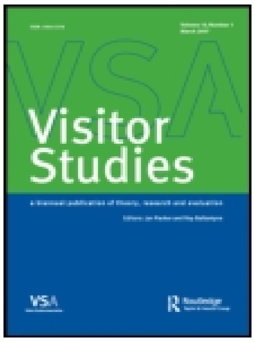

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The Impact of Environmental, Social, and Animal Factors on Visitor Stay Times at Big Cat Exhibits

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ABSTRACT

An accurate understanding of visitor interest is critical to the education and conservation missions of zoos. However, studies that consider multiple influences are rare, and measures such as stay time that have been used to measure visitor interest vary widely, making broader inferences challenging. The authors sought to (a) compare the relative influences of social interactions, animal behavior, environmental factors, and animal species on visitor stay time and (b) evaluate how conclusions vary depending on the metric of stay time used. They conducted 701 direct observations of zoo visitors at a big cat exhibit. The data suggest that animal visibility was a critical factor driving stay time. Animal species played a minor role. The relative importance of the number of other visitors present and animal activity level differed depending on the stay time metric used. Nine other factors examined were relatively unimportant in predicting stay time. These results have important implications for exhibit design, crowd flow management, animal husbandry, collection management, and educational programs in zoos.

With over 700 million annual visitors worldwide, zoos and aquariums are epicenters for human–animal interactions (Gussett & Dick, 2011). These institutions often have public education and wildlife conservation as central missions (Patrick, Matthews, Ayers, & Tunnicliffe, 2007), and these missions are met in large part through informal education, which is often integrated into and motivated by visitor experiences at animal exhibits. Improving our understanding of factors that influence visitor experience may therefore improve the effectiveness of zoos' key education and conservation missions (Mason, 2000). Further, because visitor admission and donations are significant funding sources for zoos and aquariums, ensuring visitor satisfaction is a high priority. Despite the central role of visitor experience in zoos' success in reaching mission-related goals and providing needed resources, more than 50% of zoos have been unable to conduct research on knowledge gains, affective outcomes, or conservation interventions, and zoos almost universally indicate a need for more mission-related research (Luebke & Grajal, 2011). Thus, there is substantial unmet need for information from zoo settings on variables influencing visitor experience and, in particular, their influence on visitor interest. To address this need, we investigated the influence of diverse variables on visitor interest as measured through behaviors of visitors observing big cats within zoo habitats.

Examining the Influence of Multiple Variables on Visitor Interest

A first consideration for measuring visitor behavior is the identification of an appropriate response variable that can adequately represent visitor interest. Much past research on visitor interest has focused on quantifying staff perception of visitor satisfaction, but visitors' evaluations of factors, including exhibit quality and animal welfare, may differ strongly from those of staff (Wilson, Kelling, Poline, & Bloomsmith, 2003). Even surveys of visitors themselves may not accurately quantify visitor interest since actual behavior often differs from reported behavior (Daly & Wilson, 1999). Thus, several authors have suggested explicitly using quantitative, observable metrics relating to visitor interest (e.g., Kellig & Gaalema, 2011).

Stay time, the amount of time a visitor is observed to stay at a particular exhibit, is one common form of data used to compare exhibits in museum (Serrell, 2010) and zoo studies (Kuhar, 2008). Stay time is a measurable, easily understandable metric that quantifies visitor attention and provides a common measure for comparison among different exhibits and is often assumed to be well correlated with visitor interest (National Research Council, 2009; Serrell, 1998). Furthermore, some studies have demonstrated a correlation between stay time and visitor learning (Borun et al., 1998; Serrell, 2010), with researchers looking for an atypical bimodal distribution of stay times to indicate success (Serrell, 2001); that is, a split between relatively short and long stay times suggests that the exhibit in question is effective at engaging a significant proportion of visitors beyond those who take a cursory look and then move on. Stay time also provides a valuable perspective because it is unobtrusive and observable through visitor behavior (Serrell, 2010); as such, stay time is not susceptible to problems related to inaccurate responses to questionnaires and has the potential to account for factors influencing visitor behavior about which the visitors themselves may not be aware.

