

## Final Evaluation Report

### Understanding and Improving Data Visualization Literacy:

- *Compiled front-end and partial summative evaluation data*
- *Exploratory comparative study of data visualization experiences*

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## Table of Contents

Compiled Front-end and partial summative evaluation .....	2
Evaluation Questions & Methods.....	2
Front-end Evaluation.....	2
Summative Evaluation.....	3
Results.....	4
Front-end Evaluation.....	4
Summative Evaluation: Phase 1 .....	6
Comparing the results .....	8
Exploratory, Comparative Study of 3 Data Visualization Experiences.....	10
Background.....	10
Methodology.....	10
Participants.....	11
Protocol.....	12
Findings.....	13

## Compiled Front-end and partial summative evaluation

This Innovations in Development AISL project is a collaboration of effort between Indiana University (IU), the Science Museum of Minnesota (SMM), the University of California, Irvine (UCI), and COSI's Center for Research and Evaluation (CRE - formerly known as the Lifelong Learning Group). This project is motivated by the insight that in the information age, being able to “read and write” data visualizations, or data visualization literacy, is becoming as important as being able to read and write text.

Sense-making with data through the process of visualization—recognizing and constructing meaning with these data—has been of interest to learning researchers for many years. Results of a variety of data visualization projects in museums and science centers suggest that visitors have a rudimentary understanding of and ability to interpret the data that appear in even simple data visualizations. This project supports the need for data visualization experiences to be appealing, accommodate short and long-term exploration, and address a range of visitors' prior knowledge.

The Run exhibit was designed to be installed at SMM, IU, UCI, COSI, and other possible sites that might have been identified as the project continues. This exhibit asked participants to input some personal data into a computer at the beginning of their experience. They then ran or walked, depending on the site, along a track and sensors recorded starting and ending times. These data, as well as the data entered by the participant, helped populate a data table and data visualizations that appeared on a monitor at the end of the running/walking track using the MAV software developed by the project. The goal of the software is to turn visitor activity and entry characteristics into graphic data that compares their unique data against the most recent 50 prior visitors who engaged in the experience. Participants had the opportunity to manipulate different types of data visualizations using the data they entered at the beginning of their experience as well as data entered from previous visitor participants.

Front-end evaluation occurred during the spring and early summer of 2019 at IU and at COSI. Based on results of this evaluation, SMM and IU made software and hardware changes to the exhibit components and shipped them to COSI in January 2020. After doing some testing of the final exhibit prototype, summative evaluation commenced in late February 2020 and continued through early March 2020 until the pandemic shut-down.

## Evaluation Questions & Methods

### Front-end Evaluation

During year 2 of the project, CRE developed the overarching question driving the front-end evaluation research, “*Is there a difference in engagement from a laboratory setting to in-situ on a museum floor? If so, in what ways?*”, and the supporting evaluation research questions.

- *How do participants engage with the Run (Walk) exhibit?*
- *What are participants' immediate reactions to engaging with the Run (Walk) exhibit, especially the data visualization aspect?*
- *What impressions regarding data visualization do participants take with them after engaging with the Run (Walk) exhibit?*

- *To what extent did engaging with the Run (Walk) exhibit encourage participants to “go deeper” into data visualization exploration?*

CRE tested the Walk exhibit in three separate areas during public open hours. For the lab testing, data collection was performed in a controlled environment free of noise and distractions. The first in situ testing was done in a fairly isolated and quiet hallway with little foot traffic, and the second in situ testing was done in an area that had high foot traffic and was noisy. We used the same combined observation and interview instrument for all three areas, but added think aloud interviews with visitors in the lab testing environment. For the think aloud data collection, we wanted visitors to engage with the exhibit and speak aloud what they were thinking as they went through each step of their exhibit experience to better understand why they were engaging in specific actions, especially with the data visualizations.

## Summative Evaluation

During year 3 of the project, CRE developed data collection instruments designed to measure affective and cognitive outcomes from the experience along with a measure of transference. These instruments were based on data gathered during the front-end studies (i.e., the lab testing and museum in situ testing of the initial prototype done during the second project year). Additionally, we inserted items specifically designed to measure the influence of new data visualizations added to the MAV software for the summative testing phase to the instruments. The plan called for collecting consistent outcome data at four sites, COSI, SMM, IU, and UC Irvine, using the final prototype of the MAV exhibit. The overarching question guiding the summative evaluation was *“What information is necessary for the ultimate visitor meaning-making of data visualizations?”*

Supporting evaluation questions include:

- *What personal attributes do visitors place more importance on to be connected to an experience such as the Run exhibit?*
- *To what degree did having the visitor’s personal information as part of the data set that populated the data visualizations offered in the MAV influence their interest in making meaning of the data?*
- *What other types of experiences in the museum do the visitors think this type of visualization might enhance?*
- *To what extent is this understanding transferrable to other data visualizations?*

The data collection plan also called for collecting data under four levels of interactivity between the data collector and the visitor. These levels ran the spectrum from the evaluator not recruiting or giving the visitor information about the exhibit prior to the visitor’s engagement with it, to the evaluator recruiting the visitor and giving detailed information about the study and the exhibit.

The four levels of the evaluator interactivity with the visitor are as follows:

1. The exhibit is on the floor and visitors engage with it without being recruited to do so; interview visitor at end
2. We invite visitors to engage with the exhibit; interview visitor at end
3. We invite visitors to engage with the exhibit and give basic guidance on what to do with the exhibit; interview visitor at end
4. We invite visitors to engage with the exhibit, explain the purpose of the study, and give basic guidance on what to do with the exhibit; interview visitor at end

# Results

## Front-end Evaluation

We interviewed 156 adult visitors who engaged with the exhibit either in the lab setting, one of the in-situ settings, or in the think aloud process. A summary of the overall engagement with this exhibit can be seen below in Table 1. Key findings that led to discussions and changes in the MAV included:

- Data input kiosk:
  - Height: some visitors were either not sure of child’s height or had trouble converting height in feet and inches into just inches
  - Some steps of the data entry were not intuitive, even with sign explaining what to do, and too much lag time between steps
- The competitive aspect was most important part of the experience.
- MAV engagement:
  - Overall, most frequent engagement was only with the data table
  - As the experience environment progressed from no distractions (lab testing environment) to on the floor with all the regular distractions, we saw about the same level of interaction with the data table, but less with the graph and geomap
  - The touch and drag motion for the scatter graph was not at all intuitive, even with sign explaining what to do
  - Most visitors who engaged with the MAV, understood the data that appeared in the data table, scatter graph, and geomap due to prior experience with those types of data visualizations

*Table 1: Summarizing engagement with the exhibit*

Testing sessions	# of Children-teens	# of Adults	Shortest MAV time	Longest MAV time	Average MAV time	Looked at data table	Worked with scatter graph	Worked with geomap
			Time in seconds					
Lab	16	40	27	465	176	All	All	All
Think aloud	9	7	n/a	n/a	n/a	All	All	All
1 <sup>st</sup> in situ	30	49	15	435	132	All	Usually	Sometimes
2 <sup>nd</sup> in situ	85	60	10	180	48	Usually	Rarely	Rarely

The specific findings by evaluation question follow.

### 1. How do participants engage with the Run (Walk) exhibit?

- For all settings, almost all the visitors chose to do the walking portion of the experience, with only occasionally adults merely helping to facilitate the data input for younger people in their group and not walking.
- The majority of times, visitors engaging with the exhibit when it was installed in the second in situ setting mainly looked at their time on the MAV data table and did not engage with the scatter graph or geomap.
- Visitors took considerably more time in engaging with the MAV data visualizations when the exhibit was installed in the lab setting and the first in situ setting than when it was installed in the second in situ setting.

2. What are participants' immediate reactions to engaging with the Run (Walk) exhibit, especially the data visualization aspect?

