – Is there a reason you didn't notice the phone here on display?

9. What do you think we were trying to say in particular about the phone by presenting information the way we did in this exhibit?

   a. Probe: How do you feel about being able to actually interact with this model phone?

10. When you were using this activity, you had to turn and move the dial here (point at dial). What do you think we were trying to show by having you use the dial?

    a. Probe: Can you tell me a bit more about that?

11. The dialling was meant to show you how the rotary dial works mechanically. Did you pick up on this?

Probe:

a. Yes – Can you tell me what in the activity is telling you about that?

b. No – Is there a reason you didn't notice this?

12. How did you know to dial more than once?

    a. Prompt: What caused you dial more than once?

    b. Probe: Where did you get this information from?

Exchanges Video

13. What, if anything, do you think we were trying to tell you about early exchanges during this activity?

    a. Probe: What makes you say that?

    b. Probe: Could you tell me a little more about that?

How Dial Video (11811)

14. You watched a video about how to dial, what do you think the main message of this video was?

    a. Probe: Was there anything confusing in the video?

Why Dial Video (66745)

15. You watched a video about why this phone has a dial. If you had to explain it to a friend, what would you say it was all about?

a. Probe: Was there anything confusing in the video?

16. Having watched all of this content, what do you think the overall message was that we were trying to get across?

a. Probe: Can you tell me a little more about that?

17. What do you think could be done better?

a. Probe: How would that be more helpful for you?

18. Anything else you would like to add?

Appendix H – Screenshots of Content

Contained herein are screen captures taken from the digital portion of the activity to provide points of reference when reviewing the project.

Welcome Screen:

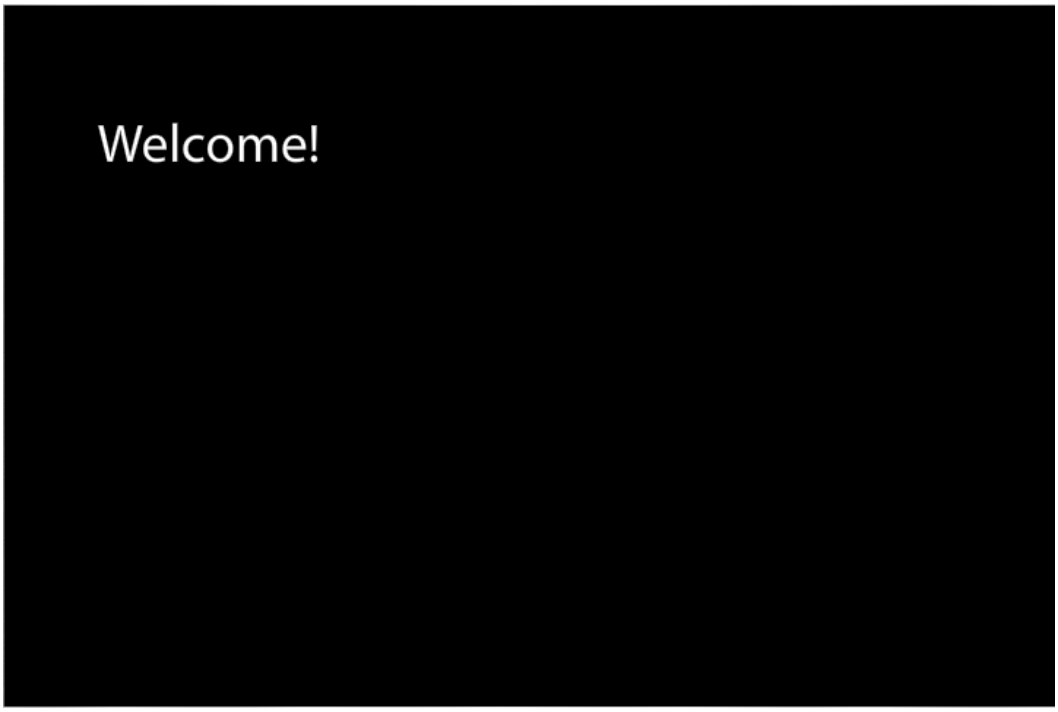


Figure 11: Welcome Screen Slide 1

Figure 12: Welcome Screen Slide 2

Intro Video:

Figure 13: Intro Slide 1

Figure 14: Intro Slide 2

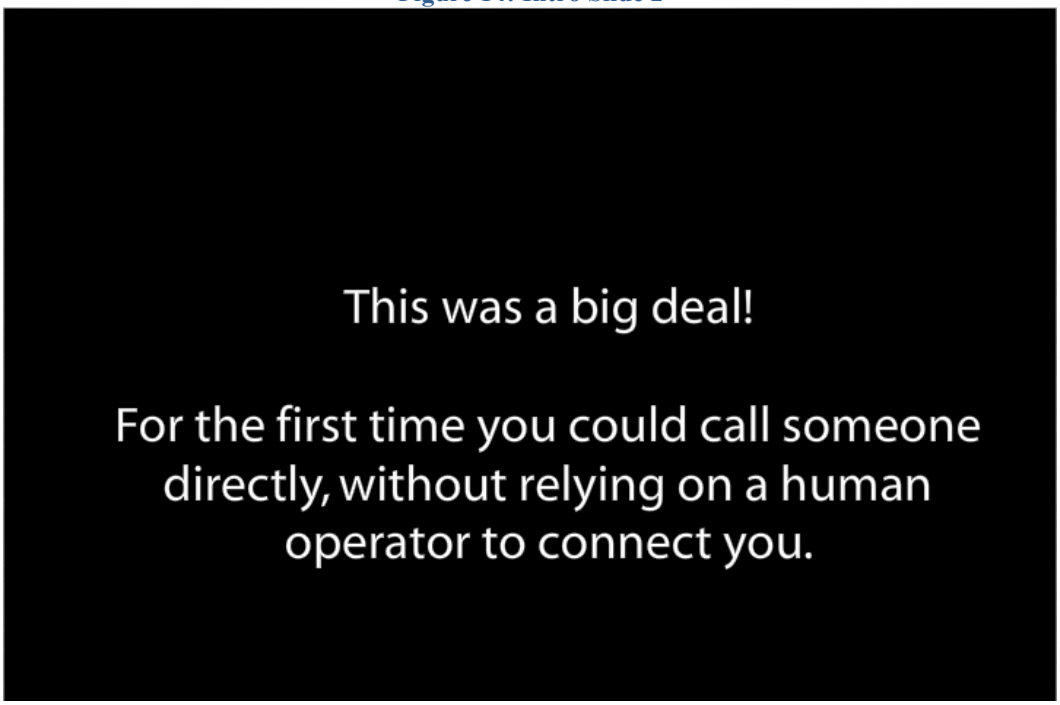


Figure 15: Intro Slide 3

Try Dialling:

Figure 16: Try Dialling Prompt

Receiver Info:

Figure 17: Exchange Slide 1

Figure 18: Exchange Slide 2

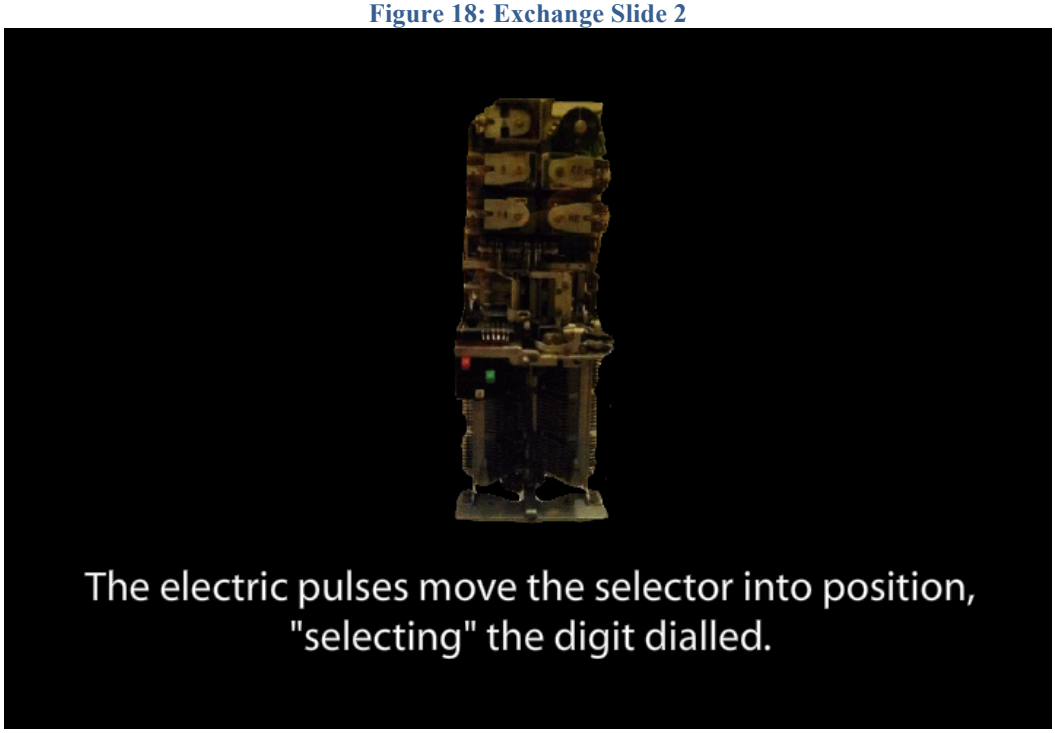


Figure 19: Exchange Slide 3

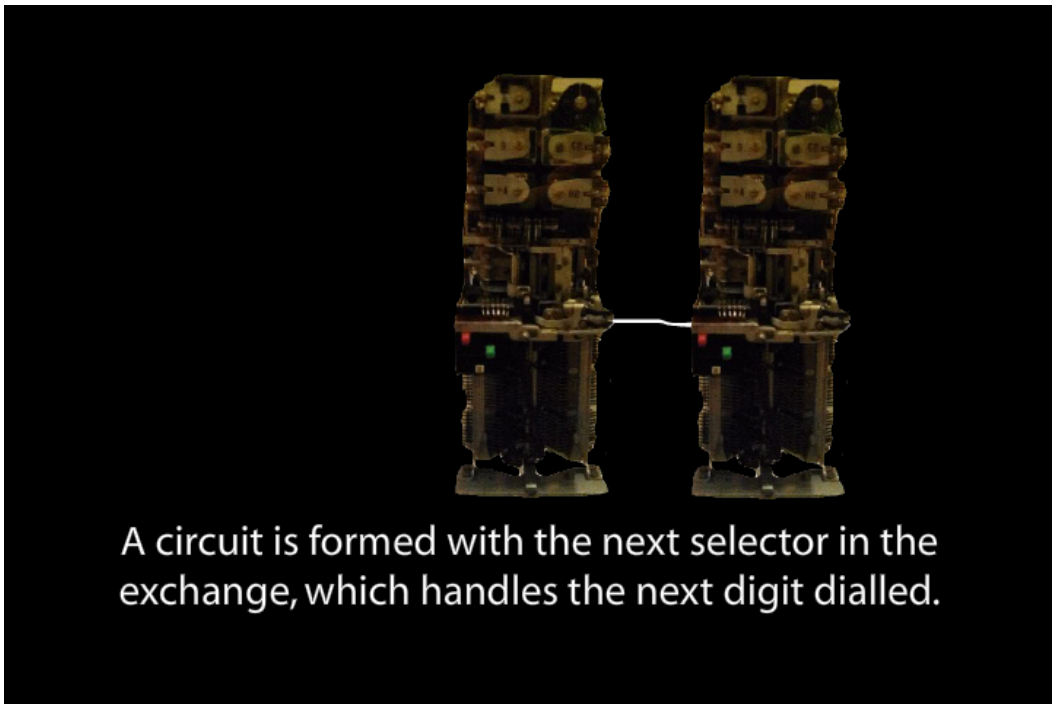


Figure 20: Exchange Slide 4

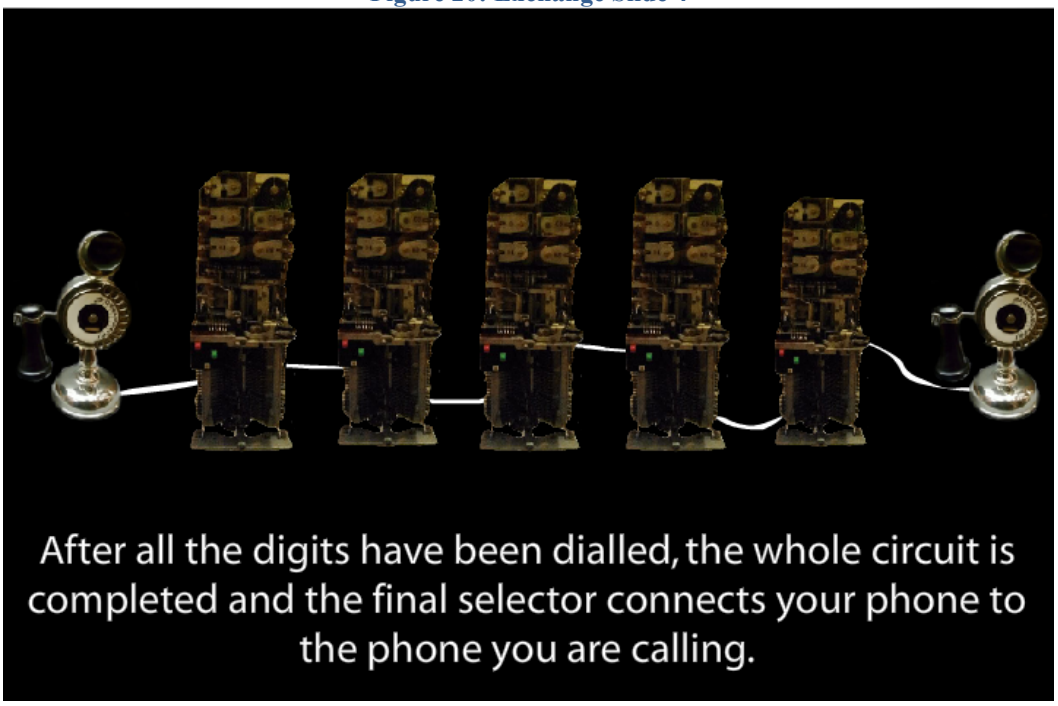


Figure 21: Exchange Slide 5

Why do I have to wait so long to dial? (11811)

Figure 22: 11811 Slide 1

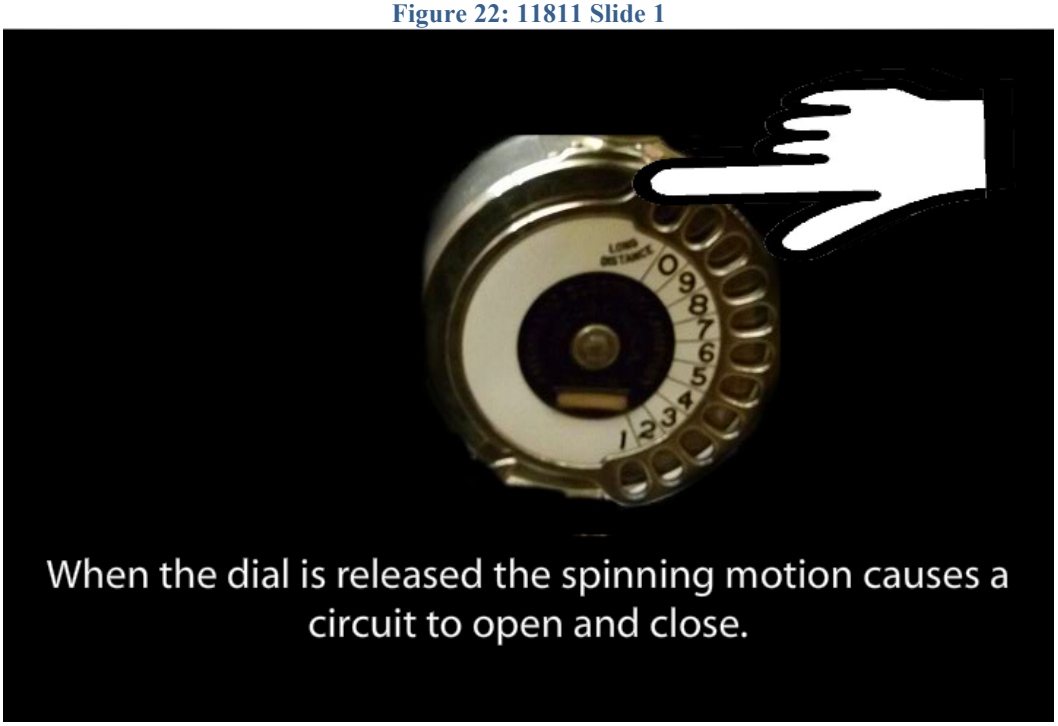


Figure 23: 11811 Slide 2

Figure 24: 11811 Slide 3

Figure 25: 11811 Slide 4

How does it know what phone to ring? (66745)

Figure 26: 66746 Slide 1

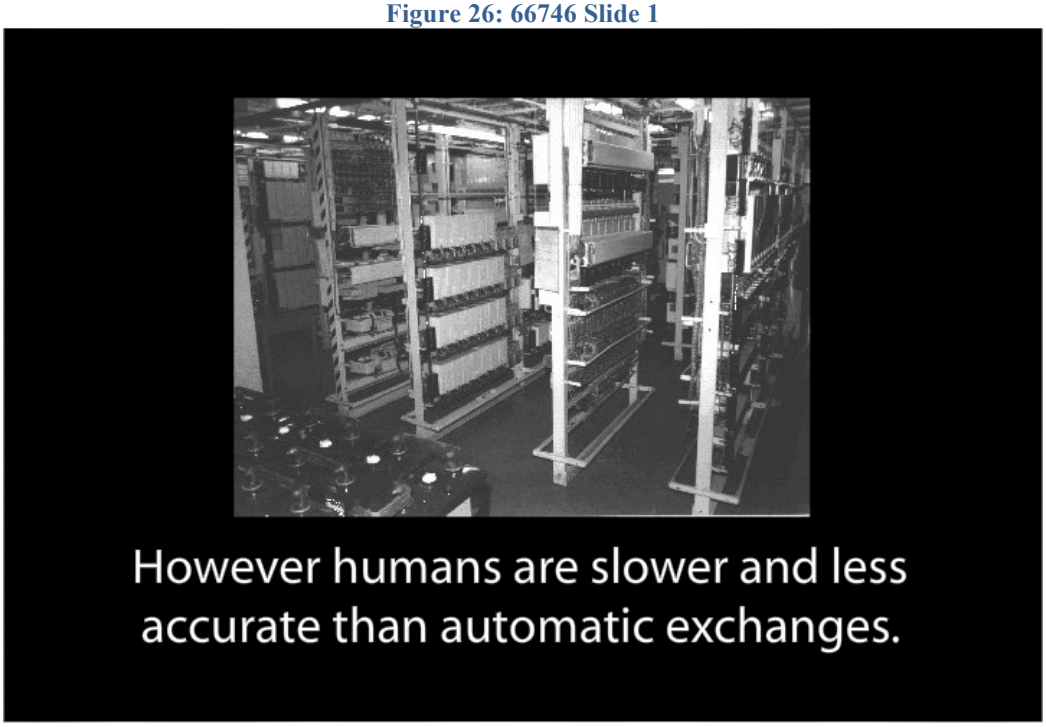


Figure 27: 66745 Slide 2

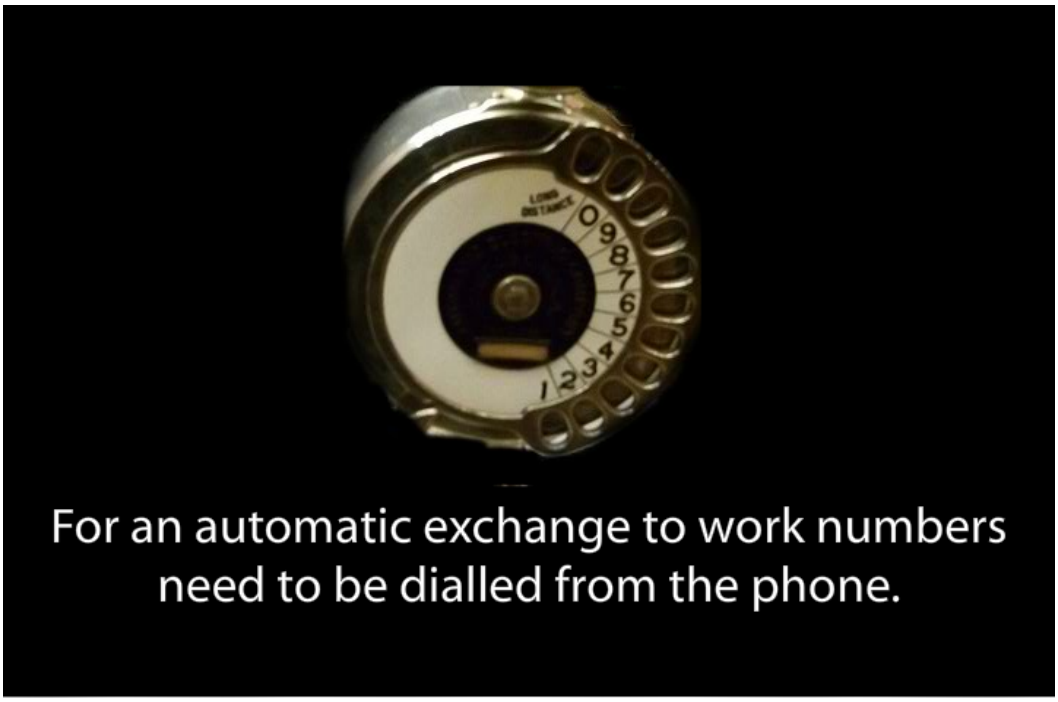


Figure 28: 66745 Slide 3

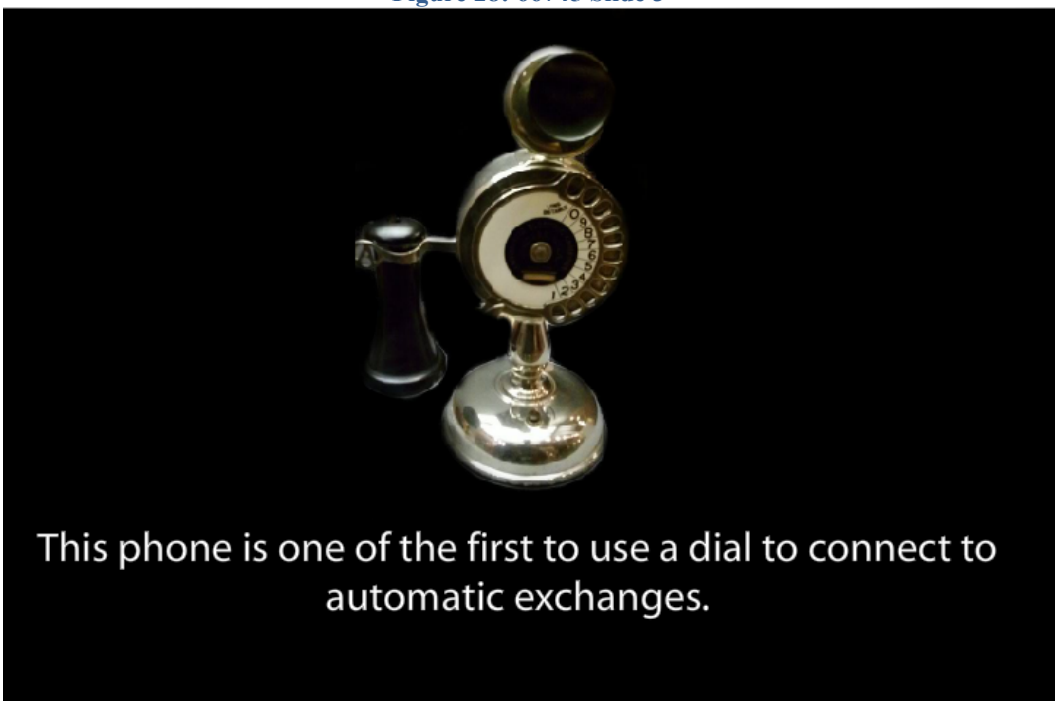


Figure 29: 66745 Slide 4

Wrong Number:

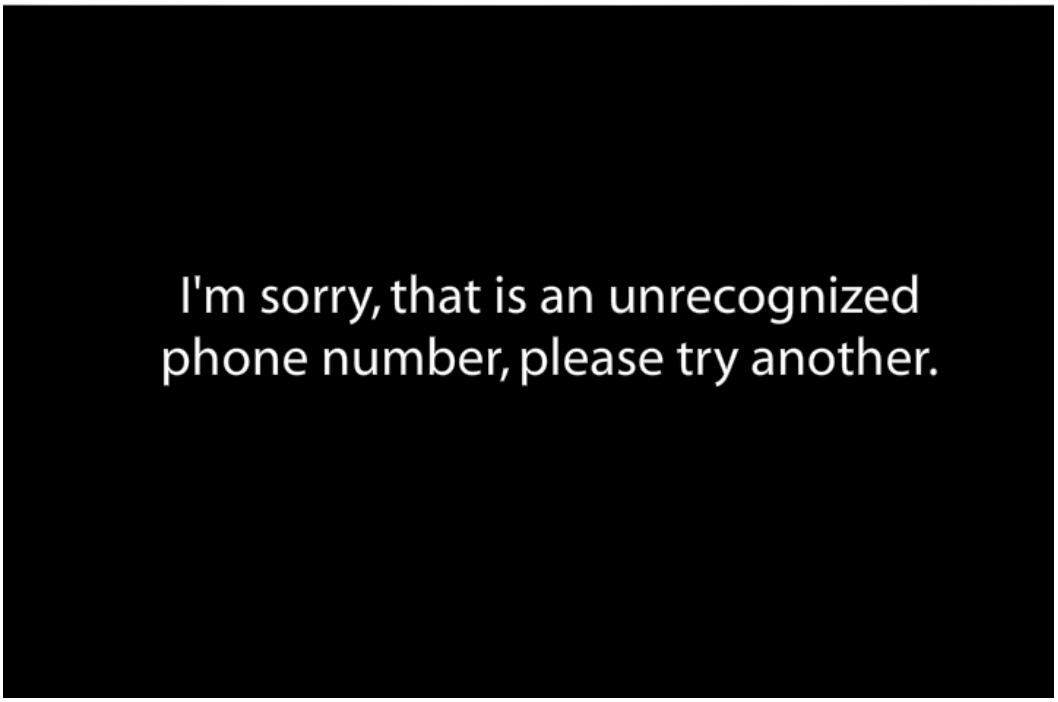


Figure 30: Wrong Number Screen

Hanging up the Receiver:

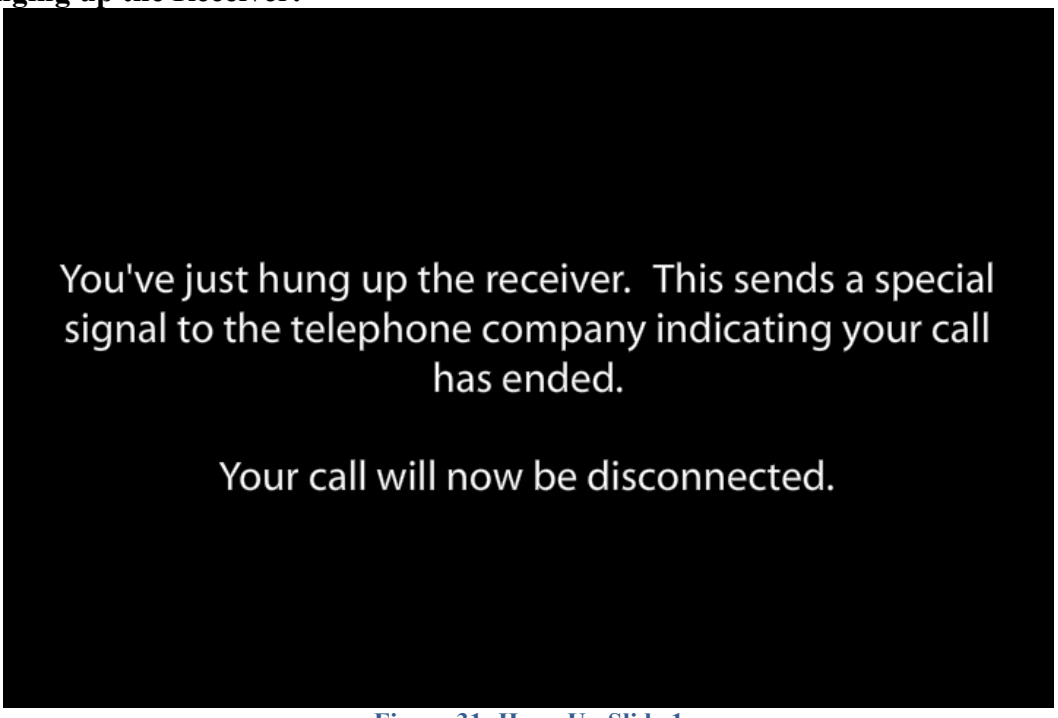


Figure 31: Hang Up Slide 1

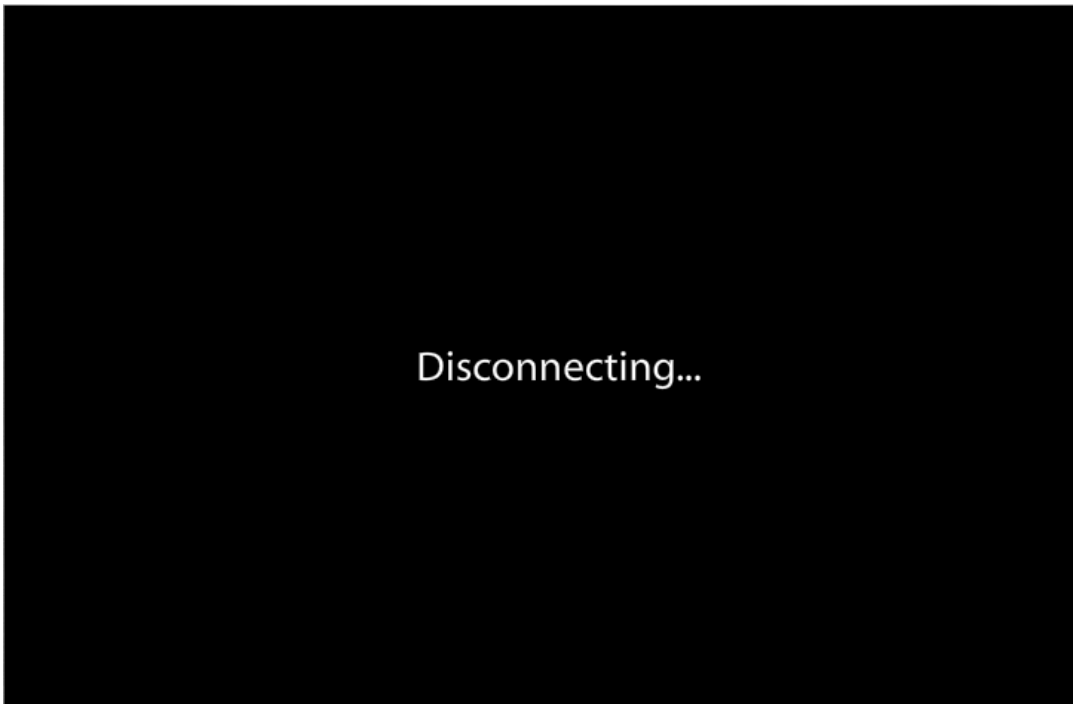


Figure 32: Hang Up Slide 2

Appendix I – P1 Source Code

Contained herein is the source code that ran the digital portion of the activity in P1.

```
/*
v1.4
*/

import codeanticode.gsvideo.*; //free open-source third-party video library (c) Andres
Colubri, gsvideo.sourceforge.net
import processing.serial.*;

GSMovie idle;
GSMovie dial;
GSMovie test;
GSMovie handset;
GSMovie mockup;
GSMovie dialed;
GSMovie currentMov;
GSMovie placeholder;
GSMovie receiverContent;
GSMovie receiverPickUp;
GSMovie dialPrompt;
GSMovie welcome;
GSMovie context;
GSMovie exchanges;
GSMovie tryDialling;

GSMovie dial1;
GSMovie dial2;
GSMovie dial3;
GSMovie dial4;
GSMovie dial5;
GSMovie dial6;
GSMovie dial7;
GSMovie dial8;
GSMovie dial9;
GSMovie dial10;

GSMovie[] dialMovies = new GSMovie[10];

GSMovie callIntro;

GSMovie call0;
GSMovie call1;
GSMovie call2;
GSMovie call3;
GSMovie call4;
GSMovie call5;

GSMovie[] callMovies = new GSMovie[6];

GSMovie call02;
GSMovie call12;
GSMovie call22;
GSMovie call32;
GSMovie call42;
GSMovie call52;

GSMovie[] callMovies2 = new GSMovie[6];

GSMovie content11811;
GSMovie content23555;
GSMovie content52432;
GSMovie content66745;
GSMovie wrongNumber;

GSMovie callEnd1;
```

```
GSMovie callEnd2;
GSMovie callEnd3;
GSMovie callEnd4;

GSMovie[] callEnds = new GSMovie[4];

GSMovie callEnd12;
GSMovie callEnd22;
GSMovie callEnd32;
GSMovie callEnd42;

GSMovie[] callEnds2 = new GSMovie[4];

int callCounter;

PImage prompt;

PrintWriter output;

int second1;
int second2;
int secdiff;
int minute1;
int minute2;
int mindiff;

int pickupSec1;
int pickupSec2;
int pickupDiff;

int offset;

PFont font;

boolean numberEntered;
boolean pulseAnimation;
boolean switchVar;
boolean pickupPrompt;
boolean displayPrompt;
boolean timeout;
boolean started;
boolean firstVid;

String recievedCode = "";
String displayFact = "";
String displayString = "";

String factOne = "The electric pulses travelling around the screen indicate\nthe number
you dialled.";
String factTwo = "The rotary dial on the Strowger phone uses tiny metallic\nlevers to
generate electric pulses.";
String factThree = "Gears cause levers in the Strowger phone to complete\na circuit after
you release the dial.";

String[] facts = {factOne, factTwo, factThree};

int factCounter = 0;

Serial serialPort;

void setup() {
  size(720, 480);
  font = loadFont("Impact-48.vlw");
  textFont(font, 23);

  idle = new GSMovie(this, sketchPath("data/dial_base.mov"));
  mockup = new GSMovie(this, sketchPath("data/interaction_mockup.mov"));
  test = new GSMovie(this, sketchPath("data/test.mov"));
  dial = new GSMovie(this, sketchPath("data/dial.mov"));
  dialed = new GSMovie(this, sketchPath("data/dialed.mov"));
  handset = new GSMovie(this, sketchPath("data/handset.mov"));
```

```
prompt = new GSMovie(this, sketchPath("data/CallPrompt.mov"));
placeholder = new GSMovie(this, sketchPath("data/placeholder.mov"));
receiverContent = new GSMovie(this, sketchPath("data/receiverInfo.mov"));
receiverPickUp = new GSMovie(this, sketchPath("data/receiverPickUp.mp4"));
callIntro = new GSMovie(this, sketchPath("data/callIntro.mov"));
dialPrompt = new GSMovie(this, sketchPath("data/dialPromptLittle.mp4"));
welcome = new GSMovie(this, sketchPath("data/Welcome_v4.mov"));
context = new GSMovie(this, sketchPath("data/context.mov"));
exchanges = new GSMovie(this, sketchPath("data/exchanges.mov"));
tryDialling = new GSMovie(this, sketchPath("data/tryDialing.mov"));

currentMov = welcome;

dial1 = new GSMovie(this, sketchPath("data/dial1.mov"));
dial2 = new GSMovie(this, sketchPath("data/dial2.mov"));
dial3 = new GSMovie(this, sketchPath("data/dial3.mov"));
dial4 = new GSMovie(this, sketchPath("data/dial4.mov"));
dial5 = new GSMovie(this, sketchPath("data/dial5.mov"));
dial6 = new GSMovie(this, sketchPath("data/dial6.mov"));
dial7 = new GSMovie(this, sketchPath("data/dial7.mov"));
dial8 = new GSMovie(this, sketchPath("data/dial8.mov"));
dial9 = new GSMovie(this, sketchPath("data/dial9.mov"));
dial10 = new GSMovie(this, sketchPath("data/dial10.mov"));

dialMovies[0] = dial10;
dialMovies[1] = dial1;
dialMovies[2] = dial2;
dialMovies[3] = dial3;
dialMovies[4] = dial4;
dialMovies[5] = dial5;
dialMovies[6] = dial6;
dialMovies[7] = dial7;
dialMovies[8] = dial8;
dialMovies[9] = dial9;

call0 = new GSMovie(this, sketchPath("data/call_base.mov"));
call1 = new GSMovie(this, sketchPath("data/call1.mov"));
call2 = new GSMovie(this, sketchPath("data/call2.mov"));
call3 = new GSMovie(this, sketchPath("data/call3.mov"));
call4 = new GSMovie(this, sketchPath("data/call4.mov"));
call5 = new GSMovie(this, sketchPath("data/call5.mov"));

callMovies[0] = call0;
callMovies[1] = call1;
callMovies[2] = call2;
callMovies[3] = call3;
callMovies[4] = call4;
callMovies[5] = call5;

call02 = new GSMovie(this, sketchPath("data/call_base_2.mov"));
call12 = new GSMovie(this, sketchPath("data/call1_2.mov"));
call22 = new GSMovie(this, sketchPath("data/call2_2.mov"));
call32 = new GSMovie(this, sketchPath("data/call3_2.mov"));
call42 = new GSMovie(this, sketchPath("data/call4_2.mov"));
call52 = new GSMovie(this, sketchPath("data/call5_2.mov"));

callMovies2[0] = call02;
callMovies2[1] = call12;
callMovies2[2] = call22;
callMovies2[3] = call32;
callMovies2[4] = call42;
callMovies2[5] = call52;

content11811 = new GSMovie(this, sketchPath("data/content-11811.mov"));
content23555 = new GSMovie(this, sketchPath("data/content-23555.mov"));
content52432 = new GSMovie(this, sketchPath("data/content-52432.mov"));
content66745 = new GSMovie(this, sketchPath("data/content-66745.mov"));
wrongNumber = new GSMovie(this, sketchPath("data/wrongNumber.mov"));

callEnd1 = new GSMovie(this, sketchPath("data/call1_end.mov"));
callEnd2 = new GSMovie(this, sketchPath("data/call2_end.mov"));
```

```
  callEnd3 = new GSMovie(this, sketchPath("data/call3_end.mov"));
  callEnd4 = new GSMovie(this, sketchPath("data/call4_end.mov"));

  callEnds[0] = callEnd1;
  callEnds[1] = callEnd2;
  callEnds[2] = callEnd3;
  callEnds[3] = callEnd4;

  callEnd12 = new GSMovie(this, sketchPath("data/call1_2_end.mov"));
  callEnd22 = new GSMovie(this, sketchPath("data/call2_2_end.mov"));
  callEnd32 = new GSMovie(this, sketchPath("data/call3_2_end.mov"));
  callEnd42 = new GSMovie(this, sketchPath("data/call4_2_end.mov"));

  callEnds2[0] = callEnd12;
  callEnds2[1] = callEnd22;
  callEnds2[2] = callEnd32;
  callEnds2[3] = callEnd42;

  callCounter = 0;

  prompt = loadImage(sketchPath("data/CallPrompt.png"));

  output = createWriter("data.txt");

  second1 = 0;
  second2 = 0;
  secdiff = 0;
  minute1 = 0;
  minute2 = 0;
  mindiff = 0;

  offset = 0;

  factCounter = 0;

  //set booleans
  numberEntered = false;
  pulseAnimation = false;
  switchVar = false;
  pickupPrompt = false;
  displayPrompt = false;
  timeout = false;
  started = false;
  firstVid = false;

  GSVideo.localGStreamerPath = sketchPath("gsreamer/mac");

  String prtName = Serial.list()[0];
  serialPort = new Serial(this, prtName, 9600);
}

void draw() {
  image(currentMov, 0, 0);

  if (currentMov.equals(welcome)) {
    currentMov.loop();
  }
  else {
    currentMov.play();

    if(currentMov.frame() > 1 && (currentMov.frame() == (currentMov.length() - 1))) {
      currentMov.stop();
      if (switchVar) {
        if (currentMov.equals(receiverContent)) {
          currentMov = callIntro;
          currentMov.goToBeginning();
        }
        else if (currentMov.equals(content11811) || currentMov.equals(content23555) ||
currentMov.equals(content52432) || currentMov.equals(content66745))
        {
          currentMov = placeholder;
```

```
          currentMov.goToBeginning();
        }
        else if (currentMov.equals(callIntro) || callCounter == 0) {
          if (firstVid) {
            currentMov = callMovies2[0];
            currentMov.goToBeginning();
          }
          else {
            currentMov = callMovies[0];
            currentMov.goToBeginning();
          }
        }
        else if (currentMov.equals(call5) || currentMov.equals(call52)) {
          if (firstVid) {
            if (recievedCode.equals("11811"))
            {
                currentMov = content11811;
                currentMov.goToBeginning();
            }
            else if (recievedCode.equals("23555"))
            {
              currentMov = content23555;
              currentMov.goToBeginning();
            }
            else if (recievedCode.equals("52432"))
            {
              currentMov = content52432;
              currentMov.goToBeginning();
            }
            else if (recievedCode.equals("66745"))
            {
              currentMov = content66745;
              currentMov.goToBeginning();
            }
            else
            {
              currentMov = wrongNumber;
              currentMov.goToBeginning();
            }
          }
          else {
            currentMov = exchanges;
            currentMov.goToBeginning();
            firstVid = true;
          }
          //content movie goes here
          callCounter = 0;
          output.println(recievedCode);
          output.flush();
          recievedCode = "";
          displayString = "";
          timeout = true;
          //second1 = second();
          minute1 = minute();
        }
        else if (callCounter < 5) { //if the movie is a regular callMovie
          if (firstVid) {
           currentMov = callEnds2[callCounter - 1]; //we're going to display an the
appropriate call image
          }
          else {
            currentMov = callEnds[callCounter - 1]; //we're going to display an the
appropriate call image
          }
          timeout = true;
          minute1 = minute();
          //second1 = second();
        }
      }
      else {
        if (started) {
```

```
          if (currentMov.equals(context)) {
            currentMov = tryDialling;
            currentMov.goToBeginning();
          }
          else if (numberEntered || currentMov.equals(tryDialling)) {
            if (switchVar) {
              if (firstVid) {
                currentMov = callMovies2[0];
              }
              else {
                currentMov = callMovies[0];
              }
              currentMov.goToBeginning();
            }
            else {
              currentMov = idle;
              currentMov.goToBeginning();
            }
          }
          else {
            currentMov = welcome;
            currentMov.goToBeginning();
          }
        }
      }
    }

    if (currentMov.equals(idle) && pulseAnimation) {
      pulseAnimation = false;
      displayString = recievedCode + "!";
      if (factCounter == 0) {
        displayFact = facts[factCounter];
      }
      else {
        displayFact = facts[factCounter - 1];
      }
      offset = 24 * displayString.length();
    }
  }

  if (timeout) {
    //second2 = second();
    minute2 = minute();
    if (minute2 < minute1) {
      mindiff = minute2 + 60 - minute1;
    }
    else {
      mindiff = minute2 - minute1;
    }
    if (mindiff >= 2) {
      recievedCode = "";
      displayString = "";
      displayFact = "";
      factCounter = 0;
      callCounter = 0;
      numberEntered = false;
      pickupPrompt = false;
      displayPrompt = false;
      pulseAnimation = false;
      timeout = false;
      secdiff = 0;
      mindiff = 0;
      firstVid = false;
      started = false;
      currentMov.stop();

/*      if (switchVar) {
        currentMov = callMovies[0];
      }
      else {*/
        currentMov = welcome;
```

```
        currentMov.goToBeginning();
      //}
    }
  }

  if (!switchVar) {
    if (numberEntered) {
      text("You dialled ", 500, 420);
      text(displayFact, 55, 100);
      if(!displayFact.equals("")) {
        image(dialPrompt, 55, 150);
        dialPrompt.loop();
      }

      if (pickupPrompt || displayPrompt) {
        pickupSec2 = second();
        if (pickupSec2 < pickupSec1) {
          pickupDiff = pickupSec2 + 60 - pickupSec1;
        }
        else {
          pickupDiff = pickupSec2 - pickupSec1;
        }
        println(pickupDiff);
      }

      if (displayPrompt) {
        image(prompt, 0, 0);
        image(receiverPickUp, 350, 200);
        receiverPickUp.loop();
      }

      if (abs(pickupDiff) >= 10) {
        if (displayPrompt) {
          displayPrompt = false;
          pickupDiff = 0;
        }
        else if (pickupPrompt) {
          pickupPrompt = false;
          pickupDiff = 0;
          displayPrompt = true;
          pickupSec1 = second();
        }
      }
    }
    text(displayString, 620, 420);
  }
  else {
    text(displayString, 300, 300);
  }
}

void serialEvent(Serial port) {

  char num = char(port.read());

  timeout = true;

  if (!started) {
    if (num == 'z') {
      started = true;
      secdiff = 0;
      mindiff = 0;
      minute1 = minute();
      currentMov.stop();
      currentMov = context;
      currentMov.goToBeginning();
    }
    else if (num == 'x') {
      switchVar = true;
    }
    else if (num == 'y') {
```

```
      switchVar = false;
    }
  }
  else if (started){

    if (switchVar) {
       numberEntered = true;

      if (num == 'y') {
        recievedCode = "";
        displayString = "";
        displayFact = "";
        factCounter = 0;
        numberEntered = false;
        switchVar = false;
        timeout = true;
        secdiff = 0;
        mindiff = 0;
        minute1 = minute();
        currentMov.stop();
        currentMov = tryDialling;
        currentMov.goToBeginning();
      }
      else if (num != 'z') { //if we get a number
        if (callCounter < 5) {
          println(callCounter);
          callCounter++;
          timeout = true;
          secdiff = 0;
          mindiff = 0;
          minute1 = minute();
          recievedCode += num;
          displayString += num;
          currentMov.stop();
          if (firstVid) {
            currentMov = callMovies2[callCounter];
          }
          else {
            currentMov = callMovies[callCounter];
          }
          currentMov.goToBeginning();
          println(callCounter);
        }
        else {
          output.println(recievedCode);
          output.flush();
          callCounter = 0;
          recievedCode = "";
          displayString = "";
          timeout = true;
          minute1 = minute();
        }
      }
    }
    else {
      //num == 'x' when reciever is picked up
      //num == 'y' when reciever is put down
      if (num == 'x') {
        numberEntered = true;
        callCounter = 0;
        recievedCode = "";
        displayString = "";
        switchVar = true;
        pickupPrompt = false;
        displayPrompt = false;
        pickupDiff = 0;
        secdiff = 0;
        mindiff = 0;
        minute1 = minute();
        currentMov.stop();
        currentMov = receiverContent;
```

```
        currentMov.goToBeginning();
      }
      else if (num != 'z') {
        numberEntered = true;
        dialPlay(num);
        recievedCode = "";
        recievedCode += num;

        if (factCounter < 3) {
          factCounter++;
        }
        else {
          factCounter = 1;
        }

        if (factCounter >=3) {
          pickupPrompt = true;
          pickupSec1 = second();
        }

        //pickupDiff = 0;

        minute1 = minute();
      }
    }
  }
}

void dialPlay(char num) {
  currentMov.stop();
  currentMov = dialMovies[int(num) - 48];
  currentMov.goToBeginning();
  pulseAnimation = true;
}

// Called every time a new frame is available to read
void movieEvent(GSMovie m) {
  m.read();
}
```

