NAVIGATION THROUGH THE DESERT MUSEUM AS DETERMINED BY GPS TRACKING AND EXIT SURVEY

By

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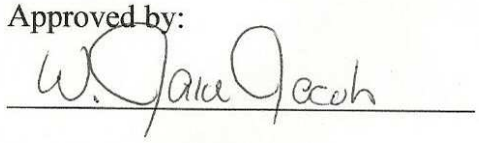
Approved by:



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Psychology

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ABSTRACT

Environmental psychologists have used observation and self-report methods in museums since the 1920's, however the introduction of Global Positioning Systems (GPS) has instigated an exciting new methodology for visitor studies. The current study uses GPS to examine actual visitor utilization of the Arizona Sonora Desert Museum, with the objective of linking utilization to self-described museum experiences and providing comprehensive feedback from visitors. This study serves as a pilot, or proof-of-concept study for GPS research within ecological parks or museums. Survey data show that the Raptor Free Flight show was the most popular exhibit while Mountain Woodland was the least popular. There was, however, a distinct divide between first-time visitors and returners, with unique preferences for different exhibits. From the successful results outside and within buildings at the museum, the study could be expanded to provide feedback not only to administration within zoos but stores, restaurants, schools, and other public facilities.

I. INTRODUCTION

Visitor Studies

Visitor studies is a branch of environmental psychology that aims to improve guests' experiences by focusing on the perspective of visitors and the environment design of museums (Bitgood 2002). Research has been conducted on everything from the physical design of museums to the emotional response of visitors. Some studies concentrate on architecture and exhibit design in relation to circulation patterns (Hillier & Tzortzi 2006), while many focus on visitor experiences, degree of impact, and factors that affect learning (Leinhardt & Knutson 2004, Falk 2006, Falk et. al 2007). Still others investigate their audience, assessing prior knowledge and demographics (Anderson 2004, Leinhardt & Knutson 2004). Visitor studies has also been expanded to include research in consumer relations as a practical way to measure satisfaction with staff within museums (Yucelt 2001), theme parks, hotels and stores (Bitgood 2002).

Although scientists continue to find novel applications and new areas of research within visitor studies, most use either observation or self-report to examine guest characteristics. Observational approaches use guest tracking to measure full museum circulation, time sampling to gauge behavior on a smaller level, and focused observation to study a few exhibits thoroughly. Self-report often focuses on the visitor perspective rather than behavior, integrating surveys to measure impressions or information recall, and focus groups to record visitor experiences (Bitgood 2002).

Environmental psychologists have used observation and self-report methods in museums since the 1920's; however the introduction of Global Positioning Systems

(GPS) has instigated an exciting new methodology for visitor studies. With GPS, a system that uses triangulation between satellites to determine an object's coordinates and velocity, the present study offers a more objective observation of visitor tracking.

Global Positioning Systems

GPS has already improved research across many disciplines. Within environmental studies, GPS has been used to study global patterns such as tectonic plate movement (Prawirodirdjo & Bock 2004) and retreating glaciers (Gao & Liu 2001) along with small-scale animal migration (Phillips et. al 1999), agriculture (Melakeberhan 2002) and mining (Gourmelen 2007). GPS has also improved human navigation on small and large scales by increasing the efficiency of emergency response (Enge & Misra 1999) and aiding in the navigation of the visually impaired (Loomis et. al 1998). Civil transportation has benefited exponentially from the advent of better maps and hiking tools, enhancing aviation along with land transportation. Other GPS technology continues to advance telecommunications, civil engineering and electric plant functioning (Enge & Misra 1999). GPS units have even been used to create better gaming environments such as three dimensional human pacman (Cheok et. al 2003).

However, there is an overall paucity of research using GPS in visitor studies, despite the invention of the travelstick, a GPS device that could provide valuable information for evaluating the public use of zoos. Only a few unpublished studies exist, which track visitor movement in comparison to animal visibility and activity.

For the current project, GPS is used to examine actual visitor use of a museum, a novel approach to visitor studies. The objective observational tracking method is complemented by a self-report exit survey. The GPS-survey pair are used to provide

comprehensive feedback on visitor experiences by linking actual spatial use recorded by GPS to guest perceptions recorded through self-report.

Site: The Arizona Sonora Desert Museum

The location of the study was the Arizona-Sonora Desert Museum. The Desert Museum, founded in 1952, is a private, nonprofit outdoor zoo and botanical garden that has won accolades for its natural presentation of the desert environment. The unique design is conducive to visitor learning as well as animal comfort to promote learning and conservation of the desert. The museum hopes to "inspire people to live in harmony with the natural world by fostering love, appreciation, and understanding of the Sonoran Desert" ("An Introduction to ASDM", 2006, para. 2). Museum activities and exhibits aim to teach community members of all ages, protect indigenous species, add to existing natural history collections, and support research on not only the desert environment, but also people's attitudes on preservation of the desert ("An Introduction to ASDM", 2006, para. 6).

Located in the Tucson Mountains, 12 miles away from downtown Tucson, the site consists of 21 acres and two miles of paths ("An Introduction to ASDM" 2006, para. 3). Although over 300 animal and one thousand plant species are described within the museum, over two thousand animals, one thousand plants, and fourteen thousand rocks and minerals have been cataloged ("A History of the Arizona-Sonora Desert Museum", 2006, para. 2).

Docents were introduced in 1972 to augment the plant and animal attractions, and have since become a fundamental part of the Desert Museum. Docents, who undergo an intensive four month training program, volunteer a total of 75,000 hours each year.

Docents are situated throughout the grounds, holding live animals, leading tours, and giving presentations such as the Raptor Free Flight show ("A History of the Arizona-Sonora Desert Museum", 2006, para. 15).

The focus on education and conservation along with the unique variety of exhibits and presentation styles makes the Arizona-Sonora an appropriate place to implement GPS research within visitor studies.