- Visitors who engaged with the Walk exhibit rated their experience slightly higher, based on a 7-point scale, when the exhibit was installed in the lab setting ( $\bar{x} = 4.9$ ) and the first in situ setting ( $\bar{x} = 5.0$ ) than in the second in situ setting ( $\bar{x} = 4.7$ ).
- Participants put high importance on the walking portion of the experience, mainly due to the friendly competitive factor within the group with which they were visiting.
- Visitors showed more interest in engaging with MAV data visualizations when the exhibit was installed in the first two more isolated and quieter areas of the building than in the louder and busier area of the building.
- Visitors told us it was important to have their data appear in the data visualizations – most otherwise would not have had any interest in the MAV data visualizations.

3. What impressions regarding data visualization do participants take with them after engaging with the Run (Walk) exhibit?

- In all the data collection settings, especially the lab and first in situ setting, there were a few visitors who told us they really enjoyed manipulating the MAV data visualizations.
- A few visitors noticed that although the geomap had a global version, there was no way to input non-American codes that would indicate where someone was from. So if there were visitors from other countries, their geographical data would not appear.
- A very small minority of visitors criticized using a scatter graph rather than other types of visualizations they felt would be more appropriate for the type of data being collected.
- Many visitors shared with us that there really was not much to manipulate in the data visualizations and therefore they did not spend much time at the MAV.

4. To what extent did engaging with the Run (Walk) exhibit encourage participants to “go deeper” into data visualization exploration?

- There were very few times visitors engaged with the MAV data visualizations other than in a cursory manner. There were, however, some exceptions:
- Lab setting: one of the young adults attending the after-hours COSI After Dark event spent the longest time engaging with the MAV data visualization and was identifying and explaining different variable connections on the graph and geomap to people in the group with whom he had attended the event.
- First in situ setting: the group that spent the longest time engaging with the MAV data visualizations – a father and his two daughters – all did the walk, and the 13-year-old daughter was showing and explaining the different data visualizations to her 11-year-old sister.
- Second in situ setting: visitors did very little with the MAV data visualizations beyond finding their time on the data table and manipulating the axes in the scatter graphs – very little discussion occurred.

In answer to the overall evaluation question – *“Is there a difference in engagement for the lab testing and the in-situ testing?”* – we would assert that there is a difference. Visitors interacted with the MAV data visualizations more often and for longer time periods in the data collection settings that were more isolated and quieter than in the data collection setting in the hallway that had much higher foot traffic and was much noisier, which is the more typical science center setting for exhibits.

## Summative Evaluation: Phase 1

During January and February 2020, we tested the components of the functional final prototype of the MAV prior to starting use of the new data collection instruments for the initial phase of the summative evaluation. After identifying and having small functional problems corrected, we started collecting data in late February 2020 and continued until very early March 2020, after which COSI closed due to the COVID-19 pandemic. This closure continued through June 3, 2021. Likewise, SMM closed and was unable to do their data collection. Therefore, in 2020, we were unable to complete any but the most basic summative evaluation data collection for the first phase of this evaluation. While we are not comfortable making transferrable or generalizable claims, the data do present ideas of how some COSI guests engaged with the MAV. Table 2 captures the key data from the preliminary phase of data collection. One component of the summative study was to supposed have been a comparison of time spent on the MAV with a comparable experience in each of the two museums, thus giving us an honest comparison of the extent to which the MAV increases engagement time for some visitors and the relative proportion of visitors who engage with an activity and a secondary component across visitors.

*Table 2: Partial Phase 1 Summative evaluation results (7-point Likert-type scale)*

Person by age group; level of recruitment	Mean time engaging with exhibit (minutes)	I like to do this type of thing	People with me like to do this type of thing	Important to see myself in the data	Able to compare with others
<b>Youth, child 8-17 yrs</b>					
Interview only (n=8)	5.04	5.8	3.2	5.9	5.8
Invite, interview (n=3)	4.00	3.8	3.3	3.8	3.2
<b>Adult, 18-29 years</b>					
Interview only (n=3)	3.46	6.0	6.0	6.8	6.5
Invite, interview (n=1)	2.23	4.5	3.5	2.5	3.0
<b>Adult, 30-49 yrs</b>					
Interview only (n=12)	4.98	5.7	5.9	5.7	5.6
Invite, interview (n=2)	3.33	3.3	3.8	4.8	2.3
<b>Adult 50+ yrs</b>					
Interview only (n=1)	-	7.0	7.0	6.5	7.0
Invite, interview (n=1)	-	5.0	5.0	4.0	1.5

### Main points:

- Youth/children and adults 30-49 years of age spent the most time engaging with the exhibit. This could be because that adult age group is likely to have children 8-17 years of age and therefore they would be engaging with the exhibit together as a group.
- Data suggest adults chose to engage with the MAV because they enjoyed that type of activity slightly more than youth/children did.
- Youth and children appear not to take into consideration whether someone else in their group would be interested in the activity when they chose to engage with it. Although all adult groups did take interest in the activity of others in their group into consideration, data suggest the older the adult is, the more they would take others' preferences into consideration.



- Participants in all age groups indicated it was important to see themselves in the data appearing on the MAV.
- Young adults (< 30 years) told us it was extremely important to be able to compare things using the MAV while the oldest adult group (50+ years) told us it was moderately important. The middle age group of adults and the youth/children thought it was important to be able to compare data.

### Open-ended responses

In addition to asking about which ways they engaged with the data touch screen, participants were asked to share what stood out about those interactions and why.

#### *Data Table (n=16)*

Five of the participants shared how they used the data table to look at their own time or the time of someone else in their group. A couple of these participants specifically noted that they were not interested in engaging with the other data or that they did not pay attention to anything but their own time. Two participants shared that they did look at data for other visitors not in their group. One shared that they compared their child's data to others around the same age and that they liked the face icons; the other noted that only five people had walked against the cheetah. Half of the participants that answered this question (n=8) expressed challenges or frustrations with the data table. A few of these visitors noted a lack of instructions, a sense of being lost using the table, and a hard time conceptualizing (thinking they would "actually race something"). Others shared user experience issues like not being able to find their name or emoji, not knowing why the data associated with the animal was highlighted, being able to see their scores but not the scores of their opponent, and not being able to figure out if they beat the squirrel. One visitor felt that other visitors "cheated" because their times were too quick. Only one participant described the data table as "user-friendly."

#### *Sorted in the data table (n=6)*

The majority of participants that answered this question shared challenges or frustrations (n=4). The participant mentioned above who could not find their name or emoji shared how they had to sort by zip code to find their data. One participant noted that it was hard to find themselves after they sorted the data, and another did not realize they were able to sort the data, assuming it would be in the order of when people walked. A different participant than referenced above also expressed a belief that people were cheating. One participant specifically noted that they "liked sorting." Another shared that they were only interested in their family's times.

#### *Scatter Graph (n=10)*

Ways participants described using the scatter graph included: changing the x-axis to compare with others; knowing the dots were for them and their sister; and looking at the animals, gray dot, and pulsing dot. One participant specifically highlighted the pulsing data on the scatter graph, but another shared that it was "hard to figure out." Two participants shared that they had difficulty finding their dots. A couple of participants noted that they only looked at the running time. One participant said that "nothing stood out."

#### *Color & Shape buttons (n=4)*

The responses about the color buttons and the shape buttons were the same. Two participants shared that they did not see the buttons or did not know what they did. Another shared that they



clicked on it, but after not being able to find their son’s dot, didn’t do much more than “just quickly look at the graph.” One participant said that they “got bored.”

*Geomap (n= 3)*

Two participants shared that they didn’t know about the geo map. One visitor shared that they “live far away and didn't think their city would show up.”

## Comparing the results

We intentionally designed the data collection instruments for the front-end and summative evaluations to obtain mostly differing types of data. However, we are able to compare the degree to which visitors participating in this study engaged with the major components of the MAV across both studies, strengthening our trust in the trends revealed (Table 3). Data suggest almost 100% of participants engaged with the data table. Because we did not specifically have an item on the front-end evaluation instrument in which to record data as to how many participants sorted data in the data table, we do not know how many chose to do so. When looking at engagement levels with the scatter graph and the geomap, we found that as the front-end environment become louder and had more distractions, the level of engagement with these two data visualizations decreased. For the summative data we were able to collect, we were unable to note any patterns of significance for interaction beyond merely looking at their data initially in the data table.

