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Does Exposure to Animal Cognition Research Influence the Zoo Visitor Experience?

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Abstract – Zoos average about 183 million visitors per year, which makes them a major source for educating the public due to the diverse and wide-ranging demographic that visit. Zoos are increasingly a source of scientific research in a variety of subfields, including animal cognition, although much of this research takes place behind the scenes. Bringing this research to the public perspective has the potential to increase engagement of zoo visitors. However, it is not always possible to show live research, but videos have been found to be an effective educational approach in other domains. Here, we presented a brief video illustrating cognitive research involving sun bears at Zoo Atlanta to determine the potential effect on visitors. We measured several aspects of visitor *behavior* (stay time and actual behaviors in the exhibit), *attitudes* (towards both animal research and educational technology), and *knowledge* gained at the exhibit. We also presented a control video that focused on sun bear enrichment to tease out whether potential effects on visitors were related to the research focus of the video, or merely an effect of a video playing in the exhibit space. Visitor behavior, attitudes, and knowledge were determined by observing a randomly selected visitor's behavior throughout their time in the exhibit space, and then requesting completion of a survey when they exited the exhibit (N = 148). We compared various aspects of behavior, attitudes, and knowledge across the Scientific Video, Enrichment Video, and No Video conditions. There were no differences between the Scientific Video and the Enrichment Video conditions; however, some differences were found between visitors who experienced a video during their visit (scientific or enrichment video) versus those who did not. Attitudes towards technology in the exhibit space were generally positive. There was also a significant correlation between visitor stay time (overall time spent in the exhibit space) and knowledge gained. Visitors learning about research in zoos remains important, but it is unclear if a video is a sufficient means to share that information.

Keywords – Zoo, Education, Science, Visitor, Sun bear, Cognition

An important duty of the scientific community is to communicate research to the general public. This can be challenging if the data is not communicated in a manner that a member of the general public can understand; oftentimes, it leads to wide-spread misunderstanding regarding scientific data and methods involved. For instance, research with animals - in zoos or other settings - has critically important implications for our understanding of humans. Yet there are many inaccuracies and much misinformation in terms of public understanding of animal research. Informal education settings, such as museums, state parks, aquariums, and zoos, are one critical means through which the general public can learn more about the importance of science and how research is carried out. These settings allow the visitor to learn by interacting with their environment and do not necessarily follow a set structure. It is important to employ effective methods in which scientific data can be communicated with the general public, because improving scientific literacy can narrow the disconnect between public perception and reality of science, especially in fields involving animal research (Funk, 2015; Maple et al., 1995).

As an informal setting, zoos play an integral role in public education, as they have the potential to influence and educate over 183 million individuals each year in the United States alone (Association of Zoos and Aquariums, 2021). With such a wide range of demographics, zoos can provide education to a population that closely resembles that of the general public (Mony & Heimlich, 2008) and serve as an exciting place to reach visitors about science (Bowler et al., 2012; Ross & Gillespie, 2009; Waller et al., 2012; Whitehouse et al., 2014). Zoos engage in a variety of research endeavors including research on conservation, informal education, animal welfare, and cognitive processes. The findings of zoo research can have important implications for the animals in the zoo, wild populations, and the visitors themselves. In fact, research is one of the four aims of modern zoos (conservation, education, research, and recreation), so exposing visitors to research serves the priorities of the zoo as well as educating the general public (Fernandez et al., 2009).

One potential area in which zoos might influence visitors is in promoting public awareness and understanding of the importance of animal research and the methods involved in such research (Smithsonian's National Zoo & Conservation Biology Institute, 2019). There is sometimes the misconception that animal welfare might be compromised during research, despite the extensive measures taken to ensure welfare and the fact that research can be a form of enrichment for animals. In some locations, such as the Orangutan Learning Tree exhibit at Zoo Atlanta, members of the public are able to observe live research with animals during their visit. Exposure to animal research suggests that it may improve overall attitudes towards research methods involving animals (Clay et al., 2011; Egelkamp & Ross, 2018; Perdue, Clay, et al., 2012; Shumaker, 2018). This is likely to be important because misperceptions or misunderstandings about the nature of animal research can have broader implications for zoos and policy. Social license to operate is the idea that many industries, including those involving wildlife, exist within the context of social approval or license to operate (Hampton & Teh-white, 2019). It is important to maintain this trust with the general public and clearly portray an accurate view of animal research rather than one based on misinformation. Hampton and Teh-White (2019) advocate for transparent and proactive engagement with the general public, especially in regard to animal welfare. Displaying animals engaged in research is one way to do so.

Historically, education programs in modern zoos focus on conservation or conveying information relating to a specific species in the exhibit such as social behavior or highlighting animal enrichment using a variety of educational methods such as static signage, docents, videos, and interactive experiences. Static signs featuring facts related to the featured species such as habitat, conservation status, lifespan, and size are prominent in zoos, but they may not attract visitor attention or be the most effective method to educate visitors (Stoinski et al., 2002). Live interpretation by docents can be a highly effective way to educate visitors (Anderson et al., 2003; Heinrich & Birney, 1992; Mony & Heimlich, 2008). However, providing docents and arranging live presentations is not always feasible for zoos, as it requires resources that can be costly. The addition of technology to exhibits offers one potential alternative. Videos and other technological additions have been linked to increased visitor stay time and knowledge gain (Perdue, Stoinski & Maple, 2012; Stoinski et al., 2002).