Appendix J – P2 Source Code

Contained herein is the source code that ran the digital portion of the activity in P2.

```
/*
v2.1 - 13/4/2012
*/
import codeanticode.gsvideo.*; //free open-source third-party video library (c) Andres
Colubri, gsvideo.sourceforge.net
import processing.serial.*; //processing's native library for using USB ports

//define movies that play during the interaction
GSMovie intro;
GSMovie idle;
GSMovie currentMov;
GSMovie placeholder;
GSMovie receiverPickUp;
GSMovie receiverInfo;
GSMovie prompt;
GSMovie welcome;
GSMovie exchanges;
GSMovie tryDialling;
GSMovie blank;
GSMovie disconnect;

GSMovie dialIntro;

//movies that represent the user dialling a digit in Play Mode
GSMovie dial1;
GSMovie dial2;
GSMovie dial3;
GSMovie dial4;
GSMovie dial5;
GSMovie dial6;
GSMovie dial7;
GSMovie dial8;
GSMovie dial9;
GSMovie dial10;

GSMovie[] dialMovies = new GSMovie[10];

GSMovie callIntro;

//movies that show the exchanges connecting in Call Mode (no phonebook)
GSMovie call0;
GSMovie call1;
GSMovie call2;
GSMovie call3;
GSMovie call4;
GSMovie call5;

GSMovie[] callMovies = new GSMovie[6];

//movies that show the exchanges connecting in Call Mode (with phonebook)
GSMovie call02;
GSMovie call12;
GSMovie call22;
GSMovie call32;
GSMovie call42;
GSMovie call52;

GSMovie[] callMovies2 = new GSMovie[6];

GSMovie phonebook; //the actual movie file that holds the on-screen phonebook

//content movies for Call Mode
```

```
GSMovie content11811;
GSMovie content66745;
GSMovie wrongNumber;

//movies that play after the regular call movies (no phonebook), basically just static
images
GSMovie callEnd1;
GSMovie callEnd2;
GSMovie callEnd3;
GSMovie callEnd4;

GSMovie[] callEnds = new GSMovie[4];

//movies that play after the regular call movies (with phonebook), basically just static
images
GSMovie callEnd12;
GSMovie callEnd22;
GSMovie callEnd32;
GSMovie callEnd42;

GSMovie[] callEnds2 = new GSMovie[4];

int callCounter; //counter for how many digits of a number the user has dialled in Call
Mode

PrintWriter output;

//counters for timers
int second1;
int second2;
int secdiff;
int minute1;
int minute2;
int mindiff;

int pickupSec1;
int pickupSec2;
int pickupDiff;

int offset;

PFont font;

boolean numberEntered;
boolean pulseAnimation;
boolean switchVar;
boolean pickupPrompt;
boolean displayPrompt;
boolean timeout;
boolean started;
boolean firstVid;
boolean displayPhonebook;

String recievedCode = ""; //string for the number the user has dialled
String displayFact = "";
String displayString = "";

//fun facts for play mode
String factZero = "Try dialling another digit.";
String factOne = "This phone uses a rotary dial, different from modern day\ntouch tone
phones.\n\nPlease dial another digit.";
String factTwo = "If you dial a 3, three electric pusles are sent down the
line.\n\nPlease dial another digit.";
String factThree = "When you dial, two levers in the dial connect to complete a
circuit.\n\nPlease dial another digit.";
String factFour = "The circuit sends electric pulses down the line\nto indicate the digit
you dialled.";

String[] facts = {factZero, factOne, factTwo, factThree, factFour};

int factCounter = 0;
```

```
Serial serialPort;

//set everything up (load movie files into memory, etc.)
void setup() {
  size(720, 480);
  font = loadFont("Impact-48.vlw");
  textFont(font, 23);

  intro = new GSMovie(this, sketchPath("data/Intro.mov"));
  idle = new GSMovie(this, sketchPath("data/dial_base.mov"));
  placeholder = new GSMovie(this, sketchPath("data/placeholder.mov"));
  receiverPickUp = new GSMovie(this, sketchPath("data/receiverPickUp.mp4"));
  receiverInfo = new GSMovie(this, sketchPath("data/receiverInfo.mov"));
  prompt = new GSMovie(this, sketchPath("data/CallPrompt.mov"));
  callIntro = new GSMovie(this, sketchPath("data/receiverIntro.mov"));
  welcome = new GSMovie(this, sketchPath("data/Welcome_v6.mov"));
  exchanges = new GSMovie(this, sketchPath("data/exchanges.mov"));
  tryDialling = new GSMovie(this, sketchPath("data/tryDialing_v2.mov"));
  blank = new GSMovie(this, sketchPath("data/blank.mov"));
  disconnect = new GSMovie(this, sketchPath("data/hangUp.mov"));

  dialIntro = new GSMovie(this, sketchPath("data/dialIntro.mov"));

  dial1 = new GSMovie(this, sketchPath("data/dial1.mov"));
  dial2 = new GSMovie(this, sketchPath("data/dial2.mov"));
  dial3 = new GSMovie(this, sketchPath("data/dial3.mov"));
  dial4 = new GSMovie(this, sketchPath("data/dial4.mov"));
  dial5 = new GSMovie(this, sketchPath("data/dial5.mov"));
  dial6 = new GSMovie(this, sketchPath("data/dial6.mov"));
  dial7 = new GSMovie(this, sketchPath("data/dial7.mov"));
  dial8 = new GSMovie(this, sketchPath("data/dial8.mov"));
  dial9 = new GSMovie(this, sketchPath("data/dial9.mov"));
  dial10 = new GSMovie(this, sketchPath("data/dial10.mov"));

  dialMovies[0] = dial10;
  dialMovies[1] = dial1;
  dialMovies[2] = dial2;
  dialMovies[3] = dial3;
  dialMovies[4] = dial4;
  dialMovies[5] = dial5;
  dialMovies[6] = dial6;
  dialMovies[7] = dial7;
  dialMovies[8] = dial8;
  dialMovies[9] = dial9;

  call0 = new GSMovie(this, sketchPath("data/call_base.mov"));
  call1 = new GSMovie(this, sketchPath("data/call1.mov"));
  call2 = new GSMovie(this, sketchPath("data/call2.mov"));
  call3 = new GSMovie(this, sketchPath("data/call3.mov"));
  call4 = new GSMovie(this, sketchPath("data/call4.mov"));
  call5 = new GSMovie(this, sketchPath("data/call5.mov"));

  callMovies[0] = call0;
  callMovies[1] = call1;
  callMovies[2] = call2;
  callMovies[3] = call3;
  callMovies[4] = call4;
  callMovies[5] = call5;

  call02 = new GSMovie(this, sketchPath("data/call_base_2.mov"));
  call12 = new GSMovie(this, sketchPath("data/call1_2.mov"));
  call22 = new GSMovie(this, sketchPath("data/call2_2.mov"));
  call32 = new GSMovie(this, sketchPath("data/call3_2.mov"));
  call42 = new GSMovie(this, sketchPath("data/call4_2.mov"));
  call52 = new GSMovie(this, sketchPath("data/call5_2.mov"));

  callMovies2[0] = call02;
  callMovies2[1] = call12;
  callMovies2[2] = call22;
  callMovies2[3] = call32;
```

```
  callMovies2[4] = call42;
  callMovies2[5] = call52;

  phonebook = new GSMovie(this, sketchPath("data/phoneBook_idle.mov"));

  content11811 = new GSMovie(this, sketchPath("data/content-11811.mov"));
  content66745 = new GSMovie(this, sketchPath("data/content-66745_v2.mov"));
  wrongNumber = new GSMovie(this, sketchPath("data/wrongNumber.mov"));

  callEnd1 = new GSMovie(this, sketchPath("data/call1_end.mov"));
  callEnd2 = new GSMovie(this, sketchPath("data/call2_end.mov"));
  callEnd3 = new GSMovie(this, sketchPath("data/call3_end.mov"));
  callEnd4 = new GSMovie(this, sketchPath("data/call4_end.mov"));

  callEnds[0] = callEnd1;
  callEnds[1] = callEnd2;
  callEnds[2] = callEnd3;
  callEnds[3] = callEnd4;

  callEnd12 = new GSMovie(this, sketchPath("data/call1_2_end.mov"));
  callEnd22 = new GSMovie(this, sketchPath("data/call2_2_end.mov"));
  callEnd32 = new GSMovie(this, sketchPath("data/call3_2_end.mov"));
  callEnd42 = new GSMovie(this, sketchPath("data/call4_2_end.mov"));

  callEnds2[0] = callEnd12;
  callEnds2[1] = callEnd22;
  callEnds2[2] = callEnd32;
  callEnds2[3] = callEnd42;

  callCounter = 0;

  output = createWriter("data.txt");

  String prtName = Serial.list()[0];
  serialPort = new Serial(this, prtName, 9600);

  reset();

  switchVar = false;

  frameRate(24);

  GSVideo.localGStreamerPath = sketchPath("gstreamer/mac");
}

//reset variables
void reset() {
  second1 = 0;
  second2 = 0;
  secdiff = 0;
  minute1 = 0;
  minute2 = 0;
  mindiff = 0;

  offset = 0;

  factCounter = 0;

  recievedCode = "";
  displayFact = "";
  displayString = "";

  numberEntered = false;
  pulseAnimation = false;
  pickupPrompt = false;
  displayPrompt = false;
  timeout = false;
  started = false;
  firstVid = false;
  displayPhonebook = false;
```

```
  serialPort.clear();

  currentMov = welcome;
  currentMov.goToBeginning();
}

void draw() {
  image(currentMov, 0, 0);

  currentMov.loop();

  if (!(currentMov.equals(welcome) || currentMov.equals(tryDialling) ||
currentMov.equals(blank))) { //if the movie is not the welcome screen, the prompt to dry
dialling, or the blank screen
    if(currentMov.frame() >= 1 && (currentMov.frame() >= (currentMov.length() - 10))) {
//if we are close to the end of the current movie
      currentMov.stop(); //stop the movie and select a new one
      currentMov.noLoop();
      if (switchVar) { //if the receiver is up
        if (currentMov.equals(exchanges)) { //if the current movie is explaining the
exchanges
          displayPhonebook = true; //display the phonebook and the first call movie with
the phonebook
          currentMov = callMovies2[0];
          currentMov.goToBeginning();
        }
         else if (currentMov.equals(content11811) || currentMov.equals(content66745)) {
//if a content video has just played
          currentMov = placeholder; //show the movie asking the user to dial another
number or hang up
          currentMov.goToBeginning();
        }
        else if (currentMov.equals(intro) || currentMov.equals(receiverInfo) ||
callCounter == 0) {
          //reset video to base call screen
          if (firstVid) { //if the user has already seen the video about the exchanges
            currentMov = callMovies2[0]; //show first call movie with phonebook
            currentMov.goToBeginning();
            displayPhonebook = true;
          }
          else {
            currentMov = callMovies[0]; //otherwise show the first call movie without the
phonebook
            currentMov.goToBeginning();
          }
        }
        else if (currentMov.equals(call5) || currentMov.equals(call52)) { //if the last
callMovie has finished playing
          if (firstVid) { //if the intro video for the exchange has played
            selectMovie(); //choose which content animation to play
            displayPhonebook = false;
          }
          else { //otherwise
            firstVid = true;
            currentMov = exchanges; //play the intro video for the exchange
            currentMov.goToBeginning();
          }
          callCounter = 0; //reset everything
          output.println(recievedCode);
          output.flush();
          recievedCode = "";
          displayString = "";
          setTimeout();
        }
        else if (callCounter < 5) { //if the movie is a regular callMovie
          if (firstVid) {
           currentMov = callEnds2[callCounter - 1]; //we're going to display an the
appropriate call image
          }
          else {
```

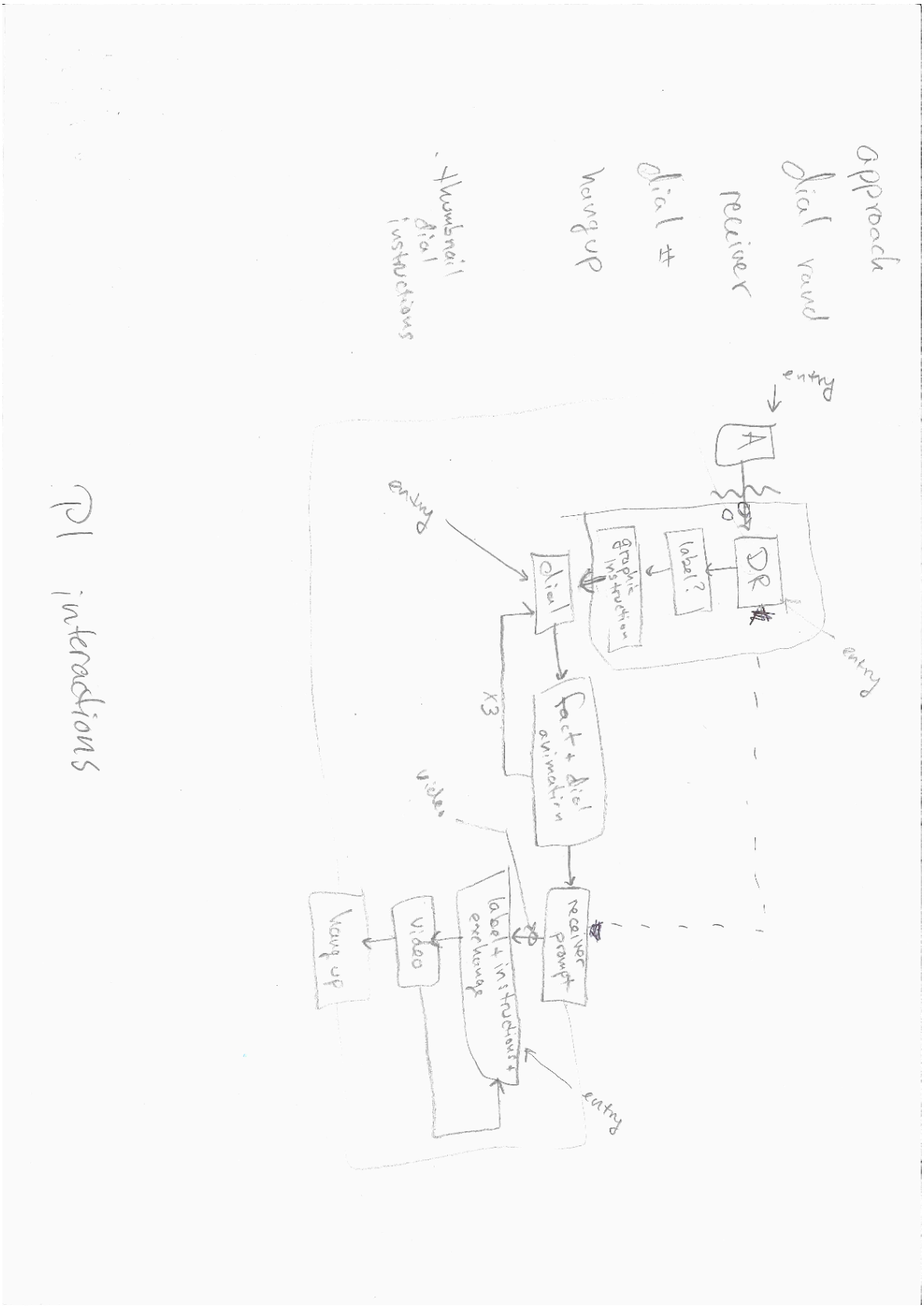
```
            currentMov = callEnds[callCounter - 1]; //we're going to display an the
appropriate call image
          }
          setTimeout();
        }
      }
      else { //if receiver is down
        if (started) {
          if (currentMov.equals(intro) || currentMov.equals(disconnect)) {
            currentMov = tryDialling;
            currentMov.goToBeginning();
          }
          else if (numberEntered || currentMov.equals(tryDialling)) {
            currentMov = idle;
            currentMov.goToBeginning();
          }
          else {
            currentMov = welcome;
            currentMov.goToBeginning();
          }
        }
      }
    }

    if (currentMov.equals(idle) && pulseAnimation) { //if the last animation was showing
pulses
      pulseAnimation = false;
      displayString = recievedCode;
      //select a fun fact to display
      if (factCounter == 0) {
        displayFact = facts[factCounter];
      }
      else {
        displayFact = facts[factCounter - 1];
      }
      offset = 24 * displayString.length();
    }
  }

  if (timeout) { //if the exhibit should be worrying about timing out
    minute2 = minute();
    second2 = second();
    //determine how many minutes it has been since we started timing
    if (minute2 < minute1) {
      mindiff = minute2 + 60 - minute1;
    }
    else {
      mindiff = minute2 - minute1;
    }
    if (mindiff >= 2 && second2 >= second1) { //if two minutes have passed since we
started timing
      currentMov.stop(); //stop the current movie
      currentMov.noLoop();
      reset(); //reset the interaction
    }
  }

  if (!switchVar) { //if the receiver is down
    text(displayString, 620, 420); //display the number that was just entered
    if (numberEntered) {
      if (currentMov.equals(blank)) {
        text("Well done! You dialled " + recievedCode + "\nNow try dialling another
digit", 240, 240);
      }
      else {
        text("You dialled ", 500, 420);
        text(displayFact, 55, 100);

        if (pickupPrompt || displayPrompt) {
          pickupSec2 = second();
          if (pickupSec2 < pickupSec1) {
```

```
            pickupDiff = pickupSec2 + 60 - pickupSec1;
          }
          else {
            pickupDiff = pickupSec2 - pickupSec1;
          }
          println(pickupDiff);
        }

        if (displayPrompt) {
          image(prompt, 0, 70);
          prompt.loop();
          image(receiverPickUp, 350, 200);
          receiverPickUp.loop();
        }

        if (abs(pickupDiff) >= 6) {
          if (pickupPrompt) { //if it has been more than 10 seconds since the user
dialled the third digit
            pickupPrompt = false;
            pickupDiff = 0;
            displayPrompt = true; //display the prompt to pick up the receiver
            pickupSec1 = second();
          }
        }
      }
    }
  }
  else {
    text(displayString, 300, 300);
    if (displayPhonebook) {
      image(phonebook, 0, 0);
      phonebook.loop();
    }
  }
}

//select which content animation to play based on which five digits the user has entered
void selectMovie() {
  displayPhonebook = false;

  if (recievedCode.equals("11811")) {
      currentMov = content11811;
      currentMov.goToBeginning();
  }
  else if (recievedCode.equals("66745")) {
    currentMov = content66745;
    currentMov.goToBeginning();
  }
  else {
    currentMov = wrongNumber;
    currentMov.goToBeginning();
  }
}

//if we get input via the USB
void serialEvent(Serial port) {

  char inByte = char(port.read());

  timeout = true;

  println(inByte);

  if (inByte == 'z') { //if the reset button is pressed
    reset(); //reset the interaction
  }
  else if (!started) { //if the interaction has not started
    if (inByte == 'x') {//if the receiver has been lifted
      switchVar = true; //let us remember that the receiver is up
      started = true;
      setTimeout();
```

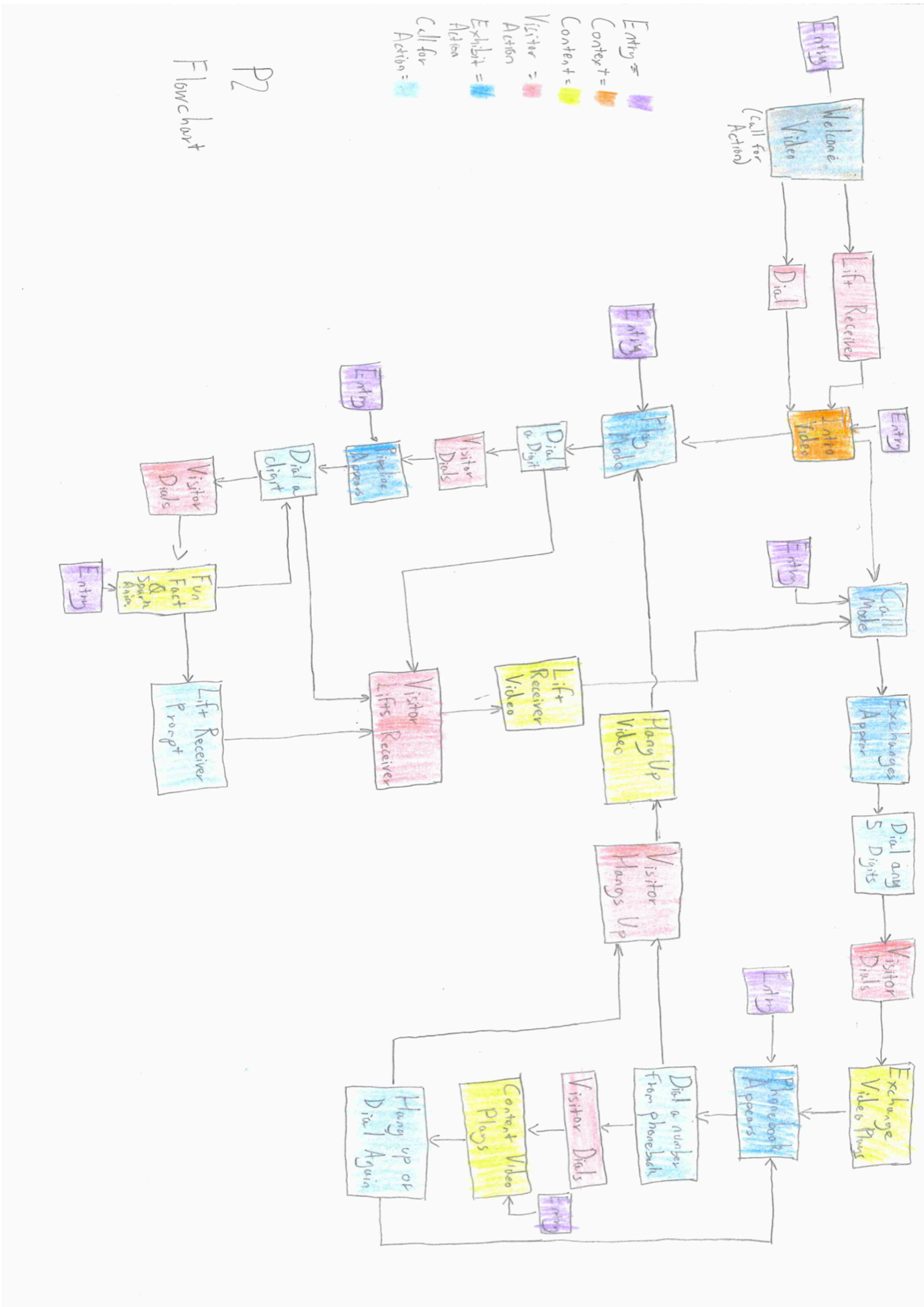
```
      currentMov.stop();
      currentMov.noLoop();
      currentMov = intro;
      currentMov.goToBeginning();
    }
    else if (inByte == 'y') {//if the receiver has been put down before any other
interaction
      switchVar = false; //let us remember that the receiver is down
    }
    else { //the user has dialled a number
      started = true;
      recievedCode = "";
      recievedCode += inByte;
      setTimeout();
      currentMov.stop();
      currentMov.noLoop();
      currentMov = intro;
      currentMov.goToBeginning();
    }
  }
  else if (started){

    if (switchVar) { //if the receiver is up
       numberEntered = true;

      if (inByte == 'y') { //if the receiver is put down
        //clear everything
        recievedCode = "";
        displayString = "";
        displayFact = "";
        factCounter = 0;
        numberEntered = false;
        switchVar = false;
        firstVid = false;
        setTimeout(); //start timing for timeout
        currentMov.stop();
        currentMov.noLoop();
        currentMov = disconnect; //show the movie about what happens when you hang up
        currentMov.goToBeginning();
      }
      else if (inByte != 'x') { //if we get a number
        if (callCounter < 5) {
          println(callCounter);
          callCounter++;
          setTimeout(); //start timing for timeout
          recievedCode += inByte; //add the new digit to the number the user has dialled
          displayString += inByte;
          currentMov.stop();
          currentMov.noLoop();
          if (firstVid) { //if the movie about exchanges has played
            currentMov = callMovies2[callCounter]; //play the appropriate call movie with
phonebook
            displayPhonebook = true;
          }
          else {
            currentMov = callMovies[callCounter]; //play the appropriate call movie
without phonebook
            displayPhonebook = false;
          }
          currentMov.goToBeginning();
          println(callCounter);
        }
      }
    }
    else { //if the receiver is down
      if (inByte == 'x') { //if the receiver is lifted
        numberEntered = true;
        callCounter = 0;
        recievedCode = ""; //clear the received number
        displayString = "";
        switchVar = true;
```

```
        pickupPrompt = false;
        displayPrompt = false;
        displayPhonebook = false;
        pickupDiff = 0;
        setTimeout(); //start timing for timeout
        currentMov.stop();
        currentMov.noLoop();
        currentMov = receiverInfo; //play the movie about what happens when the receiver
is lifted
        currentMov.goToBeginning();
       }
      else if (inByte != 'y') { //if we get a number
        numberEntered = true;
        setTimeout(); //start timing for timeout
        recievedCode = "";
        recievedCode += inByte; //set the number to the digit the user has just dialled
        if (currentMov.equals(tryDialling) || currentMov.equals(intro)) { //if the
current movie is the intro video
          currentMov.stop();
          currentMov.noLoop();
          currentMov = blank; //show a blank screen so we can ask the user to dial again
        }
        else {
          dialPlay(inByte); //play the appropriate dial movie

          if (factCounter < 5) {
            factCounter++;
          }
          else {
            factCounter = 2;
          }

          if (factCounter >= 5) {
            pickupPrompt = true;
            pickupSec1 = second();
          }
        }

        minute1 = minute();
        second1 = second();
      }
    }
  }

  port.clear();
}

//reset variables related to the exhibit timing out
void setTimeout() {
  timeout = true;
  secdiff = 0;
  mindiff = 0;
  minute1 = minute();
  second1 = second();
}

//chooses which animation to play when a number is dialled when the receiver is down
void dialPlay(char num) {
  currentMov.stop();
  currentMov.noLoop();
  currentMov = dialMovies[int(num) - 48];
  currentMov.goToBeginning();
  pulseAnimation = true;
}

//called every time a new frame is available to read
void movieEvent(GSMovie m) {
  m.read();
}
```