*Table 3: Engagement level: front-end evaluation data collection environment; summative evaluation*

	Data table		Sorted data		Scatter graph		Geomap	
	Did	Did not	Did	Did not	Did	Did not	Did	Did not
<b>Front-end Evaluation: Lab setting data</b>								
Youth/Child 8-17 years (n=16)	16	0	n/a	n/a	16	0	16	n/a
Adults 18 yrs+ (n=40)	40	0	n/a	n/a	40	0	40	n/a
<b>Front-end Evaluation: In situ data – 1<sup>st</sup> round (quiet area on the floor)</b>								
Youth/Child 8-17 years (n=30)	30	0	n/a	n/a	Usually	Unknown	Sometimes	Unknown
Adults 18 yrs+ (n=49)	49	0	n/a	n/a	Usually	Unknown	Sometimes	Unknown
<b>Front-end Evaluation: In situ data – 2<sup>nd</sup> round (on floor with normal distractions)</b>								
Youth/Child 8-17 years (n=85)	85	0	n/a	n/a	Rarely	Unknown	Rarely	Unknown
Adults 18 yrs+ (n=60)	60	0	n/a	n/a	Rarely	Unknown	Rarely	Unknown
<b>Summative Evaluation</b>								
Youth/Child 8-17 years (n=12)	11	1	0	12	6	6	2	10
Adults 18 yrs+ (n=21)	19	2	12	9	13	8	3	13

From these evaluations, it is possible to say that the engagement of the activity works, and the capture of comparative data drives interest. The evaluations suggest that there are challenges with

the interaction between the experience “Run (Walk)” and the MAV interface, but that when people do engage, the MAV does lead to reflection, asking questions, and using the graphics to make meaning.

## Exploratory, Comparative Study of 3 Data Visualization Experiences

Once COSI and SMM reopened for visitors, the opportunities for ongoing testing of the “Run (Walk)” experience were not available. Therefore, to complete the summative, an exploratory study was undertaken to further probe how visitors do or do not engage with data visualizations in experiences. Methodology for the Run (Walk) experience was replicated at the Heartrate Challenge at COSI and Slow Motion at SMM.

The Heartrate Challenge asks visitors to take their heartrate, do an activity, and then take their heartrate again. This experience is one of five opportunities to gather data that are then transferred into a computer where the person can compare their data with other visitors’ data. Evaluations of the suite of activities had shown in the past that many enjoyed the activities, but few carried the scorecard and pencil with them and even fewer entered their data into the computer.

Slow Motion at SMM is a closed space in which visitors are encouraged to do several different physical activities and have the tools necessary to complete them (e.g., balls). Before they enter, they choose an activity they will do, and when they enter the cage, a camera begins filming. At the exit they go to a band of monitors and using an assigned number, can watch themselves. There are comparison videos of professionals (e.g., athletes, dancers) as well as other visitors they can look at to see how that particular activity it is done by experts and novices. Evaluations of this activity show high levels of engagement, and more focused interest on watching videos of oneself and those with them than using the videos as data for comparison.

By using a shared protocol including observation checklist and interview schedules, we felt looking across the three approaches starting with the xMacroscope might provide important insights.

## Background

An important question continued to emerge across the evaluation studies for this project. That question was: *Does this macroscope experience vary the visitor experience from other data generating activities? And if so, in what ways?*

The original hope had been to do this study as a comparison using the data from the summative evaluation by replicating a part of the summative evaluation with two experiences in which visitor data was captured by some other means so visitors could compare their data against other data sets. The evaluation team worked with the SMM evaluation team to choose one experience at each museum that was different but provided the data feedback to the visitors. The team members then created a shared protocol to do the study.

## Methodology

During year 3 of the Sense Making of Big Data project, CRE developed data collection instruments designed to measure affective and cognitive outcomes from the experience along with a measure of transference. These instruments were based on data gathered during front-end studies: the lab testing and museum in situ testing of the initial prototype done during the second project year. Additionally, we inserted items specifically designed to measure the influence of new data visualizations added to the MAV software for the summative testing phase to the instruments.

Because of the closures of museums in 2020 due to the COVID-19 pandemic, a second component of the intended summative was unable to be completed, namely data gathering on the Macroscope at three other sites. Instead, once the museums reopened, we focused on a comparison of engagement with the data visualization among three different exhibits. The intent of the study was to begin to compare the structures of interaction of engagement in the data visualization under three very different ways of gathering then using the data.

In addition to the Run (Walk) experience developed for the project (prototyped at COSI), the Heartrate Challenge at COSI and the Motion Lab at SMM were the other two exhibits included in the summative replacement study. These were selected for this study as each:

- (1) uses a different physical activity for generating the data,
- (2) has different means of engaging with the data, and
- (3) has different structures for comparing the individual's activity against/with others.

The project's overall research inquiry, namely *does physical engagement for data generation connect people to critical data analysis using data visualizations*, is further explored with the following research questions, given the available exhibit comparisons:

- What are the reasons given for not engaging with the data visualization, post engaging in the activity?
- Of those who engage with the visual, how many look at their own data versus visually compare their data with others?
- Of those who compare data, what kind of meaning do they attempt to make from the data?
- How and how much do users like engaging with this type of activity, think others like engaging with this activity, and see themselves/others in the data?

## Participants

For the summative replacement study, we looked at two groups: 1) youth and adults who do not engage with the data viz component of the experience and 2) youth and adults who do engage with the data viz component of the experience. The study included both an observation and an intercept of an individual.

For each exhibit, although a balanced n of 35 adults and 35 youth in both categories was desired, (total N=420 across three experiences) vs. the originally proposed N=688, the distribution was determined unlikely to be even. Based on the evaluation studies, youth observations and intercepts would likely exceed adults on those who engage. For that purpose, we set a minimum of 20 and a maximum of 35 observations/intercepts for youth in each of the two categories, and 20 -35 adults across ages in each of the two categories. Age clusters for adults were set as 18-29, 30-49, and 50+ to match the summative data in the analysis. Observation forms were designed to record observations for multiple members of a group, not all of whom were intercepted. Thus, more individual youth and adults were observed than the number reported.

Table 4: n/N for study

		Walk	Move	Heart
Child/youth 8-17	Engage with activity but not data	20 -35	20-35	20-35
	Engage with activity and data	20 -35	20-35	20-35
Adults	Engage with activity but not data	20 -35	20-35	20-35
	Engage with activity and data	20 -35	20-35	20-35
<b>Total N = 240 -440</b>		80-140	80-140	80-140

## Protocol

This section details the protocol for data collection at the Heartrate Challenge and The Motion Lab exhibits. For information about the summative evaluation data collection for Run (Walk), see p. 3 of the report.

Using a continual ask with a random start, the researcher identified an individual or small group as they entered into the activity and observed through when they left the activity, including engaging with data and repeating the experience. If there was a lack of engagement with the data portion of the activity, intercept questions explored why they did not engage with the data.

As each of the three experiences is different in how engagement occurs, how individuals or groups were identified was determined by the team onsite. The onsite team also determined whether they could track and intercept more than one individual and conduct joint interviews.

There were two components to the data gathering. The first was an observation, and the second was a short intercept interview of the person/people observed. The protocol was as follows:

1. After identifying a person/group, start timing the experience.
2. Complete the observation sheet during the conduction of the activity.
3. Terminate the observation when the person is exiting the area (including after having engaged with the data and/or repeating the experience).
4. Approach the individual and ask if they can give you a moment to answer one question for those who do not engage with the data, and four simple questions for those who do engage with the data.
5. The observation is only complete when both the observation and the question/s are conducted.

Visitors who did not engage with the data were approached and asked:

- (At the Heart Rate Challenge) I noticed you did not record your heartrate. Can you tell me why?
- (At the Motion Lab) I noticed that you did not use this area. Did you see anything that would let you know what you might be able to do there?
  - It's an area where you can see your own video and compare it to other people at the museum or professional athletes. Do you think this would appeal to you? Why or why not? How would you be likely to use it?