PURPOSE AND RELEVANCE:

The purpose of the current study is to examine spatial and exhibit use at the Arizona-Sonora Desert Museum using GPS devices and provide the museum with feedback on visitor circulation patterns and experiences. This proof-of-concept study may serve as a model for methods examining the use of public or private space. The results of the study will also guide any needed procedural revisions for future research. In addition, the administration of the Arizona Sonora Desert Museum may decide to use proper interpretation (both statistical and qualitative) of the aggregate data to improve guest experiences at the museum.

METHODS:

Data were collected from February 7th, 2009 to March 8th, 2009. Each weekend, the principle investigator and a research assistant were stationed at a booth directly in front of the Arizona Sonora Desert Museum from 9 am until 5 pm. One hundred and one Desert Museum visitors participated over the five weekends during this period. (See Appendix II for visitor recruitment and retention flow chart).

Visitors who approached the booth received an oral presentation from the research assistant about participating in a University of Arizona/Desert Museum sponsored study on museum usage (See Appendix I for script). If interested, the visitor read and signed a consent form. The participant then received a GPS device and a participant number. This number connected the GPS data to the exit survey answers so no links existed between the participants' name and data. Next the research assistant recorded the time of day on a master list of participant numbers while the participant wrote down their telephone number and address on a separate slip. Participants then carried the GPS devise, which made second-by-second records of latitude, longitude, and speed throughout their visit. When participants turned in the GPS unit to the booth upon exiting, they received a Desert Museum animal guide and the slip with their address and phone number. The research assistant recorded the time they returned the GPS device next to their participant number and made certain to set that GPS unit aside for at least five minutes before checking it out to a different participant. A brief audio-recorded exit survey was also recorded that asked six questions:

How many times have you been here before (not including this time)?
How far did you walk today, approximately?
How many exhibits did you visit, approximately?
What exhibit was your favorite?
What exhibit did you learn the most at?
Is there anything else you would like to tell us about your visit today?

After the interview the participant received a debriefing form explaining in more detail the purpose of the study and expectations, along with the contact information of the principle investigator.

GPS wave points were also taken throughout the park to determine the location of each exhibit and path intersection. A map of the grounds was created from these points.

This master map was superimposed on the GPS map of each participant to reveal their path in relation to museum exhibits.

The whole project aimed to review GPS data from each participant and create individual profiles with maps and activity reports. Group trends were examined using a superimposed map of all participants and museum wide circulation patterns. Exit survey was analyzed to reveal individual preferences and uncover differences between survey claims or expectations and actual behavior.

RESULTS AND ANALYSIS

Individual Profiles

Profile pages were compiled in a binder for Desert Museum administration to view the movement of individuals. Figures 1 and 2 give examples of the maps found on each participant's profile page. Table 1 shows when the participant arrived, how long s/he stayed, and his/her average speed. Table 2 illustrates the differences between the data recorded from the GPS device and the self-report. Table 2 compares the value the participant gave for their estimated distance and exhibits visited to the actual values revealed from the objective GPS data. The table also compares the participant's favorite and most informative exhibit to their path and time spent at each exhibit.

Figure 1: Arial map from GPS data and Google maps. Exhibit names and dirt paths shown in white, paved paths in black, and participant path in light blue.