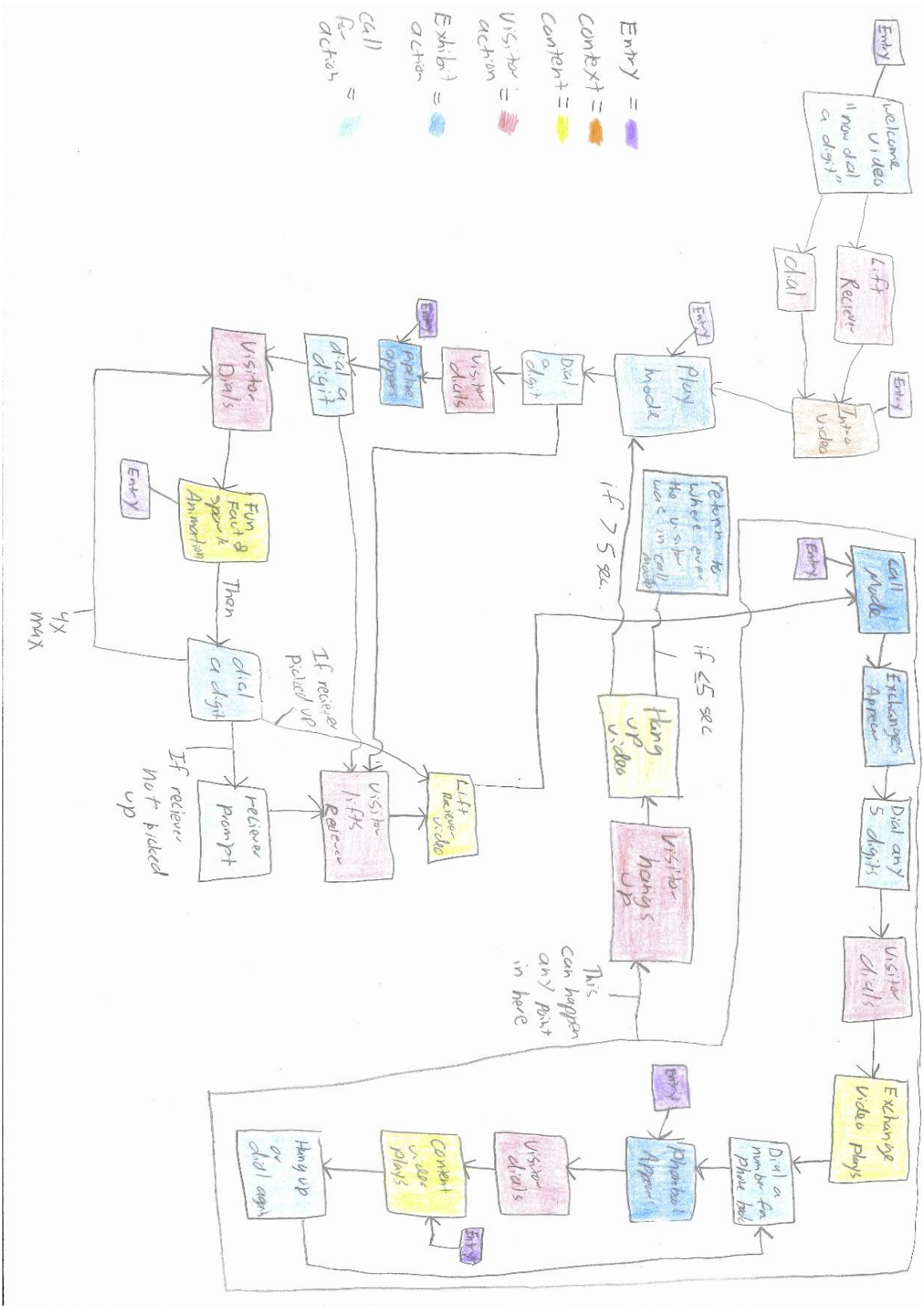
Appendix K – P1 Interaction Flow Chart



Appendix L – P2 Interaction Flow Chart



Appendix M – P3 Interaction Flow Chart



Appendix N – Storyboards

Interaction storyboards for P1

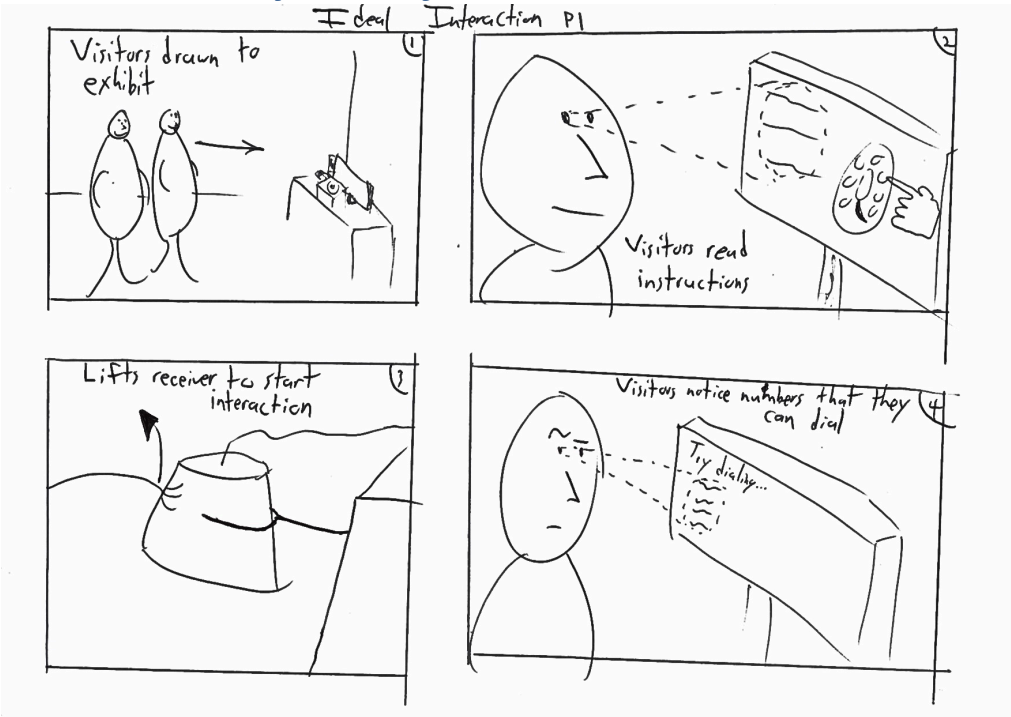


Figure 33: Franes 1-4 Ideal Visitor Interaction

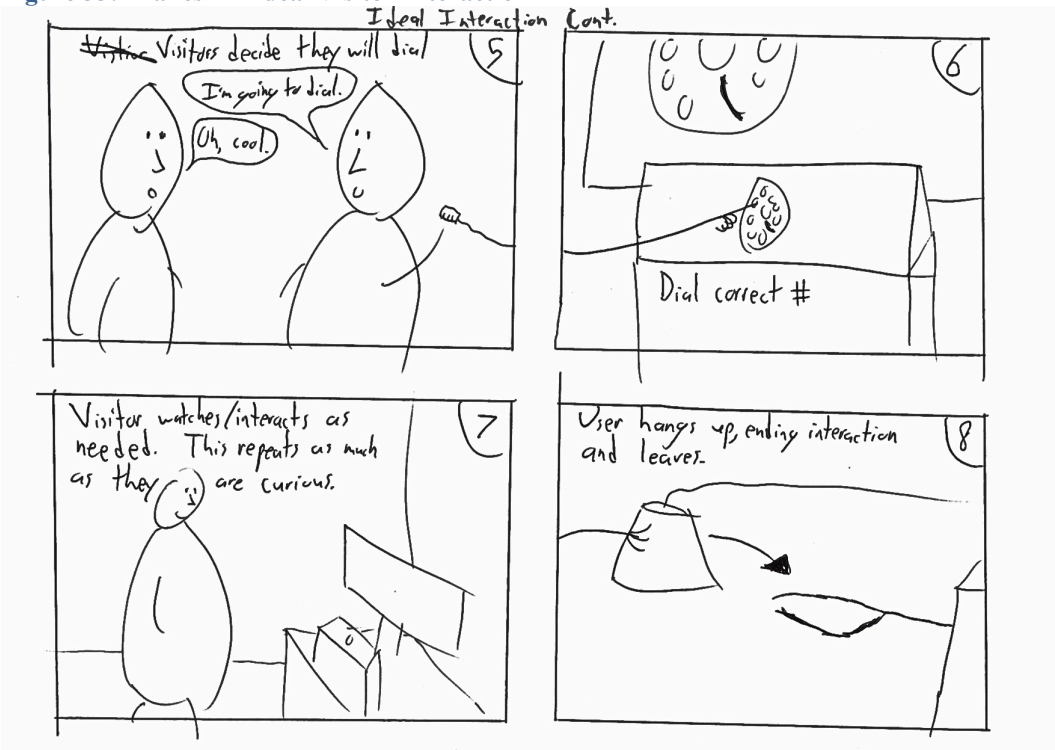


Figure 34: Frames 5-8 Ideal Visitor Interaction

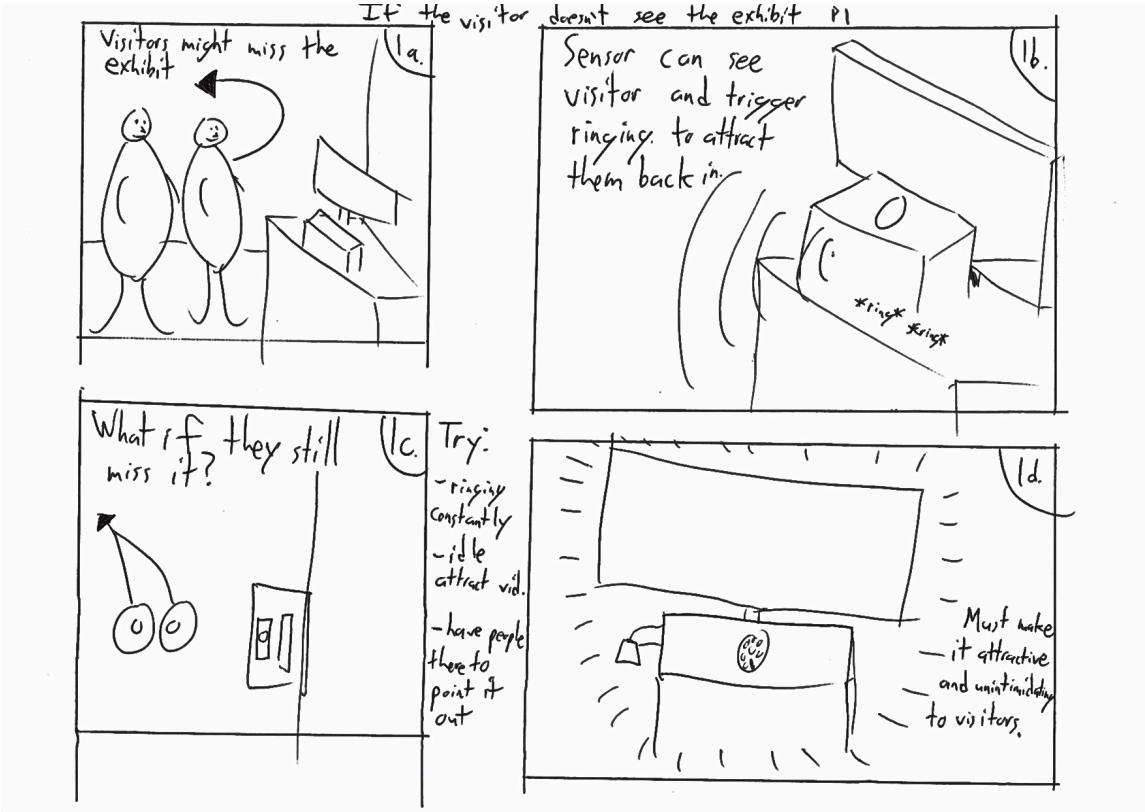


Figure 35: Potential Barrier to Ideal Interaction Frame 1

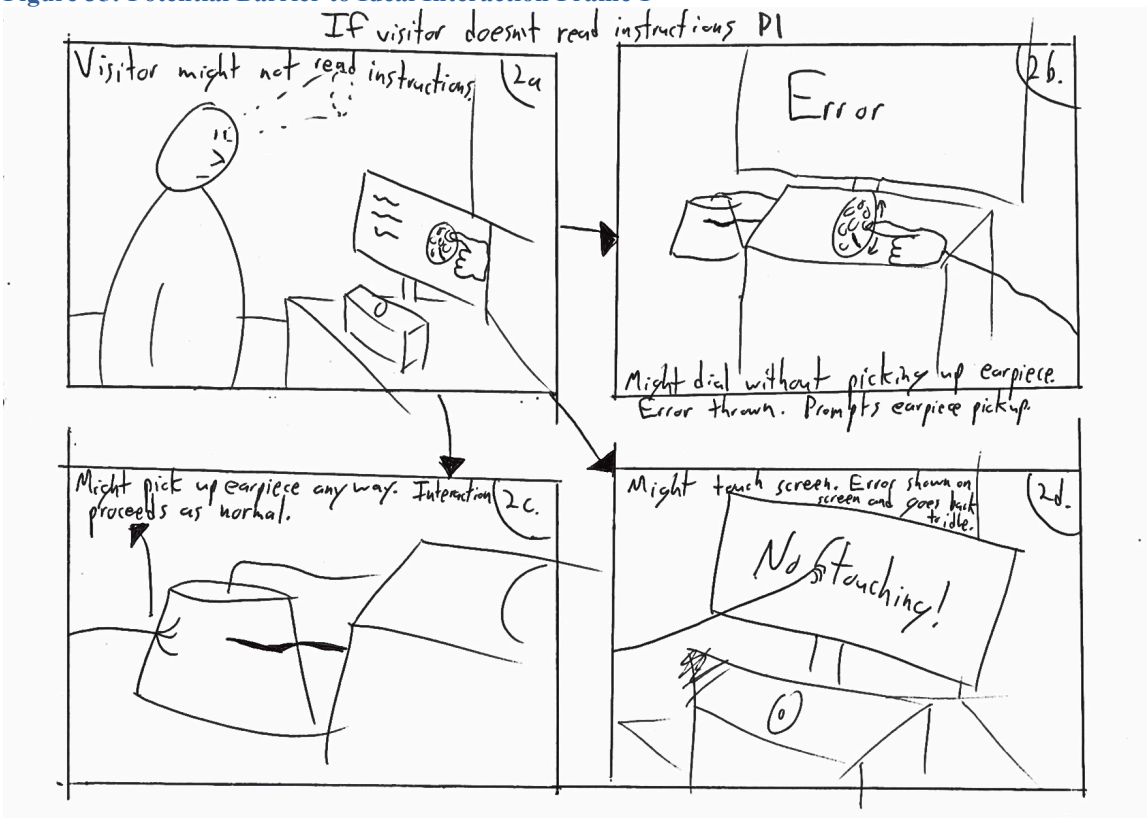


Figure 36: Potential Barrier to Ideal Interaction Frame 2

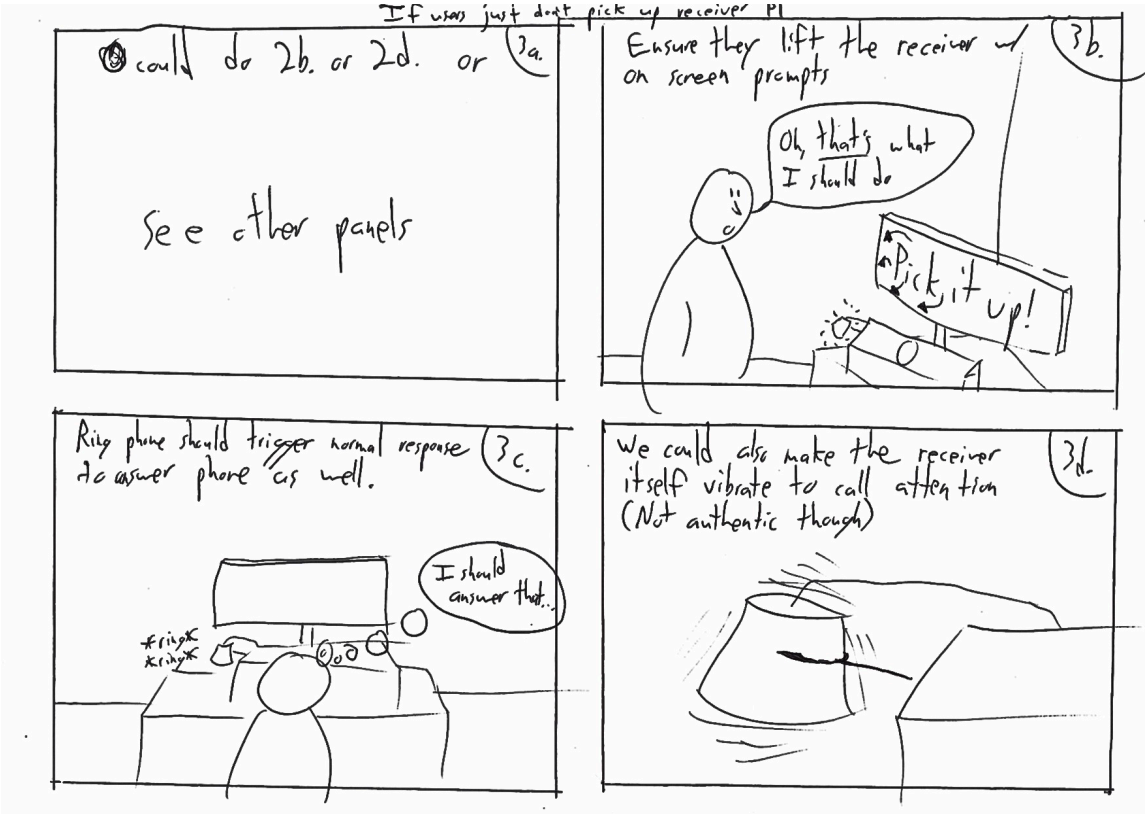


Figure 37: Potential Barrier to Ideal Interaction Frame 3

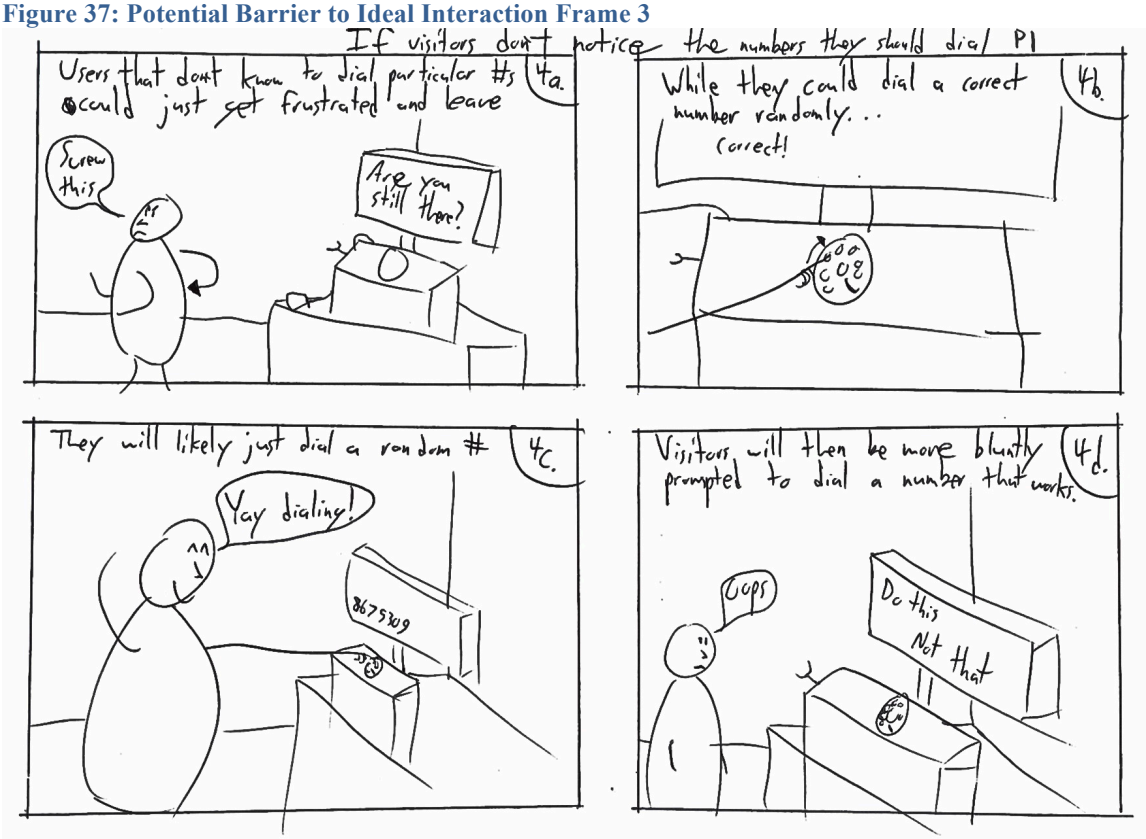


Figure 38: Potential Barrier to Ideal Interaction Frame 4

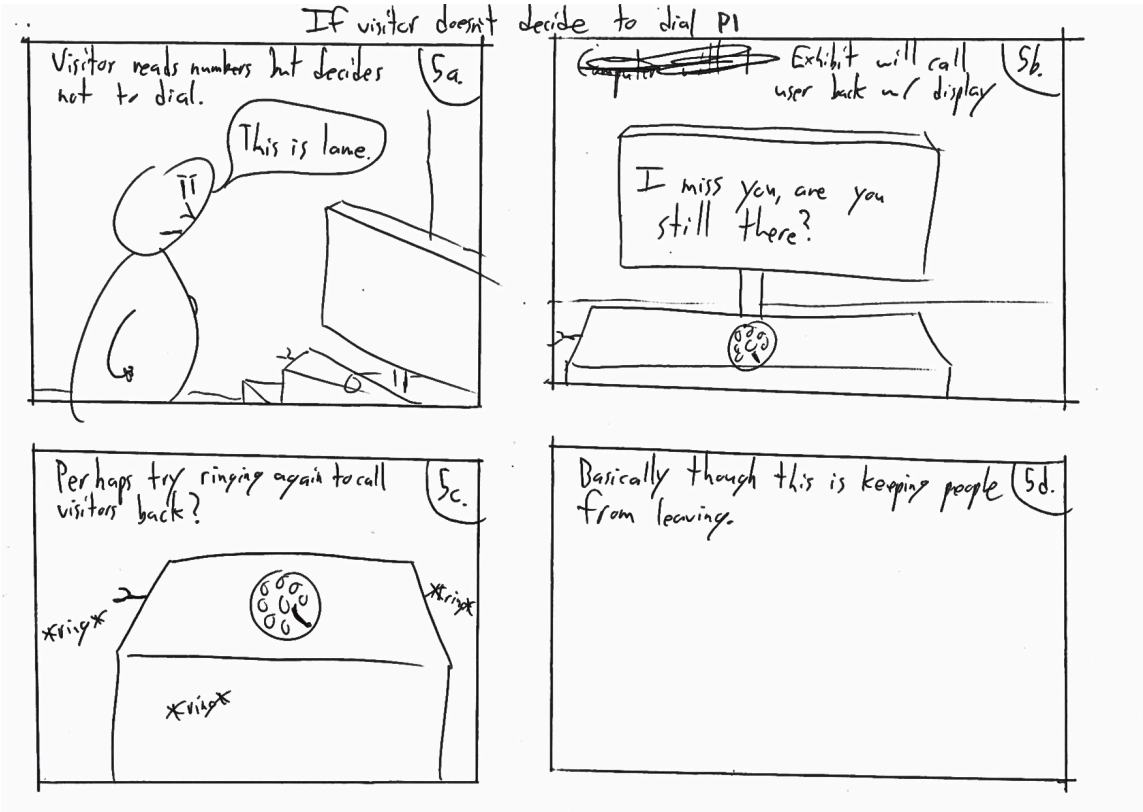


Figure 39: Potential Barrier to Ideal Interaction Frame 5

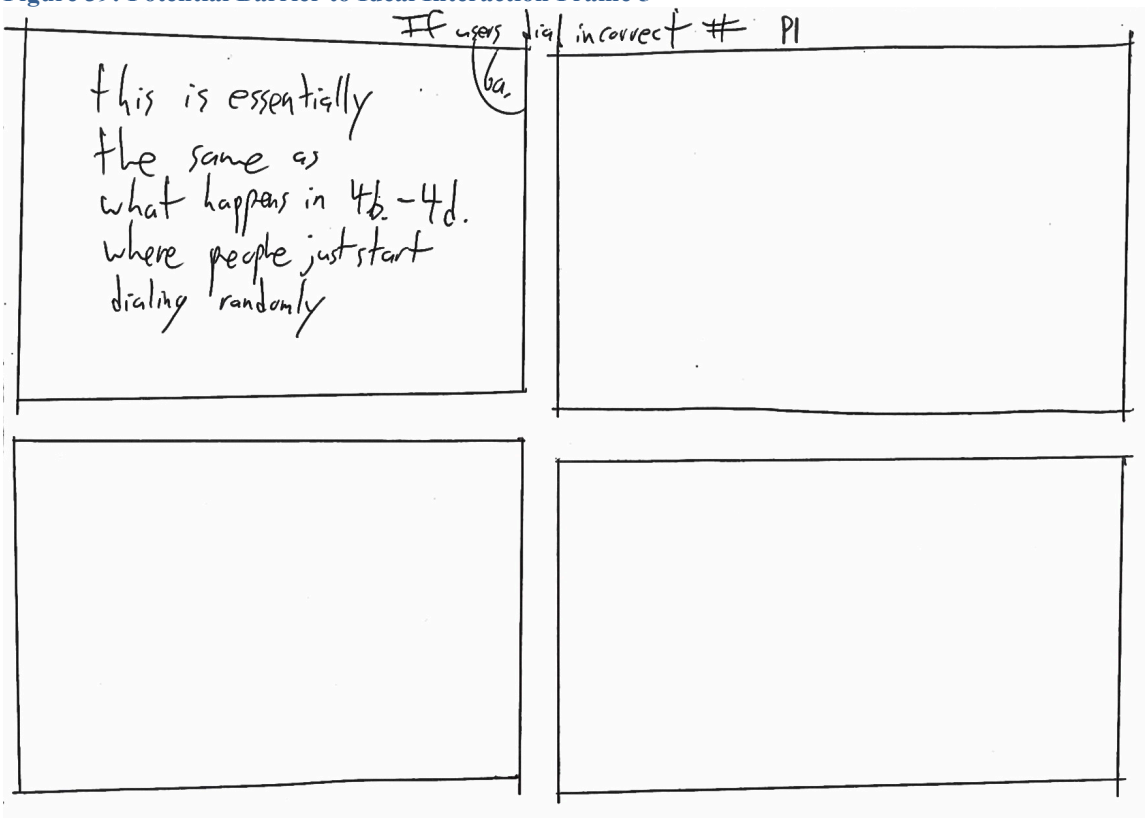


