Gigapixel Image Environments for Science Communication & Learning:

Stories in the Rock

Summative Evaluation Report

Submitted by

Rockman et al
Research & Evaluation

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595 Market Street Suite 2570 • San Francisco, CA 94105-2802 • 415.544.0788 • FAX 415.544.0789
www.rockman.com

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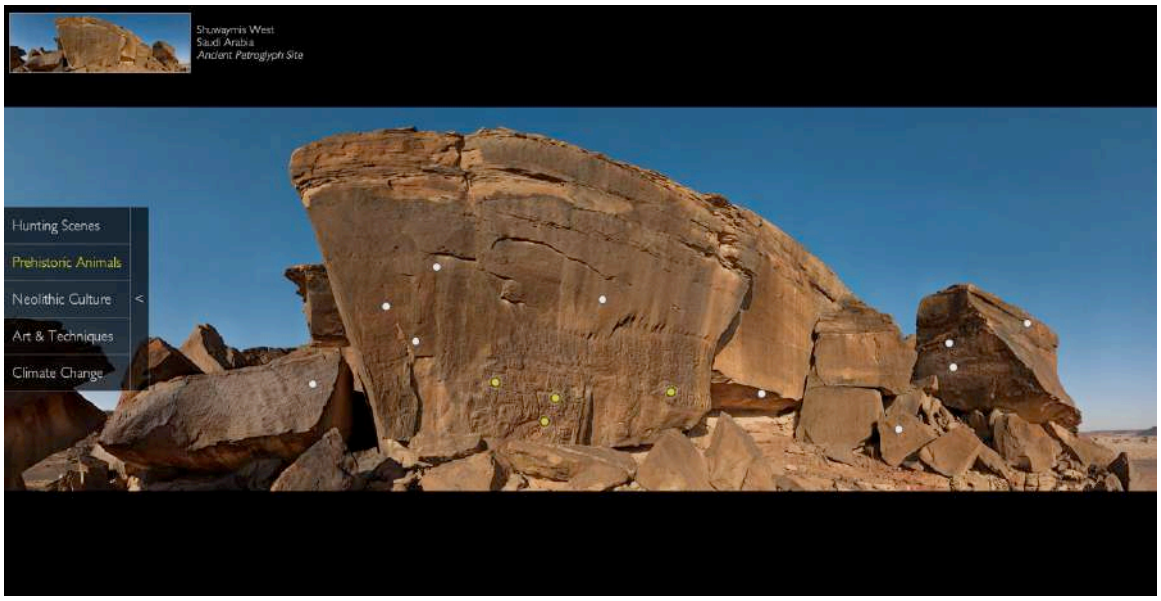

Submitted to:
Marti Louw
University of Pittsburgh Center for Learning
in Out-of-School Environments

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Compiled By: Dr. Camellia W. Sanford

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Executive Summary

"They're petroglyphs. They're rock pictures. They're called petroglyphs. Because they're saying to the untrained eye, it would just look like a regular rock. But whenever you start looking for things, you might see things carved into it."
– Mother explaining Explorable Image to her child

Rockman et al (REA), in partnership with Marti Louw and the University of Pittsburgh Center for Learning in Out-of-School Environments (UPCLOSE), conducted a summative evaluation in Fall 2012-Spring 2013 of a temporary museum exhibition at the Carnegie Museum of Natural History (CMNH) in Pittsburgh, PA called, *Stories in the Rock*. The exhibition highlighted CMNH researchers' documentation of ancient petroglyph sites in Saudi Arabia using GigaPan technology to capture high-resolution, zoomable images of the rock art. The exhibition centers around an activity called the Explorable Image, a touchscreen-based platform that allows visitors to freely explore an image or scene by panning and deep zoom, or select categorical themes and interest spots on the screen itself to find out annotated information about a particular topic or feature (see Figure A).

Figure A: Explorable Image Main Screen & Interest Spot Selection W/Overlay

The exhibition was the first of a set of demonstration projects to study the extent to which gigapixel image technology can support science communication and learning within different approaches to interactions between scientists and public audiences. The exhibition was designed using a "Public Understanding of Science (PUS)" approach, which involves experts' knowledge being conveyed to public audiences in order to increase visitors' individual understanding and interest (Bonney et al, 2009).

REA utilized a mixed-methods approach to examine how visitors were using the exhibition and thinking about its activities and content. The evaluation team

observed visitor behavior in the exhibition using a timing and tracking methodology and interviewed visitors after the experience. Additional data was collected at the Explorable Image via log files recorded by the internal computer system and video recordings of visitor interactions at the interface. Interviews were also conducted with museum leadership and the scientist whose archeological research was highlighted in the exhibition.

Key Findings

The main purpose of the *Stories in the Rock* evaluation was to see to what extent the Explorable Image facilitates science communication and learning, and to demonstrate the kinds of supports that can foster a deeper public understanding of science. A secondary goal of the study was to examine how visitors used an emerging technology platform, and what visitors and museum scientists and staff thought about the Explorable Image and its ability to support disciplinary based observational practices. Key findings are organized around the main questions guiding the study.

How do museum visitors use the Explorable Image?

Many visitors engaged with the Explorable Image; while many freely explored the image, they also used the interface's interest spots and theme selections to help them gather more information and guide what they were seeing and doing:

- About 21 users per day interacted with the Explorable Image, according to log files. There were more visitors on weekends than on weekdays, as would be expected based on common museum visitation patterns (Sandifer, 1997).

- If visitors interacted with the Explorable Image viewer, it tended to be the second thing they visited. Thus, visitors likely had some initial exposure to the exhibit content before engaging with the interface.

- Visitors spent an average of 3 minutes 38 seconds at the Explorable Image, a lengthy amount of time when compared to other studies of engagement with museum activities (Yalowitz & Bronnenkant, 2009).

    - Adult-only groups spent more time at the Explorable Image than groups with children. Adults in groups with children indicated that they might have stayed longer, but they followed their children's, rather than their own, interests.

-Visitors were more likely to select an interest spot (73%) during their Explorable Image session than a theme (52%). This suggests that visitors' searches were almost equal parts image and content-driven.

- Groups with children tended to freely explore the image and also utilized the touchscreen's interest spots more than adult-only groups. Children typically led these interactions. Adult-only groups were slightly more likely to use the themes and the audio/video overlays than groups with children.

- Visitors appeared to follow conventional reading patterns.

  - Themes at the top of the screen tended to be selected more frequently than those at the bottom of the screen, which may be indicative of a top to bottom reading preference.

  - The interest spots on the far right-hand side of the screen were the least selected. This pattern may indicate that visitors explored the image similarly to the way that they read a book, from left to right.

What do visitor interactions around the Explorable Image look like?

The Explorable Image supported rich kinds of interpretive talk around what visitors were observing. Visitors were able to use annotated features in the image, such as curved lines, to pinpoint the orientation of a figure and to identify whether it represented an animal or a person. Visitors also used evidence from the image to make inferences. For example, when they saw puppies underneath a figure and concluded that the image was of a female dog:

> *"Now, you saw in the sketches there, why they said they were male dogs. They were so detailed. To say they were male dogs, but there was one female dog because they interpret that by seeing the smaller puppies underneath her. Now, I don't know how, but once you start looking at it closely, it's like a puzzle. You do start to see things differently. Together, without them saying that, you'd never know that that's what you were looking at."*

Over the course of their engagement with the Explorable Image, some visitors appeared to move beyond a cursory exploration of the technology platform and the panoramic image:

- Visitors incorporated information from the interest spots to make sense of the image. Often, the interest spot image, text, audio, or video annotation contained information about features of the petroglyph, allowing visitors to identify specific animals, human figures, or archeological processes

- Visitors also tried to call other group members' attention to specific rock art figures, so that they could both pay attention to and examine the same image.

- Adult-only groups seemed to engage in back-and forth dialogue and image navigation. In contrast, groups with children tended to have the child lead the exploration around the image, with the adult providing commentary on whatever the child was looking at in that moment.

What do visitors think about the Explorable Image content and technology?

Over half of visitors went to the exhibition because they were drawn by the novel nature of the deep zoom technology. Visitors appreciated the rich image quality and content within the interface. Most visitors (70%) felt that the Explorable Image navigation was intuitive. They liked that the interface was interactive, allowing them to choose where to go, what to look at, and what content to explore further:

- Visitors liked the hands-on nature of the Explorable Image, and felt that the technology was easy to use. Adults with children appreciated that younger visitors could easily navigate the screen.

-Visitors enjoyed having navigational agency and choice in where to go and what to look at as opposed to a pre-determined, linear path through the interface.

- Many visitors felt that the interactivity of the technology allowed them to focus more on the details of the image and the exhibit content, instead of just passively observing.

Does the Explorable Image support noticing and disciplinary observational practices?

The Explorable Image technology supported both surface level and more in-depth kinds of observations. Users who wanted to scan the landscape for things that interested them in the petroglyph site could freely explore, zoom, and pan around the image. Visitors who wanted a deeper level of information could use themes and interest spots to help them identify salient features to look for in the rock art. In this way, the Explorable Image facilitated different levels of noticing behaviors:

- Visitors felt that the Explorable Image gave them an opportunity to examine places that they might not normally have access to in greater depth.

- Visitors liked the information provided in the multi-media overlays, and indicated that they had used the text, images, audio, and video annotations to help them to make sense of and interpret what they were seeing.

-After using the interface, most visitors (93%) were able to describe how they thought scientists might use imaging technology for their research, in particular, to communicate their work to others and to document their findings:

"As a scientist, you have to image what's there since you can't bring the science community as a whole out to the site every time. As far as the technology and the way it's presented is concerned, I think it's a great way to show others, you know, interacting with the work, with the context and the content. It's something I don't think you can get by just like taking notes and drawing a few sketches."

What do scientists and informal science education professionals think about the use of the Explorable Image within the museum?

Museum leadership and the archaeologist whose work is featured in the SITR exhibition saw value in the Explorable Image as a dynamic tool to facilitate the communication of scientific research to the public and to support visitors in making more scientific kinds of observations.

Both museum leadership and the interviewed scientist, state that one of the biggest challenges that museums face is getting their in-house researchers' work out on the museum floor in an engaging and understandable way. The Explorable Image was seen by both as an effective way to visually represent scientific ideas for visitors.

- Museum leadership indicated that the main benefit of explorable image technology is that it "provides access to ideas through images." In addition, leadership felt that thinking about ideas visually helped museum scientists to think about visitor interactions differently.

- The museum researcher used gigapixel technology to conduct her own archaeological research and documentation, and felt that the Explorable Image provided visitors with an opportunity to engage in similar observational practices.

- The museum researcher and museum leadership thought that one thing that made the project so successful was the collaboration between the museum scientists, informal science researchers, and technologists, as each group was able to learn something from the others' expertise and experiences. For example, the museum researcher learned about informal science education and what is possible with technology, while the technologists found out more about what kinds of experiences can realistically be placed in a museum context.

- Museum leadership indicated that it is important to get tools and technology in the hands of scientists as early as possible to help them begin to think about how they can use them, both in their own research and as mechanisms for communication.

Conclusion

The Explorable Image helped facilitate the communication of the Carnegie Museum of Natural History's scientific research to public audiences and supported visitors' observational practices and subsequent learning. The technology has several features that support scientists' communication of their research and visitors' observations:

- The technology mirrors scientists' own observational practices by providing visitors with an opportunity to closely examine images of settings with contextual media which they would not normally have access
- The interface supports surface-level investigations by allowing visitors to freely explore the main image, while facilitating deeper observations through the selection of content-based themes or image-related interest spots.
- The technology's novelty invites visitors to engage with the interface, while its multi-layered text, audio, and video-based resources sustain visitor interactions and result in longer time spent at the activity
- Scientists find the technology easy to use and appreciate that they can quickly get up-to-date information on the museum floor
- Visitors felt that the interface was intuitive and interactive, allowing them to delve more deeply into the evidence and its interpretation

Findings from this study (described above) demonstrate that the use of high-resolution, explorable image platforms in a museum setting can impact both museum scientists and public audiences in the following ways:

Impacts on Museum Scientists

- Participation in this project helped museum scientists learn and incorporate new strategies for effectively communicating their research to the public
- The technology became a mechanism for bringing in partners from outside of the museum and having conversations about different models for engaging with public audiences that led scientists to think differently about visitor interactions
- Through collaboration with university learning researchers and technologists, museum scientists came to understand informal learning theories and the affordances of the Explorable Image technology and how their own research could be incorporated within the interface

Impacts on Public Audiences

- The Explorable Image facilitated visitors' use of observational practices and their exposure to exhibit content
- The interface yields rich, interpretive talk and reasoning around what visitors are seeing by providing visual, textual, and audio scaffolds to help them identify figures within the petroglyph site and to make meaningful connections between the image and the archeological interpretation
- The technology supports prolonged visitor engagement: Visitors spent a longer amount of time at the Explorable Image than has been shown in previous studies of more traditional exhibit activities (Yalowitz & Bronnenkant, 2009)

Through this project, museum scientists were able to take a traditional Public Understanding of Science model and infuse it with technology to better attract and engage museum visitors with their work. This project demonstrates that scaffolded visual representations of scientific objects and sites, like the Explorable Image, can be effective tools for sharing scientists' research and ideas and for engaging public audiences with authentic interpretive and observational practices of science.

Introduction

Rockman et al (REA), in partnership with Marti Louw and the University of Pittsburgh Center for Learning in Out-of-School Environments (UPCLOSE), conducted a summative evaluation in Fall 2012-Spring 2013 of a temporary museum exhibition at the Carnegie Museum of Natural History (CMNH) in Pittsburgh, PA called, *Stories in the Rock* (see Figure 1). The exhibition highlighted the CMNH Head of Archaeology's research on Saudi Arabian rock art. The CMNH archaeology team documented ancient petroglyph sites using GigaPan technology, allowing her to capture high-resolution, zoomable images of the artworks (see Figure 1).

Figure 1: CMNH's archeology team collecting GigaPan images of Saudi Arabian Rock Art

The exhibition itself contained several activities, including:

- *Explorable Image:* A touchscreen gigapixel image viewer with thematic categories on the left-hand side of the screen and interest spot indicators that visitors could click on to learn more information about particular details and to access audio or video content.
- *Stonephones:* Three podiums, each with a different static image of the rock art that visitors could approach and pick up an earpiece to listen to the curator discuss aspects of the featured petroglyph.
- *Large Panoramic Print*: A static panorama of the entire rock wall that had three framed areas overhanging to the print. When visitors picked up one of the Stonephones, the corresponding frame would light up indicating the location of that scene in the petroglyph site
- *Activity Table:* A small table where families could either play a matching game to pair rock art figures with pictures of their real animal or human counterparts, or trace over those same pictures and attach their drawing to a smaller print of a rock wall.

Figure 2: GigaPan of the *Stories in the Rock* Exhibition*

* See http://api.gigapan.org/gigapans/119442 for a dynamic GigaPan of the exhibition.

The exhibition was the first of a set of demonstration projects to study the extent to which gigapixel image technology can support science communication and learning. Historically, scientists have had difficulty engaging public audiences around their research (Yankelovich, 2003). Many lack the tools to effectively translate their work into comprehensible and usable information. Informal institutions, like museums, have emerged as places with learning resources that can help mediate scientific understanding, interest, and participation for scientists and publics alike (NRC, 2009).