Advancement in technology has not only directly influenced informal learning opportunities for zoo visitors, but it also allows for advancements in the study of cognitive processes in nonhuman animals. In 1995, the Smithsonian debuted an unprecedented type of exhibit named the "Think Tank." This new exhibit, developed by comparative psychologist Benjamin Beck, focused on mental skills and abilities of several species of primates. The goal of the exhibit was to highlight cognitive capabilities of various primate species by allowing visitors to witness ongoing research with the animals in the exhibit. The Think Tank exhibit was the first of its kind in allowing visitors of a zoo to observe real-time scientific research with animals, thus allowing the general public to better understand animal research and cognitive abilities of nonhuman primates (Beck, 1997). The Think Tank was the first of many permanent zoological exhibits that would openly conduct great ape research under observation of the general public. In Chicago, the Lincoln Park Zoo Regenstein Center for African Apes also features research that the general public can observe.

This research emphasizes animal welfare and structures all studies to be voluntary for the primates, which provides the general public with a better understanding of the methodology and importance of animal research (Ross, 2017). Zoo Atlanta also features an exhibit, the Orangutan Learning Tree, that allows visitors to witness cognitive skills of orangutans participating in research involving touchscreen computers (Perdue, Stoinski & Maple, 2012). The Simon Skjodt International Orangutan Center at the Indianapolis Zoo is another center that displays research that is entirely voluntary for the apes. Visitors can watch the orangutans participate in daily computer-based learning and problem-solving tasks. The main objectives of the center are to maximize animal welfare and to provide visitors with a deeper connection to the apes, resulting in greater concern for conservation. As part of a summative evaluation at the center, first-time visitors were asked to complete a survey that assessed attitudes towards the species in general and conservation efforts related to the species before, immediately after, and six to eight weeks after their initial visit to the center. The results showed improved attitudes towards orangutans immediately after the visitors' visit and in the follow-up evaluations when compared to before their visit - indicating lasting effects from their experience observing orangutan cognitive research (Alexander et al., 2017; Shumaker, 2018). Overall, cognitive research involving great apes serves as positive enrichment for the animals and has received positive feedback from the observing public allowing for greater knowledge and interest in conservation issues (Clay et al., 2011; Egelkamp & Ross, 2018; Perdue, Stoinski & Maple, 2012; Ross, 2017; Shumaker, 2018; Webber et al., 2017; Whitehouse et al., 2014).

In recent years, bears have received increased attention in the animal cognition literature. This increase in bear cognition research has likely arisen in part from improved technologies such as touchscreen computer testing systems (Perdue et al., 2018). Further, bears offer an interesting opportunity for theoretically driven hypothesis testing given the range of various socioecological characteristics across the family that have been linked to cognitive abilities such as diet and social structure. For instance, dietary patterns may influence aspects of cognition such as memory or self-control, and the patterns range within bears from almost entirely herbivorous giant pandas to largely carnivorous polar bears (Perdue, 2016), which allows for testing and advancement of these theories. Recent research has identified a range of abilities in bears such as problem-solving, memory, perception, and learning (Kelling et al., 2006; Perdue et al., 2009, 2011; Vonk & Beran, 2012; Vonk & Johnson-Ulrich, 2014; Vonk et al., 2012; Zamisch & Vonk, 2012).

In zoos, animals and visitors interact in a variety of ways (see Godinez & Fernandez, 2019). This can range from more passive forms of interaction, such as when a visitor simply observes an animal from a distance, to more active forms of interaction in which visitors and animals might play games or compete with one another. If animal-visitor interactions are viewed as a spectrum from passive to active, the display or presentation of cognitive research likely falls somewhere in the middle of the spectrum. By observing an animal engaging in cognitive research, visitors are getting a direct window into the animal mind and thus, may experience the interaction through an "anthropic" frame (Webber et al., 2017). Research suggests that creating an anthropic frame when a human observes another species allows for deeper connection and promotes empathy towards that species because humans tend to relate actions of another species to themselves. For instance, when visitors were interviewed after observing orangutans interacting with digital projections, they would comment on the similarities between cognitive processes: how the orangutan acted "like them" (Webber et al., 2017). In terms of visitor-animal interactions, this exposure to animals engaging with a cognitive research task may have a positive effect on various aspects of the experience, potentially including an increased interest in gaining knowledge about the species. More specifically, does mere exposure to animals engaging in the scientific research process initiate greater interest and engagement with other elements, including the educational ones, in the enclosure space and could this indirect form of interaction positively influence attitudes towards animals in research?

At Zoo Atlanta, the sun bears have participated in several cognitive research projects, including one focused on a touchscreen computer. Bears were trained to use their tongues to touch a screen and make responses on a cognitive task. A previous study found that access to this form of potential cognitive enrichment did not adversely affect the bears in terms of anticipatory stereotypic behavior (Perdue, 2016). We were also interested in the potential benefits towards visitors being able to observe bears taking part in research. Specifically, we wanted to explore how introducing a form of visitor-animal interaction might otherwise influence their experience on the visit. Would seeing the bear "playing a computer game" inspire more attention to the educational content at the exhibit? Would it cause the visitor to spend more time watching the bears? Or change attitudes towards animal research? We were interested in the holistic influence that seeing a bear engage in a cognitive task might have on zoo visitors. Unfortunately, the touchscreen setup is accessible to the bears only behind the scenes, so we instead used a video of the bears engaging in this research that could be played on a monitor installed at the exhibit (see Perdue, 2018 for preliminary data using this approach). So, in the present study we were interested in examining the effect that observing an animal engaging in research on a video monitor might have on several aspects of the visitor experience.