Visitors who engaged with the data portion of the exhibit and agreed to answer the questions were thanked and handed a clipboard with four rating questions on a laminated sheet and a china-marker. For each item, they put an X on where they fell on each scale (7-point scale from 1 - Not at all to 7 - Completely). Similar rating items were included in the summative evaluation of Run (Walk). Follow-up prompts for each item were added for the summative replacement study.

1. Rating item: I like doing this kind of thing.
  - Prompt (Heartrate Challenge): Why do you like or not like this kind of thing?
  - Prompt (Motion Lab): What do you like or dislike about using video areas like this?
2. Rating item: Other people in my group like doing this sort of thing.
  - Prompt (Heartrate Challenge): Is there someone specifically in your group who likes or dislikes this type of activity?
  - Prompt (Motion Lab): Is there someone specifically in your group who might really like or dislike this type of activity Why might that be?
3. Rating item: I could see myself in the data
  - Prompt (Heartrate Challenge): How did you see yourself in the data? What did it show you?
  - Prompt (Motion Lab): Did the videos show you anything about yourself?
4. Rating item: I was able to compare different things.
  - Prompt (Heartrate Challenge): What did you see in comparing yourself with others?
  - Prompt (Motion Lab): What kinds of things did you pay attention to when you were comparing your videos with others?

All visitors interviewed were also asked to share their ages.

Date and initials of the data gatherer we added to the form. Final data sets were shared with CRE for analysis.

## Findings

### Sample

The target n/N for the study (as detailed in Table 4) was not reached at each exhibit. As already noted, the sample for the Run (Walk) exhibit is small because data collection was stopped in response to the COVID-19 pandemic. The Motion Lab exhibit at SMM exceeded the minimum numbers of adults and children who engage with the data portion of the exhibit, but did not meet the target for visitors who do not do the data portion of the exhibit. Data collectors at SMM reported that almost everyone used the data portion of the activity. After over 20 hours on the floor with only five non-data groups intercepted, the decision was made to stop data collection.

The number of adults and children observed and interviewed at each of the exhibits is detailed in Table 5. Given the protocol and target sample, it is important to note that these numbers should not be considered descriptive of general use. For example, with the Heartrate Challenge, once the quota for visitors that did the data portion of the activity was met, only visitors that did not do the data portion of the activity were recorded and intercepted.

Table 5: Engagement with the data portions of each exhibit

	Did the data portion of the exhibit	Did <b>not</b> do the data portion of the exhibit	Total
<b>Run (Walk) at COSI</b>			
Adults	21	1	22
Children	12	0	12
Total	33	1	34
<b>Heartrate Challenge at COSI</b>			
Adults	36	23	59
Children	27	21	48
Total	63	44	107
<b>The Motion Lab at SMM</b>			
Adults	23	2	25
Children	32	3	35
Total	55	5	60

## Observation Data

### Run (Walk) at COSI

This exhibit asked participants to input some personal data into a computer at the beginning of their experience. They then ran or walked, depending on the site, along a track and sensors recorded starting and ending times. These data as well as the data entered by the participant helped populate a data table and data visualizations that appeared on a monitor at the end of the running/walking track. Participants had the opportunity to manipulate different types of data visualizations using the data they entered at the beginning of their experience as well as data entered from previous visitor participants. During the summative data collection, visitors who looked at the data table, sorted in the data table, interacted with the scatter graph, used the color and/or shape buttons, and/or interacted with the geomap were considered to have participated in the data portion of the activity.

The average time spent using Run (Walk) was 4.5 minutes. Visitors who did not wait in a line (n=17) spent an average of 4.65 minutes, and visitors who waited in a line (n=2) spent an average of 3.19 minutes. Because only two of the visitors timed had to wait in a line to use Run (Walk), their lower average time should not be generalized as a trend for the exhibit.

Almost all of the visitors observed and interviewed engaged with the data portion of the activity. Out of 22 adults and 12 children, only one adult did not interact with the data. All (100%) of these visitors appeared to read the instructions, with a few reading them multiple times (n=1 adult and n=3 children).

Most visitors chose to input data at the beginning of their experience. Only two adults and one child did not input their data.



*Table 6: Run (Walk) Data Input*

	Input data once	Input data multiple times	Did not input data	Total
Adults (n=22)	86.4%	4.5%	9.1%	100%
Children (n=12)	83.3%	8.3%	8.3%	100%
All (n=34)	85.3%	5.9%	8.8%	100%

All of the children (n=12, 100%) ran or walked, with one doing so multiple times. The majority of adults (n=15, 68.2%) also ran or walked once, but a few (n=5, 22.7%) only watched others run or walk. One adult (4.5%) ran or walked multiple times, and another (n=1, 4.5%) did not engage with that portion of the exhibit in any way.

*Table 7: Run (Walk) Activity Interaction*

	Ran or walked	Watched someone run or walk	Ran or walked multiple times	Did not engage	Total
Adults (n=22)	68.2%	22.7%	4.5%	4.5%	100%
Children (n=12)	91.7%	0%	8.3%	0%	100%
All (n=34)	76.5%	14.7%	5.9%	2.9%	100%

The most frequent way adults and children explored the data was looking at the data table (>90% of adults and children). Over half of the adults (n=12, 57.1%) sorted the data table, but none of the children did. The scatter graph was the second most popular way to engage with the data, with the majority of adults (n=13, 61.9%) and half of the children (n=6, 50%) interacting with it. Only a few visitors interacted with the geomap (n=3 adults, 14.3% and n=2 children, 16.7%), and almost none used the color buttons (n=1 adult) or shape buttons (n=1 adult).

*Table 8: Run (Walk) Engagement with the Data*

	Looked at data table	Sorted in the data table	Scatter graph	Color buttons	Shape buttons	Geomap	Total
Adults (n=22)	90.5%	57.1%	61.9%	4.8%	4.8%	14.3%	100%
Children (n=12)	91.7%	0%	50%	0%	0%	16.7%	100%
All (n=34)	90.9%	36.4%	57.6%	3%	3%	15.2%	100%

### [Heartrate Challenge at COSI](#)

The Heartrate Challenge at COSI instructs visitors to take their resting heartrate, compete in an activity, and then take their active heartrate. The activity consists of a long table with a row of buttons along each side; visitors race to press as many buttons as possible as they light up over the course of 30 seconds. The act of visitors taking their heartrate was considered as the data portion of the activity. Entire groups were observed, but the data in this report are only of those who were interviewed. Observation results are reported first from visitors that took their heartrates, and then by those who did not.

The average amount of time spent at the Heartrate Challenge was 2.66 minutes. Unsurprisingly, visitors who had to wait in a line spent longer at the exhibit (*Mdn* = 3.44 minutes) than did visitors who did not have to wait in a line (*Mdn* = 2.05 minutes). A Mann-Whitney test indicated that this difference is statistically significant ( $U(N_{\text{line}} = 16, N_{\text{no line}} = 79) = 321.5, z = -3.089, p = .002$ ). Visitors who interacted with the data portion of the exhibit also spent more time (*Mdn* = 2.68 minutes) than visitors who did not (*Mdn* = 1.87 minutes). A Mann-Whitney test indicated that this difference is statistically significant ( $U(N_{\text{data}} = 54, N_{\text{no data}} = 41) = 520.5, z = -4.408, p < .001$ ).

*Visitors who did the data portion of the exhibit (i.e., took heartrate)*

Just over half of adults (n=19, 52.8%), but few youth (n=3, 11.1%), appeared to read the signage or instructions. In addition to the written labels, the activity includes audio instructions when the start button is pressed, so the visitors that did not read still were introduced to the button activity portion of the exhibit.

Even visitors who interacted with the data portion of the activity did not necessarily take both their resting and active heartrates. Two-thirds of adults (n=24, 66.7%) took their resting heartrate before doing the activity and their active heartrate after. Those that only took their heartrate once were more likely to take their active heart rate (n=9, 25%) than resting heartrate (n=3, 8.3%). Few took their heartrates multiple times (n=4, 11.1% resting, and n=2, 5.7% active). A similar trend was seen with children. The majority (n=15, 55.6%) took their resting and active heartrates, but one-third (n=9, 33.3%) only took their active heartrate. And again, few took their heartrates multiple times (n=2, 7.4% resting, and n=3, 11.1% active).