Although stay time is widely measured by exhibit researchers to quantify visitor interest, how stay time is measured is not completely standardized (Anderson, Kelling, Pressley-Keough, Bloomsmith, & Maple, 2003; Johnston, 1998; Moss, Francis, & Esson, 2008). Measured values can depend on how stay time boundaries are defined and whether time spent reading signs is included (Johnston, 1998). In addition, stay time varies depending on whether it includes all time at an exhibit or just time spent observing the animals; this is particularly relevant for large habitats and animals with sometimes elusive behaviors such as those in our study. To help address this concern, we have taken the unusual step of separately measuring and comparing two alternate measures of stay time to determine if the measurement method affects the determination of the factors that are most important.

Theoretical and Evidence-Based Impacts on Visitor Stay Times

Social Factors: Crowding

Visitors influence one another through effects such as crowding and pointing to animals (Bitgood & Patterson, 1987), and viewing spaces themselves may influence crowding, yet the complex interplay of social variables is still unclear. The mere presence of a crowd seems to draw more visitors to exhibits (Bitgood & Patterson, 1987). Large crowds may additionally animate animal behaviors, which, again, can create even greater draw (Kuhar, 2008; Sekar, Rajagopal, & Archunan, 2008). However, existing studies show conflicting effects of crowding on measures of visitor interest, revealing that visitor density increases visitor interest (Derwin & Piper, 1988), decreases visitor interest (Marcellini & Jenssen, 1988), or makes no difference (Phillpot, 1996). These studies suggest that the exhibit crowd size and overall park attendance may impact experiences, and that visitor group size may also impact behaviors because group behaviors help cue new visitors to animal locations.

Social Factors: Group Composition

Visitors often come to a zoo with a specific intent, such as to provide an enjoyable experience for their children or to escape everyday life (Falk & Storksdieck, 2010). A family group roaming through the zoo will have a very different intent, focus, and behavior pattern than a professional photographer carrying a telephoto lens. Indeed, the large influence of group type and mindset on visitor behavior is well-documented (Falk & Adelman, 2003; Falk & Dierking, 1992, 2000; Ross & Gillespie, 2009). Thus, perceivable group type, ages of group members, and gender composition within groups may also have an impact on visitor stay times.

Social Factors: Interpretation

Studies of the impact of staff presence on visitor interest are hard to come by; interpretive studies usually focus on educational outcomes. However, interpretive talks are known to have an impact on both visitor presence and attentiveness at exhibits (Moss, Esson, & Bazley, 2010), perhaps because interpretive staff enhance viewing opportunities through animal training and interpretive demonstrations (Anderson et al., 2003).

Animal Behavior

The activity level of animals plays a significant role in determining visitor interest levels (Johnston, 1998; Moss & Esson, 2010), especially when felids (cats) are observed (Margulis, Hoyos, & Anderson, 2003). Proximity of the animal to the visitor viewing area and animal visibility also play key roles in holding visitor attention (Johnston, 1998).

Environment

The weather and other environmental factors may influence not only whether a visitor arrives at a zoo, but also visitor interest while at a particular exhibit. For instance, hot, cold, rainy, or otherwise uncomfortable weather may reduce a visitor's interest in observing an animal. Indeed, in a study conducted during the summer, a 10°F (5.6°C) increase caused a 9.5-s decrease in the time visitors stayed at an exhibit (Johnston, 1998).

Animal Species

Among animal-related factors that impact visitors, visitor interest does not vary among individuals or groups within the same species (Mitchell et al., 1990), except when animal infants are present (Bitgood, Paterson, & Benefield 1988). This suggests that visitors view all adults of the same species as equally interesting and do not divide their attention between individual animals unless a baby or juvenile is present. However, past studies have suggested that species identity and animal size strongly influence visitor interest levels, with larger animals generally attracting more interest (Moss & Esson, 2010).