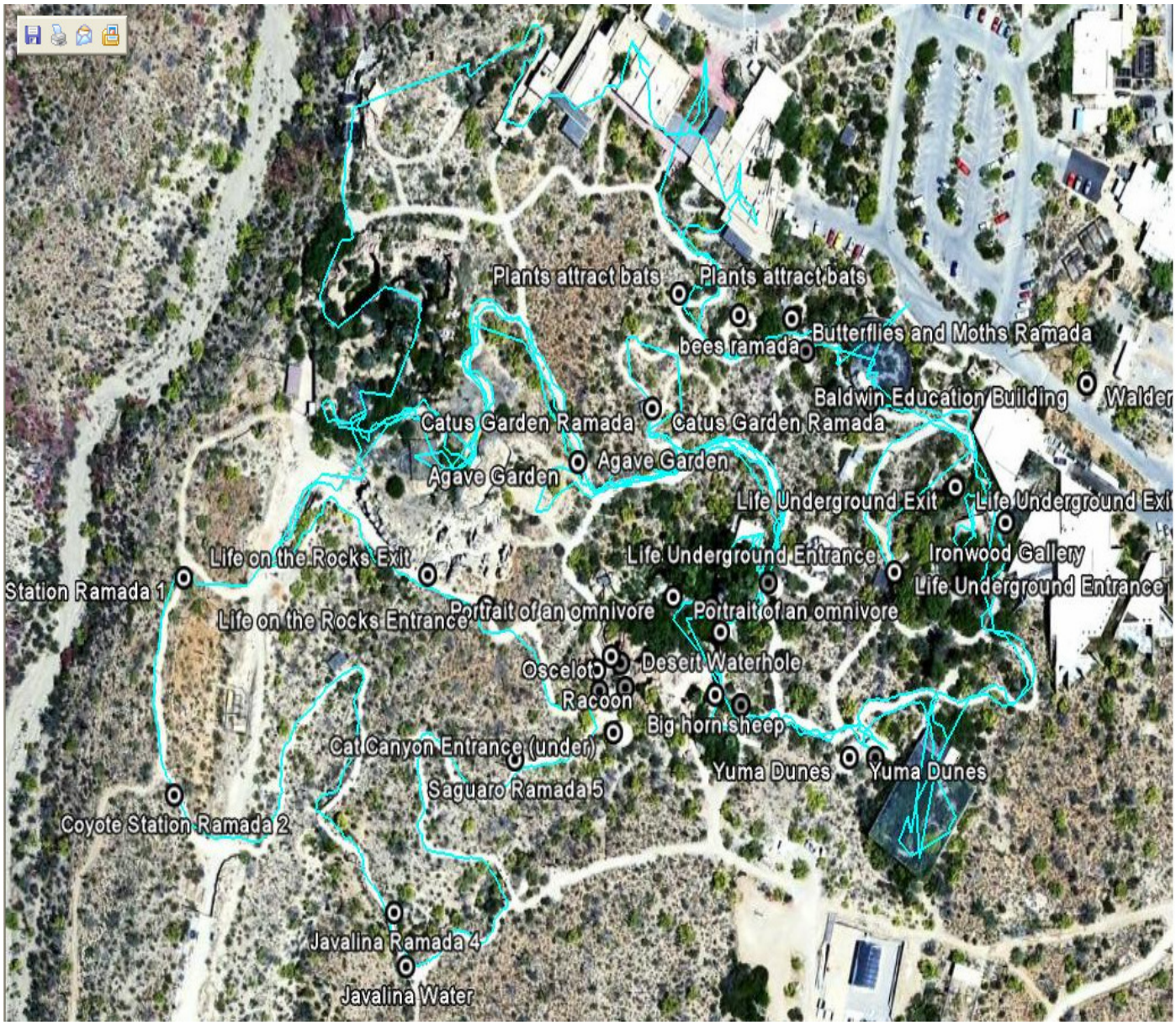


Figure 2: LandAirSea Tracking Software view of same participant, used to analyze latitude, longitude and speed.

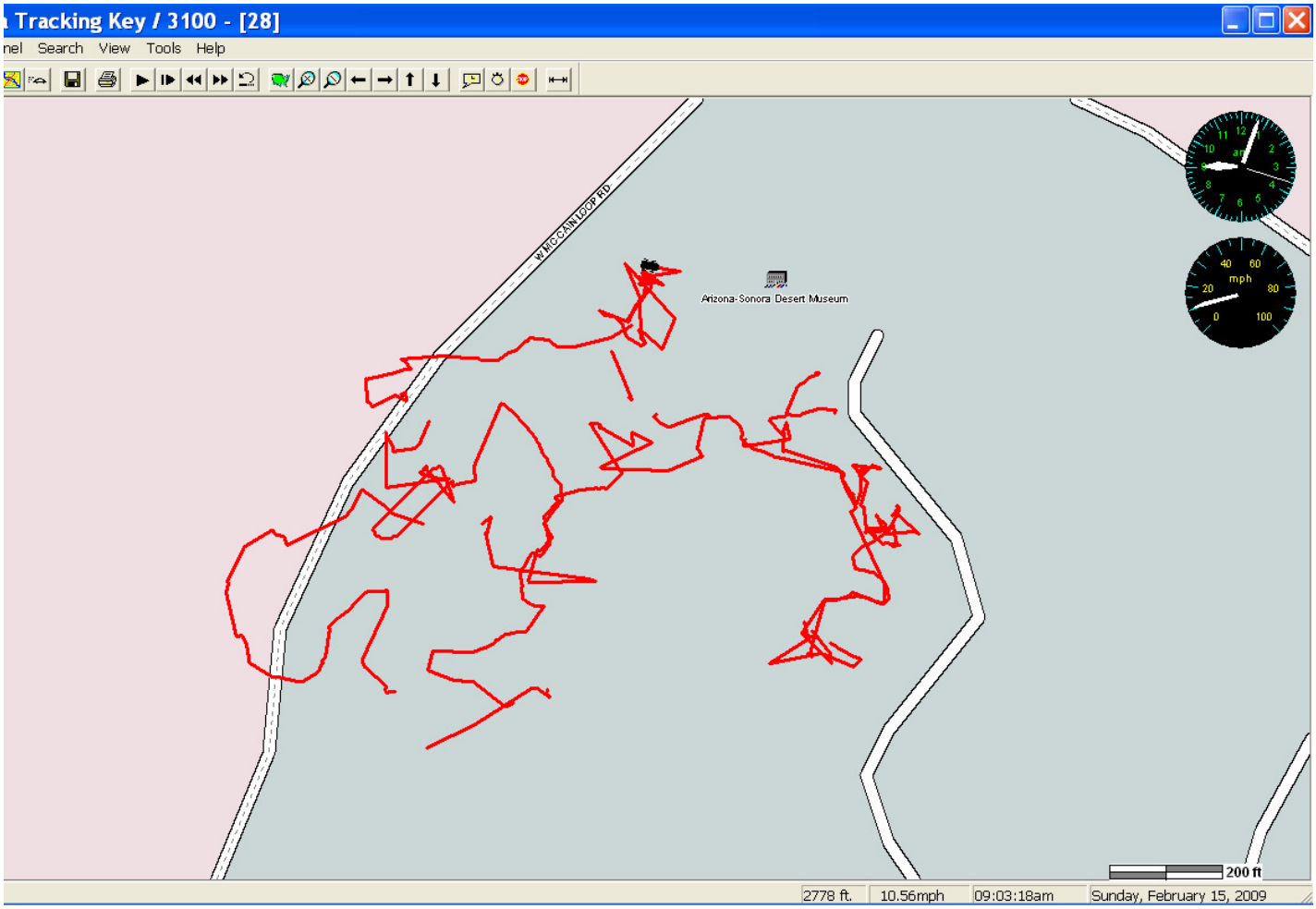


Table 1: Individual Profile of Participant

Participant Profile	
Participant #	10
Previous Visit #	0
Date of Visit	2/7/09
Arrival and Departure	9:20-12:20
Time Spent	3 hours
Time Group	Morning
Average Speed	2.74

Table 2: Numerical and Qualitative Comparison between Data from GPS Device and Self-Report