*Table 9: Heartrate Challenge Engagement with the Data*

	Took resting heartrate only	Took active heartrate only	Took resting and active heartrate	Total
Adults (n=36)	8.3%	25.0%	66.7%	100%
Children (n=27)	11.1%	33.3%	55.6%	100%
All (n=63)	9.5%	28.6%	61.9%	100%

Most adults did the activity once (n=32, 88.9%), while a few did the activity multiple times (n=4, 11.1%). Twice as many children did the activity multiple times (n=8, 29.6%), but the majority (n=19, 70.4%) still did the activity only once.

*Table 10: Heartrate Challenge Activity Interaction of Visitors that Engaged with the Data*

	Did the activity once	Did the activity multiple times	Total
Adults (n=36)	88.9%	11.1%	100%
Children (n=27)	70.4%	29.6%	100%
All (n=63)	81.0%	19.0%	100%

*Visitors who did not do the data portion of the exhibit (i.e., did not take heartrate)*

Only one adult and zero children who did not take their heartrate appeared to read the instructions or signage. This is not surprising as these panels are attached to the heartrate monitor stations.

While visitors who did not take their heartrate appear to have been more likely than those who did to do the activity multiple times, there is not a statistically significant difference between the two groups.

*Table 11: Heartrate Challenge Activity Interaction of Non-data Visitors*

	Did the activity once	Did the activity multiple times	Total
Adults (n=23)	73.9%	26.1%	100%
Children (n=21)	57.1%	42.9%	100%
All (n=44)	65.9%	34.1%	100%

### The Motion Lab at SMM

In The Motion Lab at SMM, visitors are able to record a video of themselves doing a sports-related activity (e.g., kicking a ball, doing a cartwheel, or throwing a football). Then they can analyze their movements in slow motion or compare themselves to professional athletes on screens. Using these screens was considered as the data portion of the activity. Entire groups were observed, but the data in this report are only of those who were interviewed. Because so few visitors did not interact with the screens, only observation results from visitors that did interact with the screens are reported below.

The average amount of time spent at the Motion Lab was 4.93 minutes. A Mann-Whitney test found no statistically significant difference in time spent at the exhibit between those that had to wait in line (*Mdn* = 4.8 minutes) and those who did not (*Mdn* = 3.93 minutes) ( $U(N_{\text{line}} = 30, N_{\text{no line}} = 25) = 310.0, z = -1.100, p = .271$ ).

The majority of adults and children who interacted with the screens appeared to read the signage or instructions at the exhibit (78.3% and 62.5%, respectively).

Just over a third of adults (n=8, 34.8%) who interacted with the screens did the activity once (i.e., recording their movement), but over half (n=13, 56.5%) did not do the activity. Only one adult did the activity multiple times. Over half of children who interacted with the screens (n=17, 53.1%) did the activity once, and two in five (n=12, 37.5%) did the activity multiple times. Only one child interviewed did not do the activity. These data suggest that many adults are not recording themselves, but are engaging with the exhibit by interacting with the recordings of others in their group.

*Table 12: The Motion Lab Activity Interaction*

	Did the activity once	Did the activity multiple times	Did not do the activity	Unsure	Total
Adults (n=23)	34.8%	4.3%	56.5%	4.3%	100%
Children (n=32)	53.1%	37.5%	3.1%	6.3%	100%
All (n=55)	45.5%	23.6%	25.5%	5.5%	100%

The majority of adults used the screens only once (n=15, 65%), and children were similarly likely to use the screens once (n=17, 53%) as they were to use them multiple times (n=15, 47%).

## Discussion

Earlier in the report (p. 6), a question was raised about the extent to which the MAV increases engagement time for visitors compared to other experiences. A Kruskal-Wallis test indicated that there were significant differences in the time spent at the exhibits,  $H(2) = 47.544, p < .001$ . The median time spent at Run (Walk) was 4.3 minutes, which was similar to that of the Motion Lab ( $Mdn = 4.8$  minutes), but almost twice as much as at the Heartrate Challenge ( $Mdn = 2.18$  minutes). These data suggest that the open-ended exploration of data at Run (Walk) and The Motion Lab encourages longer stay times as compared to the simpler data output at the Heartrate Challenge.

Visitors at Run (Walk) and The Motion Lab were more likely to appear to read the signage or instructions associated with the exhibit than were visitors at the Heartrate Challenge. This may be related to the set-up of the exhibits. At the Heartrate Challenge, visitors are able to watch other visitors use the heartrate monitors and button activity, the latter of which has audio instructions. So, visitors are able to understand how to use the exhibit by modeling their interaction after other visitors or listening to instead of reading instructions. In comparison, for Run (Walk), the screen is hidden, and at the Motion Lab, the video bank is at the far side from the exhibit entrance. As a result, the instructions for these activities may be more necessary for visitors to understand how to use them.

Adult visitors to the Motion Lab were more likely to skip the activity portion of the exhibit than were adult visitors to Run (Walk). Visitors that did not engage with the activity at the Heartrate Challenge were not intercepted, and thus are not included in the data. That said, the competition aspect of the Heartrate Challenge encourages multiple group members to engage with the activity together. The data input and activity for Run (Walk) is designed for an individual to complete, but visitors could explore the data as a group. Similarly, while multiple visitors could record themselves at once, the activity portion of the Motion Lab is primarily a solo activity. But again, the engagement with the screens can be done in a group. The difference in the percentage of adult visitors skipping the activity portion suggests that visitors to the Motion Lab exhibit may be satisfied with exploring the data (i.e., video recordings) of others in their group, while visitors to Run (Walk) feel more compelled to also record their own data.

At all three exhibits, visitors were more likely to do the activities once than they were to do them multiple times. However, because that was not the case for everyone, it is still important to consider reasons why some visitors decided to engage with the activities more than once. Having fun is likely a motivation for repeating any type of activity at a science museum. Two other reasons why visitors may be motivated to repeat the activity at an exhibit that includes a data-related experience are improving upon their first try or trying something different to see how that affects the data. For example, at Run (Walk), a visitor may try to get a faster time, or try walking if they ran the first time. At the Heartrate Challenge, a visitor who lost the first round may want to try to win the second time, or may want to try racing against someone else. At the Motion Lab, after watching their recording, a visitor may want to re-record themselves doing the same movement to refine their form/technique, or they may want to try an entirely different movement.

## **Rating Scale Responses**

During the interviews with those who had engaged with the data portion of the exhibit, visitors were asked to rate where they fell on a series of rating scales from 1 - Not at all to 7- Completely. All

of the rating statements were the same for the Heartrate Challenge and The Motion Lab, but only three of the four were the same for the Run (Walk) exhibit. Average ratings for each exhibit are included in the Table X.

Table 13: Mean Ratings by Exhibit

	I like doing this kind of thing	Other people in my group like doing this sort of thing	I could see myself in the data*	I was able to compare different things
<b>Run (Walk) at COSI</b>				
Adults (n=20)	5.48	5.58		5.11
Children (n=11)	5.23	3.23		5.10
All (n=32)	5.34	4.60		5.16
<b>Heartrate Challenge at COSI</b>				
Adults (n=22)	6.59	6.52	6.30	6.11
Children (n=14)	6.68	6.32	5.54	5.89
Family groups^ (n=8)	6.31	6.13	5.69	5.81
All (n=44)	6.57	6.38	5.94	5.99
<b>The Motion Lab at SMM</b>				
Adults (n=22)	5.57	5.64	5.67	5.65
Children (n=31)	5.31	4.84	5.48	4.82
All (n=53)	5.41	5.19	5.56	5.15

\*Different statement for Run (Walk); asked about importance of being able to do this

^Adults and children interviewed together completed the scale together

For the Run (Walk) exhibit, a Mann-Whitney test found that adults shared significantly higher ratings ( $Mdn = 6.0$ ) than did children ( $Mdn = 3.0$ ) for the statement “Other people in my group like doing this sort of thing” ( $U(N_{adults} = 19, N_{children} = 11) = 39.0, z = -2.849, p = .004$ ). Average adult ratings for that statement are similar to those for the statement “I like doing this kind of thing,” which suggests that adults liked the exhibit and thought others in their group would like them too. The lower ratings for children suggest that they liked the exhibits, but – potentially incorrectly – did not think others in their group would as well. There were no significant differences in ratings between adults and children at the Heartrate Challenge and at the Motion Lab.