Stories in the Rock was designed using a "Public Understanding of Science" (PUS) approach to interactions between scientists and public audiences. PUS experiences involve content experts' knowledge being conveyed to public audiences in order to increase visitors' individual understanding (Bonney et al, 2009). Here, the learner constructs his or her own knowledge about a particular topic using the experts' information as a resource. Since gigapixel technology is already being used by scientists to document and share findings with their colleagues, as well as by public audiences in educational settings to highlight topics of interest (Sargent & Nourbakhsh, 2010; Louw & Steiner, 2008), the current project sought to leverage the affordances of the technology within a museum context - represented in the exhibition through the Explorable Image - and determine how effective gigapixel technology could be designed to support communicating museum scientists' research and observational processes to public audiences.

Evaluation Focus & Methodology

The main purpose of the *Stories in the Rock* evaluation was to see to what extent the Explorable Image facilitates science communication and learning, and to demonstrate the kinds of supports that can foster public understanding of science. A secondary goal of the study was to examine how visitors used the technology and what visitors and museum scientists and staff thought about the Explorable Image and its ability to support scientific observation practices (see Appendix C for information about other SITR exhibit activities).

Questions guiding REA's evaluation were as follows:

1. How do museum visitors use the Explorable Image?
    a. How does that differ from their use of other exhibit activities?
2. What do visitor interactions at the Explorable Image look like?
    a. Are there differences in the interactions between adult-only groups and groups with children?
3. What do visitors think about the Explorable Image content and technology?
    a. What do they think of the other activities used in the exhibition?
4. Does the Explorable Image support noticing and disciplinary observational practices?
5. What do scientists and informal science education professionals think about the use of the Explorable Image within the museum?

In order to explore these questions, REA utilized a mixed-methods approach. To examine how visitors were using the exhibition, REA staff trained undergraduate researchers to observe visitor behavior in the exhibition using iForm software (www.iform.com) to collect visitor data on iPads. When a group or individual approached the exhibition, the researcher would choose a target person and unobtrusively observe that person's visit to the exhibition. Data collectors entered information about the visit such as the gender and approximate age of group members, start and end times for visiting the different exhibit activities, and behaviors such as pointing or making connections between one exhibit element and another[1] (see Appendix A for a sample iForm Observation sheet).
Log files from the Explorable Image were used to examine patterns of visitor use when researchers could not be present, including counts of what areas and elements of the touchscreen visitors clicked on, what media was played, and how

[1] On days with low visitor attendance, researchers would invite individuals or groups to come over to the exhibition and spend as much or as little time as they wanted to in the space.

long they stayed at the interface. Researchers also videotaped visitor interactions and conversations at the Explorable Image to gather additional information about what people talked about and how they used the technology. Consent was obtained after the video was taken.

To find out what visitors thought about the exhibition, researchers audio recorded interviews with individuals or groups with their consent. Visitors were asked to either reflect on the exhibition as a whole, or to comment on their use of the Explorable Image specifically, if applicable (see Appendix B for interview protocols). To investigate what museums scientists and staff thought about the use of the Explorable Image technology within the exhibition, researchers conducted telephone interviews with the scientist whose work was highlighted in the exhibition and with an informal science education professional who held a museum leadership position.

Figure 3: Adult Visitor At Stonephones & Mother and Son At Panoramic Print

Explorable Image Findings

Visitors' Experiences with the Explorable Image

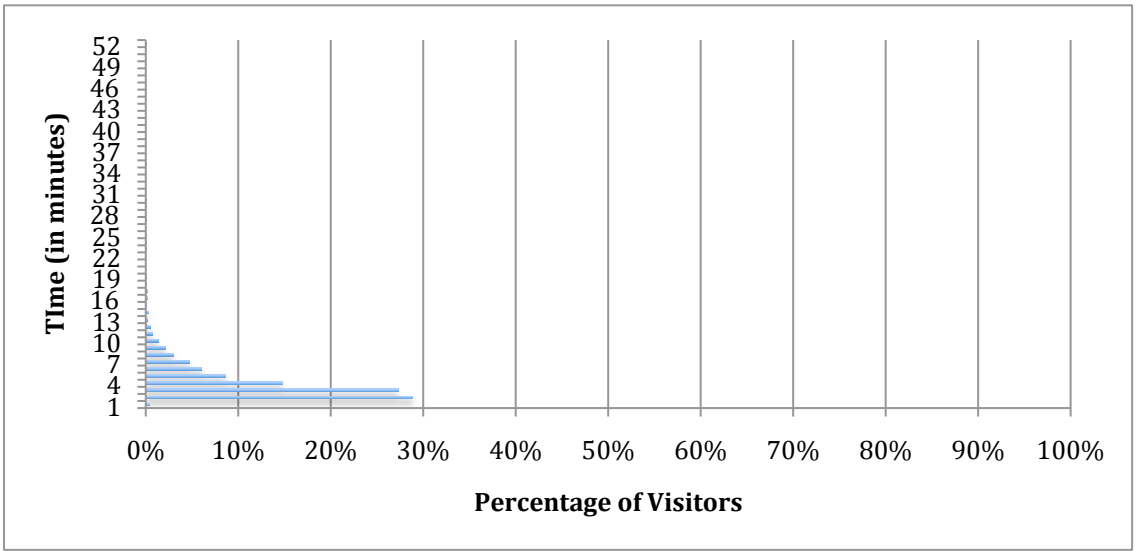
Using Log Files To Examine Visitors' Use of the Explorable Image

REA examined log file data from December 1, 2012 through March 20, 2013[2] to identify patterns in how visitors were using the Explorable Image. 1,928 sessions were logged during this time period. An examination of Daily Usage Statistics indicated an average of about 21 users per day[3] interacted with the Explorable Image. The average number of users was greater on weekends (M=30) than on weekdays (M=16), as would be expected based on museum visitation patterns (Sandifer, 1997).

Users spent an average of 3 minutes 38 seconds at the Explorable Image, with the shortest interaction being 13 seconds and the longest interaction being 51 minutes 42 seconds (see Figure 4 for a breakdown of time spent by visitors at the Explorable Image). Weekend visitors spent slightly more time on the interface (M=3 minutes 56 seconds) than weekday visitors (M=3 minutes 20 seconds). The average time logged in the log file system is higher than that recorded by exhibit observers (M=2 minutes 20 seconds), which may partly be due to the delay in time in which the system resets itself and could also be due to the fact that the system cannot differentiate when one user begins an interaction with the interface immediately after another. Regardless, visitors were spending a lengthy amount of time at the Explorable Image, when compared to other studies that have looked at engagement with museum activities (Naqvy et al, 1991; Yalowitz & Bronnenkant, 2009).

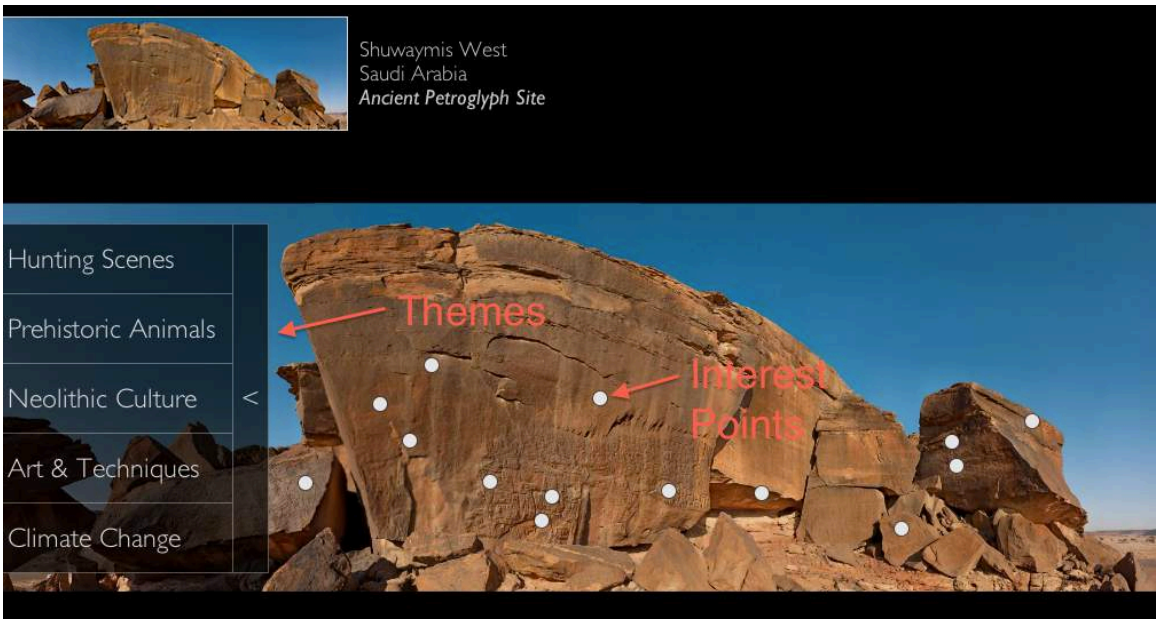
[2] Data from February 7, 2013 was removed from the system due to a computer glitch.
[3] Actual usage may have been greater, since the system could not differentiate sessions when one user left and another user immediately sat down to engage with the Explorable Image.

Figure 4: Time Spent By Visitors at the Explorable Image in Minutes



Within the Explorable Image itself, users could either freely explore the image, select a theme on the left-hand side of the screen, or tap on an interest spot on the panoramic image to find out more information about a particular section or carving (see Figure 5).

Figure 5: Location of Themes & Interest Spots Within Explorable Image



Explorable Image users selected a theme 52% of the time they engaged in an active session. Users selected an average of 2.71 themes per session out of 5 possible themes, and often returned to themes they had already selected (range of themes selected from 0 to 67).

Although theme selection was well distributed across topic, the themes at the top of the screen (Prehistoric Animals and Hunting Scenes) were selected slightly more often then the themes at the bottom of the screen, which may be indicative of a top to bottom reading preference.

Table 1: Popularity of Themes Selected By Visitors

Theme	Percentage of Times Selected (N=3886)
Prehistoric Animals	23%
Hunting Scenes	21%
Neolithic Culture	20%
Art & Techniques	20%
Climate Change	16%

Interest spots were visible in white on the touchscreen when visitors were freely exploring. Some interest spots turned yellow, if a user clicked on a corresponding theme. It should be noted that interest spots were not named for the user before he or she clicked on them, so visitors were either tapping on an interest spot independent of additional information or selecting it after choosing a theme.

Explorable Image users selected an interest spot 73% of the time they engaged in an active session. Users selected an average of 3.87 interest spots per session out of 14 possible interest points, and often returned to interest spots they had previously selected (range of interest spots selected from 0 to 58).

Many visitors made use of the interest spots without selecting a theme. This is evident because the *Stalking Leopard* was the most frequently chosen interest spot, although its theme, *Climate Change*, was least selected. Interestingly, the interest spots on the far right-hand side of the screen were the six least selected (starting with A*nimals in the Rock* – See Table 2). This pattern may indicate that visitors were viewing the image similarly to the way that they read a book, from left to right (see Figure 6).

Interestingly, even though the Recessed Rectangles, Animals in the Rock, and Artists on the Edge were among the least selected interest spots, they still had a larger percentage of media plays than some of the more frequently selected interest spots (see Table 3). In fact, overall, interest spots with audio and video were selected more often than those with images only. This result may be a coincidence, since visitors did not know what kinds of media each interest spot contained before they clicked on it. Regardless, when visitors did click on an interest spot, they were more likely to play video rather than audio content.

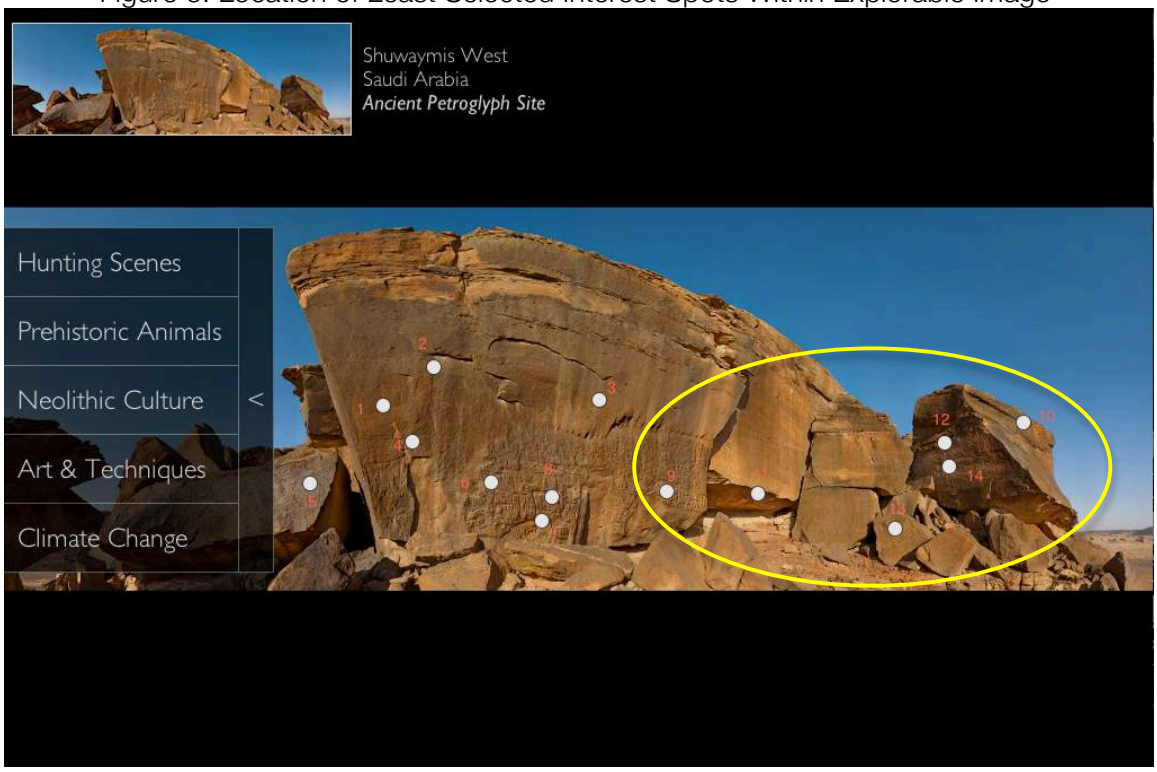
Table 2: Popularity of Interest Spots Selected By Visitors

Interest Spot	Type of Media Available	Percentage of Times Interest Spot Selected Overall (N=7469)	Percentage of Media Plays If Interest Spot Selected
1.) Stalking Leopard	Image	12%	N/A
2.) Cloaked Hunter	Audio	11%	20%
3.) Auroch Hunt	Audio	10%	21%
4.) Onager Mother & Foal in Danger	Audio	9%	19%
5.) Curator Interview	Video	8%	20%
6.) Aurochs or Wild Bulls	Video	7%	23%
7.) Asian Onager or African Wild Ass	Audio	7%	14%
8.) Detail of Auroch Head & Horns	Audio	6%	23%
9.) Animals in the Rock	Video	5%	30%
10.) Artists on the Edge	Video	5%	30%
11.) Geologic Jigsaw Puzzle	Video	5%	18%
12.) Hunting Dog Party	Audio	5%	18%
13.) Recessed Rectangles	Video	5%	33%
14.) Pelt Pattern on Canaan Dog	Image	5%	N/A

Table 3: Popularity of Interest Spots Selected By Visitors By Media Type

Type of Media At Interest Spot	Percentage of Times Interest Spot Selected Overall (N=7469)	Percentage of Media Plays If Interest Spot Selected Overall
Image Only Interest Spots	16%	N/A
Audio Interest Spots	48%	19%
Video Interest Spots	36%	24%