Comparing GPS Data to Self Report			
GPS Data		***Self Report***	
Distance walked	5.21	Estimated Distance	1.5
# Exhibits visited	7	# Exhibits estimated	10
Most Time Consuming Exhibit	Cactus Garden	Favorite Exhibit	Bighorn
Top 5 Exhibits	Cactus Garden, Pollinators, Raptor Show, Riparian, Life on the Rocks	Most Informative Exhibit	Raptor Show

Overall Patterns

Table 3: Numerical Comparison between Data from GPS Device and Self-Report

Averages For All Visitors	
Previous visits	8.131868132
Estimated Number Exhibits Visited	12.38028169
Estimated Distance Walked (mi)	2.150804598
Actual Distance Walked (mi)	9.829913117
Actual time in Museum (hrs)	2.69
Actual speed (mph)	3.159964

The mean number of previous visits was a little over eight. For this calculation, the number of participants (91) is lower than the total surveyed (101) because the first question of the exit survey was modified from, “Is this your first time here?” to “How many times have you been here before (not including this time)?” Therefore, participants from the first day who answered “No” were not included in the average.

Also, the average of 8.13 is not an accurate portrayal of the average visitor because the majority are either first timers (n=49) or members who have visited more than 10 times. To examine this difference, the previous visit calculation excluding first-timer data (n=42) gave an average of 17.619 previous visits. This average is more than twice the overall average, even without factoring in the outlier participant who visited the museum approximately 400 times. Hence, there are two distinct groups that visit the museum, and subsequent results will focus on differences between these two groups.

A second interesting finding came from the actual distance traversed in comparison to estimated distance. Estimated distance was 2.15 miles while actual distance was 9.83 miles. The actual distance figure, however, is skewed. The GPS did not record when the visitor was stationary, so the average speed figure is inflated. Since the

distance calculation uses speed multiplied by time spent in museum, the distance figure is also not accurate.

Although we guessed the average visitor would spend about 4 hours inside the museum, the actual time was 2.69 hours. Surprisingly, first-timers and previous visitors spent about the same amount of time on the grounds (2.69 and 2.61 hours respectively). Arrival times also did not differ much between first timers and returners. (Figure 3 and 4) When grouped into morning (arriving between 8 and 11 am), afternoon (11-2pm), and evening (2-5pm), both groups were slightly more likely to arrive in the morning. It is possible that these results are biased by the limited number of GPS devices, so the data do not fully capture visitor arrival.

Figure 3: First Time Participants Grouped According to Arrival at Museum

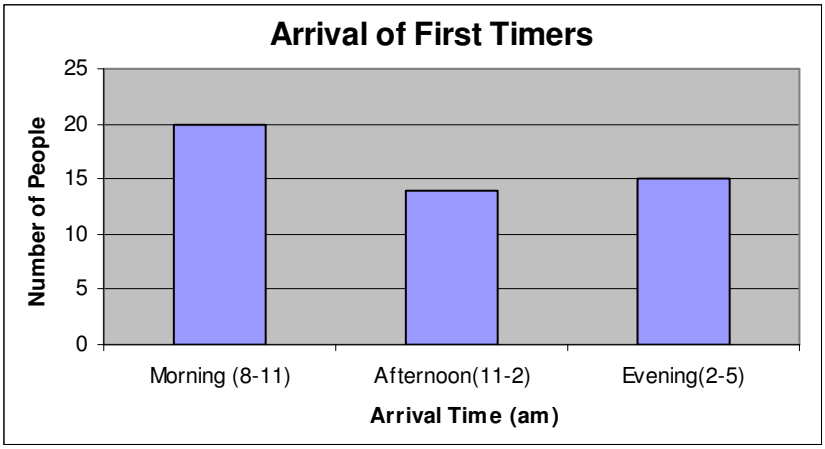
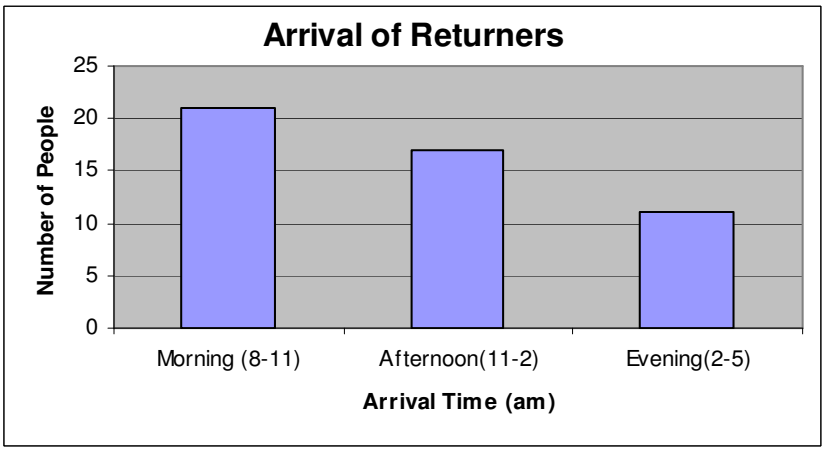


Figure 4: Returning Participants Grouped According to Arrival at Museum



Self Report Exit Survey

The visitors reported that Raptor Free Flight was the most popular exhibit, with 19% saying it was their favorite exhibit (Figure 5). Twice as many first timers (14) cited the Raptor Free Flight as their favorite than returners (7) (Figure 6). This disparity between the two groups is most likely due to the format of the presentation. In the Raptor Free Flight, the show remains fairly constant over time; the docent showcases a family of Harris Hawks in the afternoon and a variety of raptors in the morning. A similar pattern appeared with the cactus garden; 8 first timers chose the gardens as their favorite exhibit in comparison to only one returner.