A Kruskal-Wallis test indicated that there were significant differences in ratings for the statement “I like doing this kind of thing” for the three exhibits,  $H(2) = 38.491, p < .001$ . Dunn’s pairwise comparisons reveal that ratings of this statement were higher at the Heartrate Challenge ( $Mdn = 7.0$ ) than at Run(Walk) ( $Mdn = 5.5$ ) and the Motion Lab ( $Mdn = 6.0$ ). Similarly, a Kruskal-Wallis test indicated a significant difference in the ratings for the statement “Other people in my group like doing this sort of thing,”  $H(2) = 33.37, p < .001$ , with Dunn’s pairwise comparisons revealing that the ratings were higher at the Heartrate Challenge ( $Mdn = 7.0$ ) than at Run(Walk) ( $Mdn = 5.5$ ) and the Motion Lab ( $Mdn = 5.5$ ). The higher ratings for the latter statement could be due in part to the Heartrate Challenge being set up as a competition, so visitors doing the activity together with their group may have been better able to see the enjoyment levels of others they were with.

A Kruskal-Wallis test indicated that there were significant differences in ratings for the statement “I was able to compare different things,”  $H(2) = 13.513, p = .001$ . Dunn’s pairwise comparisons reveal that ratings of this statement were specifically higher at the Heartrate Challenge ( $Mdn = 7.0$ ) than at

the Motion Lab ( $Mdn = 6.0$ ). While The Motion Lab offered more ways to explore and compare on the video screens (e.g., slow motion, comparing to athletes, comparing to other visitors), the simplicity of comparing scores or heartrates (i.e., comparing two numbers) may have been easier for visitors.

## Open-Ended Responses

Visitors to the Heartrate Challenge and The Motion Lab were asked open-ended follow-up questions about each of the rating statements.<sup>1</sup>

### Heartrate Challenge at COSI

*What do you like or not like this kind of thing? (n=35 adults and n=25 children)*

Overall, both adults and children rated their enjoyment of the exhibit highly, and their open-ended responses primarily represented aspects of the activity that they liked, with very few critical or negative comments.

Adults and children were both most likely to cite being active, having fun, and competition as reasons they liked the exhibit. Half of the adults (n=17, 50%) and over one-third of children (n=9, 36%) shared responses about being active, getting moving, going fast, running, and/or racing. Just under half of adults (n=15, 44%) and over one-third of children (n=9, 36%) reported having fun or finding the activity exciting. One-quarter of adults (n=9, 26%) and over one-third of children (n=9, 36%) liked the competitive nature of the activity and competing against others.

Another quarter of adults liked the hands-on and interactive design of the activity (n=9, 26%). Few children (n=2, 8%) noted aspect of the activity this in their response. Adults also appreciated that this activity was something their group members could do together (n=6, 18%), with some specifically noting that it was appropriate for a range of ages. Only one child referenced playing together in their response.

Even with this general prompt, a few visitors referenced the data portions of the exhibit in their response. Five adults (n=15%) and three children (12%) mentioned getting to see their scores (i.e., the number of lit buttons pressed) or heartrates. As one adult visitor explained, the numbers show “a direct representation of how you did.” Only one adult (3%) and one child (4%) specially called out learning as something they enjoyed about the activity. That said, other responses to the open-ended questions suggest that visitors did take away information about heart rate from the activity.

Four adults (12%) liked that the activity was simple, easy to use, and easy to understand. Another four adults (12%) referenced specific elements of the activity that they liked, such as the buttons and lights. One in five children (n=5, 20%) mentioned specific elements of the activity in their responses as well.

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<sup>1</sup> The percentages for the open-ended responses may add up to more than 100% for each question because some visitors touched on multiple themes in their responses.



Regarding things visitors did not like about the activity, one adult noted that some of the buttons were broken, and one child called the activity “fun, but tiring.”

*Is there someone in your group who likes or dislikes this type of activity? (n=44 groups)*

The numbers in this section are reported by group. While some visitors were interviewed individually, all but one did the activity with other members of their group.<sup>2</sup>

Over half of the groups (n=24, 55%) reported that a child in their group liked the activity most. One-third of the groups (n=15, 34%) said that everyone in their group enjoyed the activity equally. A few groups (n=5, 11%) said that an adult in their group liked the activity best; three of these groups included adults and children.

Reasons given for group members liking the activity include the competition and winning (n=5), having fun (n=1), doing the activity together (n=1), and getting to see their score (n=1). Six groups shared reasons certain members of their group did not enjoy the activity, which general fit into two groups. Three mentioned participants’ physicality: a child having to run further to keep up with an adult, an adult sharing that their fitness level made the activity less enjoyable, and a teenager hurting their ankle while playing. The other three groups mentioned issues with the activity, including broken buttons, not winning, and a group where the child thought it was too hard, but one of the adults thought it was too easy.

*How did you see yourself in the data? What did it show you? (n=36 adults and n=17 children)*

High overall ratings for this scale ( $\bar{x}$ =5.94 on 7-point scale) indicate that visitors were generally able to see themselves in the data. In their open-ended responses, both adults and children were most likely to reference their heart rates in response to this question (n=16, 44% and n=12, 71%, respectively), with many noting the difference between their resting to active heart rates. A few children (n=4, 26%) were initially unsure of how to answer the question, but with gentle prompting from the interviewer or an adult with them (e.g., what did the numbers show you about yourself?), all ended up responding about their heart rate.

One-quarter of the adults (n=9, 25%) responded with an answer about their fitness or the fitness of others in their group. These included references to speed, reflexes, stamina, and being out-of-shape. None of these visitors mentioned their heart rates or scores, so it is unclear if it was the data or the doing the activity that showed them these things. Three children (18%) also mentioned fitness in their responses, specifically referencing speed and agility.

A few adults (n=4, 11%) and children (n=3, 18%) mentioned elements of the activity (e.g., buttons, competition) in their responses. Some of these visitors specifically referenced the scores in relation to seeing the number of buttons they were able to hit, who won, or that they tied. A few of the adults (n=4, 11%) and two children (12%) made comparisons between themselves and others in

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<sup>2</sup> The visitor that did the activity alone skipped this question.



their group. The comparisons included fitness, physicality (e.g., arm length and height), and heart rate (i.e., the child's heartrate was high because he had further to run).

A few of the adults (n=4, 11%) felt that their resting heartrate readings seemed inaccurate based on what they would have expected, but acknowledged that they had been active moving around the museum. Other adults (n=3, 8%) noted that their raised active heartrates were expected, average, or normal.

Two adults (6%) reported that they did not see themselves in the data. One of these adults gave a rating of 1.5 on the associated scale. They noted that they were playing with kids and not really following directions or testing themselves, explaining that playing in a group is "not useful for data." The other adult rated the associated scale a 7, but answered the open ended question with "not really."

#### *What did you see comparing yourself with others? (n=31 adults and n=24 children)*

Again, High overall ratings for this scale ( $\bar{x}=5.99$  on 7-point scale) indicate that visitors were able to make comparisons. In their open-ended responses, children were most likely (n=10, 42%) to make comparisons related to fitness. Most of the children compared their fitness to other members of their groups, with most focusing on being faster and one focusing on being more flexible. One child compared the first and second times they did the activity, noting they were able to go faster with practice, and another compared the activity to other sports where you have to run around. Almost a quarter of the adults (n=7, 23%) also mentioned fitness in their responses. Many shared comments related to speed, but others also mentioned reflexes and stamina.

Adults were most likely (n=8, 26%) to make comparisons related to physicality. They noted the height or arm span of group members, noting that longer legs and longer reach are advantage in the challenge (e.g., being able to reach the buttons by leaning instead of running). Only one child shared a comment related to physicality, explaining that their data is different because everyone has different bodies and strengths.