Figure 6: Location of Least Selected Interest Spots Within Explorable Image



Using Observations To Examine Visitors' Use of the Explorable Image

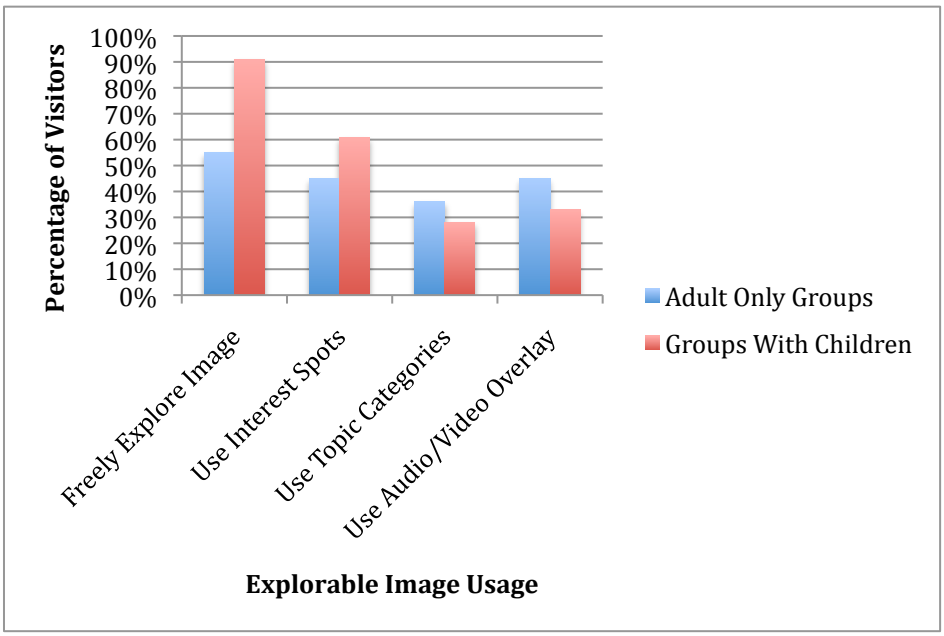
Thirty-eight percent of visitors (58 out of 152 of those observed) who entered the SITR exhibition went to the Explorable Image. Both adult-only groups and groups with children were equally likely to go to the Explorable Image. The kiosk was often the second thing that visitors approached within the exhibition, which implies that visitors often already had some exposure to exhibit content before approaching the Explorable Image.

As stated before, the average time visitors were observed at the Explorable Image was 2 minutes 20 seconds, which was lower than the time spent as indicated on the log files. The shortest visitor interaction that was observed at the Explorable Image was less than one minute, while the longest interaction was 11 minutes[4]. Adult-only groups spent slightly longer at the Explorable Image (M=2 minutes 50 seconds) than groups with children (M=2 minutes 9 seconds). Only 9% of visitors returned to try the Explorable Image again after visiting another portion of the exhibition.

[4] The observation form only recorded time spent in minute increments.

Of the 57 groups that were observed at the Explorable Image, several visitors read the overlay text on the touchscreen (34%, N=56) and the usage directions (25%, N=56). Groups with children tended to freely explore the petroglyph image and also utilized the touchscreen's interest spots more than adult-only groups (see Figure 7). Adult-only groups were slightly more likely to use the topic categories and the audio/video overlays than groups with children. In fact, in groups with children, interactions at the Explorable Image tended to be child-directed, which suggests that children were often the ones navigating the petroglyph image, selecting where to go and what to look at next.

Figure 7: Comparison of Explorable Image Usage
Between Adult-Only Groups and Groups With Children



Observers did code visitor interactions for talk and gesture, but had some difficulty hearing what visitors talked about and viewing visitors' actions unobtrusively (see Appendix C). Thus, the videotaped interactions, coupled with the log file data, provide the most reliable evidence that scientific observation behaviors were occurring in both adult-only groups and groups with children.

Using Video To Examine Visitors' Interactions Around the Explorable Image

Eighty-six visitor interactions at the Explorable Image were videotaped and transcribed to capture information about talk and gesture. A full analysis of the videos is beyond the scope of this report as they are being analyzed as part of a separate research study for publication. However, two example interactions are

provided below to give a sense of the ways in which visitors navigated the Explorable Image and the kinds of conversations that they had around things that they noticed.

The first excerpt is from an adult pair, Felix[5] and Stephanie. Stephanie initially tries to use her knuckles to manipulate the image, and Felix suggests that she use her fingers *"so you can go in, zoom in."* The transcript picks up as Stephanie clicks on the *Cloaked Hunter* interest spot (see Figure 8).

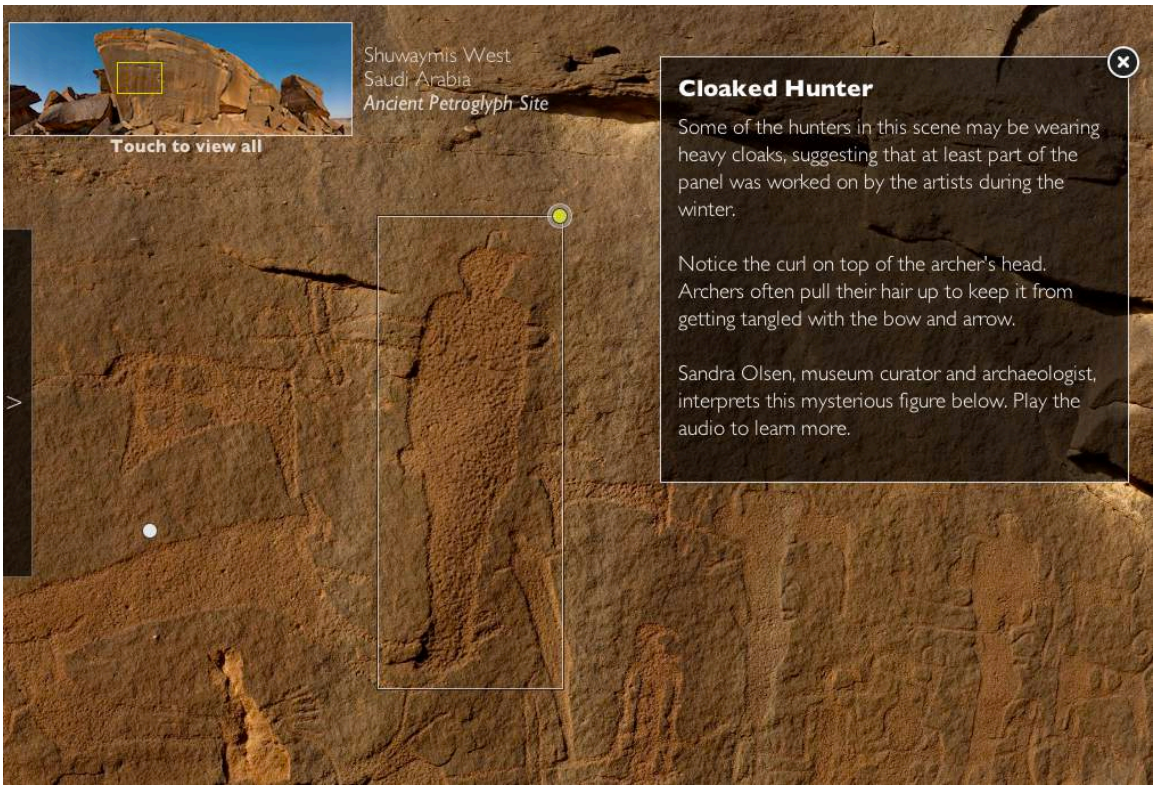
Transcript	Commentary
STEPHANIE: Certain spots. You can see the fossils. See the fossils? *FELIX: Well, what's that supposed to be?* *STEPHANIE: It tells you here.* *FELIX: Oh, cloaked hunter. How do they know that? Oh, you can zoom in.* *STEPHANIE: it seems like it-* *FELIX: Okay. We probably have to go listen to those things there.* *STEPHANIE: It tells you. Oh, this thing. There. Make it bigger.* *FELIX: Or you can probably- oh, maybe that's all it does.* *STEPHANIE: It takes you to the different things here. It's like there's some carvings.* *FELIX: In clay.* *STEPHANIE: This is all, you know, like artwork from Neolithic time.*	Stephanie is referring to the interest spots. Felix does not know what the image is and Stephanie refers him to the text on the right-hand side of the screen. Felix thinks that in order to get more information, they will need to visit the Stonephones. Stephanie and Felix are trying to figure out how to use the interface. They are able to zoom in, and then have a bit of difficulty maneuvering around the screen.

Felix and Stephanie began the interaction a bit unsure of what to do and where to get information. However, they do seem to have a basic understanding that they are looking at ancient carvings. Next, Felix makes several attempts at clicking on the curator interview, and is eventually able to get the audio to play. However, he has trouble seeing the animals that Stephanie is talking about and suggests that

[5] All names used in this report are pseudonyms.

they would be easier to see if they were outlined. They tap on the theme, *Art & Technique*, and then select another interest spot. As the interaction continues, Felix begins to gain more confidence in his ability to notice features in the image.

Figure 8: Cloaked Hunter Interest Spot

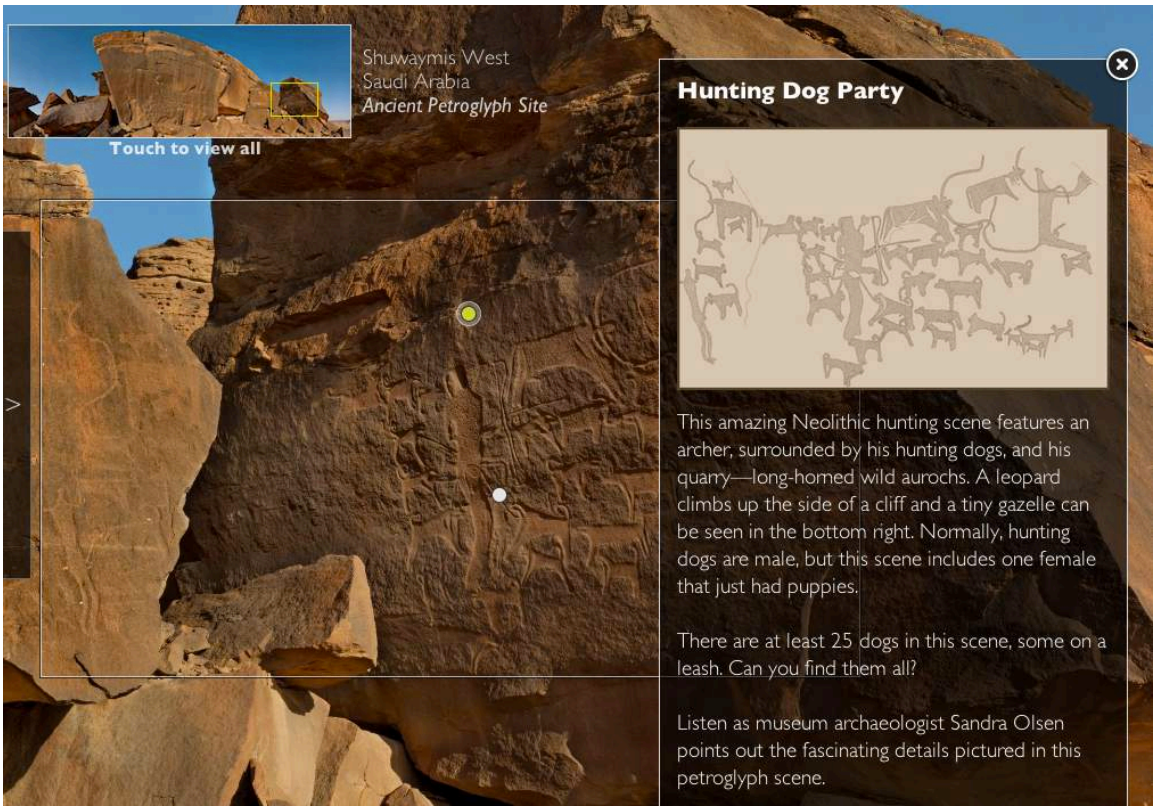


Transcript	Commentary
FELIX: Wild dog. Oh, I see. That's the tail. That's the dog. *STEPHANIE: Yeah.* *FELIX: That's the wild dog. Yeah, we're getting better at this. Climate Change. Oh, I see. Here's the tail and here's the head and the legs. The legs are bent and the head's going that way. Let's try a different one…Oh, I see. It used to be like that, but it shifted…Okay. All right. We're getting better.*	Felix identifies several features that help him orient the image and identify it as a dog. Felix also recognizes the effects of climate change on the image and feels that he is getting better at identifying features in the images.

Finally, Stephanie and Felix move on to the *Hunting Party* Interest Spot (see Figure 9). At this point, Stephanie is able to use the information provided to make

inferences about what each image represents. At first, Felix jokes around, but soon he too is able to identify features within the image.

Figure 9: Hunting Party Interest Spot



Transcript	Commentary
STEPHANIE: Hunting scenes. This is the same. This is what is there. *FELIX: They see that there, huh?* *STEPHANIE: Well, I can see this line there.* *FELIX: Oh, yeah! Yes.* *STEPHANIE: So then obviously this animal is on its side.* *FELIX: Right.* *STEPHANIE: That's a person here. See the person*.	Stephanie points to the picture on the right-hand side of the screen and motions towards the scene in the rock art. Stephanie uses the visual cues of the line to identify the positioning of the animal. She then tries to call Felix's attention to a specific figure.

Transcript	Commentary
FELIX: See this is like Florida. Then here's Louisiana, here's Texas and then California.	Felix examines the entire scene and thinks that it looks like a map of the United States.
STEPHANIE: That's funny. But here's the person. See the person?	
FELIX: Right. With the rifle? He's got a rifle!	Felix notices an object in the person's hand and wrongly assumes that it is a firearm.
STEPHANIE: Isn't that a bow?	
FELIX: I think it's a rifle.	
STEPHANIE: Oh, you can see the shapes of the animals. This part helps. So I guess that's the tail of this. I'm not sure. Or are they just lines?	Stephanie is trying to determine what the lines are representing. At first, she thinks they are tails.
FELIX: You know, I think this is- that's the tail of that. I don't know what this is the tail of. But this one looks like it's climbing up. It's going this way.	Felix notes the lines' orientation.
STEPHANIE: So, features an archer surrounded by his hunting dogs and his (??), long horned wild auroch. So these must be the horns on something.	Stephanie uses the written description of a horned animal to identify more images.
FELIX: Right.	
STEPHANIE: Because that's-	
FELIX: Oh yeah. A leopard climbs up the side of the cliff. This is the leopard.	Felix is able to find the leopard, while Stephanie identified a gazelle.
STEPHANIE: Right. A tiny gazelle can be seen in the bottom right.	
FELIX: Yeah.	
STEPHANIE: It says (??). This scene includes (??). That must be this?	The pair begins looking for a female dog, and at first, they wrongly select an elk. Once the elk is ruled out, Felix identifies another potential candidate.
FELIX: Yeah. Oh, wait. Maybe this is the female with the puppies because that's the elk thing.	

Transcript	Commentary
STEPHANIE: Oh, so underneath there. *FELIX: Okay. Maybe that explains all of these long things. They're leashes.* *STEPHANIE: Yeah, they do look like leashes. But you do see the archer?* *FELIX: Okay.*	Stephanie notices the puppies and uses them as evidence for Felix's selection of a particular image as the female dog. Felix infers that the items that they thought were tails are actually leashes. Stephanie still wants to make sure that Felix notices that the hunters are archers.