In contrast, returners favored the pollinators and aviary, exhibits that are more interactive and variable in animal behavior. It is also interesting to note that the pollinator exhibit was quite popular, with 18% rating it as their favorite. Combining the categories of Raptor Show, Pollinators, and Aviary, exhibits featuring birds were listed as favorites by nearly half of the visitors (46%). The Riparian exhibit and Earth Sciences exhibit tied for third place, and attracted both groups equally. Exhibits such as the Desert Loop and Grassland were the least popular, with only one or two visitors listing them as their favorite.

Figure 5: Percentage of Total Guests Who Reported Each Exhibit as Their Favorite (n=103)

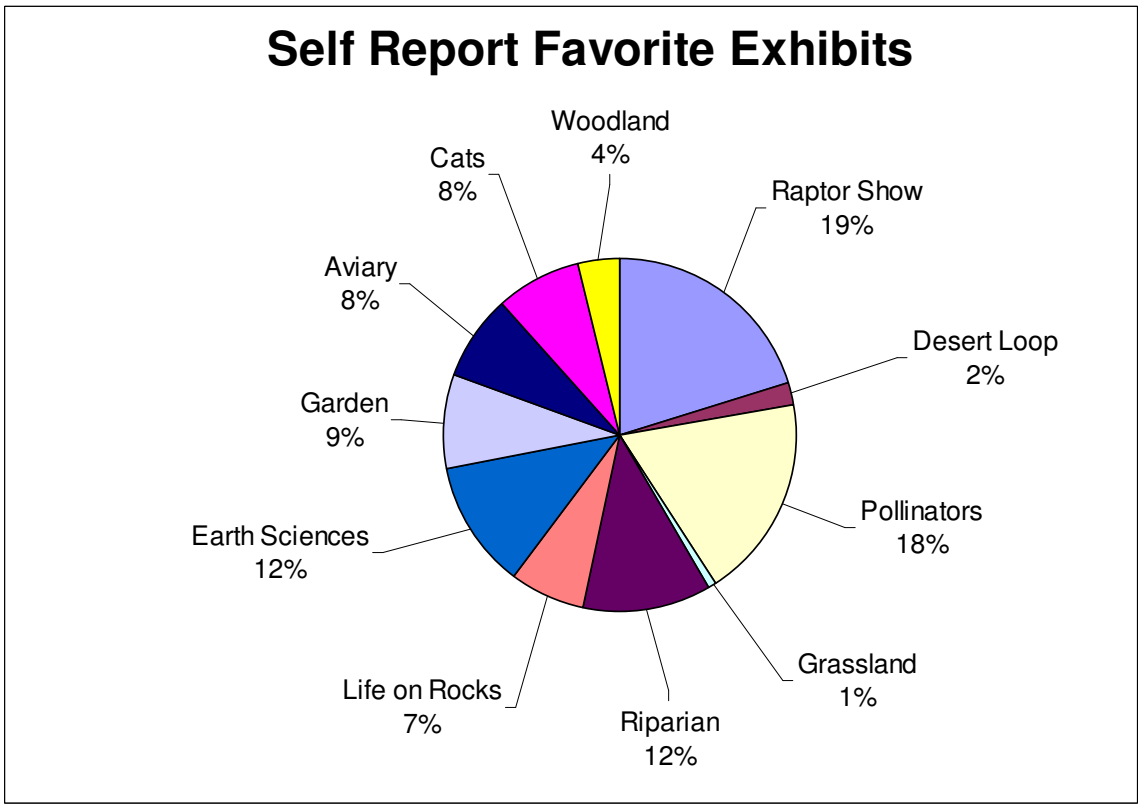
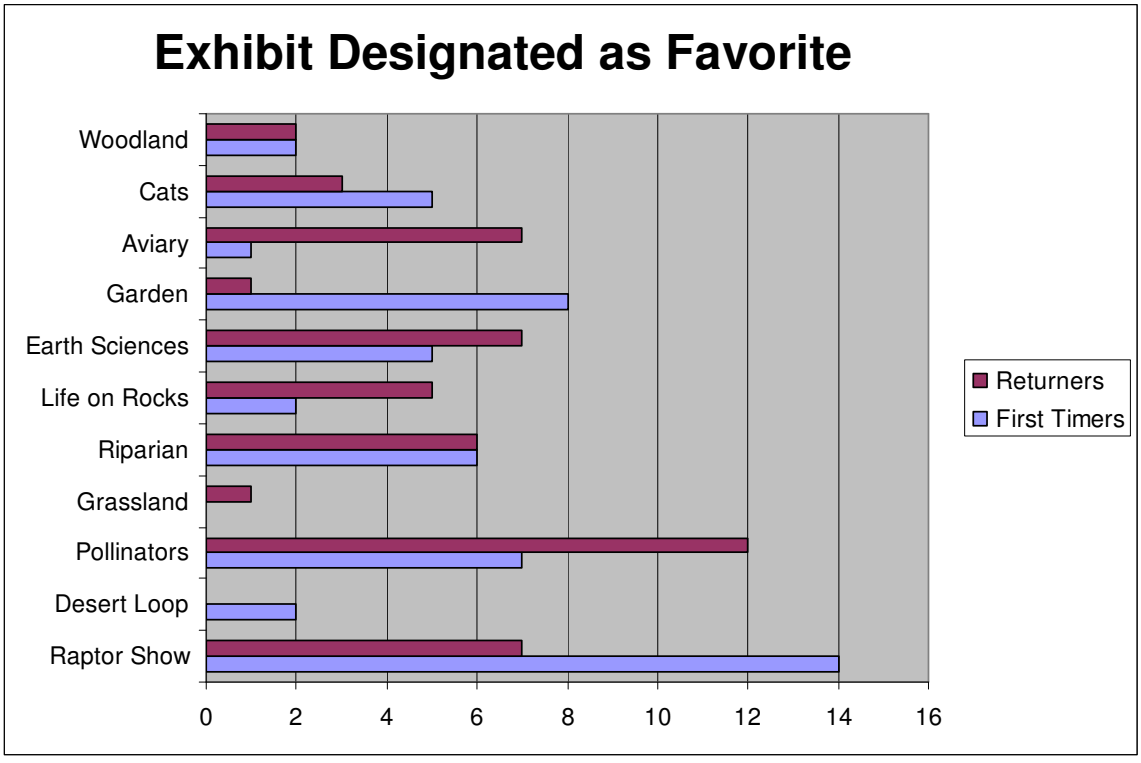