Previous research suggests that observing animals engaging in research can be beneficial to visitors (Egelkamp & Ross, 2019; Perdue, Clay, et al., 2012; Shumaker, 2018) and video monitors may be an effective way to engage visitors when live interactions are not possible (Perdue, Stoinski & Maple, 2012; Stoinski et al., 2002). Therefore, we added a video monitor to the exhibit space to display sun bears engaging in research. We wanted to assess the influence of observing an animal engaging in research on the visitor experience in terms of (a) knowledge gained, (b) visitor behavior in the enclosure, and (c) attitudes towards animals. We anticipated an increase in stay time during the video condition as previous research suggests that the more a display strikes the visitor as novel, the longer they are likely to stay at the exhibit due to increased interaction with the novel display (Bitgood et al., 1986; Ross & Lukas, 2005). The longer a visitor stays in the exhibit and interacts with the display, the more it can be expected that the visitor will possess more knowledge about that species (Serrell, 1997). Therefore, we hypothesized that visitors in the Scientific Video condition would exhibit increased stay time, increased knowledge scores, and improved attitudes as compared to visitors in a video control condition and an overall control condition with only static signage.

Method

Participants

Participants were randomly selected for observation (see Procedure for details) upon entering the Sun Bear and Tiger Terrace at Zoo Atlanta. One researcher observed them using an ethogram (see Materials) for the totality of their visit to the enclosure while a second researcher was positioned near the video monitor to control the display. When exiting the exhibit space, a third researcher stopped the visitor and requested participation in a survey. In total, we observed the behavior of 276 visitors between June 2017 and April 2018. During this timeframe, 128 of the observed visitors declined participation in the survey after being randomly selected and observed and are not included in the data presented here. Of those who were observed but declined participation in the study (N = 128), 60% were female and 78% had children with them. We successfully observed and subsequently surveyed 148 visitors (61% female, 66% with children).

Materials

Experimenter Manipulations

A researcher-controlled video monitor (see Figure 1) was installed in the Sun Bear and Tiger Terrace of Zoo Atlanta and could be turned on or off to meet one of three conditions:

Condition 1 = Scientific Video (SV), see Figure 1
Condition 2 = Enrichment Video (EV)
Condition 3 = No Video (NV), signage only

Figure 1

Top Panel: Monitor Playing Scientific Video or Enrichment Video in the Sun Bear and Tiger Terrace. Bottom Panel: Screenshot from the Scientific Video Condition Illustrating Cognitive Research with Sun Bears at Zoo Atlanta

The Scientific Video featured the principal investigator (B. M. P.) briefly introducing the concept of bear cognition followed by video of the bears interacting with a cognitive task via touchscreen display to receive small treats. The Enrichment Video was of a similar length and featured one of the animal care staff briefly introducing the importance of animal enrichment and then video of the bears interactive with standard enrichment items. There was a small control panel below the monitor. One of the researchers stood near the control panel and used it to start the appropriate video, depending on the condition, five seconds after the selected visitor entered the space. For Condition 3, the researcher stood near the control panel, but did not press the start button for either of the videos when the visitor entered. We employed this targeted starting of the video to ensure that the visitor was present in the enclosure space when the video started.

We included the Enrichment Video condition to serve as a potential control. We anticipated that simply having a video playing in the space might influence visitor behavior. If any effects were found when comparing the Scientific Video condition and the No Video condition, we wanted to be sure the effects were not simply attributable to having a video playing in the exhibit space. Thus, we created a similar length and style of video, but one that focused on enrichment practices with the sun bears. In the case of any significant differences between the Scientific Video and the No Video condition, we would be able to further discern whether differences were related to the live video or to the nature of the scientific research being presented to visitors.

Visitor Behavior, Attitudes, & Knowledge Gain

Overall Stay Time. We also recorded overall stay time at the exhibit by starting a stopwatch when a visitor entered the enclosure and stopping it when they exited.

General Visitor Behavior. A behavioral ethogram was developed (see Table A1 in Appendix A) to describe visitor behavior in the exhibit space using all-occurrence sampling. This included behaviors such as attending to signs, watching animals, and moving through space. The ethogram included distinctly defined behaviors for attending to specific signs in the exhibit space or attending to the video monitor (i.e., "Body and eye gaze oriented in the general direction of sign 1, 2, 3, or 4 OR video monitor", see Table A1). All-occurrence sampling was selected to ensure that all potentially relevant behaviors in the exhibit space would be recorded. To identify relevant behaviors, we observed visitors in the enclosure space during a pilot study in the summer of 2016 and included the commonly observed behaviors.

Knowledge Gained at Exhibit. A survey was also developed (see Appendix B) based on a pilot study to ensure variability in question responses and ensure that fact-based questions based on information presented in the signage were neither too easy nor too challenging for visitors.

Attitudes Towards Animal Research. Visitors were asked to rate agreement with the following statements about animal research and welfare (visitor rated strength of agreement from 1–7):

Bears have impressive cognitive abilities.
Zoos focus heavily on animal welfare.
Research with animals is an important endeavor.
Scientific research is an important part of the zoo mission.
Enrichment is a top priority in animal care at the zoo.
Animals enjoy participating in scientific research.

Attitudes Towards Technology for Visitors at Zoo Exhibits. Finally, visitors were asked to rate agreement with the following statements about technology and educational videos at exhibits, based on the following statements (visitor rated strength of agreement from 1–7):

Videos at an exhibit greatly enhance my visit to the zoo.
I'm likely to pay more attention to videos than signs at exhibits.
I wish every exhibit had an educational video.