The interaction above includes a lot of dialogue in which the two adults use information from the interest spots and features of the image itself to support their identification of figures. They use strategies such as process of elimination (i.e. elk) and evidence from the image (i.e. puppies) to reason and make inferences about what each image represents. After initially making an incorrect assumption that the dogs have long, upward tails, the pair is then able to take all of the information that they have learned about the image and conclude that the "tails" are actually leashes.

In contrast, groups with children tended to have the child lead the exploration around the image, with the adult providing commentary on whatever the child was looking at in that moment. In the second example, Lisa and her daughter, Celeste, approach the interface and Celeste begins to freely explore. Celeste immediately finds a person in the image, and her mother encourages her to click on a video to learn more. Celeste is impatient and clicks on the *Hunting Party* interest spot, which stops the video that was playing.

Transcript	Commentary
CELESTE: Oh, oops! Here's a hunter with some dogs, and - *LISA: Look, if you take a look at it here, you can see it more because they've taken the carvings out and put like white in the background, so it's really distinct where the hunter is and he's got dogs on leashes and what they're hunting.*	Celeste quickly identifies the image. Lisa encourages further observation by pointing out the position of the hunter, how he manages the dogs, and wants Celeste to look at what they are hunting.

Here, Lisa stops her daughter and tries to get her to notice how the hunters are interacting with the dogs and what is surrounding them. She next encourages Celeste to watch another video, but Celeste goes back to zooming in and out and freely exploring the image. Lisa's strategy of looking at the interest spot information appears to be in conflict with Celeste's strategy for exploring the image. When the talk resumes, Celeste states the purpose of the activity.

Transcript	Commentary
CELESTE: Is this about when people carved into the rock?	After taking in the images at a more exploratory level, Celeste seems to understand the main topic.
LISA: Yeah. Do you know what an archaeologist does? An archaeologist is somebody who looks at really ancient things that are left over from people. There are people that study like old animals, like dinosaur bones and things like that- those are paleontologists, but the archaeologist is more interested in the interaction of people and times gone by. So, people carved these things. It wasn't animals that did it.	Lisa uses this as an opportunity to connect to the discipline of archaeology and differentiate it from other studies of ancient things.
CELESTE: I know.	Lisa continues to emphasize that studying the rock art can provide a window into ancient life.
LISA: But it explains a lot about their life. You can see how they hunted things and what they were interested in because we can only think about things from a long time ago. We don't really know, but some of these things give us clues about what happened a long time ago.	Celeste is distracted and is still looking for images in the rock. However, she is zoomed in so close that it is hard for her to tell what the image is.
CELESTE: Is that a person?	Once she zooms out, Celeste changes her mind about what the image represents. However, Lisa extends the observation by stating a feature (legs) that would differentiate an animal from a person.
LISA: I don't know. I can't really tell.	
CELESTE: It's an elephant.	
LISA: I think it's an animal because I see- I think I see legs. You're right; it does look kind of like an elephant.	
CELESTE: Mom, I was looking up here.	Lisa wants to find out more information about the image, but Celeste wants to continue to freely explore.
LISA: Here, you can find out more about-	
CELESTE: You can go look for yourself.	

LISA: All right. I'll go look for myself.	Celeste dismisses her mother and encourages her to look at the exhibit signage for information and Celeste continues to freely explore the image by herself.

Interestingly, Lisa was one of the only adults to connect to the discipline of archaeology during her visit. However, her daughters' goal of freely exploring the image seemed to conflict with Lisa's objective of getting her daughter to notice features and use that information provided to infer things about the image. In the end, Lisa let go of her overt learning goal and focused on sustaining her daughter's engagement with the interface by allowing her to independently examine the rock landscape.

In the two examples of Felix and Stephanie and Lisa and Celeste, we see that the Explorable Image technology supported both surface level and more in-depth kinds of observations. Users who wanted to scan the landscape for things that interested them could freely explore, zoom, and pan around the image. Visitors who wanted a deeper level of information could use themes and interest spots to help them identify salient features to look for in the petroglyph scenes. In this way, the Explorable Image facilitated different levels of noticing behaviors, and provided contextually relevant information based on user explorations.

Visitors' Opinions of the Explorable Image

Thirty-three visitors who used the Explorable Image answered at least one question about their experience with the Stories in the Rock exhibition. Of these, 85% visited the exhibition with children and the rest were adult-only groups. Half of the interviewees (N=16) indicated that they were drawn to the exhibition because of the Explorable Image. Almost all interviewees (90%; N=30) who visited the Explorable Image indicated that it had been their favorite part of the exhibition. Several visitors expressed a sense of fascination with the novel technology:

> *"The resolution on that screen over there is incredible."*

> *"I think one of the greatest things about it, is that you can see overall, the picture of the whole scene, and you can zoom in on the little bits of artwork in there."*

Of those who used the Explorable Image, 83% of interviewees indicated that they had touched an interest spot and 58% reported that they had selected a theme.

Almost all interviewees (96%) self-reported that they had read some of the text provided. Of these, the majority (76%) felt that the text had provided helpful information. Many interviewees (65%) also shared that they had listened to audio or video provided in the overlays. Of these, almost all (92%) thought that the information provided from the audio/video had been helpful.

Most interviewees (70%) felt that the Explorable Image interface was easy to use and compared the swiping and zooming motions to commonly used finger movements for touchscreen-based inputs for devices like iPhones or iPads. Several visitors (22%) indicated that they initially had experienced difficulty navigating the interface, but were eventually able to figure it out *("It took us a little while to get used to it and know what to push and where. We're not as technically intuitive as some of the kids are now.").* Only a few visitors (8%) found the interface to be difficult to use.

Visitors liked the aspect of choice that the interface provided and felt that it afforded more opportunities than the other exhibit activities:

> *"I liked being able to zoom in to whatever I wanted to zoom in on, read about it, and go to the different sites and then be able to see where it is on the rock."*

> *"I just liked being able to go over to it and pick what I wanted to see, not what I had to listen - there were many options on the touchscreen, whereas the rock [Stonephone] was just one thing that I couldn't choose what else I wanted to listen to. It was just narrow. There was only one scope. I listened to it and it was done."*

Parents of young children liked that the Explorable Image was easy for their children to manipulate:

> *"I thought the screen was really nice, especially for a little guy his age. He's almost four, so it was interactive for him and it was more than just looking at a flat wall, and as an adult, I thought it was interesting too, to be able to get a closer look at the different aspects."*

> *"It's good for the little ones because they seem to like anything they can touch and like have it react, you know. I thought being able to see the rock carvings up close so you can really zoom in on them and see the whole thing as a whole, so you can get the scale of it was pretty interesting."*

However, some parents noted that it was hard to watch video or listen to audio with kids' limited attention spans. Several indicated that they would have stayed at the exhibition a lot longer if their children had not been present.

Examining Images

The Explorable Image gave visitors an opportunity to examine remote sites of scientific and cultural interest that they might not normally have access to in greater detail:

> *"I liked that we could expand everything and really look so closely at a very high definition picture of something that I'll never be able to go and see. I don't have plans to go to Saudi Arabia."*

Most visitors (96%, N=24) agreed that they had been able to look at or notice ancient petroglyph figures in the Explorable Image panorama. Of these, 60% provided specific examples of animals or human figures from the petroglyph image. The rest spoke vaguely of animals, interest spots or the picture providing finer details.

A few visitors noted that sometimes they zoomed in too much, making it hard to discern the figures, but they were usually able to return to the main screen to continue their exploration.

Visitors used the information provided from the interest spots to help them identify where to look and notice specific aspects of scene or figure that they were viewing:

> *"Whenever you first look at the kind of the macro shot, the wide shot, you miss a lot, and being able to point out for you where there's groupings of petroglyphs, then you kind of like realize how much is there."*

> *"It definitely gave you an idea of what you were looking at so you could look more for the details."*

> *"They showed you the pictures. The details explained what you were looking at so you could look more closely."*

> *"[The interest spots showed] the title of the kind of animal that it was and then we were able to say like, 'Oh, this guy is related to a buffalo…' On [the] Stonephones, it was hard to sometimes see what it was trying to depict, like that cheetah [sic]."*

"Now, you saw in the sketches there, why they said they were male dogs. They were so detailed. To say they were male dogs, but there was one female dog because they interpret that by seeing the smaller puppies underneath her. Now, I don't know how, but once you start looking at it closely, it's like a puzzle. You do start to see things differently. Together, without them saying that, you'd never know that that's what you were looking at."

Figure 10: Mother and Daughter At the Explorable Image

All visitors who were asked (100%; N=23) agreed that the Explorable Image had helped them to look at and understand the petroglyphs in a deeper way. Of those that provided a reason, most (41%) felt that the interface's interactive nature and its ability to allow viewers to examine the image close up were beneficial in helping them better understand the imagery and exhibit content (see Table 4):

> "*I think being more interactive, it forced you, instead of passively sitting there and watching it go by, you are actually engaged to actually go and find these."*
>
> *"Normally, you would just look at these, the larger pictures, and keep moving. This was a lot more interesting because it gave you the opportunity and points you in the direction to actually see the details, you wouldn't have been as aware of what you were looking at."*
>
> *"Static displays are nice, but it's neat when you can actually - I think you get more from it when you interact, but that's just my opinion…so when you walk across, you know you see it. It's there. Something's highlighted for you. It's very static. You look in those boxes. When you have something that's more dynamic, it forces you to engage more…For example, when we zoomed in, 'Okay, now let's move to the side. What do you see?'…I think you retain more from it…and me personally, I like to draw my own conclusions first, so you can zoom in and look and then you're like, 'Ah, I can't really tell what it is,' and then you can hit the interest [spot] to kind of show you."*

Table 4: Reasons Visitors Gave For the Explorable Image Assisting Them in Looking Deeply

Reason*	Percentage of Visitors
Technology (in general)	12%
Interactivity	41%
User Has Control of Experience	12%
Interest Spot Information Provides Guidance Towards Details	24%
Allows Viewer To Look At Image Close Up	41%

* Some visitors gave more than one reason.

How Explorable Imaging Technology Supports Observations

Most visitors (93%, N=23) were able to describe how they thought scientists use imaging technology in their research. Of these, most indicated that scientists use imaging technology to communicate their work to others and to document their work (see Table 5). Specifically, visitors talked about the ways that the technology supported collaboration between colleagues and a method for effectively visualizing results:

> *"As a scientist, you have to image what's there since you can't bring the science community as a whole out to the site every time. As far as the technology and the way it's presented is concerned, I think it's a great way to show others, you know, interacting with the work, with the context and the content. It's something I don't think you can get by just like taking notes and drawing a few sketches."*

> *"You can kind of zoom in and really see details that you couldn't otherwise and, you know, research aside, getting people to interact with it and see the results of the research, I think it's a benefit on both - it's useful for both the scientist and the kid patron, museum patron to really be able to - much more so than a story to visualize stuff."*

Table 5: Reasons Visitors Gave For the Explorable Image Assisting Them in Looking Deeply

Scientists' Use of Imaging Technology	Percentage of Visitors
For Communication With Other Scientists or the Public	30%
To Document a Study	26%
To View an Image Closely	22%
For Comparison	19%
To Clean Up an Image	7%

* Some visitors mentioned more than one use.

Some visitors also talked about the fact that the technology allows the image to be filtered or cleaned up to uncover additional information after the fact, or compared to other images to look for changes over time. Several visitors talked about how the viewpoint of the Explorable Image allows users to see things that wouldn't be visible if they were standing right next to the actual rock face:

> *"What you can see to the naked eye isn't exactly all that is there. If you can look at something from a different perspective, it can lead to much more knowledge about what you're researching."*

What Visitors Learned From the Explorable Image

Most visitors (77%; N=30) indicated that they had learned something from the exhibition. The importance of art and animals to the artists was the most frequently mentioned content that interviewees indicated that they learned (See Table 6).

Table 6: Reasons Visitors Gave For the Explorable Image Assisting Them in Looking Deeply

Content Learned*	Percentage of Visitors
Importance of Art & Animals	27%
Hunting Practices	17%
Location of Art in Saudi Arabia	17%
People/Culture	13%
Method of Carving	13%
Climate Change	10%
Use of Dogs/Leashes	10%
Overall Abundance of Wildlife	10%
What Animals Were Hunted	7%
Rock is From the Past	7%
Geography of Landscape	7%

* Some visitors mentioned more than one content area.

Specifically, visitors discussed that they had not previously known that there were petroglyphs in Saudi Arabia. Several were surprised that carvings would exist on exposed rock, rather than within a sheltered cave. Visitors also talked about hunting practices, the landscape, and the animals that were present back then. A few picked up on *"the fact that the animals that were depicted weren't the only animals that were around…the tribes tend to associate with those animals and elevate them. They were picking and choosing particular animals."* Some visitors mentioned learning specific facts such as hunters being cloaked in winter, a fear of the stalking leopard, and placing leashes on dogs.

For the most part, visitors (60%, N=25) did not appear to gain new insights into what archaeologists do or how they study petroglyphs. Most visitors (71%, N=17) did not realize that researchers at the Carnegie Museum of Natural History were

currently studying the rock art in the exhibition. Future iterations of the interface and supporting exhibit elements could better emphasize this information *("Something that says that you're actively studying it versus maybe like a 'here's the picture that we found.'").*

Practitioners' Perspectives on Using Explorable Image Technology to Support Observational Practices & Facilitate Scientific Communication in Museums

Two practitioners were interviewed about their experiences with the project to find out what they thought about the use of gigapixel technology and Explorable Image viewers at the Carnegie Museum of Natural History. The first interviewee worked in a leadership role to connect museum staff and scientists with the project's university partners, and was interviewed before Stories in the Rock was placed on the museum floor. The second interviewee was a curator, and the scientist whose archeological research was featured in the Stories in the Rock exhibition. She was interviewed after the exhibition had completed its run. Each practitioner represents a particular role and viewpoint within the museum and the project, yet both were focused on trying to connect the museum's research to public audiences.

According to museum leadership, one of the big issues that natural history museums are currently grappling with is, *"how to get current research on the floor quickly [and] how to engage people with current research."* The scientist agreed, *"I think, for me, as a curator, the most important thing is that people realize that behind the scenes, the scientific staff is really doing some exciting research all over the world."* As a scientist, she also indicated that there are geographic challenges in sharing one's work (i.e. how to make findings accessible, avoid jargon and cultural stereotypes).

Another challenge for scientists in natural history museums is to create engaging experiences for the public:

> *"The biggest irony, I think, at a natural history museum…is, when, you know, scientists wanted to develop exhibits where people couldn't do anything and all I could think of is, 'If we took away all your collections and you couldn't touch anything, would you come to work?' And I think that's the message natural history museums need to get through to their scientific staff. Would you be doing what you're doing if you couldn't touch and investigate and experiment with and access in all these different ways all this cool stuff? Would you show up for work if all you could do is read about it and see it and not touch it or do anything with it?"*

The museum's leadership recognized Explorable Image technology as one way to approach this issue since explorable high-resolution photography *"provides access to ideas through images. It provides access to information through images. It*

provides access to people through interactive means around images. It is a tool for facilitation." Thus, the museum identified scientists at the museum whose work had *"a visual component that was complex, and currently, it was frustrating. The [scientist] wanted to work on a solution or an approach. There was a problem that [the museum] thought could be visually solved."* Here, leadership was not looking to *"add work to anyone's plate."* Rather, they chose projects that museum scientists were already passionate about and had done some previous work around, and encouraged those scientists to think about how the Explorable Image could be used as a mechanism to communicate their own research.