Figure 6: Comparison of Favorite Exhibits of First-Time Guests vs. Returners (n=103)



Similar trends appeared in the data on most informative exhibit. An even greater percentage of people (26%) said that Raptor Free Flight was the most informative exhibit (Figure 7). Interestingly, about the same number of first timers and returners (12 vs. 10) said that they learned the most from the raptor show (Figure 8). Although favorite and informative exhibits were often the same, this is not always the case. For example, Riparian was less popular in the category of informative exhibits than it was a favorite exhibit. The Desert Loop had interesting differences too, since it went from only 2% of favorites to 7% of informative responses. The Woodland exhibit became even less popular with fewer responses for most informative exhibit (2%) than favorite (4%).

Figure 7: Percentage of Total Guests Who Reported Each Exhibit as Most Informative (n=85)

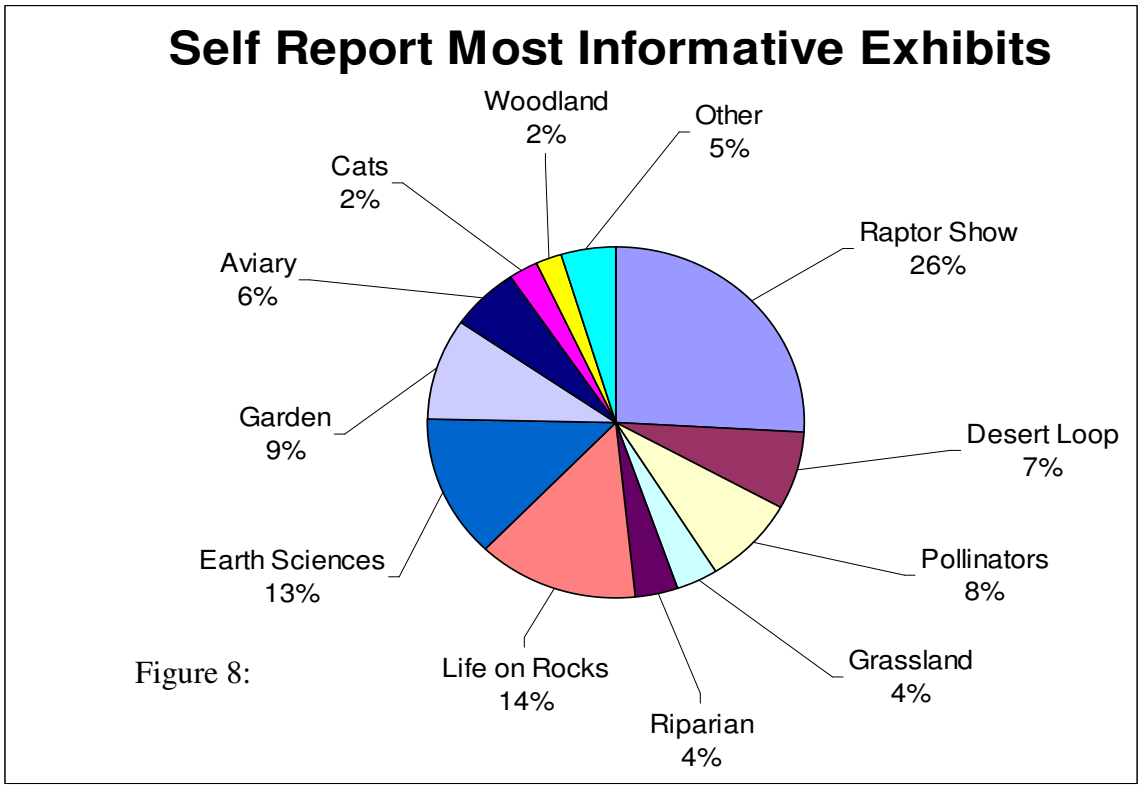
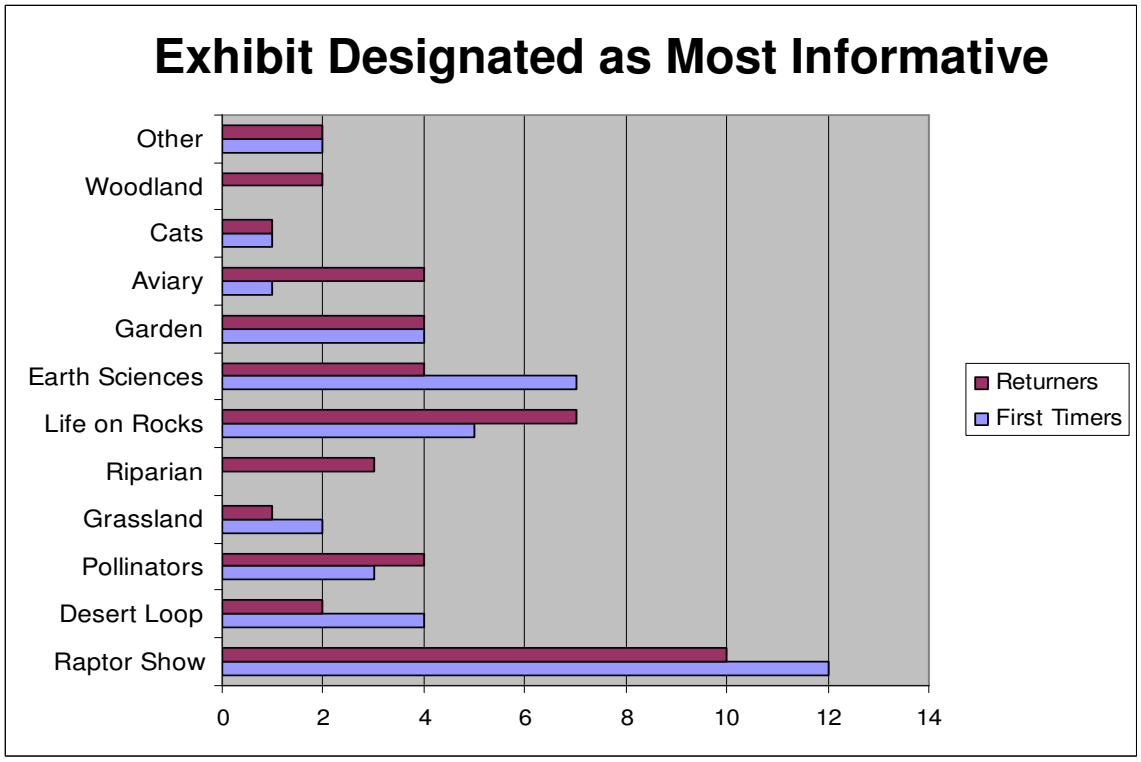