Procedure

Data collection took place in the Sun Bear and Tiger Terrace at Zoo Atlanta. Researchers were trained undergraduate students at a local College working in the principal investigator's lab. They wore their everyday clothes in an effort to be inconspicuous in the enclosure space while observing visitors. The exhibit space is an elevated platform that overlooks both the sun bear and tiger enclosures. It is covered by a roof and has one access point through a bridge walkway which leads to entry onto the terrace through a single door location. A predetermined and randomly ordered list was used to determine the condition for each observed visitor prior to them entering the exhibit space (No Video, Scientific Video, or Enrichment

Video to be played). In an effort to randomize participant selection, every fifth visitor to enter exhibit space was selected for observation. One researcher began observing visitors as they entered the terrace through the doorway. A stopwatch was started as soon as the visitor entered the space (i.e., stepped through the doorway) and the researcher unobtrusively observed the visitor using the all-occurrence behavioral ethogram in Table A1 throughout the remainder of their visit to the enclosure. The researcher stood near a corner of the enclosure space with a clipboard and tried to avoid eye contact or attracting the attention of the visitor that they were observing. A second researcher was positioned near the control panel for the monitor and turned on the appropriate video approximately 5 s after the visitor entered the enclosure space. In the video conditions, the second researcher would either play the Scientific Video (Condition 1) or the Enrichment Video (Condition 2). For the No Video condition, the researcher simply moved their hand near the control panel, but did not start a video. In a pilot study, we had the different videos running on a loop for a predetermined amount of time; however, the timing of the videos often did not directly coincide with the visitor being in the space. Thus, we adopted a more targeted approach of starting the video when the selected visitor entered the space to maximize the likelihood that the video was playing when the visitor was in the space.

When visitors prepared to exit the exhibit space, the researcher approached and requested participation in a brief survey (see Appendix B). This was continued until approximately 50 visitors were observed *and* agreed to complete a survey in each of three conditions:

- Condition 1. Scientific Video (SV)
- Condition 2. Enrichment Video (EV), control video condition
- Condition 3. No Video (NV), signage only, overall control condition

The order of conditions across visitors was randomly pre-determined. Researchers used a pre-filled datasheet to determine the condition at the start of each observation. The video was either kept off (Condition 3) or turned to the corresponding video for Conditions 1 or 2 after the selected visitor entered the space. On any given day, data was collected in all three conditions.

Upon exiting, if the observed visitor agreed to complete the survey, the researcher asked a series of questions and recorded their responses. The survey took approximately five minutes. For each surveyed visitor, we had three relevant categories of data resulting from the behavioral observation and survey: behavior, attitudes, and knowledge that were compared across the three video conditions (SV, EV, and NV):

1. Behavior
    a. Overall Stay Time
    b. General Visitor Behaviors
2. Attitudes
    a. Towards Animal Research and Sun Bears
    b. Towards Educational Technology at Zoo Exhibits
3. Knowledge Gain

Statistical Analysis

Pairwise comparisons across the levels of our independent variables (i.e., No Video, Scientific Video, and Enrichment Video conditions) were made using independent sample t-tests with an alpha value of .05. These comparisons were made for the different dependent variables in the categories of visitor behavior, attitudes, and knowledge.

Results

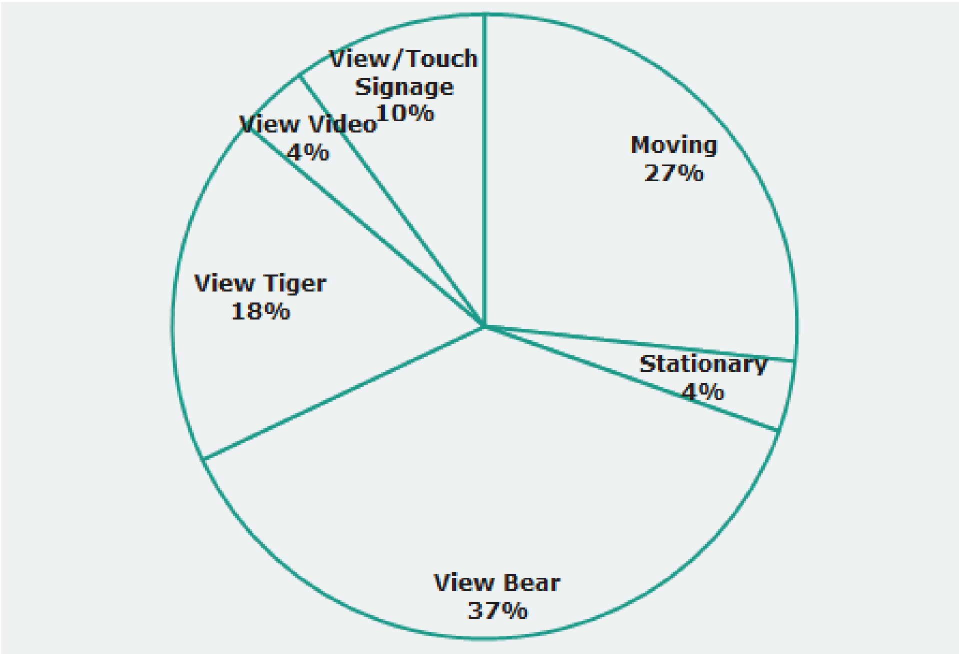
First, we statistically compared the behavior, knowledge, and attitudes in the Scientific Video condition and the Enrichment Video condition to see if there was a direct increase in engagement across our various measures as a result of observing the research in the video. We found no significant differences for any of our measures across video conditions (all *t*'s < 1.79, *p*'s > .076, see Table 1 for exact t and p values). Thus, for the remainder of the analyses, we aggregated the video conditions and compared them to the No Video (signage only) condition in an effort to explore the effect of a video playing at the exhibit.

Behavior

Visitors spent an average of 102 s in the exhibit space and the majority of the time was spent observing animals and moving throughout the exhibit space (see Figure 2). Overall time spent viewing signage was only 8.5 s. However, when visitors who did not attend to the signage at all (n = 89) were excluded from the analysis, the average time viewing signage was 21 s. In other words, those who engaged with signage spent an average of 21 s viewing the information. There were no significant differences in behavior across the Scientific and Enrichment Video conditions (all *t*'s < 1.39, *p*'s > .167, see Table 1 for exact t and p values). However, when both video conditions were collapsed and compared to the No Video condition, we found that visitors spent more time observing the video screen when a video was playing, $t(146) = -3.35$, $p = .001$. There was a marginal difference in overall stay time between the No Video (M = 88.3 s, SD = 39.49) and Video conditions (M = 108.5 s, SD = 68.17), $t(146) = -1.91$, $p = .06$, but this difference did not reach traditional levels of significance. There were no significant differences in time spent viewing, $t(146) = -0.73$, $p = .47$, nor touching signage, $t(146) = -0.90$, $p = .37$ (see Table 2).