When the project began, museum leadership saw the work as a way to build institutional capacity and *"leverage what the scientists [were] already committed to and provide an additional opportunity for them to move forward and really challenge them to take their work to the next level"* by "*providing professional development to our scientific team about publics, and how to work with publics, and how to have publics as an audience."* To that end, a meeting was held with museum leadership and staff, university learning researchers, museum scientists, and computer programmers, to brainstorm ways in which gigapixel technology could be used by museum scientists to showcase and disseminate their work. Through this meeting, museum leadership *"learned that you've really got to get the tools in the scientists' hands early so they can play with it."* In other words, before scientists can imagine the possibilities of how their work might be translated via an Explorable Image interface, they must first find out about the technologies' capabilities. In addition, the collaboration supported professional development amongst the museum staff, particularly around theories of learning: *"Everyone comes with expertise, and is supposed to leverage that expertise and actually understand the other person's expertise and grow and have a different understanding. Mutual learning is supposed to happen throughout this project…It gave scientists and public programs…a chance to dig in together and for the scientist to really think about the fact that science education has theories, and it has processes, and it does research."*

The scientist whose work was highlighted in the Stories in the Rock exhibition, also recognized the value of these meetings:

> *"I think having these three components: Technologists/technology, informal science education and someone with museum experience is critical…the worst thing for a scientist is to just be holed up in their own office - You don't grow if you don't collaborate, so it's just critical and so it was a nice opportunity for me to collaborate with people that are not archaeologists but they know so much about their own fields that I've learned from them, and I think they've learned something from me too. It's mutual."*

In fact, she saw the benefit of sharing her expertise about what does and does not work on a museum floor with the technology developers:

> *"It works both ways because we're telling the CMU guys, 'You're really quick on a computer, but that person walking up to the touch screen for the first time - They don't know what's next. You have to make it really straightforward, and also, they're only going to be there, on average, maybe three minutes. So we can give them the choice of spending more time and going in depth, but we also want them to get an enriching, satisfying experience in that three minutes.'"*

Benefits of the Explorable Image Technology

The museum scientist first took gigapixel images of ancient rock art during a research expedition to Saudi Arabia, then brought this photo documentation back to the Carnegie Museum of Natural History for further study:

> *"I can have this great big panel, a very nice picture that tells me something about the topography of the region and what that rock is shaped like and so forth, and I can get the spatial relationships amongst the different figures because I can see the whole thing and then I can zoom in and then I can the change in the patina. The fresher ones have brighter colors because they're exposing the natural color of the rock. The patina is being taken away. I can also see overlapping images that will tell me something about what's older, what's younger, so the Gigapan is really useful for that."*

As a researcher, she saw the potential of the technology for her own research because she could explore the images in more detail than she could have on site, she saved time and money by conducting her research back at the museum, and the interface allowed her to share the images with other scientists and experts to confirm observations, and so that they could explore their own research questions with the data. She also felt that she learned more about informal science education and *"what's possible with the technology"* as a result of her participation in the project. In fact, the museum scientist recognized that the Explorable Image provided visitors with a taste of the process she goes through when she studies petroglyphs:

> *"When I'm doing my observation, I'm sitting at my desk and looking at a computer screen and manipulating the Gigapan similar to the way the visitors are doing it and I'm navigating all over and zooming in and, uh- and they're having kind of a parallel experience…Every time I look at a particular image, I learn something new."*

The museum scientist felt that the main benefits of the Explorable Image as a museum activity were that the touchscreen is an interface that people are used to, it is low maintenance, can be paired with other artifacts, and the information can be changed quickly *("When something is out of date because of a new discovery, you can get that new discovery right there out on the floor right away.")* She also thought that the presence of two stools in front of the exhibit encouraged more interactions between visitors. However, the main reason she liked the Explorable Image as a showcase for her research was that it allowed visitors to control what and how they want to learn:

> *"It's extremely dynamic. You can do so many things, and it allows- gives the visitor some freedom of choice. Like I want to learn about the dog, I want to learn about hunting, I want to learn about the weapons guy or the environment change through time. Whatever that visitor is interested in, given the topics, the range of topics, they get to choose. That means they're proactive. They're involved. They're engaged and that's very different from reading label copy."*
>
> *"It's less linear. It's more spreading out in different directions, seeing the connections – like a net."*

These insights are exactly what museum leadership hoped that CMNH scientists would get out of incorporating Explorable Image technology into exhibitions: *"Creating visual platforms makes you think about an idea differently, and so it makes you think about a [visitor] interaction differently."*

In sum, museum staff and scientists who participated in the project saw the value of the Explorable Image as a dynamic and valuable tool, both for sharing current research findings with the public and for supporting visitors in making more scientific kinds of observations:

> *"I think it's important for museums to have different ways of communicating information to the public. So this is one relatively new way. I mean, computer touchscreens have been around for a while and they're getting better and better, but the gigapixel images are different from what they're used to, so it is expanding their horizons that way and we're always trying to come up with new ways of interesting the public like making it more fun to get access to information. I can tell you as a researcher, this- from my own point of view as a scientific researcher, the gigapixel technology has way deepened my understanding. Unbelievable how useful it is compared to regular photographs, so I know that it has to be doing the same for visitors. I mean they're just able to explore the rock art panels in a way that- you really couldn't do any other way."*

Conclusions & Next Steps

The use of the Explorable Image in the *Stories in the Rock* exhibition successfully demonstrated that the technology could be used to help scientists effectively communicate their research to public audiences in compelling and appropriate ways. Visitors who used the Explorable Image viewer engaged with it for a significant amount of time, and most tended to use the supports within the interface (i.e. themes and interest spots) to delve more deeply into the exhibit content and details of the archeological site. Museum staff and scientists who participated in the project saw the benefits of the Explorable Image, both as a way to quickly get new findings on the museum floor, and as a tool to support visitor observations in ways that mirror researchers' own scientific practices. In addition, the project helped museum scientists learn new informal science education strategies for collecting and presenting scientific content using technology, broadening their perspectives on ways to engage public audiences.

Next steps for this project include examining videos of visitors' conversations and gestures during their use of the Explorable Image, to determine the specific kinds of observational and learning talk that the interface supports. Future work in this area might focus more on changes in individuals' observational practices after engaging with gigapixel technology in a different context. For example, the next demonstration project will likely examine how youth and citizen scientists utilize a gigapixel resolution digital teaching collection of stream insects to support learning observation and identification practices, and the evaluation team might look at individuals' insect group categorizations and explanations of those categorizations as evidence for learning from the insect ID tool. These efforts will expand studies of the use and impact of explorable images beyond a Public Understanding of Science transmission model, and examine the technology as a tool that can potentially support Public Participation in Scientific Research (i.e. public audiences collecting and analyzing data and engaging in scientific practices) (Bonney et al, 2009).

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Appendices

Appendix A: Observation Form

Overall Start Time [Timestamp]
Press Select

Activity Table & Panel
Start Time [Timestamp]
Press Select

Order Visited [Skip, 1,2,3,4,5,6]
Click "Skip" if did not go to activity.
Will need to keep track of order visited in your head

Activity Table Behaviors
Adult POINTS features w/in image ON TABLE
Child POINTS features w/in image ON TABLE
Adult POINTS at ACTIVITY WALL
CHILD POINTS at ACTIVITY WALL
Adult GESTURES b/t two OTHER exhibit elements
Child GESTURES b/t two OTHER exhibit elements
Adult MOVES from/to table to wall
Child MOVES from/to table to wall
NOTE: Can go back in to add behaviors if need to capture other categories.
NOTE: Can unclick behavior if made a mistake

Activity Table Talk
Adult OBSERVATIONAL COMMENT about a feature
Child OBSERVATIONAL COMMENT about a feature
Can't really hear
NOTE: Observational Comments are talk about features (i.e. "Look at its long tail!") or connecting content together (i.e. "This auroch is just like the one over there.")

Read Directions at Activity Table/Wall
Yes/No

Pair Matching Activity
0,1,2,3,4,+
NOTE: + is if they do pairing more than once during same visit

Tracing Activity
Yes/No

Figure Scavenger Hunt Activity
Yes/No

Collaborate at Activity Table/Wall
- Adult-directed (adult leads)
- Child-directed (child leads)
- Collaborative (Turn taking)

Repeat Activity Table/Wall
- Yes/No

NOTE: If repeat, DO NOT restart time, code for talk or behavior. Can use audio notes at end of each section to discuss what happened during repeat visit.

Activity Table End Time
- Press Select

Observation Audio Notes1
- Press Record to capture own notes. Press Stop when done.

Observation Audio Notes2
- Press Record to capture own notes. Press Stop when done.

Overall Start Time [Timestamp]
- Press Select

Stonephones

Start Time [Timestamp]
- Press Select

Order Visited [Skip, 1,2,3,4,5,6]
- Click “Skip” if did not go to activity.
- Will need to keep track of order visited in your head

Stonephone Behaviors
- Adult POINTS features w/in image ON PODIUM
- Child POINTS features w/in image ON PODIUM
- Adult NOTICES/POINTS at highlighted GIGAPRINT
- CHILD NOTICES/POINTS at highlighted GIGAPRINT
- Adult WALKS from/to podium to Gigaprint
- Child WALKS from/to podium to Gigaprint
- Adult GESTURES b/t two OTHER exhibit elements
- Child GESTURES b/t two OTHER exhibit elements

NOTE: Can go back in to add behaviors if need to capture other categories.
NOTE: Can unclick behavior if made a mistake

Stonephone Story Selection
- Listen Stalking Leopard – Whole
- Listen Stalking Leopard – Part
- Listen Wild Bulls – Whole
- Listen Wild Bulls – Part
- Listen Dogs – Whole
- Listen Dogs – Part

NOTE: Only for target person in group.
NOTE: If they did not go to a story at all, leave it blank

Stonephone Talk
- Adult OBSERVATIONAL COMMENT about a feature
- Child OBSERVATIONAL COMMENT about a feature
- Can't really hear

NOTE: Observational Comments are talk about features (i.e. "Look at its long tail!") or connecting content together (i.e. "This auroch is just like the one over there.")

Read Directions at Stonephone
- Yes/No

Repeat Stonephone
- Yes/No

NOTE: If repeat, DO NOT restart time, code for talk or behavior. Can use audio notes at end of each section to discuss what happened during repeat visit.

Stonephone End Time
- Press Select

Observation Audio Notes1
- Press Record to capture own notes. Press Stop when done.

Observation Audio Notes2
- Press Record to capture own notes. Press Stop when done.

Explorable Image

Start Time [Timestamp]
- Press Select

Order Visited [Skip, 1,2,3,4,5,6]
- Click "Skip" if did not go to activity.
- Will need to keep track of order visited in your head

Explorable Image Behaviors
- FREELY EXPLORE IMAGE (zoom around, make big or small)
- USE INTEREST SPOTS (click on white or orange dots)
- USE TOPIC CATEGORIES (categories on left-hand side)
- Play AUDIO? VIDEO Overlay
- Adult COMPARES SCREEN & OVERLAY
- Child COMPARES SCREEN & OVERLAY
- Adult NOTICES/POINTS GIGAPRINT
- CHILD NOTICES/POINTS GIGAPRINT
- Adult GESTURES b/t two OTHER exhibit elements
- Child GESTURES b/t two OTHER exhibit elements

NOTE: Comparing screen and overlay is making reference between text/audio/video on right hand of screen and other portions of screen
NOTE: Can go back in to add behaviors if need to capture other categories.
NOTE: Can unclick behavior if made a mistake

Explorable Image Talk
- Adult OBSERVATIONAL COMMENT about a feature
- Child OBSERVATIONAL COMMENT about a feature
- Can't really hear

NOTE: Observational Comments are talk about features (i.e. "Look at its long tail!") or connecting content together (i.e. "This auroch is just like the one over there.")

Read OVERLAY Text (on screen right side)
- Yes/No

Read USAGE Directions (small panel on left side)
- Yes/No

Read LEFT Wall Text Panel (up high on left side panel)
- Yes/No

Collaborate at Explorable Image
- Adult-directed (adult leads)
- Child-directed (child leads)
- Collaborative (Turn taking)

Repeat Explorable Image
- Yes/No

NOTE: If repeat, DO NOT restart time, code for talk or behavior. Can use audio notes at end of each section to discuss what happened during repeat visit.

Explorable Image End Time
- Press Select

Observation Audio Notes1
Press Record to capture own notes. Press Stop when done.

Observation Audio Notes2
Press Record to capture own notes. Press Stop when done.

Panorama Petroglyph Print

Start Time [Timestamp]
Press Select

Order Visited [Skip, 1,2,3,4,5,6]
Click "Skip" if did not go to activity.
Will need to keep track of order visited in your head

Panorama Print Behaviors
Adult POINTS at features w/in image on GIGAPRINT
Child POINTS at features w/in image on GIGAPRINT
Adult GESTURES b/t two OTHER exhibit elements
Child GESTURES b/t two OTHER exhibit elements
NOTE: Can go back in to add behaviors if need to capture other categories.
NOTE: Can unclick behavior if made a mistake

Panorama Print Talk
Adult OBSERVATIONAL COMMENT about a feature
Child OBSERVATIONAL COMMENT about a feature
Can't really hear
NOTE: Observational Comments are talk about features (i.e. "Look at its long tail!") or connecting content together (i.e. "This auroch is just like the one over there.")

Repeat Panorama Print
Yes/No
NOTE: If repeat, DO NOT restart time, code for talk or behavior. Can use audio notes at end of each section to discuss what happened during repeat visit.

Panorama Print End Time
Press Select

Observation Audio Notes1
Press Record to capture own notes. Press Stop when done.

Observation Audio Notes2
Press Record to capture own notes. Press Stop when done.

Right Wall Panel Text

Start Time [Timestamp]
Press Select

Order Visited [Skip, 1,2,3,4,5,6]
Click “Skip” if did not go to activity.
Will need to keep track of order visited in your head

Read Right Wall Panel Text
Yes/No

Right Wall Panel Behaviors
Adult POINTS at features w/in image on GIGAPRINT
Child POINTS at features w/in image on GIGAPRINT
Adult GESTURES b/t two OTHER exhibit elements
Child GESTURES b/t two OTHER exhibit elements
NOTE: Can go back in to add behaviors if need to capture other categories.
NOTE: Can unclick behavior if made a mistake

Right Wall Panel Talk
Adult DISCUSSES CONTENT
Child DISCUSSES CONTENT
Can’t really hear
NOTE: Discuss content of exhibition/signage

Repeat Right Wall Panel
Yes/No
NOTE: If repeat, DO NOT restart time, code for talk or behavior. Can use audio notes at end of each section to discuss what happened during repeat visit.

Right Wall Panel End Time
Press Select

Observation Audio Notes1
Press Record to capture own notes. Press Stop when done.

Observation Audio Notes2
Press Record to capture own notes. Press Stop when done.

Research Team Sign

Start Time [Timestamp]
Press Select

Order Visited [Skip, 1,2,3,4,5,6]
Click “Skip” if did not go to activity.
Will need to keep track of order visited in your head

Read Research Sign
Yes/No

Research Sign Behaviors
- Adult POINTS at features w/in image on GIGAPRINT
- Child POINTS at features w/in image on GIGAPRINT
- Adult GESTURES b/t two OTHER exhibit elements
- Child GESTURES b/t two OTHER exhibit elements

NOTE: Can go back in to add behaviors if need to capture other categories.
NOTE: Can unclick behavior if made a mistake

Research Sign Talk
- Adult DISCUSSES CONTENT
- Child DISCUSSES CONTENT
- Can't really hear

NOTE: Discuss content of exhibition/signage

Repeat Research Sign
- Yes/No

NOTE: If repeat, DO NOT restart time, code for talk or behavior. Can use audio notes at end of each section to discuss what happened during repeat visit.