Multiple Variables

A wide range of variables may influence visitor interest in exhibits but, in part due to the complexity and difficulty of measuring them simultaneously, they have rarely been considered in combination (Kellig & Gaalema, 2011). Observational and statistical methods that can clarify the separate contribution of multiple variables on visitor interest, while controlling for confounding factors, are needed to understand the relative importance of each variable.

Goal, Objectives, Hypotheses, and Focus

Our goal in this study was to improve our understanding of the key factors that influence visitor interest at a large exhibit of big cats. Specifically, our first objective was to compare the relative influence of visitor social interactions, visiting group type, presence of interpretive staff, animal behavior, environmental factors, and animal species on visitor stay times. On the basis of previous research indicating that animal activities can strongly impact visitor stay times (Johnston, 1998; Margulis et al., 2003; Moss & Esson, 2010), we hypothesized that animals' visibility, proximity, and activity would play a more significant role in visitor behaviors than other potential factors. Our second objective was to evaluate how the relative influence of these factors vary with distinct metrics of visitor stay times. We used two metrics, animal observation time and attention to habitat time, that represent alternate means of measuring stay time. The two metrics both examine time spent in the exhibit area, but differ in whether they account for visitor search time or visitor distractions, respectively; these metrics are described in further detail below. On the basis of previous studies of stay time indicating that crowds decrease the time visitors spend looking for an animal and enhance interest, we hypothesized that animal observation time would demonstrate different significant social factors, such as crowding, than attention to habitat time (Bitgood & Patterson, 1987). We focused on five exhibits featuring six big cat species at the Philadelphia Zoo, which attracts more than 1.2 million visitors per year (The Zoological Society of Philadelphia, 2014).

METHOD

First Niagara Big Cat Falls of the Philadelphia Zoo

Debuted in 2007, *First Niagara Big Cat Falls* is a naturalist immersive trail exhibit that incorporates touch screens, ambient sound, a short film theater, and an area devoted to the conservation of key cat species through educational tools and fundraising outlets. The exhibit contains five outdoor habitats; the outer two are designed for large crowds and large cat species (African lions, Amur tigers) and the interior three are designed for smaller crowds and smaller felids (pumas, spotted jaguars, melanistic jaguars, snow leopards). At the time of this study, these smaller species were sometimes rotated throughout the three interior habitats. Although spotted and melanistic jaguars are not different species (they are color morphs of the jaguar *Pantera onca*), many visitors may perceive them as distinct, and we therefore treated them as separate species for the analysis in this article. Although most visitors flow counter-clockwise through the exhibit, visitors can flow freely in either direction. This study took place prior to the instillation of the *Cat Walk*, which allows the felid collection to walk over the heads of visitors as they transition spaces.

Data Collection

Data collection was conducted by unobtrusively observing visitor and animal behavior at the main viewing window for each habitat. These outdoor viewing windows are approximately 3.5 meters wide. To ensure data independence when visitors arrived in groups, only one observation was conducted per group; observations were of a single individual of the group selected randomly among those individuals able to choose where to observe on their own accord (typically toddlers and older but not babies). For each observation, we measured 13 variables in four major categories (Table 1); these variables were thought likely to affect visitor stay times (Kellig & Gaalema 2011).

The activity level measure incorporated a four-level coding scheme following Shettel-Neuber (1985), enabling greater detail than the typical approach of qualifying an animal as only active or not (Johnston, 1998). Because day of week and time of day were not the focus of this analysis, we controlled for these variables by stratifying observations of each habitat and species over time. Because the presence of cubs may influence visitor stay times (Bitgood, Patterson, & Benefield, 1988), and not all of the species visitors viewed had cubs during the observation period, we restricted our study to observations of adults without cubs present. One observer collected all data to avoid interobserver differences. To prepare for this research, the observer made a visit to the exhibit on two separate occasions to develop, practice, and refine the coding scheme used in this study to develop a consistent and manageable observation method. During the study, there were three occasions during which the observer was unable to record all variables. Data for the three subjects were removed from the analysis. All observations were completed on 13 days from March 25, 2011, to November 30, 2011.