Figure 2

Chart Illustrating Visitor Time Spent Engaging in Various Behaviors at the Sun Bear/Tiger Terrace



Note. Overall average stay time was 102 s.

Table 1

Statistical Output Comparing Various Measures in Science Video (SV) versus Enrichment Video (EV) and in in Video Conditions Collapsed versus No Video (NV)

Category	Measure	*t*-value	95% Confidence Interval
	Science Video (SV) versus Enrichment Video (EV)		
Behaviors	Visitor watching video	$t(97) = 0.15, p = .882$	3.15, 3.66
	Total View Signage	$t(97) = -1.2, p = .231$	-11.24, 2.75
	Total Touch Signage	$t(97) = -1.39, p = .166$	-3.04, 0.53
	Total Stay Time	$t(97) = -0.77, p = .442$	-37.87, 16.66
Visitor Ratings	Bears have impressive cognitive abilities.	$t(97) = -1.36, p = .176$	-0.87, 0.16
	Zoos focus heavily on animal welfare.	$t(97) = -1.34, p = .183$	-0.93, .0.18
	Research with animals is an important endeavor.	$t(97) = -0.97, p = .333$	-0.70, 0.24
	Scientific research is an important part of the zoo mission.	$t(97) = -0.13, p = .900$	-0.53, 0.47
	Enrichment is a top priority in animal care at the zoo.	$t(97) = -0.86, p = .391$	-0.80, 0.31
	Animals enjoy participating in scientific research.	$t(97) = 0.67, p = .503$	-0.41, 0.84
	Video enhanced visit	$t(97) = -1.79, p = .076$	-1.54, 0.08
	Likely to pay more attention to videos than signs	$t(97) = -1.08, p = .284$	-1.26, 0.37
	Wish every exhibit had educational videos	$t(97) = 0.062, p = .951$	-0.80, 0.87
Knowledge	Overall knowledge score	$t(97) = -1.40, p = .165$	-0.77, 0.13
	Video Conditions Collapsed versus No Video (NV)		
Behaviors	Visitor watching video	$t(146) = -3.35, p = .001$	-6.53, -1.68
	Total View Signage	$t(146) = -0.73, p = .470$	-8.46, 3.92
	Total Touch Signage	$t(146) = -0.90, p = .369$	-1.95, 0.73
	Total Stay Time	$t(146) = -1.91, p = .058$	-40.91, 0.70
Visitor Ratings	Bears have impressive cognitive abilities.	$t(145) = -0.20, p = .839$	-0.50, 0.41
	Zoos focus heavily on animal welfare.	$t(145) = -0.39, p = .697$	-0.60, 0.40
	Research with animals is an important endeavor.	$t(145) = 1.45, p = .148$	-0.09, 0.62
	Scientific research is an important part of the zoo mission.	$t(145) = 1.02, p = .309$	-0.21, 0.66
	Enrichment is a top priority in animal care at the zoo.	$t(145) = 2.12, p = .035$	0.03, 0.88
	Animals enjoy participating in scientific research.	$t(145) = 0.41, p = .681$	-0.46, 0.70
	Video enhanced visit	$t(144) = -0.53, p = .594$	-0.89, 0.51
	Likely to pay more attention to videos than signs	$t(144) = 0.03, p = .974$	-0.72, 0.75
	Wish every exhibit had educational videos	$t(144) = -0.56, p = .578$	-0.94, 0.53
Knowledge	Overall knowledge score	$t(145) = -0.61, p = .544$	-0.54, 0.29