Research Sign End Time
- Press Select

Observation Audio Notes1
- Press Record to capture own notes. Press Stop when done.

Observation Audio Notes2
- Press Record to capture own notes. Press Stop when done.

Overall End Time
- Press Select

Today's Date
- Press Select

Interviewer's Initials
- Select Your Initials

Target Participant
Gender

Target Participant Approximate Age
- Select based on approximate decade

Who else came with gender and approximate ages?
- Example: If target participant is 40 year old female accompanied by 60 year old female and 12 year old male, then say [f40], f60, m12

Observation Notes
Written Observation Notes
Can type in notes, if have time

Observation Audio Notes1
Press Record to capture own notes. Press Stop when done.

Observation Audio Notes2
Press Record to capture own notes. Press Stop when done.

Interview
Was person interviewed?
Yes/No

Click on Interview box if they agreed to be interviewed.
Click on Done if no Interview and you are completely done with the form.

Appendix B: Interview Protocols

SITR General Interview Questions

Interviewer Initials:

My name's _____ and I'd like to ask you a few questions about what you thought about the exhibit you just visited. Please answer as honestly as possible. Your responses will help us improve the exhibit. Do you mind if I audio record our conversation? Great. Let's get started.

Interviewee Description: [Target person gender & age], gender & age of other visitors in the group

---

So, whom did you come with to the museum today?

What drew you to the exhibit? What did you first notice about the exhibit?
a. Why did that stand out?

Tell me a bit about what you did at Stories in the Rock today.

Overall, what did you think about this exhibit area? What did you like most about the exhibit and why? (What were the best or most appealing parts?)

What did you like least about the exhibit and why? (What were the weakest parts?)

Did this exhibit spark any interesting conversations?

Were there parts of the exhibit that you thought were difficult to use or confusing? Tell me more.

Now, I'd like to ask you about some of the topics you encountered in the exhibit today.
What were some of the things you found out today from the exhibit? [Prompt: Did you find anything out about climate changes, hunting practices, Neolithic culture, art, conducting research or other topics?]

Were you aware that the museum has an active research program?

Do the exhibit help you better understand what an archeologist does?
Please describe how you think an archeologist studies and interprets petroglyphs.

Based on what you have seen in the exhibit, how do you think scientists use imaging technology to support their observations and research?

Do you have any suggestions to improve the exhibition?
Are there any lingering questions you have or topics of interest that you think could be covered more in-depth?

Thank you for your time. Here is a museum pass that you can use for a future visit.

SITR Explorable Image Questions

Interviewer Initials:

My name's _____ and I'd like to ask you a few questions about what you thought about the exhibit you just visited. Please answer as honestly as possible. Your responses will help us improve the exhibit. Do you mind if I audio record our conversation? Great. Let's get started.

Interviewee Description: [Target person gender & age], gender & age of each visitor in group

---

So, whom did you come with to the museum today?

Tell me a bit about what you did at Stories in the Rock today.

Overall, what did you think about the exhibit? What did you like most about the exhibit and why? (What were the best or most appealing parts?)

What did you like least about the exhibit and why? (What were the weakest parts?)

Now, I'd like to talk with you about the Explorable Image interactive Kiosk.

Did you use the topic categories, interest spot buttons, or freely explore the image?

Did you read any of the text on the screen? Was the information helpful (If yes: How so?; If no: What could be changed?)

Did you listen to the audio/watch the video? Was the information helpful (If yes: How so?; If no: What could be changed?)

Did you find the touch screen difficult or easy to use? Please explain.
Did you find things to look at and notice in the image?

Were you able to find any patterns or figures in the petroglyphs?

Do you feel like this technology helped you look at and understand the petroglyphs in a deeper way? How so?

Now, I'd like to ask you about some of the topics you encountered in the exhibit today.
What were some of the things you found out today from the exhibit? [Prompt: Did you find anything out about climate changes, hunting practices, Neolithic culture, art, conducting research or other topics?]

Do you have a better understanding of what an archeologist does?
Please describe how you think an archeologist studies and interprets petroglyphs.

Were you aware that the museum has an active research program?

Based on what you have seen in the exhibit, how do you think scientists use imaging technology to support their observations and research?
Do you have any suggestions to improve the exhibition?

Thank you for your time. Here is a museum pass that you can use for a future visit.

Scientist and Museum Staff Interview Questions

Thank you for agreeing talk with me today. I'd like to ask you some questions about the Stories in the Rock demonstration project to explore the use of gigapixel technology for science communication and learning. As part of the summative evaluation for the NSF grant, we also want to understand the value of this project for the scientists involved. The call should take about 45-60 minutes. Please be as honest as possible about what you think the benefits and challenges of the project have been. All of your responses will be kept confidential. We may use quotes from this interview, but you will not be identified by name. I'd like to audio record our conversation as a way to take notes. Would that be okay? Do you have any questions before we get started? Great, let's begin.

1.) Tell me a bit about your role at the museum. What kinds of projects and programs are you responsible for?

a.) How have you engaged with the NSF Gigapixel Images for Sci Comm and Learning project to-date? How did you first get involved? What roles or responsibilities have you had related to the project?

For each project he/she was affiliated with:

2.) What interested you about SITR project? What were the key reasons that you decided to participate?

3.) When you first became involved in the project, what did you think the project was about/supposed to do?

a.) Now that you have been involved in the project, has SITR project worked the way that you expected it to? [Prompt: How has it been similar to what you expected to happen? How has it been different?]

b.) What were/are the goals of the project?

c.) In your own words, what do you think the project is trying to show visitors?

d. What do you hope people will learn/take away from seeing the petroglyphs?

4.) Do you think that SITR project has been successful? In what ways?

a.) For visitors?

b.) For museum staff and researchers? (i.e. in what ways is the project building capacity within the museum?)

c.) Have you formed any new partnerships as a result of this project? What was it like to work with the university on a shared grant?

Talk a little bit about the exhibition development process. What is hard about getting your research, and exhibits in your area out onto the floor and online? What kinds of things do you think would make it easier, more efficient to communicate

your research and to be able to make more/better museum learning experiences available?
Compared to past exhibits what were the similarities and differences in getting the gigapixel on the museum floor?

What aspects of your research / field most seem to interest public audiences? What is challenging about communicating and engaging public audiences in your research? How does gigapixel technology address those challenges? In what ways does the technology help you engage public audiences? Support scientific communication?

5.) If applicable: How have you, as an administrator, used this project and technology as a motivational tool for your staff? What strategies have you used to increase staff buy-in?

6.) What did you value most about this experience?

7.) What, if anything, did you learn from your participation in [SITR} that you didn't know before?

a.) about designing and implementing science activities in the museum?
b.) about incorporating technology in exhibitions and programming?
c.) about staff coordination/logistics?
d.) about using technology as a tool in communicating science to public audiences?
e.) about partnering with universities? About working with programmers?

8.) What have been some of the challenges to adoption of the technology? The logistics of the project? Implementing Gigapixel technology in the museum?

a.) What strategies have you used to address those challenges?

9.) This project explores three approaches to public-science learning interactions. Through your participation in this project, what new information have you found out about public understanding of science programs? Public engagement with science programs? Public Participation in Scientific Research programs?

a.) Do you have a preference for one of the three approaches? Do you think gigapixel image technology lends itself more to one type of program over another? What makes you think so?

10.) What are some of the ways that you have seen visitors interacting around Gigapixel technology? Have there been any surprising interactions?

a.) In what ways do you think that Gigapixel technology is deepening or extending the visitor experience?

11.) What ideas do you have about ways you will apply your experience with this project to your future work?

12.) How have your plans for implementing public engagement activities changed? How likely are you to implement a public engagement activity using gigapixel image technology in the future?

13.) What do you wish you had known before starting the project about PUS, PES, and PPSR? About Gigapixel technology? What might advice might you give someone who is thinking about incorporating Gigapixel technology in a museum exhibition or program?

Can you talk a little bit about scientific observation and what it means to look with the eye of a zooarcheologist – to study petroglyphs? How do you think about teaching people to observe with the eyes of science….?

In the future, how might you use the gigapan platform to engage the public and peers in dialogue about your research?

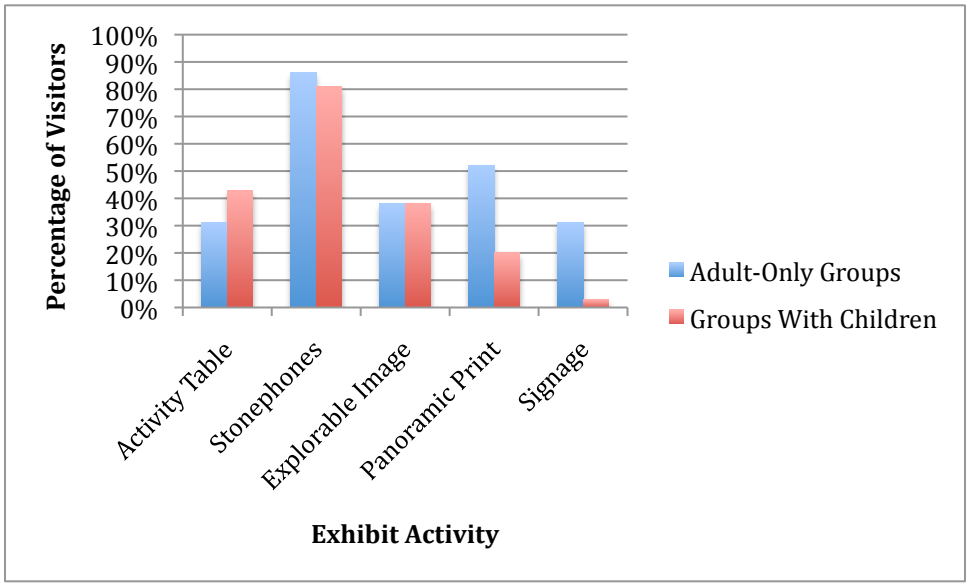
Appendix C: Findings Across SITR Exhibit Activities

Visitor Behavior in *Stories in the Rock*

152 visitors were observed using the exhibition. Of these, 29 were adult-only groups and 123 had at least one child present.

In terms of activities at which visitors stopped, visitors tended to go to the Stonephones most often and the signage least often (see Figure 11). There were some differences by group type. Groups with children were more likely to go to the Activity Table during their visit, while adult-only groups were more likely to visit the Panoramic Print and the exhibit signage. Both groups were equally likely to go to the Explorable Image.

Figure 11: Percentage of Visitors Who Went To A Particular Exhibit Activity



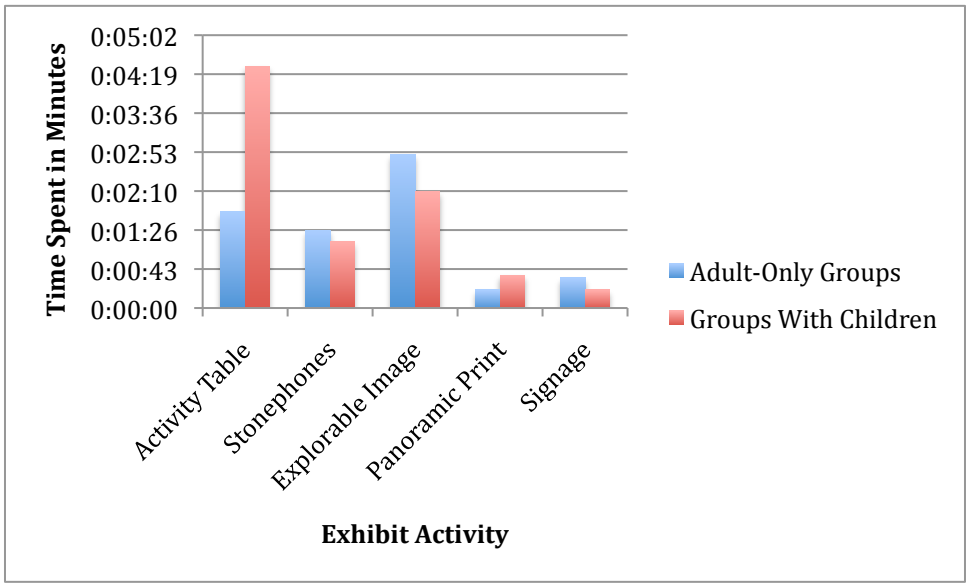
Comparing Time Spent at Different Activities

Visitors spent an average of 5 minutes and 16 seconds in the exhibition (with a minimum of 1 minute and a maximum of 31 minutes)[6]. Groups with children tended to spend more time in the exhibition (M= 5 minutes 14 seconds), on average, than adult-only groups (M= 3 minutes 46 seconds). Visitors, in general, spent the most amount of time at the Activity Table and the least amount of time at the signage (see Figure 12).

[6] Note that time spent was only calculated at minute intervals, so visitors received a "0" minutes designation if they were at an exhibit element for less than 60 seconds.

There were some differences, depending on whether the group consisted of only adults or had at least one child present. Adult-only groups tended to visit the Explorable Image for slightly longer than groups with children. Not surprisingly, groups with children spent more time at the hands-on Activity Table than adult-only groups.

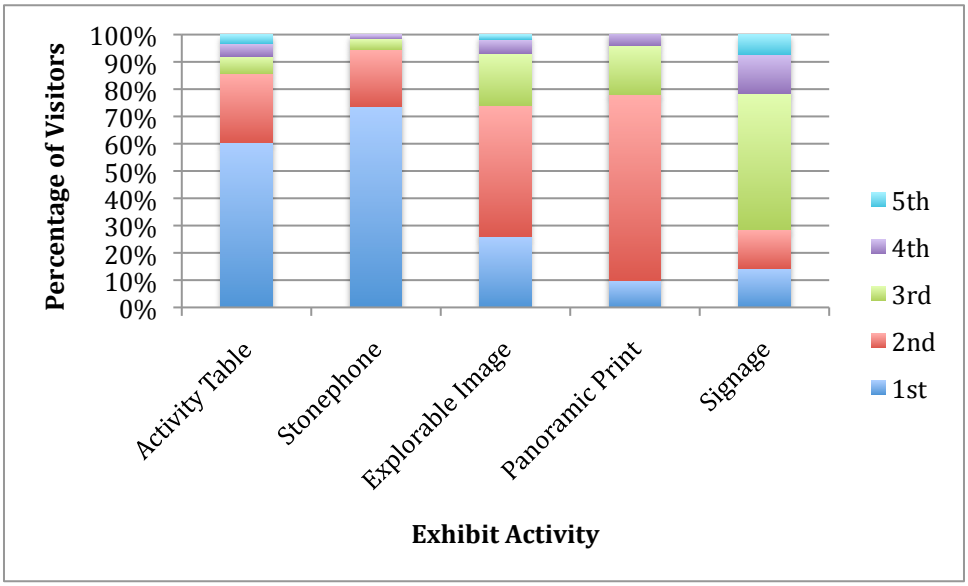
Figure 12: Amount of Time Spent At Exhibit Activities By Different Groups



Comparing Order Visited at Different Activities

Visitors tended to go to either the Stonephones or the Activity Table first, and either the Panoramic Print or the Explorable Image second (see Figure 13). If they looked at the signage, it tended to be in the middle of their visit to the different activities. Groups with children followed this pattern. Adult-only groups were more likely to go to the Stonephones first and the Panoramic Print second.