Deriving Visitor Interest Measures

Total time was the duration of time in the exhibit viewing space (within 3 m of a viewing window). Seeking time was the time that elapsed between arriving in the exhibit viewing space and spotting an animal in the exhibit. Body orientation, hand gestures, eye contact, and facial expression, in conjunction with spoken words, were used to determine the moment a visitor identified an animal. Percent attention to habitat was the percentage of time in the exhibit viewing space in which the visitor's attention was directed towards the animal habitat rather than interpretive elements,

Table 1. *Definitions of stay time variables by category and subcategory*

Category/subcategory	Variable	Definition
Social		
Crowding		
	Group size	The total number of individuals within the observed group.
	Others present	The number of people present in the viewing window space when the study group arrived.
	Attendance	The total zoo attendance for the day.[a]
Group composition		
	Group type	Whether the visitor arrived as an individual (solitary visitor), or part of a pair, family group (one or a few adults with one or a few children), social group (indicating teens or adults with an unknown relationship and no children), or school group (one or more adults and >5 same-aged children).
	Youngest	The approximate age of the youngest member of the group.
	Oldest	The approximate age of the oldest member of the group.
	Portion male	The percentage of the group that was male.
Interpretation		
	Flow	The factors that may influence flow, such as the presence of a guide, an interpretive employee, a professional photographer, or free flow (i.e., none of the above were present) during the observation.
Animal behavior		
	Activity level	An ordinal scale ranging from 0 (*inactive*) to 3 (*highly active*) that captured the activity level of the most active cat. 1 = mildly active in one place, such as grooming; 2 = a cat moving about the habitat at a walk-like pace or playing animatedly with a toy; 3 = rapid movement such as jumping, running. or playing with other cats.
	Visibility	The extent to which an animal was visible. Low = the animal could be found but it was not obvious and searching was necessary; High = the animal was obvious. Cases where the animal was not visible to visitors at all were excluded from the analysis.
	Proximity	The approximate distance of the closest cat to the viewing window.
Environment		
	High temperature	The highest temperature documented at the zoo for the day.[a]
Animal and exhibit		
	Cat species	The species or subspecies.

[a]Data provided by the Philadelphia Zoo.

handheld devices, or other distractions. Attention to the habitat was the duration of extended eye contact, allowing for occasional glances away while maintaining torso orientation toward the viewing window or animal direction. From these we derived two measures of stay time:

$$\text{Animal Observation Time} = \text{Total Time} - \text{Seeking Time}$$
$$\text{Attention to Habitat Time} = \text{Total Time} \times \%\text{Attention to Habitat}$$

Both measures were calculated in seconds. For the first measure, cases in which the animal was not visible or otherwise never located by an observer, and thus with an animal observation time of zero, were excluded from the analysis.

Analysis

Prior to analysis, we identified candidate models that could provide a plausible representation of key factors influencing stay times. These models included different combinations of key variables from Table 1 and their interactions. (See below for further detail on how particular models were identified and selected.) Then we compared the fit of each model using a model estimation and selection procedure. This procedure used a well-established, theoretically supported approach to identifying the most parsimonious model based on information theory (Burnham & Anderson, 2002). Specifically, we selected models with the corrected Akaike's Information Criterion (AICc). AICc is a modification of Akaike's Information Criterion, or AIC, a statistic that ranks candidate models by measuring the relative fit of a model to data while controlling for model complexity (Akaike, 1973). In this way, AIC identifies models that provide maximum inference to other studies and avoids overfitting, a common statistical problem in which models may appear highly precise in one study but perform poorly when applied to other datasets (Burnham & Anderson, 2002). AICc controls for potential biases in AIC when sample sizes are small and converges on AIC values when sample sizes are large (Sugiura, 1978). We compared models with ΔAICc, which is the difference between the AICc value of a candidate model and that of the model with the lowest AICc value; in other words; the best model has a $\Delta\text{AICc} = 0$, and other models with some statistical support have low values for ΔAICc. We used a ΔAICc value of 4 as a threshold for further consideration of a model; models with a $\Delta\text{AICc} > 4$ are generally interpreted as having little support relative to the best model (Burnham & Anderson, 2002).