Survey Responses

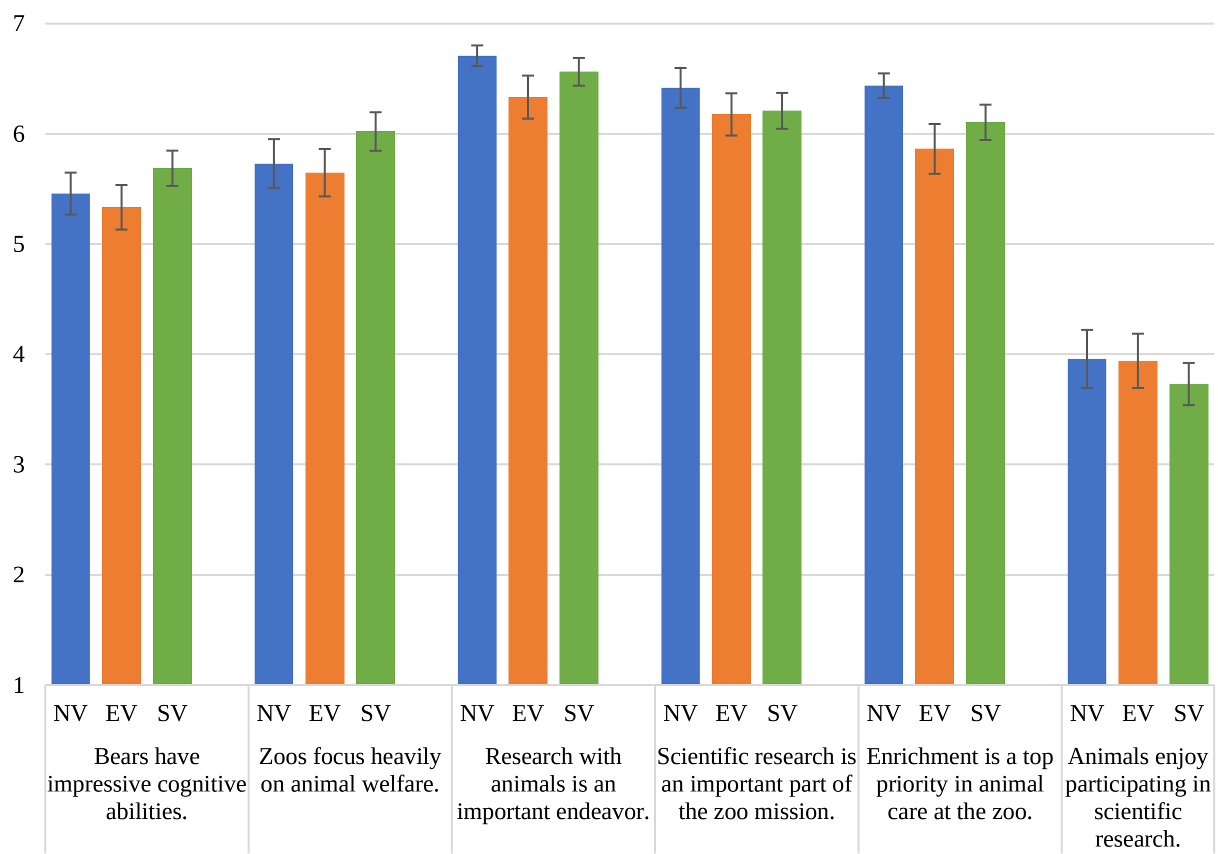
For all survey items, we first compared the Scientific Video to the Enrichment Video. No significant differences were found for any of these measures across video conditions (all t's < 1.79, p's > .076, see Table 1 for exact t and p values) and remaining analyses compare the aggregated video conditions to the No Video condition (signage only).

Attitudes

Survey questions were designed to gather information on ratings of various statements relating to animal research and welfare, and cognitive abilities. There were no significant differences between conditions in terms of the responses to these questions ((all t's < 1.79, p's > .076, see Table 1 for exact t and p values). Overall, responses were largely positive for most questions relating to animal cognition, the importance of scientific research and animal welfare (see Figure 3). Visitors in the No Video condition more strongly agreed with the statement that "Enrichment is a top priority in animal care at the zoo" compared to those in the video conditions, $t(148) = 2.123$, $p = .035$. No other differences were significant when comparing the Scientific Video and the Enrichment Video, nor when comparing the Scientific and Enrichment Video conditions to the No Video condition).

Figure 3

Visitor Ratings of Statements Related to Animals and Research



Note: Visitor attitudes relating to scientific research with animals in No Video (NV), Enrichment Video (EV), and Scientific Video (SV) conditions (1 = strongly disagree to 7 = strongly agree).

Knowledge

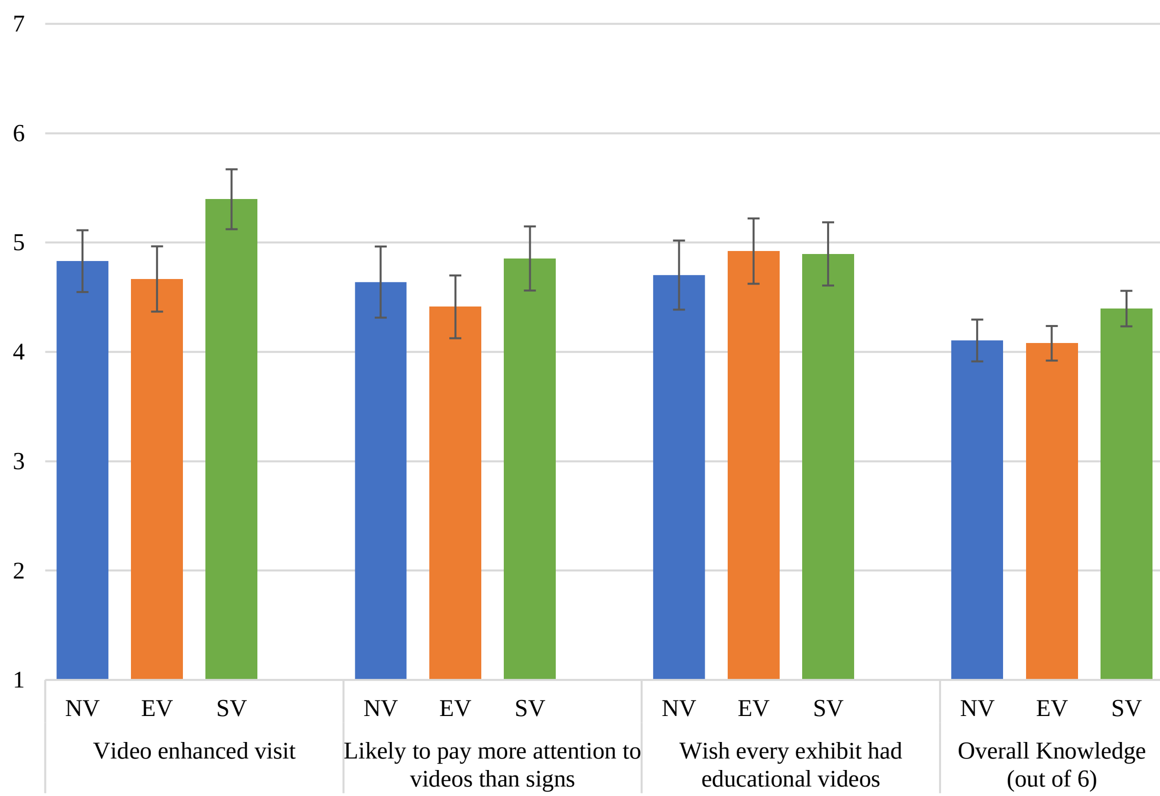
We included several questions about sun bears that could have been observed in the signage throughout the exhibit. Our interest was to assess whether exposure to an animal engaging in cognitive research might influence the learning in the exhibit space. Recall of factual information from the signage was intended as a proxy measure for visitor engagement with the enclosure signage. We created a "total knowledge" score by summing up their scores on the various questions. These total knowledge scores did not differ significantly across video conditions $t(97) = 1.40$, $p = .165$, CI[-0.77, 0.13], nor when comparing the video conditions to no video, $t(145) = -0.61$, $p = .544$, CI[-0.54, 0.29] (see Figure 4).