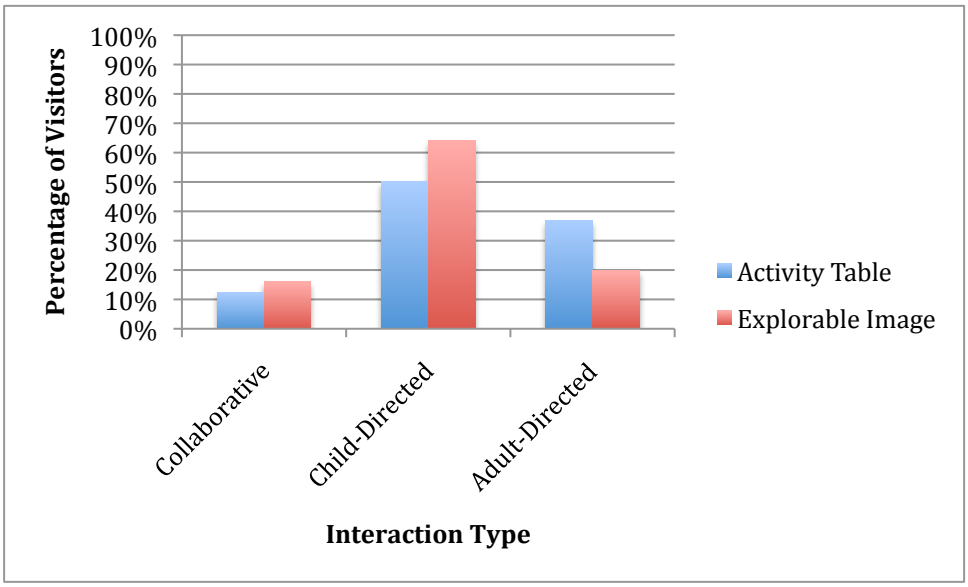
Figure 13: Order That Groups Visited Different Activities



Comparing Visitor Interactions at Different Activities

Observers were asked to classify visitor behavior at the two interactive elements of the exhibition: The Activity Table and the Explorable Image. Observers coded the overall interaction within groups with children as adult-directed (the activity was led mainly by an adult in the group), child-directed (the activity was led mainly by a child in the group), or collaborative (both an adult and a child in the group took turns leading the activity). At both activities, visitor interactions tended to be more child-directed (see Figure 14). Yet, interactions were more likely to be child-directed at the Explorable Image and adult-directed at the Activity Table. It may be the case that the Activity Table was utilized more often by the youngest visitors, while the Explorable Image was frequented by older children. However, since both young children and older children were observed using the two activities, the data suggests that the Explorable Image may have been slightly more conducive to child-directed interactions.

Figure 14: Differences in Visitor Interactions By Activity



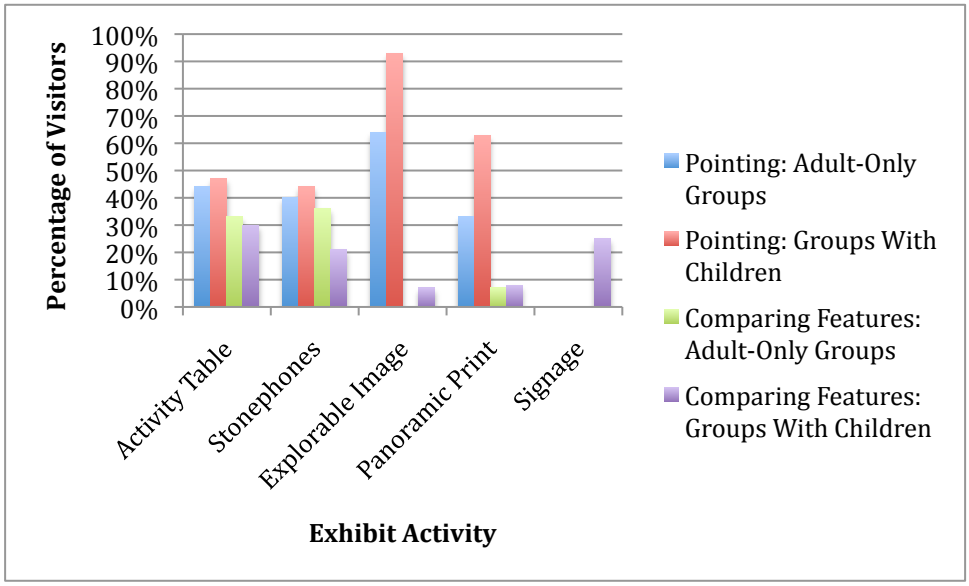
Comparing Noticing Behaviors At Different Activities

Observers documented two types of noticing behaviors in order to examine whether different exhibit activities afforded distinct levels of observational practices among adult-only groups and groups with children. The first behavior that was tallied was "pointing". Pointing either involved gesturing to an image immediately in front of the visiting group or pointing to a related part of the activity. In the case of the Explorable Image, pointing was also defined as freely exploring the image by using one's fingers to zoom in and out of the image or to move across the image. The second behavior that was counted was "comparing features." This code was given when a visitor gestured or physically walked from the current activity to an exhibit activity in another area to make a quick comparison between what they had just seen and the new exhibit element.

Figure 15 indicates that visitors, overall, tended to engage in pointing more often than comparing features. The Explorable Image appeared to support the greatest percentage of pointing behaviors[7]. The Stonephones and the Activity Table supported the greatest percentage of feature comparisons. Interestingly, groups with children engaged in many more pointing behaviors around the Explorable Image and Panoramic Print than they did during other activities.

[7] Pointing behaviors were not coded at exhibit signage.

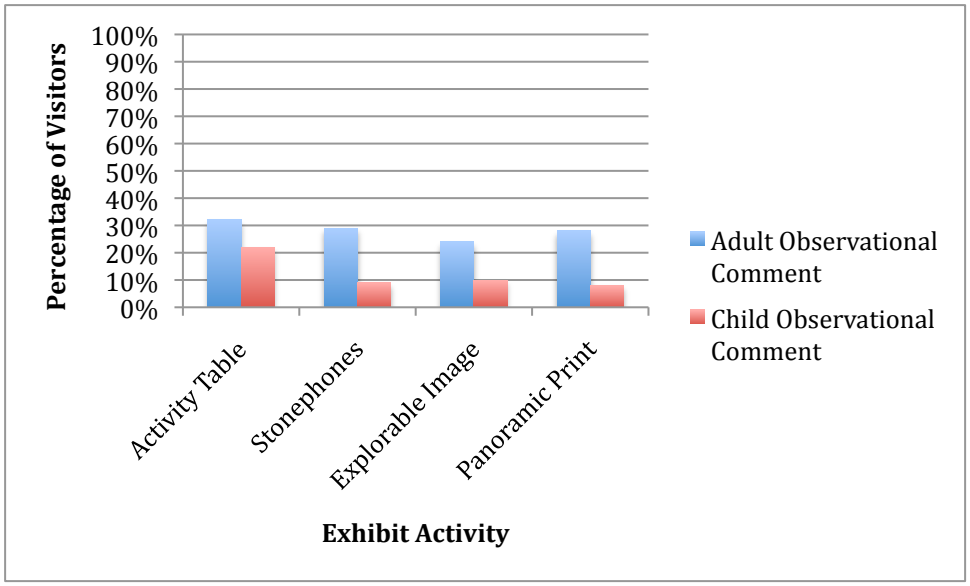
Figure 15: Noticing Behaviors By Activity For Different Group Types



Observers also attempted to tally whether an adult or child made an observational comment at any time during their visit to each exhibit activity. Observational comments were defined as statements such as, “Look at this!” or “See the curved tail?” One limitation of this data is that visitors’ conversations were sometimes hard to hear. Another limitation is that some data collectors may have stopped listening to the conversation at the Explorable Image once a video recording was taking place. Thus, the percentages of visitors who uttered observational comments at the various activities may be greater than Figure 16 shows.

Between 20-30% of visitors made an observational comment at an exhibit activity. Adult visitors provided more observational comments than children. This is not surprising as many of the children in visiting groups were under three years of age. Children provided the most observational comments at the Activity Table. The Explorable Image had the lowest amount of observational comments overall, but again, this may have been due to data collector error.

Figure 16: Percentage of Visitors' Observational Comments By Exhibit Activity



Visitor Behavior at Specific Activities

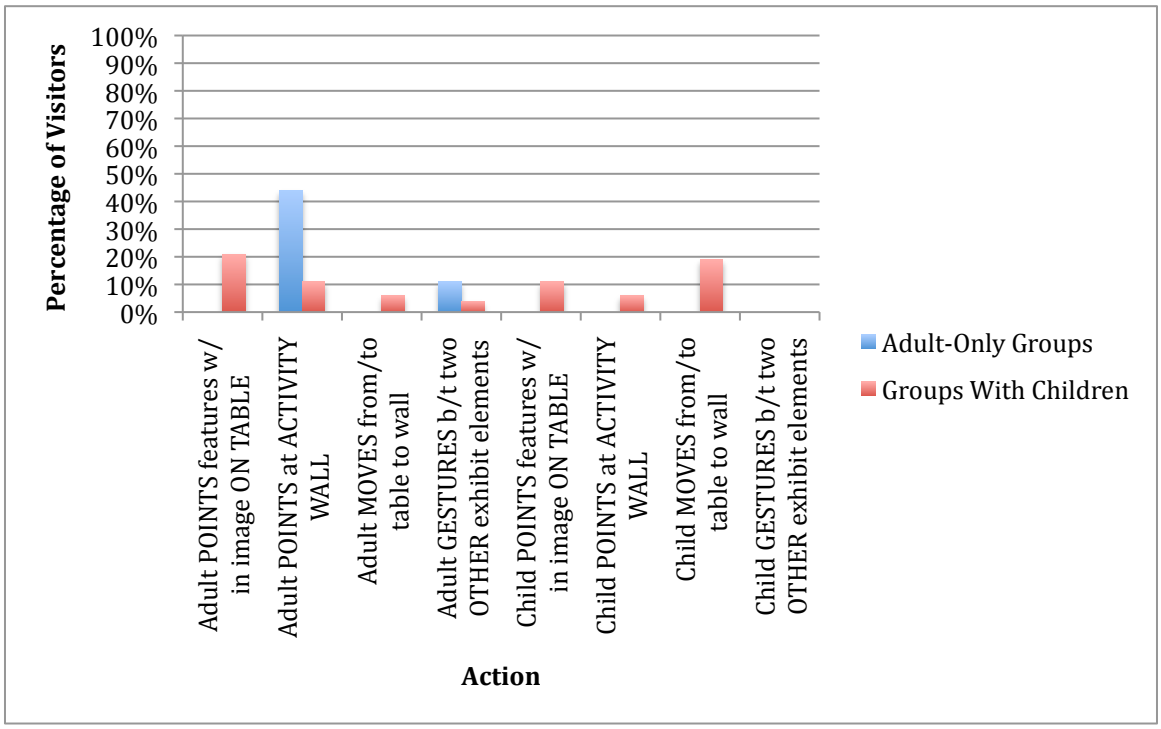
Activity Table

Of the visiting groups who went to the Activity Table (N=62), many (47%) did the tracing activity. Several groups (11%, N=53) attempted the pair matching activity and only a few (2%, N=60) tried the figure scavenger hunt. Visitors were not very likely to read the directions (16%). Some visitors (11%) did return to the Activity Table again after visiting another portion of the exhibition.

Figure 17: Child Tracing Image At Activity Table

At the Activity Table, adult-only groups tended to point at the wall adjacent to the activity where visitors had hung up their drawings, and gestured to other exhibit elements more than groups with children (see Figure 18). Groups with children were more likely to have adults point to the pictures on the table and have children go up to the adjacent wall to hang their drawings.

Figure 18: Actions at the Activity Table for Different Group Types



Stonephones

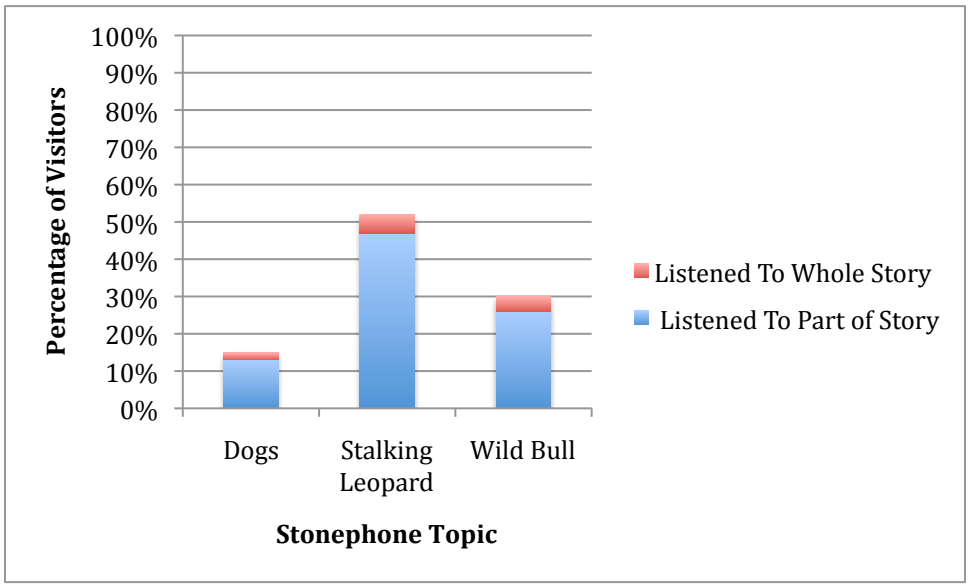
Of the 124 visiting groups who were observed listening to at least part of a story on the Stonephones, most heard at least two stories (one story (48%), two stories (30%), three stories (22%)). Visitors tended to listen to the Stalking Leopard story the most and the Dog story the least (see Figure 19). Regardless of which story they listened to, visitors rarely stayed to hear the entire story.

Several visitors read the directions (30%, N=116). Some visitors (15%, N=117) did return to the Stonephones again after going to another part of the exhibition, usually coming back to listen to another story.

At the Stonephones, adult-only groups tended to refer more to the highlighted print on the wall that corresponded to the story they were listening to, whereas adults in groups with children pointed slightly more often to the image on the podium itself

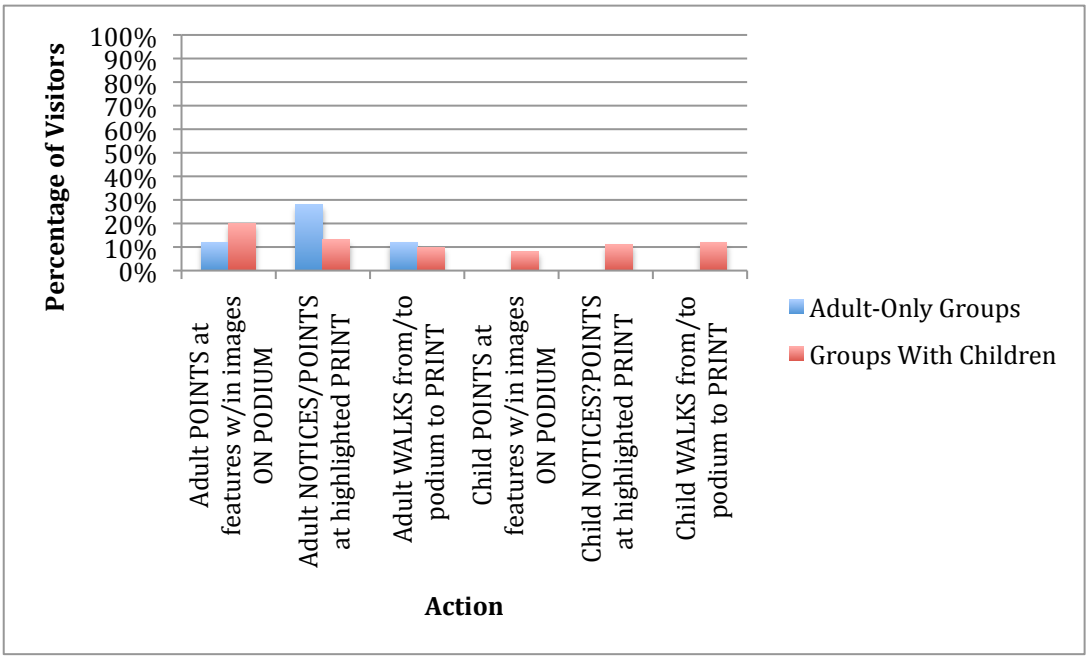
that related to the story (see Figure 20). While at the podium, children did not seem to point to images or make linkages between the Stonephones and the Panoramic Print very often.