One-third of the children (n=8, 33%) and one in five adults (n=6, 19%) compared their heartrates to others in the group, noting similarities or whose heartrate was higher. A few of the visitors related higher heartrates to moving more or going faster than other group members. Five adults (16%) and five children (21%) compared their scores to their opponents' scores, noting who won or if they tied. Again, some of these visitor noted reasons one group member did better, such as height, speed, and one side having broken buttons.

A few adults (n=5, 16%) and one child (4%) said they did not compare themselves to others. A few of the adults noted that it was hard to compare themselves to a child in their group. That said, these adults still shared an average rating of 5.8 on the corresponding scale.

A few adults (n=4, 13%) and children (n=3, 13%) shared other points of comparison or unrelated answers not about comparing themselves to others. Other points of comparison included an adult wanting to see what average resting and active heartrates are for "normal people" in comparison to athletes, a child noting that she and her sister had "different data," and another child noting that certain people are good at specific things. Unrelated comments were about needing to do more

exercise, seeing their heartrate go up after running around, not seeing their number but breathing hard, and having fun rushing to the buttons.

### The Motion Lab at SMM

*What do you like or dislike about using video areas like this? (n=23 adults and n=32 children)*

Adults (n= 7, 30%) and children (n= 12, 38%) were both most likely to cite being able to see what they did as what they liked most about using the video screens. This included getting to watch the recordings of themselves after completing the activity and seeing what they did well or what they could do better. Six adults (26%) and six children (19%) specifically highlighted that they liked the slow motion aspect of the videos. A few of the adults commented that they felt it was unique or uncommon to get to see themselves or their kids in slow motion. Adults (n=5, 22%) and children (n=5, 16%) also mentioned enjoying being able to compare what they did to others. Many of these visitors specifically mentioned comparing themselves to athletes, professionals, “real” players, or “someone good at it.”

Even though the question was about the screen portion of the activity, five children (16%) commented on the recording portion of the activity, noting that they enjoyed being active and doing the movements (e.g., kicking the ball, throwing a football, doing a hair flip and back walk). Two children (6%) shared that they liked being able to choose which activity or sport to do and record. None of the parents shared comments related to choice or being active. As discussed previously, adults were more likely to skip the recording portion of the activity and just use the screens with the children in their group.

A few adults (n=4, 17%) and one child (3%) liked that the activity was easy to use and understand. A couple of the adults specifically liked that it was something their children were able to do themselves, and the child liked that the directions were explained well. However, other adults (n=3, 13%) and another child (3%) felt that the activity was hard to understand or easy to misuse. One of the adults wanted more signage about what to do in the recording area, but another adult noted that their kids did not understand what to do because they did not read the instructions. The child and their adult noted that she stood outside the box so she did not show up on the video.

Two adults and one child (9% and 3%, respectively) described the activity as fun or exciting. A couple of adults (9%) appreciated the hands-on, interactive nature of the activity. A few of the children interviewed (n=5, 16%) shared general, positive comments about the activity (e.g., “It was cool” or “I liked it”).

One adult (4%) and one child (4%) shared suggestions to improve the activity. These suggestions included changing direction you throw the ball so everything faces the same way (adult), and having multiple modes – slow, regular, and fast (child).

*Is there someone specifically in your group who might really like or dislike this type of activity? Why might that be? (n=44 visitors)*

When asked who in their group might really like or dislike the activity, three-quarters of respondents (n=34, 77%) shared that a child in their group liked the activity most (including

children who said they liked it the most and others who said a child in their group liked it the most). One in six (n=7, 16%) said their whole group liked the activity equally, and few (n=2, 5%) said an adult in their group liked the activity the most. Four visitors (9%) shared that they or someone in their group did not like the activity.

Top reasons shared for liking the activity the most include enjoying being active (n=8, 22%), getting to see their results (n=8, 22%), and general, positive responses (n=8, 22%). Other reasons shared include being able to compare what they did to others (n=4, 11%), seeing the video in slow motion (n=4, 11%), the hands-on nature of the activity (n=3, 8%), the activity being fun (n=1, 3%), and being the only one in their group who tried it (n=1, 3%).

Reasons given for disliking the activity include a child not being able to understand the directions without help from adults in their group, a child being more into computers than sports, a child being disappointed nobody else in their group could do a back walk, and a child who thought others in their group would not like recordings of themselves to stay on a device for others to watch.

#### *Did the videos show you anything about yourself? (n=16 adults and n=28 children)*

When asked if their videos showed them anything about themselves, over half of adults (n=9, 56%) and children (n=15, 54%) mentioned getting to observe their form (i.e., their body movement and execution of the action). Almost half of these children (n=7) and a couple of these adults (n=2) specifically noted that they saw they had bad form (e.g., “When I threw the basketball, my hands flopped all over the place”). Only one child specifically noted that they had good form, explaining that they could tell they did the action well by watching how their body moved. A few adults (n=3, 19%) and one child (4%) referenced technique in their responses (i.e., seeing how to do an action the correct way). More adults than children referenced comparing themselves to others (n=6, 38% & n=3, 11%, respectively). Five adults (31%) and five children (18%) mentioned noticing things they could do to improve their actions (e.g., “It showed me I need to pull my arm back further when I throw”). One child said the video would probably not help them improve how they did their action.

A few adults (n=3, 19%) and children (n=2, 7%) mentioned getting to see themselves in slow motion. A few children (n=5, 18%) also mentioned just getting to see themselves complete the action in the video. A few children were unsure how to answer the question (n=3, 11%) or said that the video did not show them anything about themselves (n=2, 7%).

#### *What kinds of things did you pay attention to when you were comparing your video with others? (n=20 adults and n=28 children)*

One in five adults (n=4, 20%) and over one-third of children (n=10, 36%) reported that they did not compare their videos with others'. The majority of these visitors (n=10) said they did not know about that part of the activity, but several noted that it was something they would like to have done if they had known about it. Another one-quarter of adults (n=5, 20%) and three in ten children (n=8, 29%) reported only watching their own video or only using the slow motion feature. More visitors reported comparing their video to videos of athletes than to videos from other visitors. Four adults (20%) and three children (11%) compared themselves to an athlete, while only one adult (5%) and one child (4%) compared themselves to other visitors.

In regard to what they paid attention to while watching or comparing their videos with others, adults and children were both most likely to mention form (60% & 43%, respectively) and technique (20% & 18%, respectively). A few adults and children specifically noted paying attention to the correctness of their form or technique (e.g., doing them correctly, seeing them done correctly by athletes, and identifying opportunities for improvement). A few children (n=4, 14%) and one adult (n=1, 5%) mentioned noticing differences between their video and others. A couple of adults shared suggestions or concerns about the comparison aspect of the activity. One noted that they was no representation of left-handed athletes in the videos, and the other noted the risk of comparison turning into negative criticism (but also noted it can be an opportunity for observation and improvement).

### Discussion

These open-ended responses suggest that a visitor's ability to see themselves in the data and make comparisons with others is influenced by the types of physical engagement offered by the exhibit, as well as the types of data and how visitors can engage with them. The engagement, data collection, and data output at the Heartrate Challenge are simple. Visitors take their active and resting heartrates, producing two numbers for themselves and two numbers for their companion. The activity is set up as a competition; scores are produced for each opponent based on the number of buttons they pressed. The data being in pairs of numbers sets up basic comparisons of higher, lower, and equal/tied. Visitors were able to make comparisons with their individual data, comparing their resting and active heartrates. They also made comparisons based on the competition of the activity (e.g., who had the higher score or "won"). Some went further to consider explanations for the differences in their heartrates or scores (e.g., physicality, fitness). For example, noting that longer arms are an advantage for pressing more buttons or explaining that the child needing to run to press the buttons meant their active heartrate was higher. These reflections suggest scientific thinking among visitors, even if they did not identify it as such themselves.