Figure 40: Potential Barrier to Ideal Interaction Frame 6

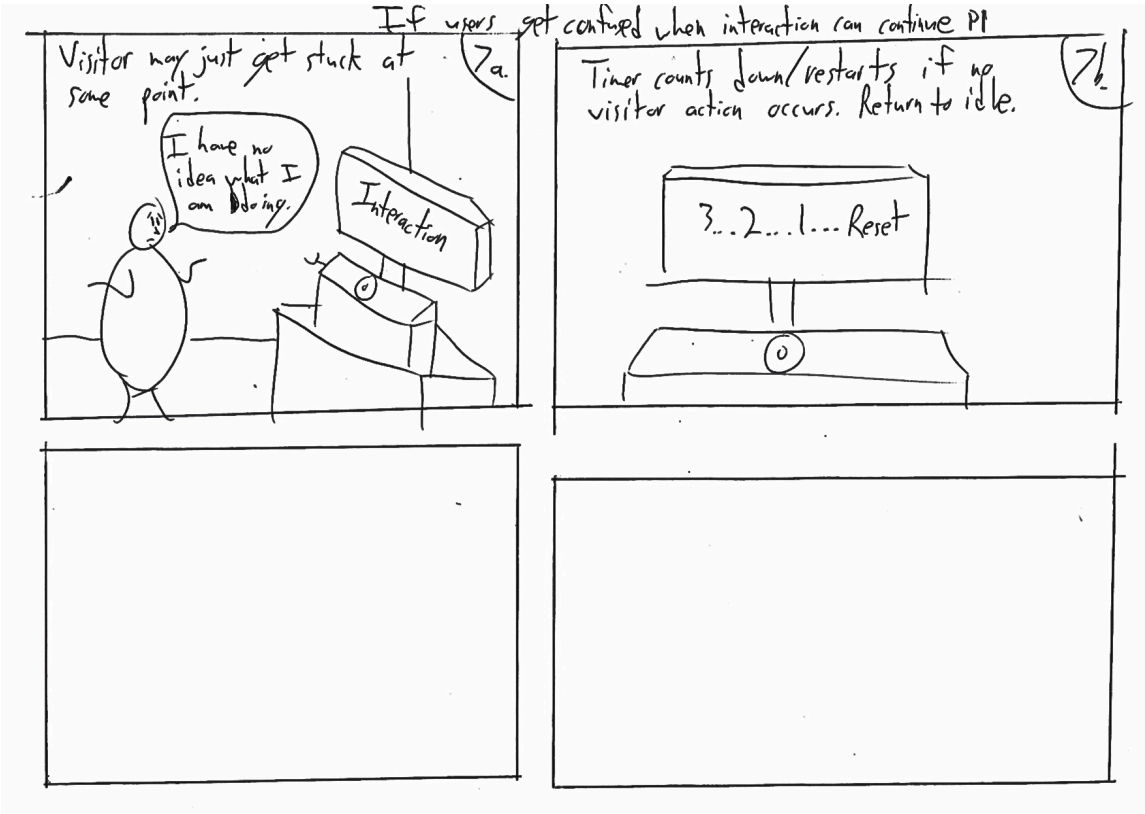


Figure 41: Potential Barrier to Ideal Interaction Frame 7

Content Storyboards for P1

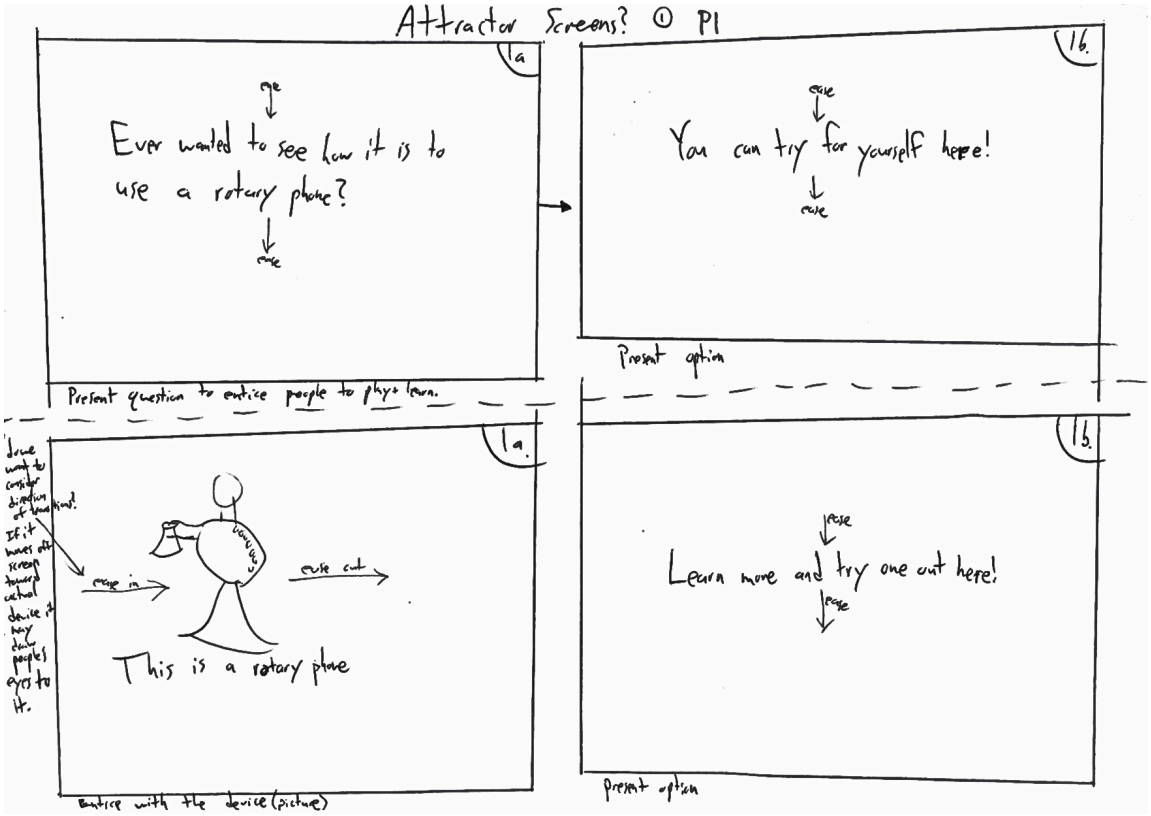


Figure 42: Attractor Screen

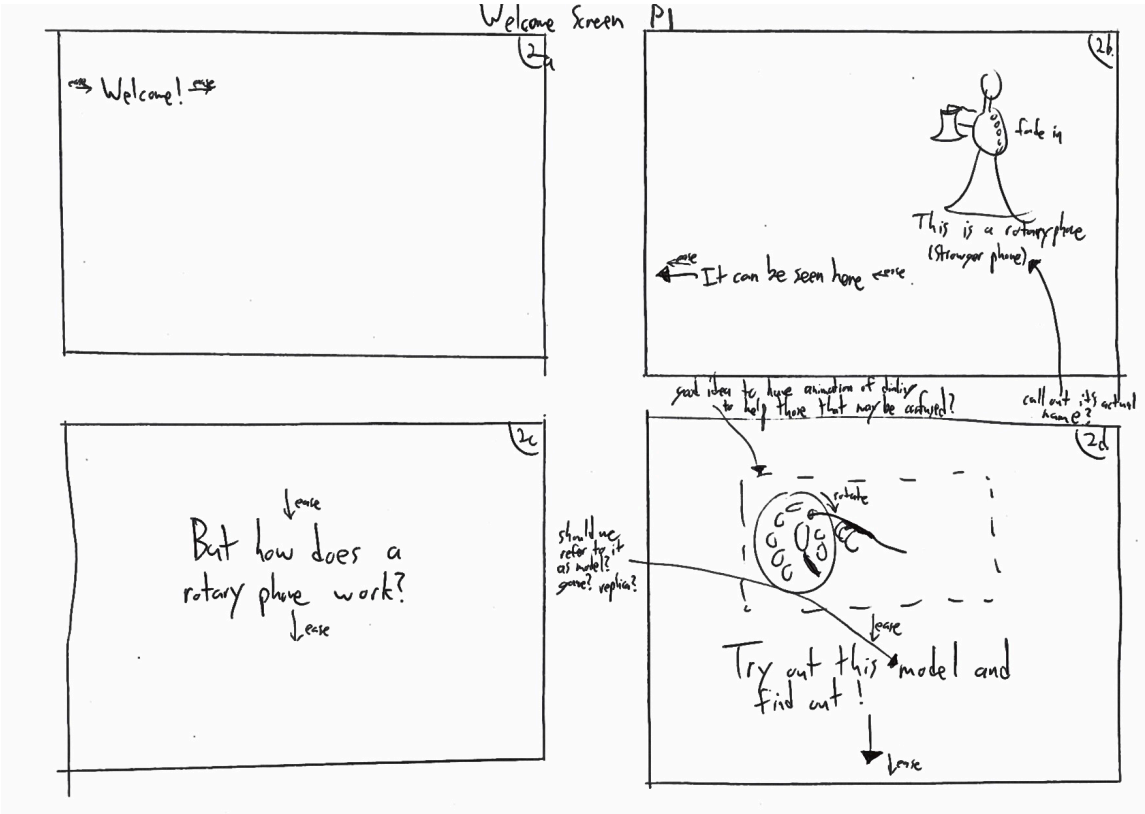


Figure 43: Welcome Screen

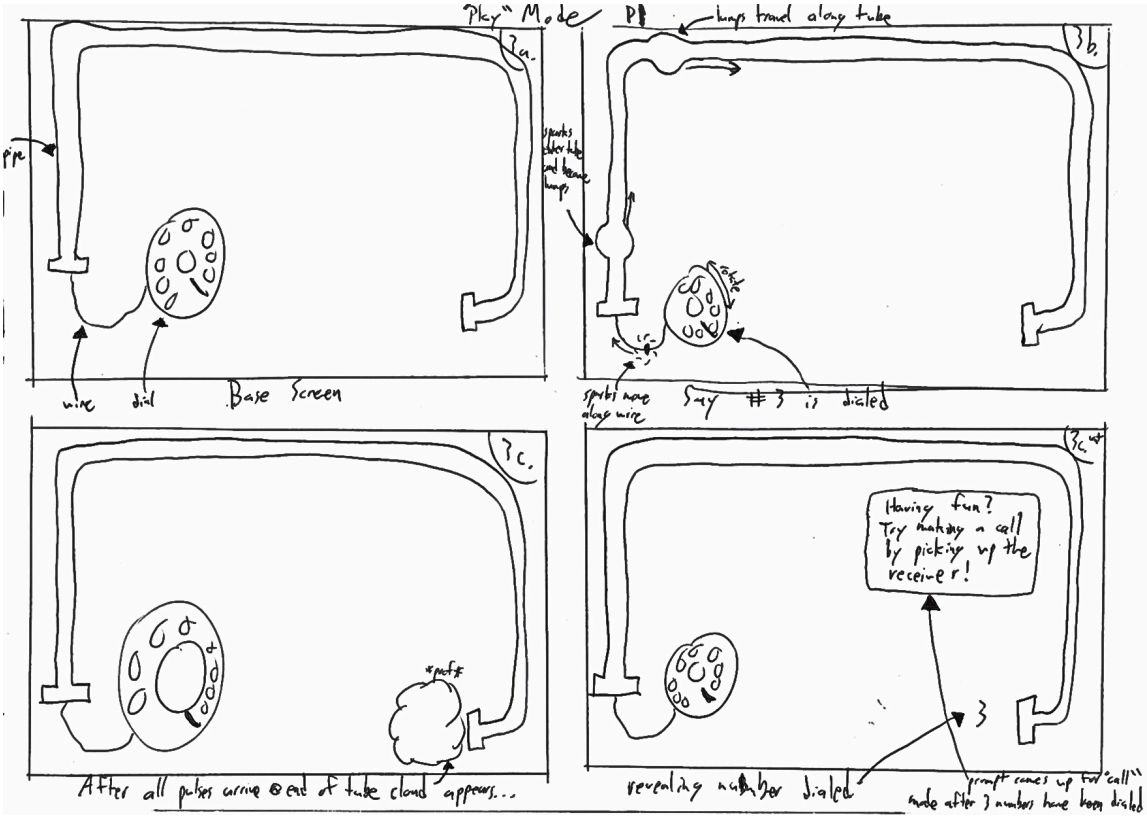


Figure 44: Play Mode

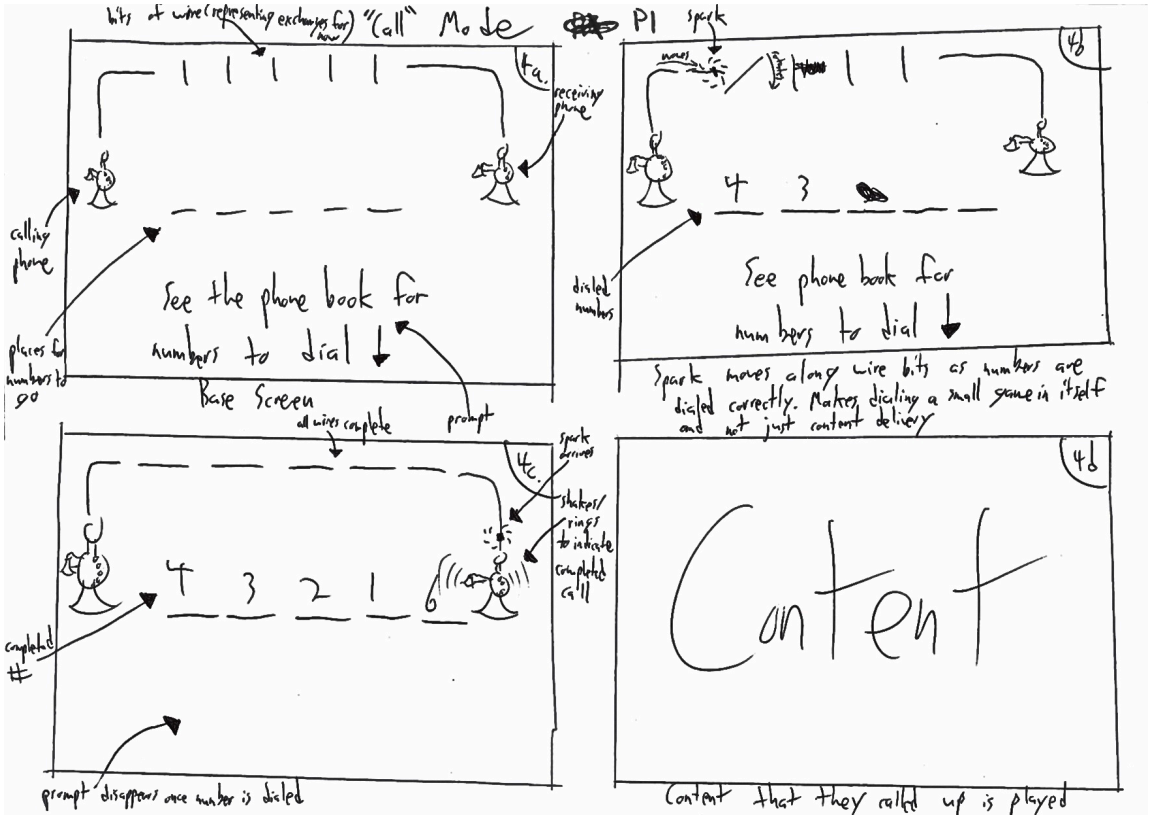


Figure 45: Call Mode

Interaction Storyboard for P2

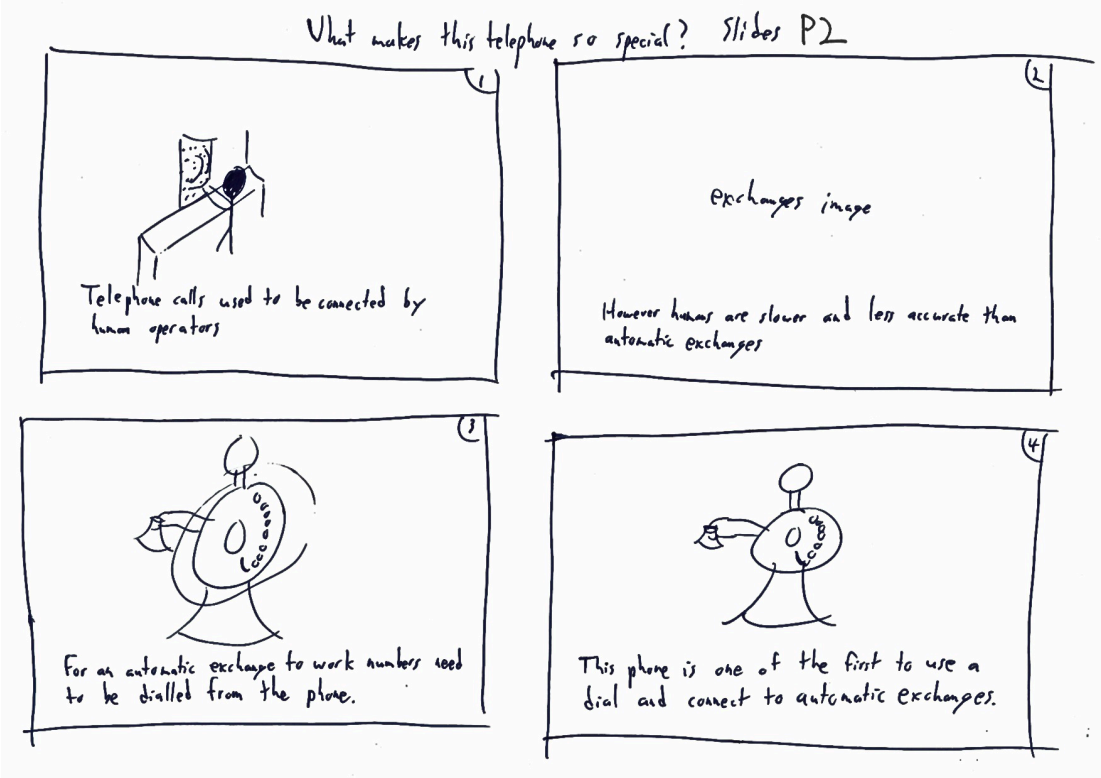


Figure 46: What makes this telephone so special?

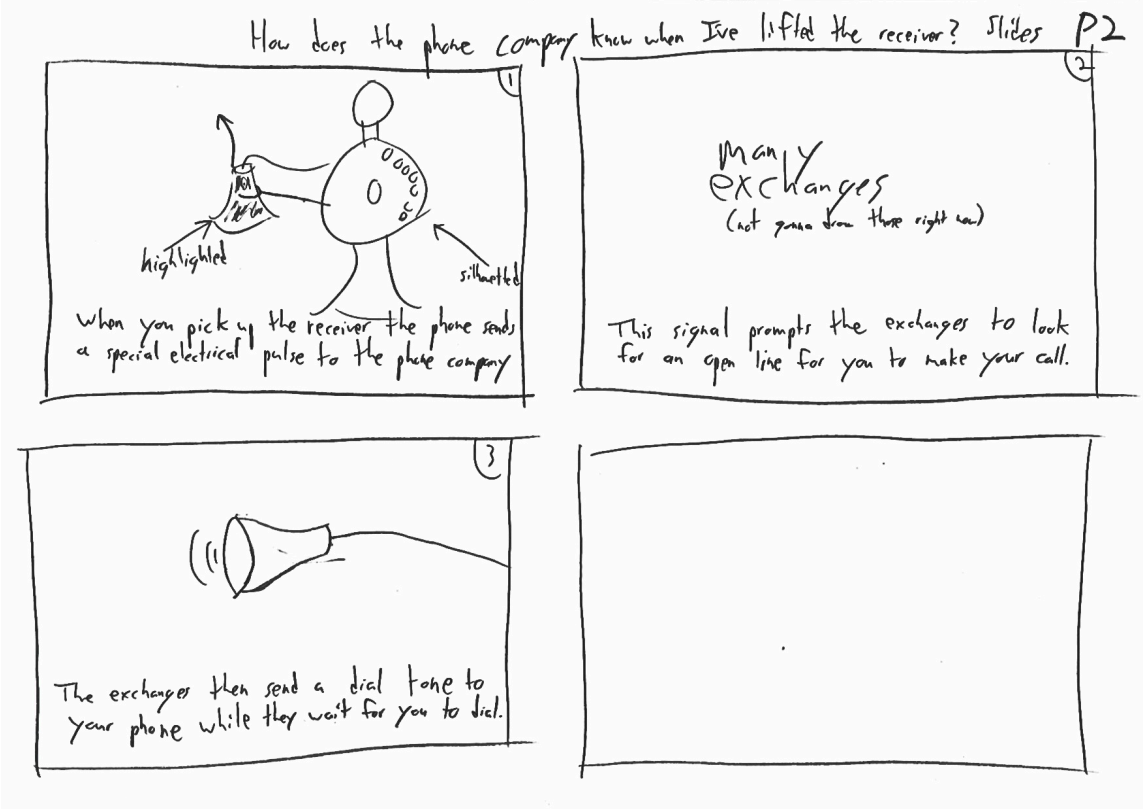


Figure 47: How does the phone company know when I've lifted the receiver?

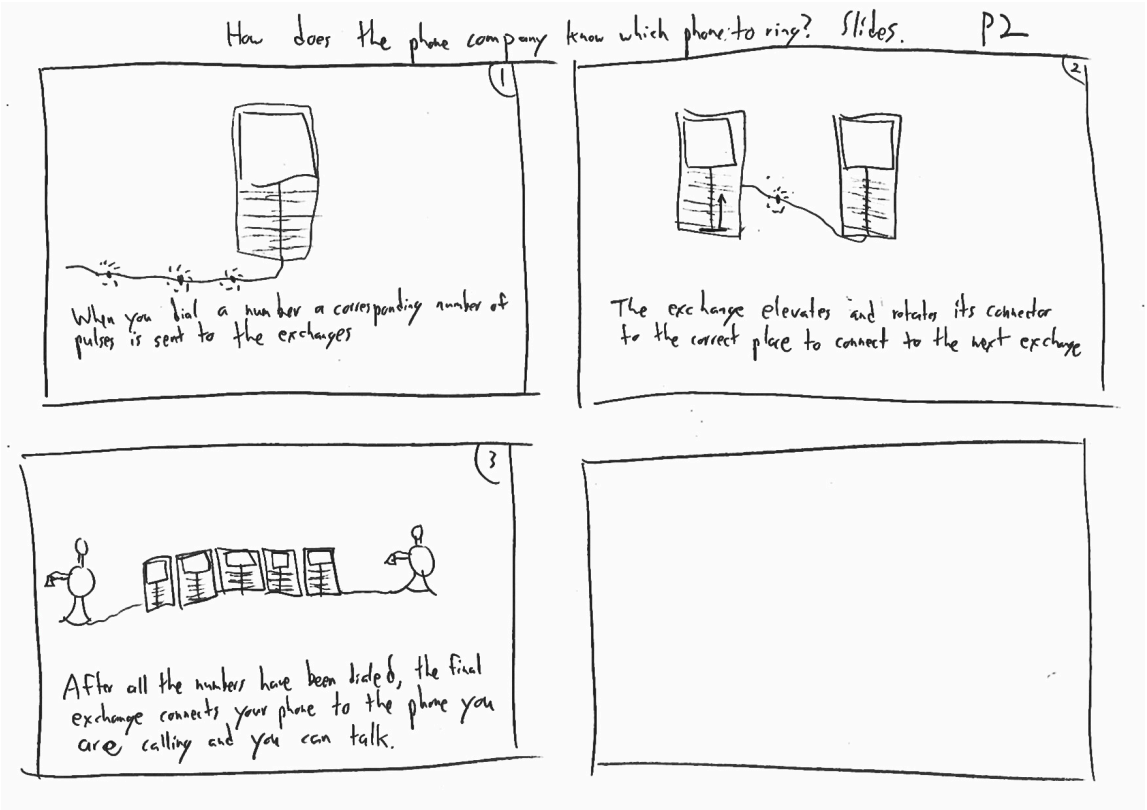


Figure 48: How does the phone company know which phone to ring?

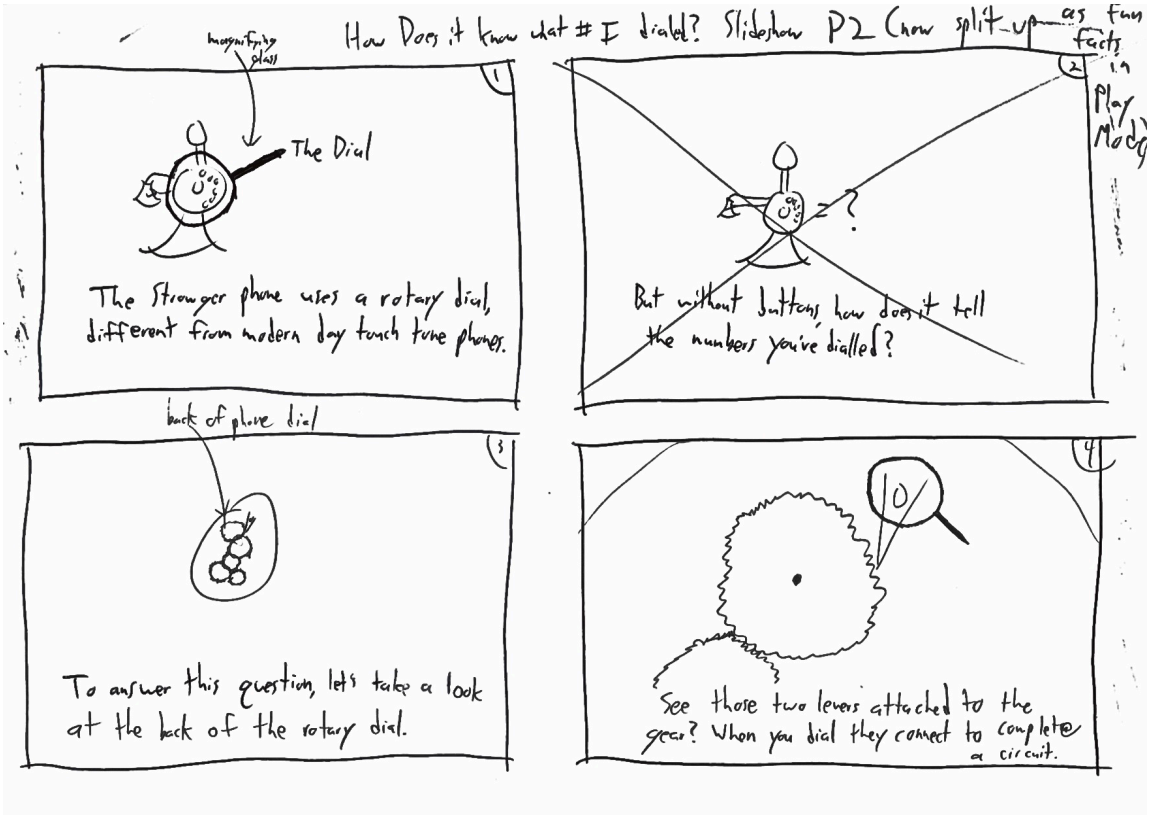


Figure 49: How does it know what number I dialled?

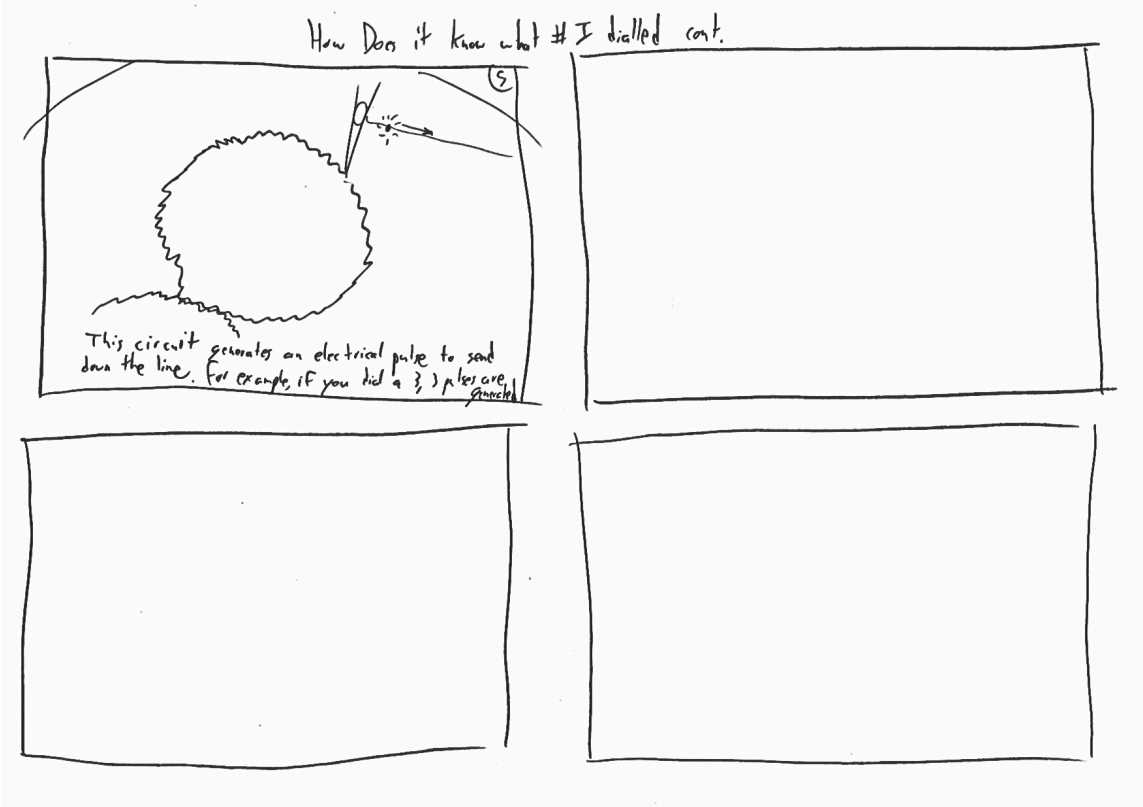


Figure 50: How does it know what number I dialled? cont.