Figure 19: Stories Visitors Listened to on the Stonephones*



Note: Some visitors listened to more than one story.

Figure 20: Actions at the Stonephones for Different Group Types



Explorable Image

Of the 57 groups that were observed at the Explorable Image, several visitors read the overlay text on the touchscreen (34%, N=56) and the usage directions (25%, N=56). Only 9% of visitors returned to try the Explorable Image again after visiting another portion of the exhibition.

Groups with children tended to freely explore the image and also utilized the touchscreen's interest spots more than adult-only groups (see Figure 21). Adult-only groups were slightly more likely to use the topic categories and the audio/video overlays than groups with children.

Based on visitor observations, adults in adult-only groups did more comparisons between the image and the information that popped up on the side of the screen than groups with children (see Figure 22). Although groups with children were not observed making a lot of overt comparisons between the image on the screen and the audio/video overlays, it should be noted that visitor actions were difficult for observers to see unobtrusively. Thus, the videotaped interactions of visitors at this activity described earlier in the report, coupled with the log files, provide additional evidence that these behaviors were taking place both in adult-only groups and in groups with children.

Figure 21: Visitors' Use of the Explorable Image for Different Group Types

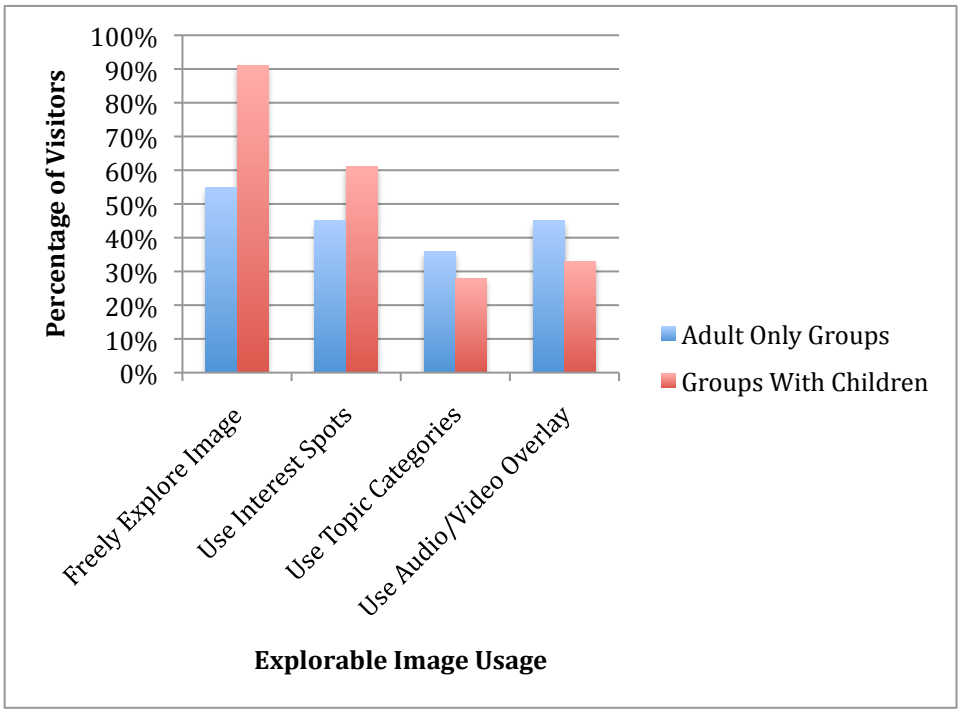
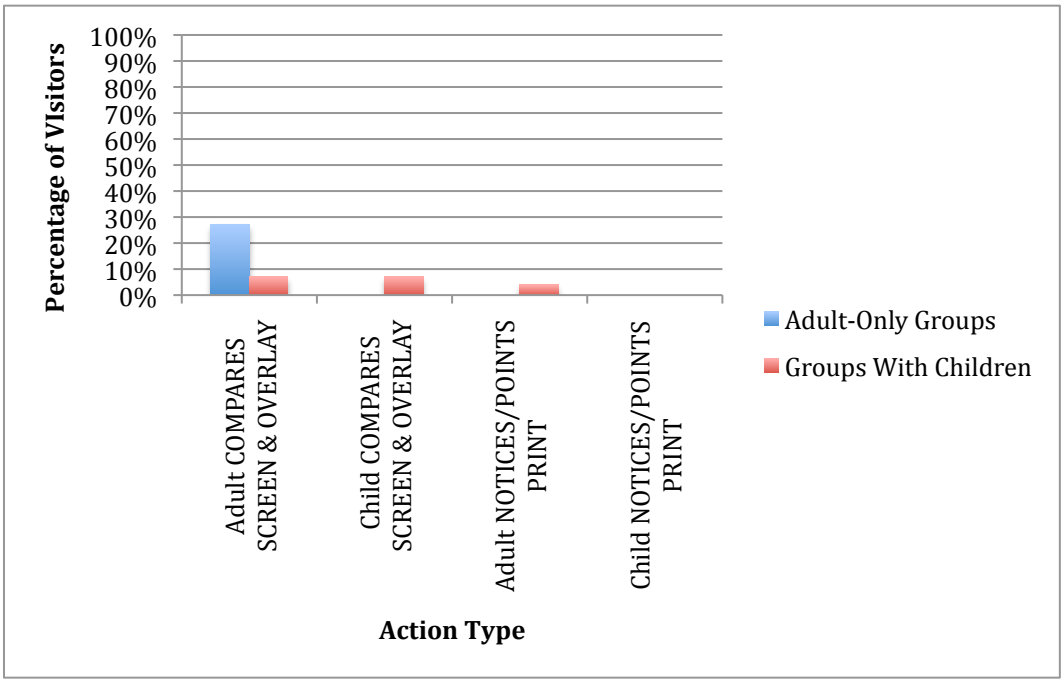


Figure 22: Actions at the Explorable Image for Different Group Types



Panoramic Print

Of the 39 visitors who went to the Panoramic Print, none of them revisited the activity after moving on to another portion of the exhibition. Adults behaved very similarly at the Panoramic Print, whether they were with other adults or with children (see Figure 23). Adults in both group types mainly pointed out features of the images in the Panoramic Print. In groups with children, younger visitors also pointed out features of the images. Visitors did not often gesture to other portions of the exhibition while at the Panoramic Print.

Figure 23: Actions at the Panoramic Print for Different Group Types

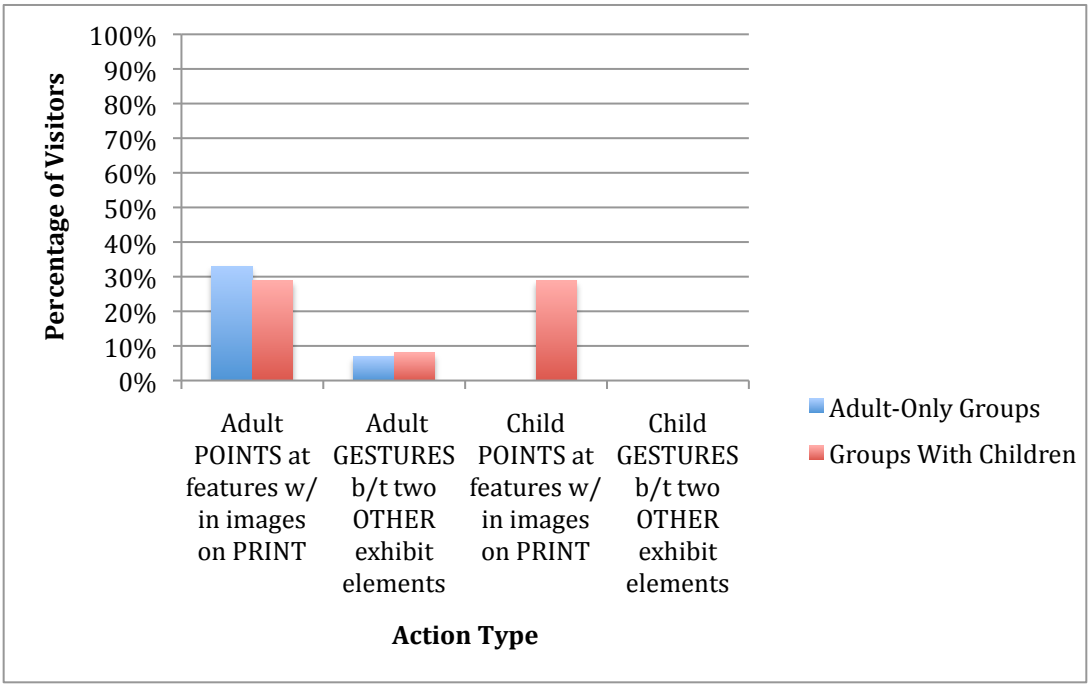
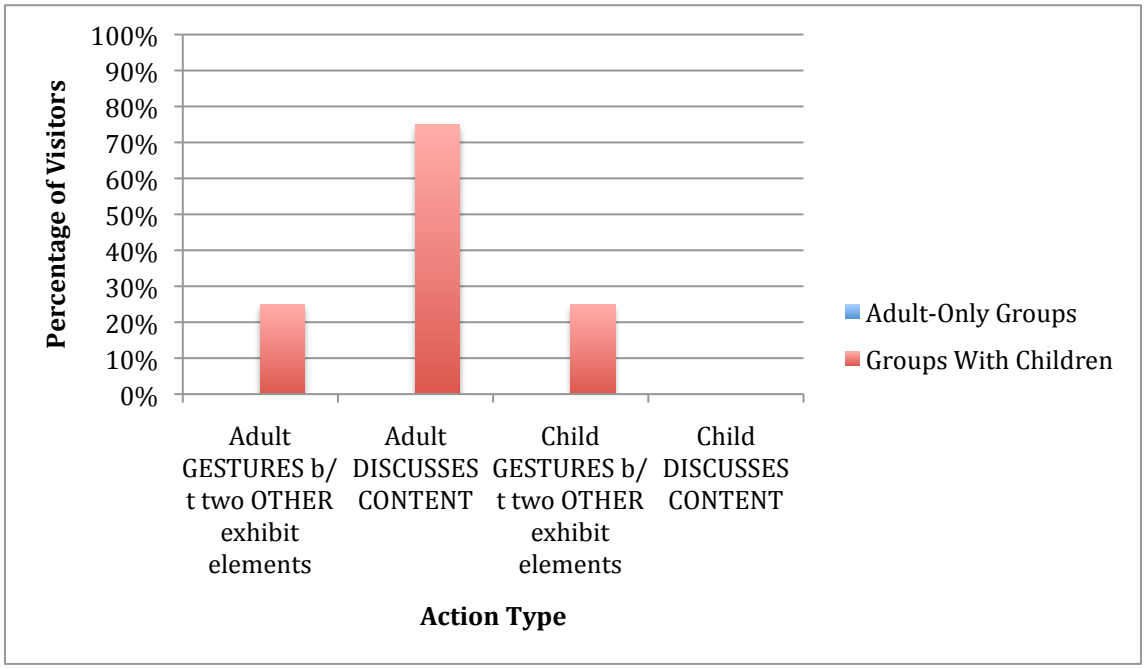


Exhibit Signage

Most visitors did not read the exhibit signage. However, visitors who did read the signage tended to either look at the left panel text (N=14) or the right panel text (N=13) along the main wall of the exhibition. Visitors rarely (N=2) appeared to read an introductory sign describing the research being conducted at the Carnegie Museum of Natural History. No one revisited the signage once they had initially read it.

When looking at signage, adult groups did not interact (see Figure 24). Groups with children tended to have adults discussing the signage content and, to a lesser extent, adults and children referencing other parts of the exhibit. However, it should be re-emphasized that the number of visitors who approached the signage was very small.

Figure 24: Actions at Exhibit Signage for Different Group Types



Suggestions for Improvement of the Exhibition

Visitors and the evaluation team had several recommendations to improve the exhibition as well as suggestions for changes to specific activities:

General

- Include a real rock from the area being shown or replica carving for visitors to touch for an additional hands-on experience.
- Place the exhibition in a more centralized location, so that visitors do not miss it and perhaps have a brighter color scheme to make it stand out in relation to other areas of the museum.
- Include more activities or content, such as books about rock art.
- Some visitors had a hard time understanding the objective of the exhibition, but did not read the signage.
    - Other forms of mediation and wayfinding could be used to address the focus on observation practices.

Stonephones

- Have the narrators speak slower and have more of a pause in between when a visitor picks up the phone and the narration begins.
- Improve sound quality and reduce static as many visitors found the audio hard to understand.
    - *"Listen to it. It's difficult to discern what exactly is being said. You pick it up. You listen. It's a muffled speaker and my attention is being drawn by the 35 other sounds that are occurring in this hall. I had a hard time sort of trying to listen to what this person is saying."*
- Either indicate on the podium that the highlighted areas on the Panoramic Print correspond to the image on the Stonephone podium or have a non-static image on the podium.
    - *"I'm looking at this screen. It would be much more successful if there was something on the screen that was moving at the same time, that was correlating with what this person is speaking about…Because there are even things that each of the three speakers had mentioned and I tried to reference over here and I couldn't find the relevant materials in this."*
- Think about the placement of the podium. Some visitors found the image on the podium difficult to see due to glare.
- Visitors wanted longer cords on the Stonephones, a mix of tall and short stools to sit on, and multiple phones for the same podium available to make it easier for more than one person to listen simultaneously.
- Some visitors were concerned about germs on the Stonephones. Perhaps provide a disposable cloth.

Explorable Image

- Expand the size of the screen.
- Give visitors an option of listening to audio via headphones as it was sometimes difficult for them to hear on crowded museum days.
- Include more images for things like vegetation in the area, clothing, and hairstyles that were mentioned in the signage.
- Think about providing a simpler version of the interface for non-readers.

- Add a layer, where visitors can see the outlines of specific animals and figures. Some visitors suggested that this layer could accompany the video narration to silhouette images being discussed.
    - *"I wanted more information and if you look at this is really good, but there's so much going on that it's hard to pick out, unless you have a perfect image of it, and to me this is the creature here. But what is all this other stuff? What is this? Or you could even have like a little bar here where you could change the contrast or take it all away to just an outline."*

Activity Table

- Provide a method for visitors to *"anchor the tracing paper to the picture."*
- One parent suggested brass rubbing instead of tracing for younger children.

Additional Activities/Content

- More information was needed regarding archeological practices and encouraging visitors to view the rock art through a disciplinary lens.