The data produced by the Motion Lab is more complex; there is no quantitative output to compare. Visitors record themselves doing a movement and then can observe their form/technique on the video screens and compare it to others'. Correct form/technique is less obvious of a comparison than which number is higher or lower. Further, many visitors did not compare their videos to others (i.e., they only looked at their own video or watched it in slow motion). With more options of how to use the exhibit, visitors may skip or miss the comparative aspects of the exhibit (even if they were considered integral in the design).

### **Reasons for Not Participating**

Observed visitors who skipped the data portion of the exhibit were asked quick follow-up questions to learn why they did not engage with the exhibit in that way.

#### Run (Walk) at COSI

There was only one visitor who did not interact with the data portion of the Run (Walk) exhibit. When asked why they chose not to do the data monitoring station, they explained, "Didn't know it was there - didn't pay attention to anything but my time."

#### Heartrate Challenge at COSI

*I noticed you did not record your heartrate. Can you tell me why? (n=23 adults and n=21 children)*

Adults were most likely to cite children in their group as the reason they did not take their heartrate (n=9, 39%). These visitors explained that their child was too young, had too short of an attention span, or that they were just following their child and they skipped the heartrate stations. Only one teenager interviewed mentioned children in their response; they felt that it was more interesting for younger kids to see their heartrate.

A quarter of the adults (n=6, 26%) said they did not know what the heartrate monitors were, that the stations were part of the activity, or that they could or were supposed to take their heartrate. This was one also of the most common reasons children gave for not taking their heartrate (n=6, 29%). A couple of adults (n=2, 9%) said that they did not even notice the heartrate monitors, while a couple others (n=2, 9%) did notice the monitors, but reported that they were blocked by other visitors. More children noted this as the reason they did not take their heartrate, with one-quarter (n=5, 21%) saying that they did not notice the monitors.

Another quarter of adults (n=6, 26%) shared that they just wanted to do the activity, with some noting specifically that they had taken their heartrate earlier or on previous visits. One in five (n=4, 19%) children also shared that they wanted to go straight to the activity.

Unlike the adults, several of the children (n=6, 29%) were unsure of why they skipped taking their heartrate or were unable to articulate their reason to the interviewer. Other reasons adults shared for not taking their heartrate included not recording any of their measurements in the *Life* gallery<sup>3</sup> (n=1) and thinking that their family was going to leave so there would not be time (n=1).

### The Motion Lab at SMM

Because so few visitors were observed not engaging with the data portion of The Motion Lab, there are few responses to these questions about why visitors did not use the screens.

*Did you see anything that would let you know what you might be able to do there? (n=3)*

One child thought the screens looked boring. Another child said they did not notice the screens and kept walking; the adult with them shared that they watched a little bit but had to go with their kid who was walking away.

*[After a one-sentence explanation of the screens] Do you think this would appeal to you? Why or why not? How would you be likely to use it? (n=4)*

Three of the four visitors who answered this question said they would use the screens. One adult and one child noted they would use them to see or compare themselves to professional athletes,

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<sup>3</sup> The *Life* gallery at COSI allows visitors to participate in various exercises and activities (e.g., strength, flexibility, etc.) to record their measurements and compare their results to other visitors'.

and another adult thought using the screens to see form would be “cool.” The child who walked away earlier was still not interested and thought it sounded boring.

### Discussion

Despite the uneven number of respondents, a common reason across all three exhibits for not engaging with the data portion of the exhibit was not noticing it, or noticing it but not knowing what it was or how they were supposed to use it. At both the Heartrate Challenge and the Motion Lab, adults shared that their decision not to engage was driven by a child in their group – either following the child’s lead to skip it or skipping it because their child was too young. Responses at the Heartrate Challenge also suggest that an activity can draw attention away from the data portion of an exhibit, with visitors explaining that they just wanted to race or press the buttons. The video recording and screens at the Motion Lab seemed to be more linked for visitors, though again, not all visitors used the screens to make critical comparisons.

## Conclusion

*What are the reasons given for not engaging with the data visualization, post engaging in the activity?*

The three main reasons visitors shared for not engaging with the data portion of the exhibits included 1) not noticing it, knowing what it was, or that it was a part of the exhibit; 2) making the decision to skip it based on the children in their group; and 3) wanting to do the other part of the exhibit more.

To address point one, exhibit developers should consider how the data portion is integrated into the exhibit. It should visually stand out, making it harder to miss, but should still be clearly connected to the exhibit (e.g., physically, through instructions, etc.) so visitors know to use it and how to use it.

To address point two, exhibit developers should consider ways to make the data portion of the exhibit more appealing for kids and ways to help adults facilitate making meaning of the data with younger members of their group. If adults feel more supported and capable of facilitating that process, they may be less likely to decide to skip the data portion of the activity.

Formative testing of the exhibit could be an important strategy for addressing point three. By understanding how visitors actually use the exhibit before it is finalized, exhibit developers can better incorporate the data portion as an integral part of the whole exhibit experience.

*Of those who engage with the visual, how many look at their own data versus visually compare their data with others?*

Due to the way the data was collected, it is difficult to answer this question quantitatively. However, the open-ended responses offer some insight into how visitors interacted with their own data and those of others.

In the small number of open-ended responses for the Run(Walk) exhibit (p. 7), participants reported looking at their own data and looking at the data of others in their group, but less frequently, comparing their data to other visitors’.



At the Heartrate Challenge, visitors made different comparisons depending on the type of data. Generally, they compared their own heartrates (i.e., resting vs. active), but compared their score (i.e., how many buttons they pushed) to their opponents’.

At the Motion Lab, there was high use of the video screens, but many visitors were not using them to make comparisons between themselves and professional athletes or other visitors. Instead, they focused on reviewing their own video or using the slow motion feature. This finding suggests that when developing interactives with multiple modes of engagement, exhibit developers should consider how to highlight the different features and encourage visitors to try them all.

*Of those who compare data, what kind of meaning do they attempt to make from the data?*

At the Heartrate Challenge, most visitors could easily identify the reason for their increased active heartrates – moving around to press the buttons. More interestingly, some visitors sought to make meaning of their scores, noting differences in physical features (e.g., height) or fitness levels that served as an advantage or disadvantage in pressing the buttons. At the Motion Lab, some visitors who observed their form or technique identified ways it was correct, ways it differed from others’, and areas for improvement.

At exhibits with a goal of having visitors make meaning of data, exhibit developers should consider ways to facilitate visitors’ scientific thinking. The interviews suggest that visitors are inclined toward this type of thinking when prompted, so building opportunities for reflection into the exhibit might help visitors take their meaning making further.

*How and how much do users like engaging with this type of activity, think others like engaging with this activity, and see themselves/others in the data?*

Visitors were asked to rate the following statements on a seven-point scale (1 - Not at all to 7- Completely): *I like doing this kind of thing, Other people in my group like doing this sort of thing, I could see myself in the data,*<sup>4</sup> and *I was able to compare different things*. Average ratings were above the mid-point of the scale for all the rating statements at each exhibit.

Overall, visitors liked each of the three exhibits and thought that others in their group would like them as well. The only exception was children to Run(Walk) who shared lower ratings for others in their group liking the exhibit than did adults to Run(Walk). That said, because adults generally reported liking the exhibit, these lower ratings suggest a disconnect between children’s perceptions and their group members’ experiences, rather than being reflective of visitors actually disliking the activity.

Reasons given for liking the exhibit differed between the exhibits. At the Heartrate Challenge, visitors most commonly highlighted being active, having fun, and competition as what they liked about the exhibit. At the Motion Lab, visitors most frequently cited being able to see what they did, seeing their videos in slow motion, or comparing themselves to others as what they liked most. Interview participants at the Motion Lab were specifically asked what they liked about using the

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<sup>4</sup> This rating statement was asked differently for Run(Walk).



screens. That said, it is still worth noting that visitors to the Heartrate Challenge were more likely to mention the activity portion than the data portion when asked what they liked about the exhibit.

The data collected in this study suggest that visitors can have positive experiences at data-based exhibits. While a fun activity can sometimes overshadow the data portion of the exhibit, it can also serve as a way to draw people in. As discussed above, when they engaged with the data portion of the exhibit, visitors were capable of making meaning of their data.