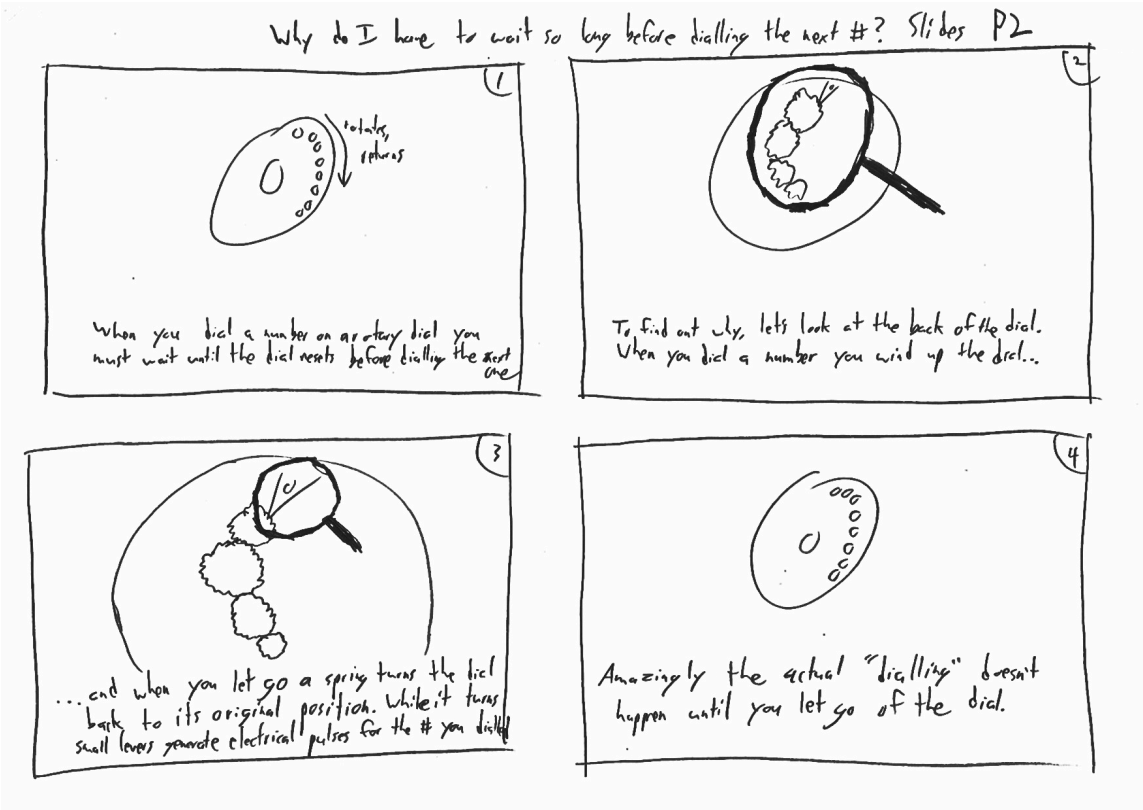


Figure 51: Why do I have to wait so long before dialling the next number?

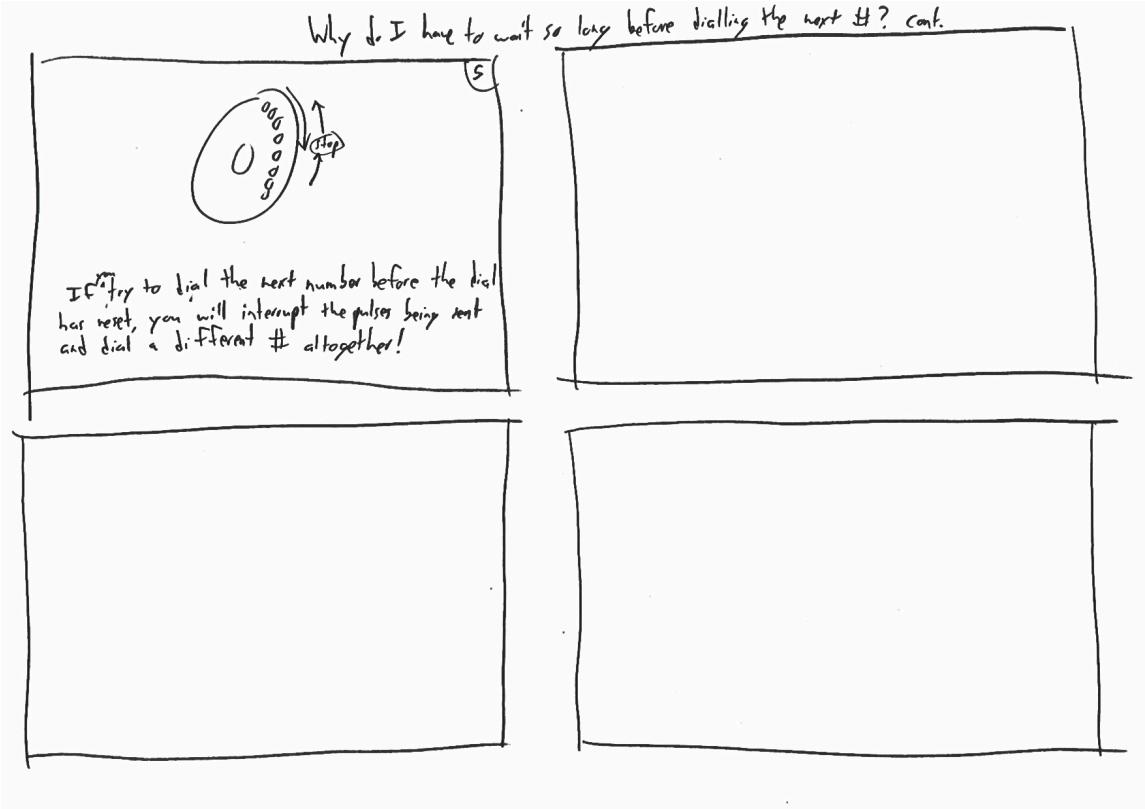


Figure 52: Why do I have to wait so long before dialling the next number? cont.

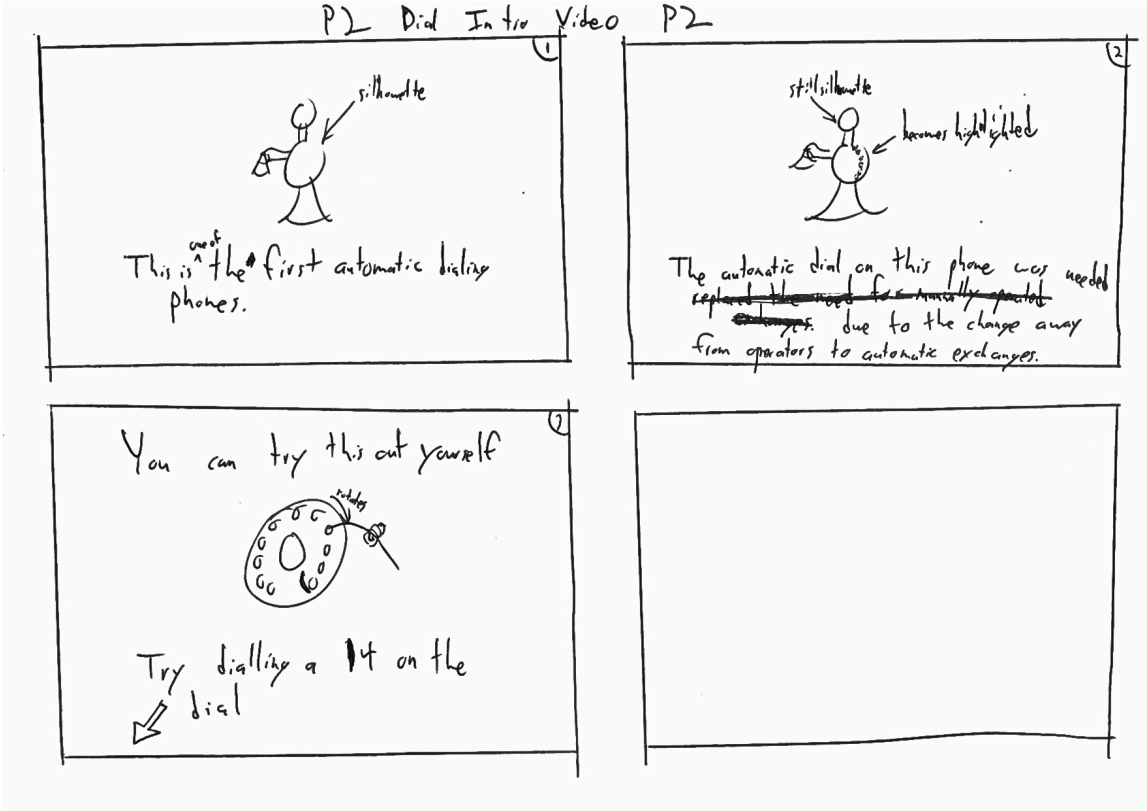


Figure 53: Dial Intro Video

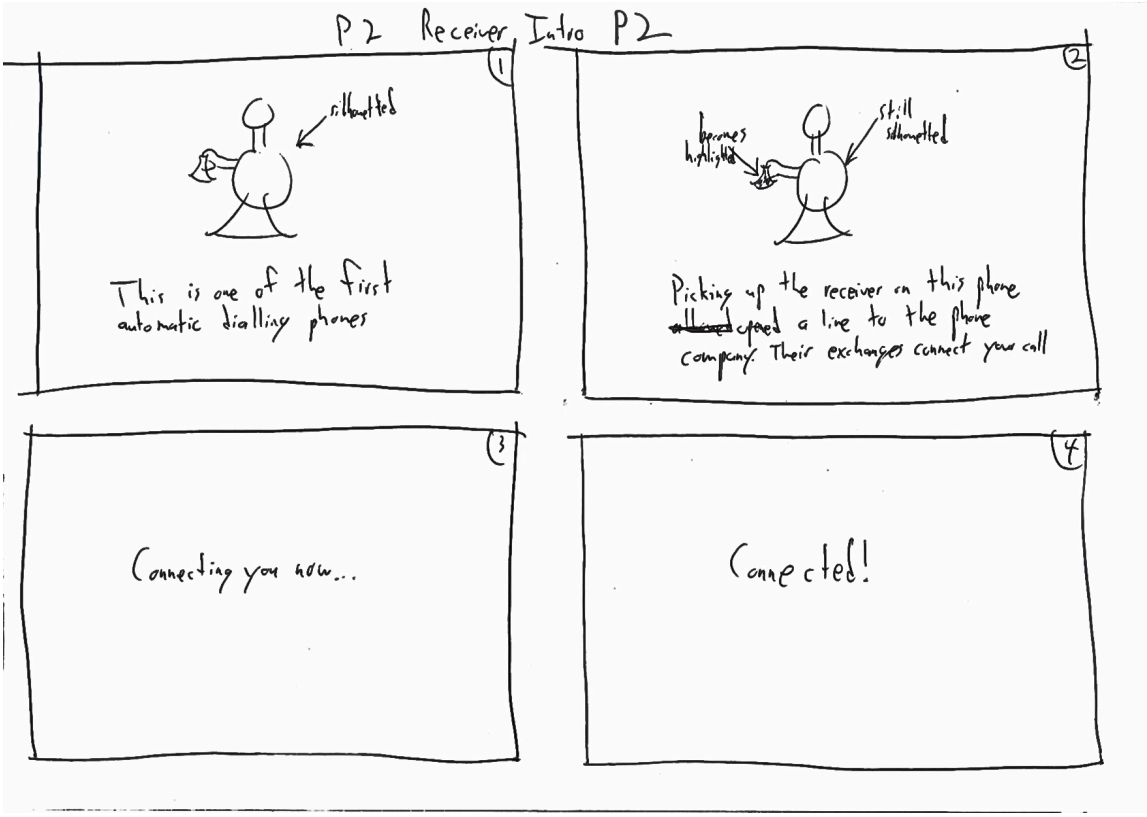


Figure 54: Receiver Intro Video

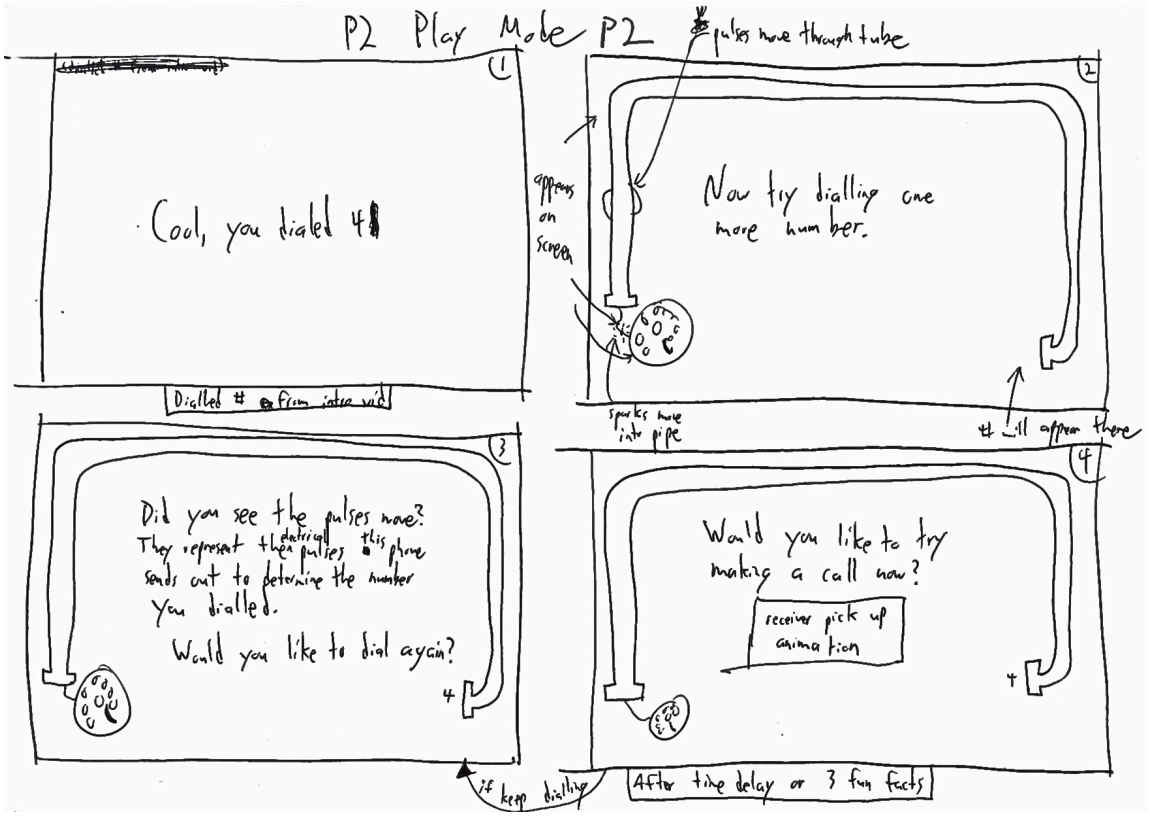


Figure 55: New Play Mode

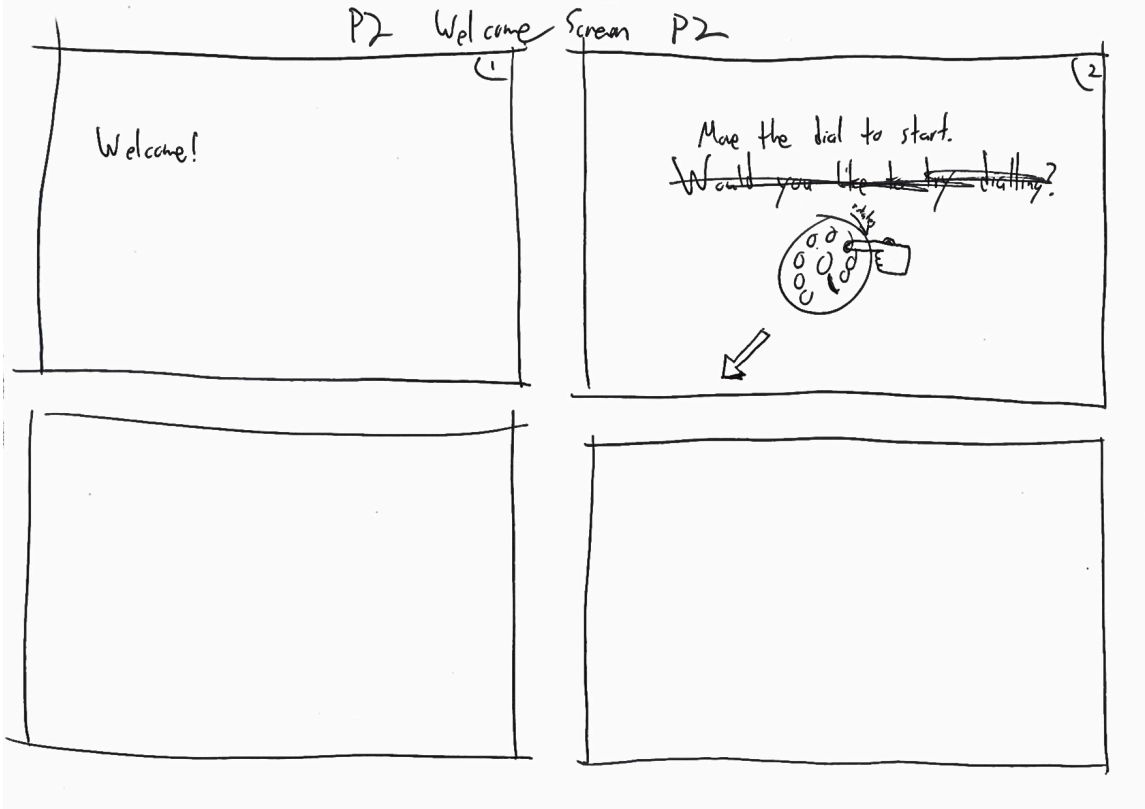


Figure 56: New Welcome Screen

Appendix O – Health and Safety Forms

Contained herein are the Health and Safety forms filled out to perform testing of the exhibit.

NMSI Risk Assessment Form

Nature / type of task being assessed and location/s	P1 Physical/digital Prototype				
Date of Assessment	29/3/12	Date by when assessment must be reviewed	ongoing	Assessment Completed by / Department	Jared Erb ARAA
How many people could be at risk?	up to 40	What category of person may be at risk (e.g. employee, contractor, public, young, old, special needs?)	visitors including children and staff		

Hazard / risk	Conse-quence	Likeli hood	Score C x L	Risk rating	Action/solution	Time scale	✓
Monitor can possibly fall onto visitor	2	1	2	Tol.	Screen has been taped down		
cables could be a trip hazard.	3	1	3	Mod.	cables taped down to floor.		
sharp corners on trolley and prototype could injure if fallen on.	2	1	2	Tol.	corners have been padded and exibit is made from soft materials		
"phone cord" stands as a possible entanglement hazard.	1	1	1	Tri.	visitor will be asked to be careful		
Arduino and other circuits could be potential shock hazard.	2	1	2	Tol.	there are no exposed circuits and the device is shiled to shock hazards.		

NMSI Risk Assessment Form

Nature / type of task being assessed and location/s	P2 Physical/Digital Int.				
Date of Assessment	14/3/12	Date by when assessment must be reviewed	ongoing	Assessment Completed by / Department	Jared Erb ARAA
How many people could be at risk?	up to 50	What category of person may be at risk (e.g. employee, contractor, public, young, old, special needs?)	visitors including children and staff		

Hazard / risk	Conse-quence	Likeli hood	Score C x L	Risk rating	Action/solution	Time scale	✓
Monitor can possibly fall onto visitor	2	1	2	Tol	screen has been taped down		
cables could be a trip hazard	3	1	3	med	cables taped to floor		
sharp corners on Trolley and prototype could injure if fallen on	2	1	2	Tol	corners have been padded exhibit is made of soft materials		
"phone cord" stands as a possible entanglement hazard	1	1	1	Tri.	visitor will be asked to be careful		
Arduino and other circuits could be potential shock hazard	2	1	2	Tol	There are no exposed circuits and the device is shielded to shock hazard		
speakers could damage a visitors hearing	2	1	2	Tol	speakers will be turned down and audio levels will be adjusted to comfort.		

assessment values		classification of risk rating (C x L = score)		action from risk rating	
consequence (C)	likelihood (L)	score	risk rating	action	time scale
Marginal - 1 (slight injury, minor first aid)	unlikely - 1	1	Trivial	No further action required	-
		2	Tolerable	Keep control measures under review	within 3 months
Dangerous - 2 (serious injury or damage)	likely - 2 (to occur at some time)	3-4	Moderate	Fine tune control measures	within 3 months
Very dangerous - 3 (could cause death or widespread injuries)	very likely - 3	6	Substantial	Urgent control measures needed	within 1 month
		9	Intolerable	Stop activity until risk reduced	immediately

- Your assessment will need to consider who and how many people may be affected by the hazard/s – ie children or the elderly may be most at risk. In these circumstances the risk rating will need to reflect this.
- Where the activity or task is a one off event – the 'time scales for action' may need to be amended to ensure that safety controls are implemented before the activity takes place.
- Please remember you are not expected to risk assess activities that are outside of you knowledge, expertise or experience.
- Further information and assistance can be obtained from the NMSI Health & Safety Advisor.

Remember

Hazard means anything that can cause harm.

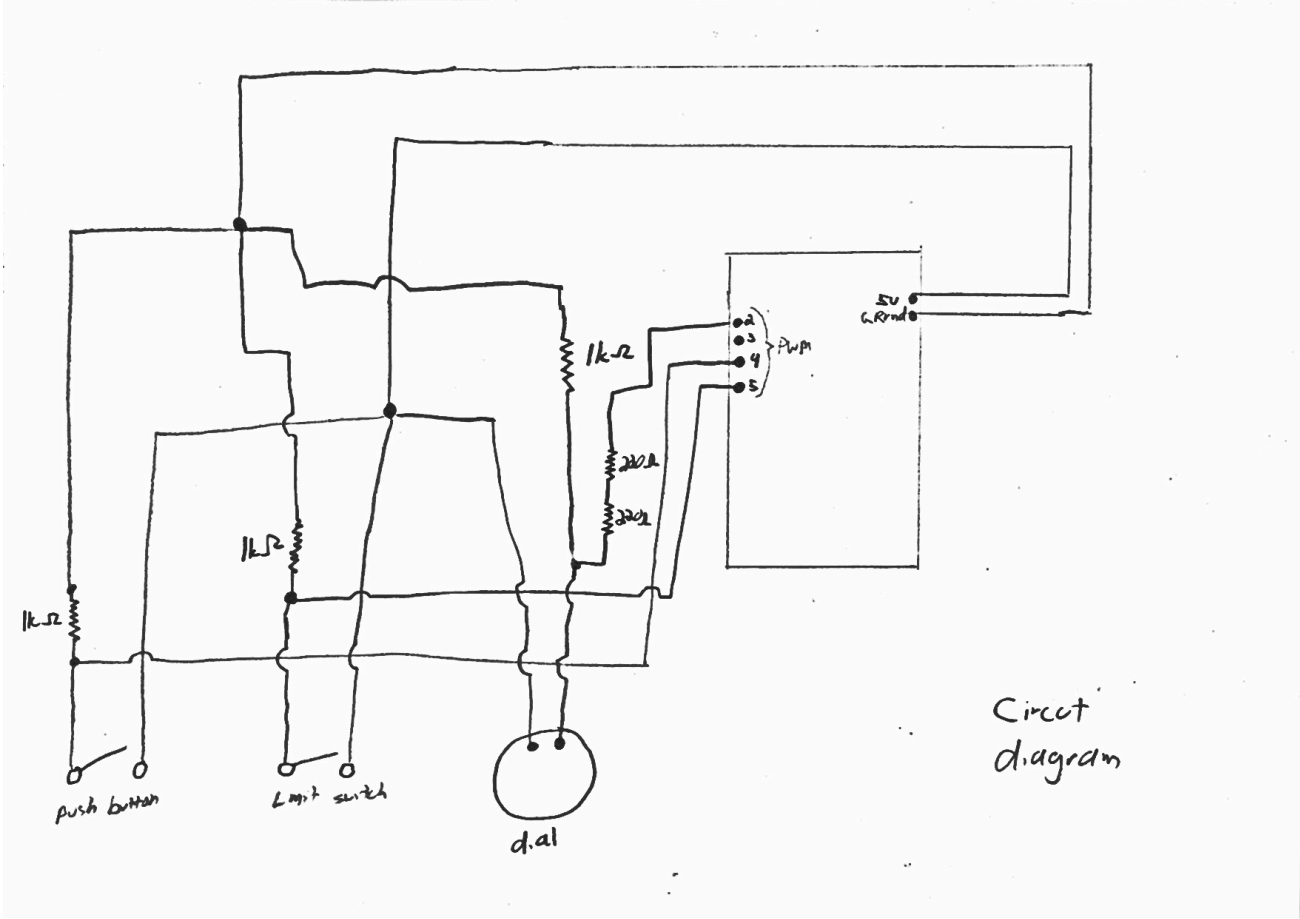
Risk is the chance, high or low that somebody will be harmed by the hazard

Five Steps to Risk Assessment

- Look for the hazards
- Decide who might be harmed
- Evaluate the risks and decide whether the existing precautions are adequate or whether more should be done
- Record your findings.
- Review your assessment and revise it if necessary

Appendix P – Circuit Diagram

Contained herein is a circuit diagram describing the wiring of the physical portion of the exhibit (both P1 and P2).