Educational Video Preferences

A post-hoc series of questions was included in the survey to assess visitor preferences and attitudes towards videos at an exhibit. There were no significant differences across groups (Scientific Video, Enrichment Video, and No Video), but overall rankings of visitor attitudes towards videos were generally positive (see Figure 4). In addition to the high rankings for these items, we found a strong, positive correlation between each of the statements (see Table 2). In other words, those who indicated that videos enhanced their visit also indicated that they were likely to pay more attention and had a desire for educational videos at each exhibit.

Figure 4

Visitor Ratings of Educational Videos and Knowledge



Note. Visitor attitudes about videos playing in the exhibit space in No Video (NV), Enrichment Video (EV), and Scientific Video (SV) conditions Ratings (1 = strongly disagree to 7 = strongly agree) and overall knowledge score total out of 6.

Table 2

Correlations Between Various Items Relating to Visitor Preferences for Videos at the Exhibit Space

Visitor Ratings	Video enhanced visit	Pay more attention to videos	Wish every exhibit had videos
Video enhanced visit	-		
Pay more attention to videos	.511**	-	
Wish every exhibit had videos	.548**	.638**	-

Note: ** $p < .001$

Demographic Variables

Finally, we made comparisons across different variables of interest, including demographic characteristics included in the survey. As shown in Table 3, knowledge gain was significantly correlated with the number of zoo visits in the last year ($p = .013$), a visitor's stay time at the exhibit ($p < .001$), and the amount of time spent reading signage ($p = .007$). There was also a significant correlation between stay time and time spent viewing signage ($p < .001$). We also ran a regression with these factors, including condition and interactions with condition, as predictors of knowledge score. The overall model was significant, $R^2 = .14$, $F(11, 133) = 1.96$, $p = .038$, and it was found that zoo visits significantly predicted knowledge ($\beta = .26$, $p = .028$).

Table 3

Correlations Between Various Aspects of Behavior, Knowledge, and Demographic Characteristics

Demographics/Behavior	View Signage	Total Stay Time	Zoo visits?	Knowledge Gain
View Signage	-			
Total Stay Time	.461**	-		
Zoo visits?	-0.105	0.013	-	
Knowledge Gain	.184*	.222**	.206*	-

Note: $*p < .05$, $**p < .001$

Discussion

This work presents an investigation of how a video illustrating animal research at a zoo exhibit might influence the visitor experience. Because of the potential anthropic lens created by exposure to animals engaging in scientific research (Webber et al., 2018), we predicted that the Scientific Video would yield higher scores compared to the other conditions in terms of attitudes, knowledge, or behaviors such as stay time. However, the results of the current study did not support our hypothesis that exposure to animal research might have broad influences on visitor behavior, including increased stay time, engagement with signage, knowledge gain, and attitude changes. It is possible that exposure to scientific research is not an effective way to create an anthropic lens that inspires greater engagement and learning at an exhibit. However, there may also be limitations that obscured potential effects of the exposure to the Scientific

Research video such as a lack of interactivity or logistical design elements that will be discussed in more depth below.

One possible reason for the lack of difference between video conditions is that the videos were passively played in the exhibit space regardless of visitor behavior or engagement. In other words, the video was turned on to the pre-selected condition once the visitor entered the space. It was entirely possible that someone in the video condition did not attend to the video at all. Exhibits that promote interactivity have been linked to improved outcomes (Boisvert & Slez, 1995; Derwin & Piper, 1988; Sandifer, 2003; Schwan et al., 2014); and this lack of interaction is a likely shortcoming of the current study. Further, given that the terrace overlooked two animal exhibits (sun bears and tigers), it is likely that the animals themselves captured the attention of the visitor. Future work should directly explore this possibility by requiring a visitor to choose to engage with the content. For example, there might be a visitor panel that allows one to press a button to select a scientific video or an enrichment video. Then visitors would be more actively engaged with the content and potentially more likely to be influenced by it. A similar approach might involve having a docent or volunteer announce that a video is about to play in the exhibit space. More active engagement with the content has the potential to yield better outcomes than the passive exposure approach employed here (Anderson et al., 2003).

Because we did not find the predicted effect between the two video types, we more closely examined the general effects of a video playing in the exhibit space on visitor behavior (time spent engaging in various behaviors in the space), knowledge (fact-based questions gleaned from signage), and attitudes towards animal research as well as the importance of videos in exhibits. Some interesting patterns were observed in the data that might contribute to future work and implementing practices for science education at the zoo. There was a trend towards the presence of a video in the exhibit space extending stay time. We found that longer stay time was correlated with greater knowledge gain. Thus, efforts to increase stay time such as videos or engaging content in the exhibit spaces will be an important consideration for exhibit design or anyone intending to increase the educational potential of zoo spaces. However, it is also possible that additional factors, such as prior interest in animals, might influence both stay time and knowledge gain as an unmeasured third factor, and future research should be designed to tease apart the exact nature of the relationship between these variables. Finally, it should be noted that these correlations, though statistically significant, were moderate to low, so there are likely additional factors such as prior interest that future research should continue to explore.