Figure 8:

Figure 8: Comparison of Most Informative Exhibits of First-Time Guests vs. Returners (n=85)



FUTURE IMPLICATIONS:

Site Specific

Individual maps were created for each participant; however more analysis is necessary to create topographic probability maps that reveal the likelihood of a visitor being in a particular location, and therefore provide a measure of time spent at each exhibit. With these topographic maps it will be possible to analyze visitor preferences according to time spent and compare these preferences to their exit survey responses on favorite exhibit and most informative exhibit. Further analysis on intersections will also help determine circulation patterns.

More in-depth studies at the Desert Museum would also be useful, as this study simply helped to pilot methods and serve as a model for future studies. Future studies should be done to expand the exit survey questionnaires to include more detailed questions about the museum experience and assess visitor demographics. Docents might also wear the GPS devices as part of a study on visitor-docent interactions and related circulation patterns.

Broader Applications

Outside of the scope of the Desert Museum, this pilot-study offers promising results for research within a variety of other tourist sites. GPS research could improve visitor studies in zoos, amusement parks, and even hiking trails. Also, the GPS tracking worked surprisingly well inside buildings such as the auditorium, restaurant, and gift shop, which has exciting implications for indoor research. This pilot study could now be

expanded to provide feedback not only to administration within zoos but stores, restaurants, schools, and other public facilities.

It is also possible to find individual implications besides these broad scale patterns measuring consumer behavior. GPS has been used extensively to improve human navigation, but now it could be applied more specifically to individuals to measure everything from how someone utilizes their house to creating specialized exercise plans and researching the movement of the cognitively or visually impaired.

ACKNOWLEDGEMENTS:

I would like to thank Professor W. Jake Jacobs and Pedro Wolf for their valuable input and guidance and research assistant Jonathan Nation for his determination and support. I would also like to thank the Arizona Sonora Desert Museum for the opportunity to analyze this particular sample.

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APPENDIX I: Experiment Instructions and Forms

Desert Museum GPS Experiment Instructions

Set up

- Get briefcase and drive to the Desert Museum (☺)
- Check in at the visitor booth
- Get the table set up in front and put up the advertisement banner
- Insert new batteries into the GPS devices

Recruitment

- When participant approaches, explain study (use researcher script)
- If they agree, give consent form, make sure they sign to participate
- Fill out master list with their GPS # and current time **WHILE**
- Participant fills out address slip (explain that they get slip back when they return device)
- Give GPS to participant (make sure device # matches # on master list and address slip for that participant)
- Tell participant to put the device in their pocket or purse for the visit **AND** to return device when they leave! Also briefly remind them of the five minute survey and free tote bag.

Return

- When participant returns, get GPS device back **AND** write down the time participant returned on master list (by checking GPS #)
- Set GPS aside (must sit for 5 min at table before handed out again)
- Tell participant that now will do a 5 min tape recorded exit survey. Say "No private questions will be asked, however you have the option of going to a room inside if you desire privacy." If they say they need a room, go to the visitor window and ask for a room.
- If not, start the tape recorder. Say "Participant # _____" and then read off the questions.
- Feel free to give clarification if necessary (e.g. You can tell them for Q1 we want any form of distance: miles, meters, ect, but not time spent)

Debriefing

- Thank them for their participation
- Read debriefing sheet
- Give tote bag

Researcher Introductory Script

Navigation Through the Desert Museum as Determined by GPS Tracking and Exit Survey

You are being invited to take part in a research study because you are an adult visitor of the Desert Museum. The present study aims to use GPS to examine how visitors use the Arizona Sonora Desert Museum, linking usage to self-described museum experiences, while providing comprehensive feedback on visitor experiences. This study will serve as a pilot study for research with GPS devices inside of ecological parks or museums. By participating you provide the administration of the Arizona Sonora Desert Museum with data that can be used to improve guest experiences.

If you volunteer to be a part of the study, you will first read and sign a consent form. You will then receive a GPS unit and write down your telephone number and address. This information is kept only while you have the GPS device, so the researcher can contact you if you forget to return it. You will be asked to carry the devise, which makes second-by-second records of latitude, longitude, and speed, throughout your visit. When you turn in the GPS unit to the booth upon exiting, you will receive a Desert Museum tote bag and the slip with your address and phone number. A 5-minute exit survey will also be audio recorded. The oral records will be kept in a locked file cabinet in the faculty advisor's laboratory in the Psychology building at the University of Arizona. After completing data collection, data will be used to analyze museum usage patterns and examine the relations between the GPS information and self-report.