Appendix Q – Arduino Source Code

Contained herein is the source code that ran on the Arduino board that acted as an interface between the physical and digital portions of the exhibit.

```
/*----------------------------------------
-PROJECT INFORMATION
-Worcester Polytechnic Institute
-Science Museum, London UK
-Revision: 2.3
-25-Apr-2012
----------------------------------------*/

//Variable Definitions

int needToPrint = 0;
int count;
int lastState = LOW;
int trueState = LOW;
long lastStateChangeTime = 0;
int cleared = 0;
int recievercondition = 999;
boolean limitcond = true;
boolean startcond = true;
int counter =0;
// constants

int dialHasFinishedRotatingAfterMs = 100;
int debounceDelay = 10;

//Pin Values

int Pin_Dial = 2;
int Pin_Start = 4;
int Pin_LimitSwitch = 5;

void setup()
{
  //Opens the serial port
  Serial.begin(9600);

  //Sets inputs
  pinMode(Pin_Dial, INPUT);
  pinMode(Pin_LimitSwitch, INPUT);
  pinMode(Pin_Start, INPUT);
}

void loop()
{


  //reads in the values from the digital inputs
  int reading = digitalRead(Pin_Dial);
  int limitread = digitalRead(Pin_LimitSwitch);
  int startread = digitalRead(Pin_Start);



  //reads out the limit switch.

 //This is for when the reciever is picked up
  if (limitread == 1 && limitcond == true)
  {
  Serial.print("x");
  limitcond = false;
```

```
 delay(20);
 }

 //This is for when the reciever is hung up
 if (limitread == 0 && limitcond == false)
 {
 Serial.print("y");
 limitcond = true;
 delay(20);
 }

 //This is for the push button
if (startread == 1 && startcond == true)
 {
 Serial.print("z");
 startcond = false;
 delay(20);
 }


 if (startread == 0 && startcond == false)
 {
 startcond = true;
 delay(20);
 }


if ((millis() - lastStateChangeTime) > dialHasFinishedRotatingAfterMs)
{
  // the dial isn't being dialed, or has just finished being dialed.
  if (needToPrint)
  {
  // if it's only just finished being dialed, we need to send the number down the serial
  // line and reset the count. We mod the count by 10 because '0' will send 10 pulses.
  Serial.print(count % 10, DEC);
  needToPrint = 0;
  count = 0;
  cleared = 0;
  }
}

if (reading != lastState)
{
  lastStateChangeTime = millis();
}
if ((millis() - lastStateChangeTime) > debounceDelay)
{
  // debounce - this happens once it's stablized
  if (reading != trueState)
  {
  // this means that the switch has either just gone from closed->open or vice versa.
  trueState = reading;
   if (trueState == HIGH)
    {
    // increment the count of pulses if it's gone high.
    count++;
    needToPrint = 1; // we'll need to print this number (once the dial has finished rotating)
    }
  }
}
lastState = reading;
```

Appendix R – Initial Design Charts

Table 1: Numerical Evaluation Chart

Constraints and Objectives	Morse Code Apparatus	Large 5-needle Cooke and Weatstone	Marconi 1.5kW Transmitter	Carbon Microphone	Strowger Rotary Phone	Generic Mobile Phone
C: Under $150						
C: Interesting		**X**	**X**	**X**		
C: Safe to use						
C: Easy to repair						
C: 7 Weeks						
C: Ease of Construction		**X**	**X**			
O: Teach patrons about object	**7**				**9**	**5**
O: Durable/Long Shelf Life	**8**				**9**	**7**
O: Show inner-workings	**8**				**9**	**5**
O: Digitally Highlight Object	**4**				**8**	**5**
Total:	**27**	**X**	**X**	**X**	**35**	**22**

Table 2: Pairwise Comparison Chart

Pairwise Comparison Chart							
Objective	Safety	Shelf Life	Ease of Use	Teach Patrons about Objects	Instructions	Show Inner Workings	Total
Safety		1	1	0	1	1	4
Shelf Life			0	0	0	0	0
Ease of Use				0	1	1	3
Teach Patrons about Objects					1	1	5
Instructions						0	1
Show Innerworks							2

Table 3: Morphological Chart

Morphological Chart					
Function	Means				
Control Exhibit	Computer	CD	DVD	Arduino	●●●●
Output Audio	Large Speakers	In-ear piece Speaker	Combination of the Two	Overhead speaker	●●●●
Easy to Use	Sound Instructions	Pictures	Detailed use instructions	Video Instructions	Museum Staff Help
Durable	Well Built	Good Materials	Polycarbonate Glass	●●●●	●●●●
Teach Patrons about Objects	High Quality Audio Files	Clear Animations	Interesting Information	Relate it to Patrons	●●●●
Safety	Instructions	No Pinch Points	Safe Materials	Audio Level Tests	●●●●

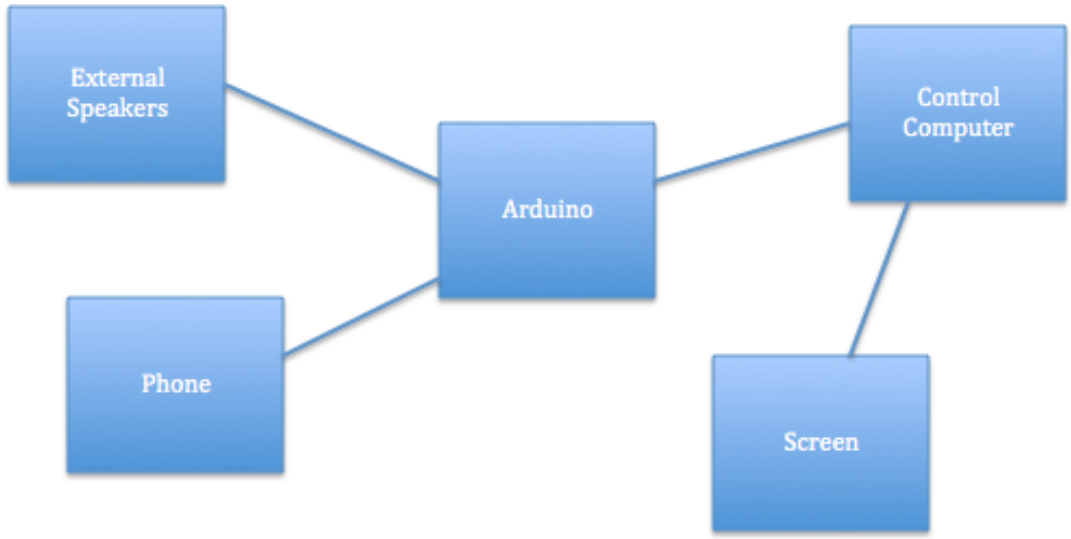


Figure 57 - This layout diagram outlines the general design of the exhibit.

Appendix S – Testing Journals

Contained herein are the group's thoughts and reflections throughout testing and evaluation (P1 and P2).

P1

- Need to shorten time between 3rd fun fact and receiver prompt - JOB
- Receiver prompt shouldn't clear/reset on dial - JE
- After first day of testing, we positioned the prototype differently so that it more clearly frames the actual object and completely blocks out another nearby phone. Kayte has told us that this is more realistic since an interactive would be built right next to an object, without any other objects to distract the visitor – JOB
- We need to test for pacing in p2 testing, ask Kayte for tips on what questions we should ask? – JOB

First Day Reactions

- **First day feelings: - JOB**
  - The exhibit is fun
  - Had a few good phys/digi experiences
  - People are getting close to the main concepts, but missing some key points
  - Need to get better at teaching
  - Not enough people noticed the real object
- **First day thoughts – RC**
  - People have fun
  - Many noticed, enjoyed the physical digital interaction
  - People can still enjoy the experience without seeing whole experience
  - Need to call out object more
  - Surprisingly the button to start seems to be working fairly well

- **First day thoughts – TC**
    - Dialling is fun
    - Receiver needs sound
    - Doesn't draw enough attention to the actual object (may be related to placement of screen)
    - Phonebook seems to be working
    - Not teaching enough
- **First Day thoughts – JE**
    - People had fun
    - Some of the instructions were unclear
    - NOSTALGIA
    - I personally don't like the phonebook but people seem to have liked it.
    - Some people really like the start button and some really don't
    - Need to reference the object WAY MORE

<u>Second Day Reactions</u>

- **Second Day Thoughts – JOB**
    - Good
        - People having fun
        - Making it through the interaction with little/no instruction
        - Getting SO CLOSE to the core concepts and learning outcomes
            - People are saying "pulses", "how dialling works", "how exchanges used to work", "old phones"
            - Know it's about old phones, just not the Strowger in particular
        - Impressed with the number of people that used every aspect properly (dial, receiver, phonebook)
    - Bad
        - Probably should angle the "start" button arrow so that it points to the button and not straight down

        - Need to highlight the object even more strongly
        - Some people have been unclear as to the overall goal of the activity
        - People are concentrating too much on the screen
        - Sometimes people concentrate too much on the dial and miss important bits on screen
            - Perhaps a beep sound plays every time they dial during the "fun fact" phase to steal their attention?

- **Second Day Thoughts – JE**
    - Some real patterns are emerging
    - People are starting to get content without being shown a content video
        - People are leaving with a little bit better understanding
    - The down arrow is confusing people at the start
        - Put screen right behind box or light up button or something
    - People are requiring very little coaching to get through the exhibit.
    - The object is being overshadowed a little
- **Second Day Thoughts – RC**
    - People enjoy playing so much!
    - So glad to have gotten all the IA's done!
    - Starting to see patterns. Things are not so hyper educational, but people are getting the "gist" of things
    - People seem to at least recognize in words that the Strowger phone is the focus, but don't always notice the phone itself
- **Second Day Thoughts – TC**
    - Most people liked it
    - Seemed good for children
        - May need more context – needs more research with families
    - People are still missing most of the facts, as well as the object itself
    - Needs sound

Third Day Thoughts

- **Third Day Thoughts – RC**
    - holy crap do people want this to make sound
    - first person I have seen trying to touch screen, but they realized not to when nothing happened
    - parents LOVE sharing the nostalgia and experience of what they used to use with their kids, who have never used these
    - yet, kids generally know how to use the dial
    - We should better demonstrate on-screen how to use the dial
    - There is so much more conversation within families than there was between IAs
    - We need to point out phone more. People (even kids) mention Strowger, but do not necessarily know that the phone that's right there is the Strowger phone
- **Third Day Thoughts – JOB**
    - All families today, fyi
    - Good
        - A few families mentioned "pulses"
        - A few families made the connection to the phone
        - Parents were extremely nostalgic
        - Kids all had fun most learned something
        - Kids all said the exhibit was "for them"
        - All parents agreed, and quite a few said adults can enjoy it as well
    - Bad
        - A few kids tried to grip the outside of the dial and twist
            - Parents corrected them and it was fine
            - Need to work on the "try dialling" animation?
        - Group chatter caused people to miss some key info on screen

        - Missing too many of the learning outcomes, everyone thinks it's about exchanges and dialling, but missing the key ideas
            - Rethink intro video and "fun facts" section?
        - The "fun facts" section was too busy
            - People either noticed the pulses, or the facts, rarely both
            - Possibly have a blank screen first, then facts on second dial?

- **Third Day Thoughts – JE**
    - Families seem to enjoy it
    - Parents really helped the kids through it
        - "if we weren't standing here he probably wouldn't have gotten it.
    - "it was interesting to see how old phones were" – Male, 15
    - The fun fact screen seemed to be to busy for children
        - "yea, I didn't read it"
    - "White on Grey and Black and white are awful"
    - Some think that it was very interesting
    - Sound will play a major role for children..
- **Third Day Thoughts – TC**
    - Need much clearer instructions/better animations
    - Kids do seem to like it though
    - People don't seem to be getting much out of it
    - A surprising number of kids do know how to use a rotary dial
    - Needs sound

P2

1. **Day 1**

a. Alex's Thoughts
    i. First full interaction seemed more like P1, with some minor improvements
        1. Commented on pacing being too slow
        2. Didn't notice phone
        3. Questioned us about authenticity of 5-digit numbers – "we had a 6-digit number"
        4. Didn't notice receiver
    ii. Second interaction went much better
        1. Noticed physical phone!
            a. From full picture of phone, which may contradict our design principle about visual abstraction
        2. Seemed to understand a lot of the content
            a. Talked a lot about electricity and circuits
        3. Were confused by digital phonebook – looked for physical phonebook
b. Jack's Thoughts
    i. After the first one:
    ii. Still didn't notice phone
    iii. Only real conversation at the comment about 5-digit numbers, mom didn't believe us! Dad and her talked about how her old number was 6 digits, but dad agreed 5 was probably right for the early 1900s
    iv. Started with a dial, which was great!
    v. Mom mentioned that it was "nice to use the old dial" again, daughter mentioned it was fun to "interact and dial"
    vi. Dad mentioned it was interesting to see how simple old dials were, and how technology progressed
    vii. Talked a lot about history of phones, and about the actual mechanism of dialling:

1. Mom made a squeezy pulse kind of motion with her hand when we asked her about what we were showing with dialling and talked about the "signal being transmitted", so close!
2. Talked a lot about how you have to let the dial go all the way or else the wrong number is sent (this is the content video they watched)

viii. After the second one:

ix. OH MY GOD BEST INTERACTION EVER.

1. Mom and son, they got <u>everything</u>. Mom mentioned concept of pulses (electricity, circuits, connection), son mentioned that it was very interesting to learn that dialling happens when you let go. They got all the way through perfectly and watched both videos and relayed all the content back to us in the interview. At one point in play mode, Mom told son to slow down dialling so they could read the facts. Only down side was they did not notice the phone until the very end: at the end of video 66745 there's a still shot of the Strowger, she pointed to the phone at this point. This made today worth it, I was so happy to see this work properly.

c. Jared's Thoughts

i. We had two families

1. Pacing was to slow
2. One noticed phone, one understood it was abut a phone in the gallery but not which one
3. Glitches need to get fixed
4. Sound was too quiet
5. Voiceovers would be nice
6. Kids didn't have much trouble using it but they both said they have never seen one before

7. Kid said "its about he mechanics of the dial"
8. Both started with the dial
9. The history of phones was a major tobic but some talked about connections and electrics
10. One family had lots of communication
    a. They were French so one was translating for the others
11. The other family the dad helped guide the kid along
12. "it should be fast, technology is fast these days"
13. The phonebook needs to either moved down or the arrow needs to point up
14. One person mentioned it might be nice to have the dial off the strowger on the activity
15. One person actually questioned about the letters on the dial.

d. Ryan's Thoughts
    i. We got a lot of really solid feedback from the two families we talked to, despite the unfortunately limited time we had to test today.
        1. Pacing HAS to be addressed. Poor first kid seemed bored as hell during the intro video.
        2. We still have a couple bugs to fix
        3. People seem to like exploring for all of the content, dialling both numbers in phone book. Would likely dial more if we had them there.
        4. People seem to want more sound. Voice-overs would have been ideal.
        5. Parents continue to provide solid scaffolding and maintain discussion with their kids
        6. Maybe make the interactive look more like the Strowger phone?

7. People really get that it's about old phones/how those old phones worked but still aren't really showing that they get the meat of the details
8. Still haven't seen someone start by lifting receiver. Either the prompt is working or maybe people just go in a linear path anyway, which honestly does seem to make more sense.
9. I want more data to work off! Longer time spent testing on Monday and Tuesday will help.

2. Day 2

a. Alex's Thoughts
   i. More people noticing the phone, which is nice
   ii. Some people not quite picking up on the revised technical information
   iii. Most people are fixating on the idea that the activity is meant to show the difference between old and modern phones
   iv. Noticed a few people dialling a few times immediately at the intro screen – might be related to the fact that the animation shows the hand dialling three numbers
   v. Doesn't quite feel like enough has improved

b. Jack's Thoughts
   i. Seems like people are noticing the phone more, which is great!
   ii. Visitors are having quite a lot of fun dialling
   iii. Seems to be much more conversation this time around
   iv. Play mode has been functioning better this time around. We actually had one mother slow her son down so that they could read the facts aloud together. So great!
   v. Most people are mentioning "old phones" "connections" and "signals", and "difference between then and now" and "how intricate/complex it was connecting a call"
      1. So close to the main learning outcomes and concepts

vi. Interestingly enough, the on screen phone book has proved more confusing than the paper phone book… but this is likely due to poor layout selection. A bigger screen and more delineated phonebook would make this better

c. Jared's Thoughts
    i. Phonebook is sucking
    ii. People are kinda getting the content
    iii. Need more sound
    iv. Some people are still confused
    v. People seem to have fun
    vi. More people are noticing phone
    vii. THE PROMT NEEDS TO POP UP IMMEDATLY
d. Ryan's Thoughts
    i. We got a couple solid interactions today and are progressing well into the total we want.
        1. Noticed something strange today. Most people in fact did notice the phone, and even pointed to it/mentioned it while they were using the interactive.
        2. People were also very keen on reading the content as it appeared, often commenting on it or sharing anecdotes amongst their group.
        3. However, people could still only give the most basic of answers/explanations when we interviewed them, specifically about content.
        4. One kid mentioned getting "more technical" but admitted that he was a bit of a technical guy as is.
        5. Parents still provide amazing scaffolding.
        6. Perhaps we sped things up a bit too much now. Comments here or there saying that it might have been too fast for kids to read on their own, but parents seemed ok with it.

7. Surprisingly people actually got confused by the phonebook? Maybe it just doesn't work on screen.
8. I guess overall people are getting more from this and it's working better in the end, but more should have improved.
9. Also, we finally ended the looping exchange video problem

3. Day 3

a. Alex's Thoughts
   i. Dwell time seems to be higher than P1
   ii. Need a better way to get people to look at the object
      1. Put the screen above the phone?
   iii. Got some comments about Play mode being too long / repetitive
   iv. A lot of people wanted voices in the receiver
      1. Not necessarily voiceovers of content, but when you use a phone you expect a voice on the other end
   v. Lots of people mentioned nostalgia / evolution of old phones
      1. Might just be what they assumed it was about

b. Jack's Thoughts
   i. Today we got many more IA's done
   ii. First time this has happened to me, on three separate occasions today, new visitors came up to the exhibit and played with it while we were interviewing someone else
   iii. Patterns I've noticed:
      1. Surprising number of people struggling with the phonebook
         a. Proves that simply digitizing something is not enough. We clearly didn't put enough thought into how it was arranged on screen.

iv. Decent number of people noticed the phone, still not enough though
    1. Need to be careful, people see pictures of the phone in the exhibit, and when we point it out later go "oh yes I noticed that…" and they're actually kind of lying. We need to make sure they noticed it DURING the interaction and NOT when we showed it to them afterwards.
v. People still getting content in call mode fairly well
    1. Many mention learning about "how it dials when you let go of the dial"
vi. The Play mode interaction is working better.
    1. More visitors are observed to dial, look at the screen, dial, and look at the screen. Good flow. Content still needs some work though; I'm worried it might be too vague and general.
vii. People having quite a lot of fun overall dialling and using the exhibit
viii. Many visitors believe the exhibit is about the "difference between phones then and now", "progress of technology and communication", "how complex it used to be", and I've even heard one or two say "how important the dial was and how this kind of phone changed how we communicate"

c. Jared's Thoughts
    i. "I think the interaction between the physical and digital was good"
    ii. Ring back is a tad confusing coming from both places but most people got it.
    iii. The phone is being noticed but I think some people only notice it after it is pointed out.

iv. Some people skipped lots of videos but this was psrt impatience and part not knowing what to do. We guided them to the video.
v. Play mode worked bettwe but at times it was stated it was a little long.
vi. People really wanted voice-overs
    1. They comment the receiver is nice but the lack of a voice-over makes it a bit lacking
    2. Recommend for P3
vii. Phonebook continues to be a problem.
    1. We have had more problems from this one then the paper one.
viii. Every digital interaction needs to have a very clear defined reason
ix.

d. Ryan's Thoughts
    i. Lots of IAs today. In fact mostly all IAs.
    ii. Patterns emerging/initial preliminary findings
        1. Phonebook seems to be a real problem. This implementation of a digital phonebook doesn't work. Maybe it need to be more clearly set apart from the rest of the screen or maybe it needs to be more clearly pointed out, but it doesn't work to just take the physical one and put it in digital form
        2. People want more sound, especially voice-over
        3. Call mode content is getting across fairly well
        4. new structure for the Play Mode is working. People are no longer confused. However the content presented there is still iffy. Change how info is presented.
        5. Phone is getting noticed more, and more explicitly now. People actually point to it or mention it.

6. I think our idea about visual abstraction is a bit off. Although people respond to the images that came directly off the phone and highlight certain parts (the dial, etc) they also like the images of the entire phone. Also, many people have explicitly asked that we consider making the physical bit into a model of the phone
7. People also seem to want a bigger version of the dial/see-through box to house everything so you can actually see the gears and levers that are mentioned at work.
8. Lots of talk about the "progress of phones" and history and such. Outside of the scope of this interactive, but still good to know the are curious

Appendix T – Bill of Materials

Contained herein is a list of the materials that went into the construction of the physical model.

Merchandise	**Retailer**	**Cost (£)**
Arduino MEGA 2560 Board	Amazon	34.27
Getting Started With Arduino book parts plus pack	Amazon	7.99
Mach Screw (x2 @ £3.68)	B&Q	7.36
Mach Screw	B&Q	4.28
Utility Knife	B&Q	4.98
40mm PVC Couple	B&Q	1.49
Western Electric Blue Aqua Rotary Trimline Desktop Telephone	eBay	16.95
Cotton String Ball	Imperial College	1.39
Polyboard White A1 (x3 @ £8.50)	London Graphic Center	25.50
Polyboard White A3	London Graphic Center	1.65
Polyboard White A4 (x4 @ £1.25)	London Graphic Center	5.00
Blu-Tack Handy	London Graphic Center	1.75
UHU All Purpose Solvent	London Graphic Center	2.55
Stereo 3.5 Extension 3m	Maplin	8.99
Stereo Splitter 3.5/3.5	Maplin	2.69
Total		***126.84***
Total (USD)		***$205.43***

Table 4 - This Bill of Materials outlines the items purchased to construct the prototype

Appendix U – Phonebooks from P1 and P2

The Phone Book *Dial these numbers when prompted to learn more!*	
23555	How does it know which numbers I've dialled?
11811	Why do I have to wait so long before dialling the next number?
66745	How does the phone company know when I've lifted the receiver?
52432	How does the phone company know which phone to ring?

The Phone Book *Dial these numbers when prompted to learn more!*	
66745	Why does this telephone have a dial?
11811	Why do I have to wait so long before dialling the next digit?

Appendix V – Science Museum Brief

WPI London Project Centre Proposal Form 2012

Innovative Digital Interpretation Project
Term D12 (March 7th – April 27th 2012)

General Information:

Liaison name, address and contact information

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Project Aim:

The aims of this project are:

- To create a working prototype for a hybrid physical and digital exhibit that can allow visitors to have a greater understanding of an object through physical manipulation of a digitally enhanced replica.
- To evaluate through visitor testing the success of the interpretation method by highlighting the challenges and opportunities and responding to barriers encountered in proceeding prototypes

Brief Background

1. The Museum:

The Science Museum is the UK's most popular destination dedicated to science, technology, engineering, medicine, design and enterprise. As the home of public

engagement with science, we combine our unparalleled collection of historical objects with cutting-edge technology and contemporary science news and debate, to help our visitors make sense of the science that shapes their lives and to inspire the next generation of scientists. We welcome over 2.7 million visitors every year.

http://www.sciencemuseum.org.uk/about_us.aspx

2. Departments you will be working with:

This project will be managed and organised by the Audience and Research and Advocacy team but working in very close partnership with the New Media Team who are responsible for the Museums digital interpretation offer. Due to the technical nature of this project your contact in New Media (Anne) will be vital to the success of the product development.

3. History and context of the problem:

Extensive research has shown us that visitors to Museums vary hugely from one another and come with different knowledge levels, different learning style and different areas of interest. Objects have traditionally been interpreted through text panels which can be restrictive.

The Museum is currently developing a new object-rich gallery called Making Modern Communication and we are looking for innovative ways of interpreting our collections which addresses the differing needs of our visitors with the result of providing genuine life enhancing experiences (by this we mean experiences that are engaging, memorable and inspiring) and meaningful engagement with our objects and their content.

We see this as a great opportunity to experiment with new and imaginative types of physical and digital interpretation of objects in order to bring them to life for our visitors

Problem statement and Objectives

We often say Science Museum's objects are mute. Science and technology objects haven't been designed to be looked at and our audience often find it difficult to connect with them.

We think a physical understanding of how the object works and its functional design will helps our visitor to engage with certain type of objects. However, sometimes the working mechanisms are hidden inside the "box", or our visitors do not have sufficient knowledge to understand what they are seeing without additional explanation and labelling. Our objects are also often fragile and we can't allow visitor to manipulate them directly.

We think manipulating a replica model could bring a high level of physical understanding for the visitor. Additionally we think we can make things more obvious to the visitor by digitally highlighting/enhancing/ labelling the relevant part of the objects mechanics. However we need to test if and how manipulating a model could help visitor to actually engage with the real artefact

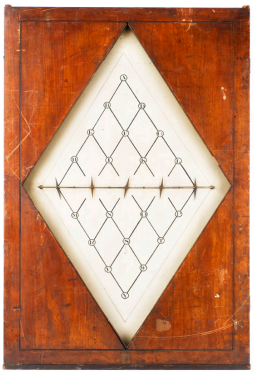
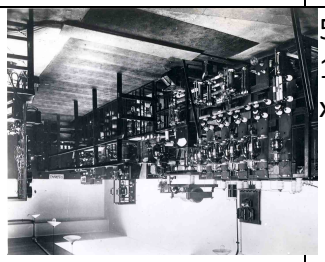
Your task:

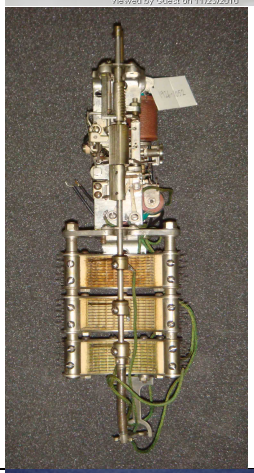
To develop a physical computing exhibit that will allow visitors to have a meaningful and engaging experience with an object through digital interpretation that responds to the physical manipulation of a model.

Details:

The Objects:
We wish the team to choose between objects that will feature in the Making Modern Communication gallery and that have already been indentified as being suitable candidate for this type of interaction:

Object	Description	Interaction	Image	Physical Spec
Morse code apparatus	The usual manual method for preparing two-unit (morse) tape for sending on an automatic transmitter. This was faster than manual sending, as the message could be prepared off-line (as we say now) and sent at high speed, thus maximising use of the line.	This could include using some sort of marking tape to prepare the message		260 wide by 485 deep by 315 ht (with paper stand raised)

Large 5-needle Cooke and Wheatstone telegraph. 1837	Identified as one of the original pair of five-needle dials used to demonstrate the electric telegraph to the directors of the London & Birmingham Railway and others in September 1837.This was one of the earliest demonstrations of the practical electric telegraph. Although the system was not adopted by the L&B it led to a similar trial on the GWR in the London area in 1839.	When manipulating the handles it is quite easy to understand how the operators were forming the letters. However digital output could help figure out what happen internally and how the manipulation got transformed into electrical impulses		720 wide by 145 deep by 1200 ht
2LO Marconi 1.5kW transmitter, 1922,	This is 2LO, the transmitter that began BBC broadcasting on 14 November 1922. The initial service was quite restricted, and the signal did not travel beyond around fifty miles, meaning that Londoners were the only people who could receive the first radio broadcast.	The original object is huge. A scaled down model will allow visitor to indentify its different working parts from a unique interrogation point. But we ought to ask what can a model bring that an image on a touch-screen can't?		5500 x 1300 x2000

Carbon microphone	We will have several of them on display	Here the physical element could be worked on and actually demonstrate how the microphone works. Digital interpretation could be used to help visitor to make sense of what they are seeing.		About 100 high
Strowger table pattern telephone, manufactured by the Automatic Electric Company, c. 1905	Made and used in the USA several years before an auto telephones were seen in Britain. Very fine nickel plating, a telephone intended to be seen as well as used.	The interpretation could show how the electrical impulse is generated by the rotating dial. Additionally this could also show how the same electrical signature was operating the switch (second picture) to direct the call.	 	320 high by 200 wide by 190 deep
Generic mobile phone	For example The Nokia 3410	With the expansion of Smartphone and touch surface, the use of 10 digit key phone will almost		

		disappear, how can we give future generation a feel of what people use to do with a limited amount of key and such a tiny screen?		

Interaction & outcome

- We wish the team to choose the object that has the greatest potential for innovative interpretation. The team should identify what type of content would benefit from interaction, how it would bring the object to life and helps with the understanding of the way it operates.