We also found generally positive attitudes towards video installations in exhibit spaces. This is another important consideration as some visitors may view the zoo as a natural escape and may prefer to avoid technology. Davey (2006) discusses the connection between exhibit naturalism and the visitor experience in zoos, including the importance of naturalistic design on visitor perception. Previous research has found support that visitor attitudes tend to be generally positive towards technology at the zoo for both the animals and visitors (Perdue et al., 2011), which is in line with the present study suggesting that educational videos are largely regarded as positive. However, a balance must always be the goal regarding exhibit naturalism and technological advances.

There are several additional factors that might have influenced the results of this study. The video monitor was placed in the corner of the exhibit (largely due to logistical and technological constraints), which may have had some unintended, negative consequence (see Lukito & Arvanda, 2017). The location meant that the video was behind the visitors as they were observing the animals. This placement may have negatively impacted visitor attention to the video screen. The terrace itself also presented some challenges in terms of data interpretation because it is one of the few covered locations in that portion of the zoo. Anecdotally, it seemed that the space was used by visitors to seek respite from the elements (sun, rain, etc.) and visitor behavior and knowledge gain may have been skewed by visitors who were using the area for that purpose. It is also possible that some people realized they were being observed during the behavioral observation period. Researchers were college students wearing everyday clothes who attempted to inconspicuously record data, but nonetheless behavior might have been influenced if a visitor suspected they were being observed.

Future research in this domain might focus on controlling some of the aforementioned issues with particular attention focused on a more interactive interface. Incorporating a broader range of species to highlight the ongoing work in zoos would also be an important development. Finally, creating more contrast between video conditions to emphasize scientific research with animals might allow for a more nuanced evaluation of how showing science to visitors influences their experience. It is likely that the scientific content of the video was not clearly distinctive from the control video focused on enrichment from the visitor perspective. Thus, future explorations regarding how exposure to cognitive research, and its potential to initiate an anthropic frame and increase engagement, should be sure to explicitly highlight the research. Overall, there remains great potential for zoos to serve as an informal education venue for scientific research and play a role in increasing scientific knowledge and literacy in the general public.

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Appendices

Table A1

Behavioral Ethogram Used to Describe Visitor Behavior in Exhibit

Terms	Abbreviation	Operational Definition
Viewing Bear	B	Body and eye gaze oriented in the general direction of the bear exhibit.
Viewing Tiger	T	Body and eye gaze oriented in the general direction of the tiger exhibit.
Viewing Sign 1	S1	Body and eye gaze oriented in the general direction of the sign.
Viewing Sign 2	S2	Body and eye gaze oriented in the general direction of the sign.
Viewing Sign 3	S3	Body and eye gaze oriented in the general direction of the sign.
Viewing Sign 4	S4	Body and eye gaze oriented in the general direction of the sign.
Motion	M	Visitor takes at least two steps in a given direction (includes pauses of up to 3 seconds if another behavior does not occur during that pause interval and then motion is resumed).
Touch Sign 1	T1	Visitors having physical contact using their hand and/or utensil with the sign(s).
Touch Sign 2	T2	Visitors having physical contact using their hand and/or utensil with the sign(s).
Touch Sign 3	T3	Visitors having physical contact using their hand and/or utensil with the sign(s).
Touch Sign 4	T4	Visitors having physical contact using their hand and/or utensil with the sign(s).
Stationary	S	Not exhibiting any orientation towards the exhibit or signs and not taking any steps.
Exhibit Other	EO	Exhibit Other is related to exhibit but not in our immediate observations (i.e., talking about bears or exhibit).
Non-Exhibit Other	NEO	Non-Exhibit Other is related to behavior not pertaining to the bears, tigers, or exhibit (i.e., on the phone, texting, tending to children, etc.).
Watching Video	V	Body and eye gaze oriented in the general direction of the video monitor.

Appendix B

The following questions are based on your opinion. There are no right or wrong answers. Using the following scale, how much do you agree or disagree with the following statements.

1	2	3	4	5	6	7
Strongly Disagree			**Partially Disagree and Agree**			**Strongly Agree**

1. Bears have impressive cognitive abilities. ______
2. Zoos focus heavily on animal welfare. ______
3. Research with animals is an important endeavor. ______
4. Scientific research is an important part of the zoo mission. ______
5. Enrichment is a top priority in animal care at the zoo. ______
6. Animals enjoy participating in scientific research. ______

Please answer the following questions to the best of your knowledge.

1. All bear species hibernate. True or False?
2. Sun bears use their tongues for foraging and exploration. True or False?
3. Which of the following best describes sun bear populations in the wild?
   a. Not threatened in the wild
   b. Threatened in the wild.
   c. Extinct in the wild.
4. Where are sun bears found in the wild?
   a. Asia
   b. Europe
   c. Africa
   d. South America
5. Which of the following best describes the sun bear diet?
   a. Herbivorous (mostly plants)
   b. Omnivorous (plants and meat)
   c. Carnivorous (mostly meat)
6. Comparative cognition research investigates which of the following?
   a. Learning, memory and problem-solving
   b. Social behavior and interactions
   c. Sensory systems
   d. Interaction with enrichment

Did you notice a video playing during your visit to this exhibit? YES or NO If yes:

A. I noticed, but didn't really pay attention to the video.
B. I learned some from the video.
C. I learned a lot from the video.

How much do you agree with the following statements (1=Strongly Disagree – 7=Strongly Agree).

1. Videos at an exhibit greatly enhance my visit to the zoo. _____
2. I'm likely to pay more attention to videos than signs at exhibits. _____
3. I wish every exhibit had an educational video. _____

How many zoo visits in the last year? _____ Age _____ Children? Y N Zoo Member? Y N