The things that you will be doing have no known risks and the only cost to participating is your time. The information obtained from the GPS devices and the exit survey will be kept confidential. Your participation in this study is voluntary. You may decide not to begin or to stop the study at any time. Your refusing to participate will have no effect on your Desert Museum experience. You can discontinue your participation with no effect on your experience either.

Whom can I contact for additional information?

You can call the Principal Investigator to tell him/her about a concern or complaint about this research study. The Principal Investigators Pedro Wolf, M.S., and Jasmine McBeath can be called at (520) 626-4825. If you have questions about your rights as a research subject you may call the University of Arizona Human Subjects Protection Program office at (520) 626-6721. If you have questions, complaints, or concerns about the research and cannot reach the Principal Investigator; or want to talk to someone other than the Investigator, you may call the University of Arizona Human Subjects Protection Program office. (If out of state use the toll-free number 1-866-278-1455.) If you would like to contact the Human Subjects Protection Program via the web (this can be anonymous), please visit http://www.irb.arizona.edu/contact/

Debriefing Form

Navigation Through the Desert Museum as Determined by GPS Tracking and Survey

This experiment is part of the branch of environmental psychology called Visitor Studies, which aims to improve guests' experiences. It focuses on the perspective of visitors and the environment design of museums. The introduction of Global Positioning Systems (GPS) has inspired an exciting new methodology for visitor studies. This study examines how visitors use the Desert Museum and will link the answers participants gave on the exit survey to their GPS-recorded movement. The study will provide feedback on visitor experiences and serve as a pilot study for research within parks or museums. In addition, the Desert Museum can use the data to improve guest experiences.

If you have any complaints, concerns, or questions about this research, please feel free to contact the Principal Investigator Pedro Wolf, M.S., who can be called at (520) 626-4825.

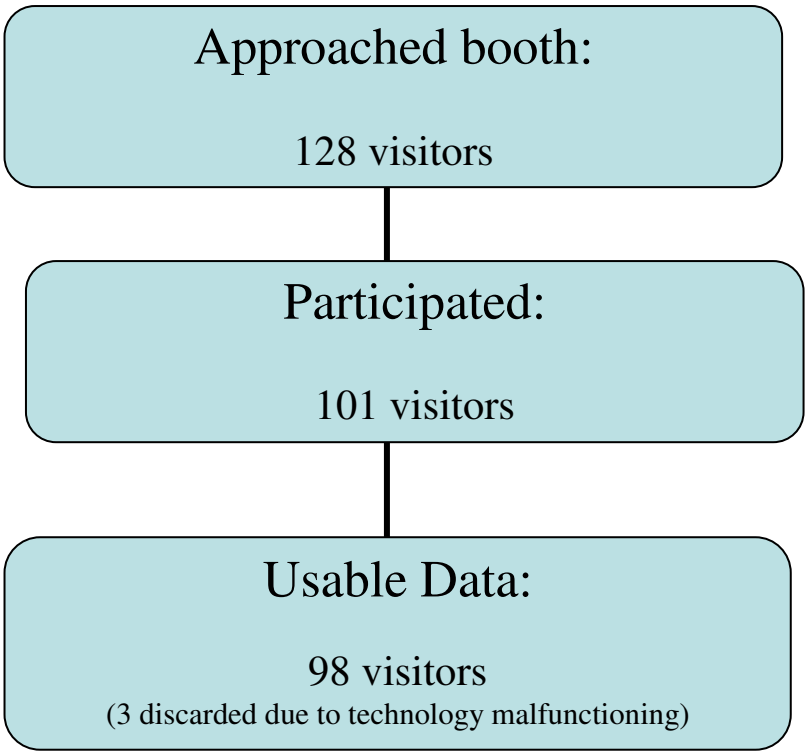
If you are interested in this area of research, you may wish to read the following reference:

Bitgood, Stephen. (2002). "Environmental Psychology in Museums, Zoos, and Other Exhibition Centers." In Bechtel, I. Churchman, A. (Eds.), *Handbook of Environmental Psychology* (pp 461-480). Hoboken: John Wiley and Sons.

Thank you very much for participating!

APPENDIX II.

Visitor Recruitment and Retention



APPENDIX III: Visitor Questions

Appendix III presents a compilation of miscellaneous questions visitors asked the PI or research assistants. Although many are insignificant, research should be done to investigate questions that are asked by multiple visitors. Since most visitors had similar perspectives and desires when entering and leaving the park, many questions were repeated, and overall themes appeared. When entering, visitors wanted to know directional information such as the location of the gift shop, entrance, or bathrooms, along with animal identification and clarification questions. When leaving, many visitors wanted to know more about other local attractions and the best route home. Listed below are the questions and the number of times repeat questions were asked.

Directional Questions and Admission

Do you have a map? (5)
Where's the gift shop?
How much do guides cost? (2)
How much does admission cost?
How much does membership cost?
How long do the shows last?
Where do I enter?
What is the difference between the two entrance lines?

Basic Needs: Food and Bathrooms

Where can we eat near here without paying to enter? (3)
Where can I get coffee? (2)
Where are the restrooms? (4)

Animal Identification Questions

Can you identify this species of plant or animal? (2)
What type of bird is the docent holding? (8)
What is the peak season for cactus blooms?

Local Attractions

What is in Old Tucson?
Where is the Saguaro National Park?
What is up the road from here?
How do you get back to Picture Rocks?
Where is Reservation Road?
Where is a good picnicking site?
What is the fastest way to get to Phoenix or the 1-10? (6)

Other

Does the museum want to sell Navajo items in the gift shop?
Where is the closest grocery store? (2)
What are the hours of the University of Arizona Observatory?