- No staff on the exhibition floor will guide our visitors through the manipulation of the model therefore guiding and accompanying feedback should be incorporated in the interaction concept itself.

- The model does not need to be a direct replica of the object. It should looks similar enough to allow recognition but a minimalist approach could help to control interaction.

- The feedback from the interaction can happen within the model or be outputted on a different interface: ambient sound, projection mapping, screen behind the object, etc… However we want to bring to attention that visitors often find it difficult to identify where they have to look especially in a busy exhibition space and we recommended to the team to really carefully choose what their output interface will be.

Programming Platforms:

We recommend you to use **Arduino** board and choose between the following programming platforms:

Openframeworks
Processing and alike

Alternatively the team could look onto graphical programming environment. Those could also be hooked onto **midi controller** sensors as well as Arduino.

MaxMSP

PureData

Or finally **Flash** (ActionScript) and use **Phidgets** as well as Arduino. Flash is really processor power hungry and is our least favoured choice.

The Science Museum is confident to use and support all the above platforms. The team will chose the platform of their choice based on personal skills and preferences as well as in consideration of identify interaction. The team is welcome to make suggestion of alternative platform but the Science Museum keeps the right to decline if the solution is proven difficult to maintain internally.

Project Objective:

- To investigate how this kind of digital interpretation can support our visitors in having a life enhancing experience with an object in our collection

Work Plan:

Preparation stage

During this eight week preparation stage we would like the students to

1. become fully familiarised with the attached reading list and areas of study,
2. be exploring the research area outlined below
3. be indentifying interpretation opportunities and be presenting an initial concept for the exhibit,
4. be developing a first prototype

We would like fortnightly meetings (to begin) with the group via Skype or some other video conferencing mechanism in order to start building a working relationship between the project team and us at the Museum, to be kept updated regarding research progress and in order for the group to have access to support, advice and guidance from project initiators in the ScM.

We would also suggest the opportunity to brainstorm via email with William Turkel who teaches Exhibit Design at the University of Western Ontario.

To complete the work expected in the preparation stage, we would like the team to:

- Document all research and processes via a Blog (to be set up by students on platform of their choice)

- Fully acquainting themselves with the Science Museums learning philosophy

- Visit a Science Museum to acquaint yourselves about how visitors behave and learn in Museum environments

- Research into good examples of digital interpretation (either in or outside the cultural heritage field). Students need to focus on:
    - Object interpretation – especially examples where the interpretation highlights but doesn't overshadow the real artefact.
    - Interaction that has a physical dimension either having movement control, tangible interface, awareness of space, etc.
    - Exhibit that uses innovative interface: Sensor, Augmented reality, Projection Mapping, Kinect, etc.

  We do not expect a report but examples of good practice or effective ideas that would demonstrate your understanding and develop conceptual design skills.

- Familiarisation of the development element – the programming, electronic, sensor manipulation etc. This will include
    - Researching what work is being done in the field – universities, commercial etc. Action research – utilising forums to discuss and question innovative new technologies or initiatives.
    - Contacting and communicating with developers and getting advise etc

- Select an object and design of the interaction concept.
    - Selecting an object and producing a storyboard for the interactive interpretation. We wish to reiterate that the model will sit next to the actual object. We expect the interaction to utilise and highlight the physical proximity between the object and the interactive model.
    - Identifying sensors and getting familiarised with the programming and treatment of the data they generate.
    - Choosing type of interpretative content and selecting the appropriate output interface.
    - Producing rough sketches of the final exhibit, including layout that highlights the relationship between the digital model and the real artefact.

- Building a 1st prototype to be completed by time of arrival. This include:
    - Building the model - Development of a rapid prototype either using modelling foam, softwood, moulded plastic, 3D printing or by hacking similar object (for example for the telephones). More detail on the object will be provided after object selection.
    - Compiling a library of code ready to manage communication with chosen sensors.

- Having working media components for the interpretation feedback such as video or audio playing function. And having at minimum placeholder for assets and content. The final interpretation content will be refine at the museum during the first weeks after arrival.
- Having worked up a couple of scenario for potential interaction. (for example If visitor press this button it play this sound etc)

We expect the group to bring the model they have built. The Science Museum will provide additional output devices (projector, screen, speakers, etc) if the output interface is not part of the model.

At the Museum

The project group will be managed and situated in the Audience Research and Advocacy team. In the first week the team will receive training on visitor research methodologies, writing questionnaires, writing up findings, reporting back on evidence and making recommendations. As this project will be done in partnership with New Media an introduction from that team will also be provided. This will consist in visiting and talking through of the works currently on gallery.

While the first technical prototype should be well into its development by the time the group arrive in the UK the first few weeks will be spent working with the teams here at the ScM to finalise the interpretative content and ready the prototype for evaluation, to utilise the expertise of the staff here and to gain extra knowledge and ideas to moulding the prototype into a workable piece of interpretation.

Following the development work that was done during the preparation period and the work done in the museum you should be ready to test the first prototype of the interpretation two weeks or so after arrival. This evaluation will highlight barriers and opportunities and help inform the development of the second prototype.

A second, and near final, prototype which incorporated findings and recommendations from previous evaluation will be tested again by the group with visitors before the end of the project.

Who will you be testing this prototype with?
We see this being a piece of digital interpretation for both adults and children and therefore will need to be tested with our Independent Adult (adults visiting without any children) and Families with children aged 11 years+ audiences. These people will be recruited in the museum but as our family audience tends to come at the weekends Saturday and/or Sunday work will be expected (days off in lieu mid week will of course be built in to your schedule!). Full evaluation and recruitment training will be provided.

Project Deliverables

1. Working prototypes to be delivered at two points the course of the project with an aim to produce an almost completed product by the end date
2. The code source of all the development assets.
3. Blog – fully documented the research, development, evaluation and outcomes
4. Report making recommendations based on the prototype development and evaluation
4. Two page summary of findings of the whole project
5. Face to face feedback to interested stakeholders.

We will also send a really rough work programme document for your reference, which indicates some key dates and deadlines for your project. This of course can be discussed, amended and added too and we expect to discuss this with the group.

Caveats/constraints

1. It would be very helpful if each student came equipped with his/her own laptop
2. All students should be confident English speakers
3. Security clearance will be arranged before the visit
4. Some evening and weekend work will be expected.
5. Office space is scarce at the museum. While every effort will be made to provide the students with a permanent desk they must be able to able to 'hot desk' and be flexible for working space.

References and useful information:

Mandatory Reading:

Science Museum Reports (will be provided via FTP)

Brehaut, Jo and McSweeney Kayte (2010). *"Strategies for promoting: Life Enhancing Experiences with Objects*". Presentation prepared at the Science Museum, London

'Defining, planning and measuring a life-enhancing experience', unpublished internal guidance document (London: NMSI, 2009), www.sciencemuseum.org.uk/about_us/about_the_museum/~/media/FF1474E860A44E17AC9F8365EC9F9395.ashx

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Gammon, Ben and Siems, Jo (2001). *" Making the Modern World – a summative evaluation".* Report prepared at the Science Museum, London.

Teixeira, Teresa (2010). *"Audiences and Objects in Museums: an overview of what we have learned from audience research".* Report written for the Science Museum, London

TW Research (2009), "The Treasury Galleries: 'Science Gallery' & 'Digital Lives' Research" Report prepared for the Science Museum, London.

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Falk, John H. and Dierking Lynn D. "Learning from museums: Visitor experiences and the making of meaning". Lanham, Md.: Rowman and Littlefield 2000

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Gammon, Ben. "Visitors' use of computer exhibits". *Informal Learning Review* 38 (1999a): 10-13

— . "Everything we currently know about making visitor-friendly mechanical interactive exhibits". *Informal Learning Review* 39 (1999b): 1-13

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Preston, Jennifer (, 2011). "Speaking Digitally about our exhibits" in New York Times March 16, 2011
http://www.nytimes.com/2011/03/17/arts/design/speaking-digitally-about-exhibits.html?_r=2&p...

Relevant books – The Technical and Interaction Design Side

http://www.amazon.com/Programming-Interactivity-Designers-Processing-Openframeworks/dp/0596154143

http://www.amazon.com/Physical-Computing-Sensing-Controlling-Computers/dp/159200346X/

http://www.amazon.com/Processing-Programming-Handbook-Designers-Artists/dp/0262182629

http://www.amazon.com/Arduino-Cookbook-Michael-Margolis/dp/0596802471/

http://www.amazon.com/Making-Things-Talk-Sensors-Networks/dp/1449392431/

http://www.amazon.com/Make-Electronics-Discovery-Charles-Platt/dp/0596153740/

http://www.amazon.com/dp/0945053312/

http://www.amazon.com/Handbook-Modern-Sensors-Physics-Applications/dp/1441964657/

http://www.amazon.com/Building-Scientific-Apparatus-John-Moore/dp/0521878586/

http://www.amazon.com/Touch-Code-Interactive-Installations-Experiences/dp/3899553314/

http://www.amazon.com/Talk-Me-Communication-between-Objects/dp/0870707965/

Resources websites

There you will get the 3rd party software, programming guides and active forum for question and discussion

- http://www.openframeworks.cc/
- http://processing.org/
- http://www.arduino.cc/

- http://wiring.org.co/
- http://fritzing.org/
- http://cycling74.com/
- http://puredata.info/

Websites to review and investigate:

http://makezine.com/

http://williamjturkel.net/teaching/history-9808a-digital-history-fall-2011/ especially the reading material suggested for some of the classes

http://itp.nyu.edu/physcomp/Intro/HomePage

http://hybrid.concordia.ca/cart360_vincent/

http://astro.temple.edu/~cvecchio/

Suggested Reading (if time allows)

Facer, Keri; Joiner, Richard; Stanton Danaë; Reid Josephine; Hull Richard; and Kirk David S. "Savannah: mobile gaming and learning?" *Journal of Computer Assisted Learning* 20, no. 6 (2004): 399-409

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Appendix W – Design Principles

The research conducted for this project, as well as the prototype testing, has led to a collection of Design Principles for both interactive exhibits as a whole (General Exhibits) and strictly Physical/Digital interactive exhibits.

General Exhibits

The objectives of the interactive should be clear to the visitor. "Objectives" here refers to both learning objectives and activity objectives. Without a clear learning objectiven, visitors won't know what to look for in the activity. Lacking activity objectives, visitors will be confused about how to use an interactive at all. The consequence of a lack of clear objectives is the lack of comprehension of content on the visitor's part, and a failed interaction.

The interactive should enhance understanding of the actual object. Research has shown that interactions with an object allow for a much deeper understanding of that object. Thus the activity should be focused solely on enhancing understanding of the object it represents. Without this, the interaction will not be an educative experience.

The interactive should be engaging and entertaining. An engaged and entertained visitor will be much more focused on the interaction, and thus much more likely to absorb content from it. Pacing is key. The timing of points of the interactive should allow enough time for visitor comprehension, but should not be so slow that visitors get confused or become disinterested. Authenticity helps as well, as visitors appreciate being able to use "the real thing". Also, research has shown that the actual object (as opposed to text or photographs) has a much higher density of information: visitors can get a feel for the scale of the object, its textures and shapes, and insight into its use and impact. A visitor engaged with an interactive fully will be much more receptive to content and information.

The interactive should be intuitive to use, requiring little to no instruction. Visitors often do not read labels, so a good interactive will speak for itself and require very little instruction to use. If a visitor is confused at how to use an interactive, they will probably spend a great deal of time working out how to use it, and will not actually use the activity at all.

Physical/Digital Exhibits

The interactive should digitally interpret a physical interaction. This ensures that each piece of the interaction is used to its strength. The physical interaction affords intuitive insight into the object itself, offering a deeper understanding than text or photos could ever hope to provide. Alternatively, the digital interaction can provide a wealth of information dynamically based on the physical interaction, something simply physically using an object will never be able to convey. Together, the digital description of a physical interaction, the digital and physical enhance understanding of the object.

The interactive should augment understanding of the object without overshadowing it. This is similar to an above principle, but has an added level of complexity: with physical and digital interactions already engaging the visitor, the object can easily be missed. The activity should maintain a focus on the actual object, and ensure that understanding of the actual object is augmented. The activity should reference the actual object, and the overall goal should be for visitors to become engaged with the actual object through the use of the physical/digital interactive.

References to the object in the interactive should be abstract. Textual abstraction (referencing the object with descriptive terms, as opposed to directly by name), as well as visual abstraction (using an abstract model of the object, as

opposed to a replica) will encourage the visitor to use the actual object as a reference point. If a visitor is interacting with an exact replica of the object, there is no need for engagement with the actual object. Also, it was also found that mentioning the object by name during the activity results in visitors being able to parrot the name of the object back without ever having actually engaged with it.

Ideally, every interaction should result in feedback. Constant feedback keeps visitors interested and helps avoid confusion. Also, it provides motivation for the visitor to use the interactive. If a visitor interacts with the activity (physically or digitally), and receives no feedback, they may feel confused and believe they have done something wrong. Also, they may become disinterested if the time between actual interactions is too long. If each interaction results in feedback, visitors will be much more engaged and thus more receptive to content.

Appendix X – General Physical Digital Exhibit Conclusions

Background

Physical/digital interactive exhibits mix elements of physical interaction and digital interpretation to enhance visitor understanding of a particular object. With a **physical interaction**, visitors can get an intuitive understanding of the function of an object, and how the object might perform that function. . However, the knowledge gained can be a bit limited. Visitors may not be able to see all of the inner-workings of a model that are hidden within the model, and could miss out on key concepts by not fully seeing how an object works. **Digital interactions** allow a great depth of information to be conveyed, and this information can be dynamically adapted to the current state of the interaction. By digitally interpreting a physical interaction, the information conveyed can highlight specific portions of the physical interaction, with the digital information beginning right at the edge of physical intuition. This would also allow a visitor to vicariously engage with an object in a case that they would not normally be able to actually interact with.

These claims have been tested in the evaluation of a prototype physical/digital exhibit intended to model an interaction with a rotary dial telephone, as well as enhance visitor understanding of the physical mechanisms behind dialling.

Executive Summary

Physical/digital exhibits can be very effective means of interacting with and interpreting an object. When done properly, a digital interpretation of a physical interaction with an object allows insight and understanding not possible with any other kind of interaction or exhibit.

There is great potential for visitors to gain a deep understanding of an object that cannot be achieved by simply displaying an object in a case, or even through interacting solely physically or solely digitally with representations of that object. A combination of both physical and digital affords a very comprehensive look at an object and can convey a

wealth of information and understanding. Physical/digital exhibits allow for not only an interaction with an object, but an *interpretation* of that interaction. Visitors can intuitively learn by doing, and physical/digital exhibits capitalize on this by using a computer screen to provide contextual information about the physical interaction, and build upon the concepts laid down by physical interaction.

These types of interactions must be structured very carefully:

- Focus must remain on the object itself.
- Content must be conveyed in such a way that it is allowed to be absorbed by the visitor.
- The activity must enhance a visitor's understanding of the actual object, not simply be entertaining.

These exhibits have clearly shown potential to be effective means of object interpretation, but more research is needed before it can be determined conclusively that the set of design goals outlined by the group are sure to yield effective physical/digital exhibits.

Findings

This research has shown that barriers exist to the implementation of delivering content/information and use of these exhibits on gallery. Along with the design principles (attached as an appendix to this report) developed, the group identified and outlined the potential for and major barriers to success of these exhibits:

1. A major barrier identified was visitors not noticing the object in the case. The cause of this barrier was distraction due to the interaction with the physical exhibit, which heavily overshadowed the object in the case, instead of highlighting it.
2. Also, digitally presenting content alongside instructions on screen simultaneously proved problematic. Visitors will tend to perform the action as instructed, but not be able to absorb the content. A possible solution is that information and

instructions not be presented simultaneously, as visitors will not be able to absorb both at the same time.

To address these barriers in future exhibits solutions could include:

- Digital interpretation a physical interaction
- References to the object within the activity to encourage visitor engagement with the object
- Abstraction of both the physical shape of the object
- Instructions and information be kept separate during the activity.

Most importantly and essential to the success of all physical/digital exhibits, the activity should digitally interpret a physical interaction with the object

Digital interpretations of physical interactions

A successful physical/digital exhibit will digitally interpret a physical interaction that one might have with the object. This is the most important finding in this document. The reason for a physical/digital exhibit is to exploit the strengths of digital interactions to provide additional information and context beyond the edges of a physical interaction. This is an important distinction to make. The digital interaction must *interpret* the physical interaction. Similarly, the physical interaction must drive the digital interpretation. At no time should the physical simply be a stepping stone to the digital, but the digital should enhance the physical and create a deeper understanding of the physical interaction, and in turn the object itself. The exhibit must be structured in such a way that the physical interaction leads directly into the information conveyed on screen, and that on screen information should augment understanding of the physical interaction.

Visitors can intuitively learn by doing, and physical/digital exhibits should capitalize on this by using a computer screen to provide contextual information about the physical interaction throughout the course of the activity, and build upon the concepts laid down by the physical interaction. This is a fundamental principle of physical/digital exhibits and it distinguishes them from simply being information kiosks. A physical/digital

exhibit should not simply allow access to information by pressing a button, pulling a lever, or spinning a wheel; a successful physical/digital exhibit will provide a digital interpretation of exactly what happens when the button is pressed, the lever is pulled, or the wheel is spun, thereby augmenting understanding of the physical action to a point not possible otherwise.

Focusing on the object

The aim of the sections above was to highlight barriers and discuss methods to overcome them in the hopes of increasing visitor engagement with both the exhibit and the object the interaction has been designed to explain. Testing this kind of exhibit showed that roughly half of visitors noticed the object the activity attempted to highlight, meaning that much more needs to be done to guide visitor attention to the object in that particular exhibit. Abstraction and separation of interactions are important, but the object itself must be highlighted as much as possible to ensure visitor engagement.

More importantly, visitors need a specific call to action to engage with the object itself. Physical/digital exhibits provide an excellent source of information for a visitor, but are also quite distracting when it comes to actually engaging with the real object. To avoid this, a physical/digital exhibit can use a call to action to engage with the object. This could be done by:

- Directing visitor attention to the object during the activity with explicit instructions on screen ("The actual object is located over there on gallery" with an arrow pointing to the location, for example)
- Using lighting effects to highlight the object on gallery when it is referenced in the activity (if the object is small, for example)

More research is needed to determine the best method for highlighting the object, and it may be that those methods differ for each physical/digital exhibit.

Also, the interaction needs to be structured in such a way to encourage the visitor to engage with the actual object. Abstraction (as mentioned earlier) of the physical is an excellent method to achieve this. By using an abstract physical model, visitors may notice that the actual object (due to an image on screen, or by noticing it in the gallery) is different from the physical model with which they are interacting. A visitor that is able to make this distinction, or considers the real object in this way, is actually engaging with the real object. A successful physical/digital exhibit will be structured in this way, and cause the visitor to think critically about the physical nature of the actual object.

Abstraction

Abstraction (both visual and textual) in an activity is important. An abstract physical model of an object, for example, should require the visitor to use the actual object as a point of reference.

Abstraction shifts attention from the activity to the object itself – if all of the information about the object were contained within the activity, there would be no need for the actual object at all. The activity itself should then aim to answer these questions, and direct the visitor's attention past the abstract model to the actual object.

However this must be used carefully:

- A physical model must be abstract enough to not distract from the object. A physical model suggests the nature of the object, but is not specific, thus forcing visitors to wonder at which object is represented and its significance.
- The physical model should not be an exact replica of the object itself. Were this the case, the visitor would have absolutely no motivation nor reason to ever look past the model to the object.
- It must not be so abstract that a visitor cannot determine what object it represents and easily make a mental connection back to the object on display.
- The model must be able to mimic the physical interaction (physically dialling in the case of this project) but not serve as a replica of the original object.

Similarly, textual references to the object on screen must be careful to only mention the object by name when absolutely necessary. It has been found that by using the proper name of the object, visitors would often reference that name without truly understanding what the name represents; visitors would not engage with the object despite knowing its name.

Other references to the object must be abstract, but obvious enough descriptions so that the visitor realizes which object the activity references. The abstraction must convey the significance of the object by hinting at the object with descriptive vocabulary. As opposed to using the actual name of the object, consider the reason the object is important, and use those reasons to refer to the object.

It is important to note however that visual images of the object on screen are also effective in increasing engagement with the actual object, so long as references are to the actual object, and not the images on screen.

Separation of interactions

Interactions in a physical/digital exhibit must be clearly defined and clearly delineated. Visitors interacting with an activity are often found to only be capable of absorbing one piece of information at a time, and so interactions must be carefully planned so that only one piece of information is conveyed at a time.

- "Interactions" here refers to one of two things: a call to action, or information conveyance. A call to action is an instruction to perform some action ("push a button", "spin the wheel, etc.). Information conveyance involves delivering some form of content to the visitor.

A call to action and information conveyance must never occur at the same time during an activity. When both of these occur at the same time, the visitor will either absorb the content information, or follow an instruction; only very rarely will they do both.

Frequently visitors would understand the content, but misinterpret the instructions, or miss the content entirely and only perform the instructed action. In order to effectively convey either content or a call to action, they must be kept separate.

A call to action must be very clear, to ensure that it is a singular event with a beginning and end. If the instruction is vague, the visitor will not be sure that they have completed the call to action, and may continue performing the action indefinitely (or until they become disinterested).

- An explicit instruction that has a clear beginning and end (for example "dial a single digit") forces the visitor to shift attention back to the screen for further instructions, at which time content may be presented.

In this way, well-defined instructions encourage shifting attention between physical and digital, and create a better environment for delivering content.

Information must be kept separate for a call to action for the very same reason. If information is conveyed during a call to action, the information does not have time to sink in. Visitors will read the information, read the call to action, and then perform the action. The information by then has either been forgotten or become vague in the mind of the visitor. By separating the call to action from information, visitors have time to adjust their minds to a more receptive state, and actually engage in the content being delivered.

Appendix Y – Exhibit Code Read Me

Required Libraries:
GSVideo - free, open-source third-party library for videos in Processing. (c) Andres Colubri, gsvideo.sourceforge.net
processing.serial - Processing's native serial communication library

Code Structure:

import statements

Variable declarations

void setup() - is called once when the program first starts up. Loads movies into memory, assigns variables, sets up display

window, etc.

void reset() - is called by setup() and whenever the program times out or it receives the 'z' character from the USB

connection (currently indicating that the reset button has been pressed). Resets most variables to their starting states.

void draw() - continually executes. displays the current frame of the current movie, as well as any text, and checks to see

if the current movie is close (within 10 frames) of ending. If it is, it selects the appropriate movie to switch to. Also

checks for timeout.

void selectMovie() - is called by draw() when the last call movie finishes. Selects the appropriate content movie to play

based on what number the user has entered (stored in recievedCode), or plays the wrongNumber movie if the user has entered a

wrong number

void serialEvent() - is called every time the application gets input from the USB connection. Receives the input as bytes

which are then converted to chars. Currently, an 'x' indicates that the receiver has been lifted, a 'y' indicates that it has

been put on the hook, a 'z' indicates that the reset button has been pressed, and a digit represents what digit the user has

just dialled on the rotary. What the application does with this input is different depending on what state the application is

in, with the exception that pressing the reset button will always reset the application to something resembling the starting

state, no matter what is currently going on in the program. Obviously, if the receiver is off the hook it will not be placed

back on the hook, but the application will remember that it is off the hook.

void setTimeout() - is called whenever the user takes an action. Records the current minute in the hour and the current

second in the minute for comparison when draw() checks whether the program should timeout.

void dialPlay() - is called whenever the user dials a digit in Play Mode. Determines which animation to play based on what

digit the user has dialled.

void movieEvent() - is called every time a new frame is available to read from the current movie. Reads the next frame.

Exporting to Application for Mac OS X:
1.) In Processing, go to File -> Export Application
2.) Select desired OS format to export to and whether the application should run in full screen
3.) Select 'Export'
(Assuming the application is exported for macs)
4.) Wait for the application to export. It should create a folder called 'application.macosx'
5.) Move a copy of the 'data' folder containing all of the videos for the application into the application.macosx, along with

the 'source' and '[name_of_application].app' folders

6.) Move a copy of the 'gstreamer' folder, which can be found in your GSVideo -> library folder, into

[name_of_application].app -> Contents -> Resources -> Java. If this is for Mac Os X, you can delete the windows32 and

windows64 folders inside the gstreamer folder.
7.) Move the application.macosx folder and all subfolders to the computer it will run from
[If the application was exported on a windows machine]
8.) Open a terminal window on the Max OS X machine
9.) Navigate to the application.macosx directory
10.) Type 'chmod +x [name_of_application].app/Contents/MacOS/JavaApplicationStub

Running the Application (Mac OS X):
The application can be run by simply double-clicking [name_of_application].app, however, this may cause the application to

freeze/loop more frequently. The application appears to be more stable when run from the terminal, which requires opening a

terminal window, navigating to [name_of_application].app/Contents/MacOS/ and running JavaApplicationStub by typing

'./JavaApplicationStub'

Know Issues:
Freezing/looping when the application is run by double-clicking, as mentioned above
When the program first starts the arduino sends an 'x', a 'z' and a '1'. This can start the interaction, but it can be reset

using the reset button.
Occasional sound looping, may be related to running the application by double-clicking

Appendix Z – Testing Schedules

Prototype 1

29/3/12
1st Shift
11:00-12:00 – Alex, Jack
12:00-13:00 – Jared, Ryan

2nd Shift
14:00-15:00 – Alex, Jack
15:00-16:00 – Jared, Ryan

30/3/12
11:00 – 12:15 Jack, Jared
12:15 – 13:30 Alex, Ryan
13:30 – 14:45 Jack, Jared
14:45 - 16:00 Alex, Ryan

31/3/12
11:00 – 12:15 Jack, Ryan
12:15 – 13:30 Alex, Jared
13:30 – 14:45 Jack, Ryan
14:45 - 16:00 Alex, Jared

The pair not gathering data on the museum floor will be analyzing data and beginning development of what we know will be in P2.

Prototype 2

Saturday:

12:00 -13:30 Alex, Jack
13:30-15:00 Jared, Ryan
15:00-16:30 Alex, Jack
16:30-18:00 Jared, Ryan

Monday:

11:00 – 12:15 Jack, Jared
12:15 – 13:30 Alex, Ryan
13:30 – 14:45 Jack, Jared
14:45 – 16:00 Alex, Ryan

Tuesday:

11:00 – 12:15 Jack, Ryan
12:15 – 13:30 Alex, Jared
13:30 – 14:45 Jack, Ryan
14:45 - 16:00 Alex, Jared