Because some variables were conceptually related by source of factor influence (Table 1), we used a hierarchical procedure to compare related models at lower hierarchical levels before comparing unrelated ones at higher levels (Hocking & Reynolds, 2011). Our general approach was to first select among related variables by evaluating alternate models containing those variables. We then used only the selected variables in a subsequent suite of plausible models that contained only unrelated variables. This hierarchical procedure enabled us to identify models containing the most appropriate variables while avoiding statistical biases associated with the inclusion of correlated variables in the same model. Specifically, variables in best models from each subcategory were used to determine the set of candidate models examined at the category level, then variables in best models from the category level were used to determine the set of candidate models examined at the full model level (Table 2). Where there was only one variable in a category, this variable was used in the set of candidate models at the next higher level. For simplicity, only simple interaction effects were included, and only at the category and full model levels. Variables likely to be strongly correlated (visibility/proximity and youngest/oldest) were never included in the same candidate model. One potential complicating factor was date; multiple observations were conducted on the same date, but it was unclear whether the particular date of the observation might affect visitor stay time. Such a complication might occur if, for

Table 2. *The best model and all other strongly supported models for animal observation time*

Level	Model type	Model#[a]	Model[b]	Δ_i[c]	w_i[d]
Subcategory	Crowding	S1-2	Oth	0	0.960
Subcategory	Group composition	S2-1	GT	0	0.794
Category	Social	S3-1	Oth	0	0.857
Category	Animal behavior	S4-2	V	0	0.642
		S4-6	AL+V+AL*V	1.307	0.334
Full	Full	S5-8	Oth+V	0	0.377
		S5-19	Oth+V+Oth*V	0.454	0.301
		S5-10	V+Sp	2.674	0.099
		S5-3	V	3.433	0.068

[a]Model numbers are from Supplemental Tables S1–S5.
[b]Variables are: Oth = others present; GT = group type; AL = activity level; V = visibility; and Sp = species. Best models were selected on the basis of AICc.
[c]Δ_i is the difference in AICc between the best and the alternate models in each set. All models with a $\Delta_i \leq 4.0$ are shown.
[d]w_i is the Akaike weight, the weight of evidence for each model given the data (where 1.000 represents the highest likelihood of the model relative to the alternate model).

example, some unmeasured variable, such as whether it was a school day or the occurrence of other activities at the zoo, influenced visitor stay times. We addressed this potential confounding factor statistically by determining whether the date on which observations were completed would affect model selection. Specifically, we evaluated the most comprehensive plausible model that did not contain correlated variables (i.e., the saturated global model at the full model level) both with and without a random effect for date. If the random effect was selected, then model selection proceeded with the random effect as part of all candidate models at that level; otherwise the random effect was left out of subsequent models (Zuur, Ieno, Walker, Saveliev, & Smith, 2009, p. 574). This procedure enabled an accounting of the importance of the random effect after accounting for the effects of all other variables. Particular candidate models used at each level are detailed in the online supplementary materials (Supplemental Tables S1–S15).

The two response variables were examined separately using the same procedure. In each case, the response variables were natural-logarithmically transformed and the variable portion male was arcsine transformed to meet assumptions of normality. Analyses were completed with multiple linear regression of the predictor variables in the candidate models on each response variable, or linear mixed effects models in which random terms were included. Analyses used restricted maximum likelihood (REML) estimation.

RESULTS

We conducted 701 observations of visitors at the five exhibits. Visits from arrival in the exhibit viewing space until departure (i.e., total time) ranged from 5 s to 13 min, 30 s. The average total time was 76.2 s and the median time was 56 s. The following sections describe the partial model findings by factor categories before demonstrating the final full models of both interest metrics.

Animal Observation Time

Partial Models: Subcategory and Category Levels

Among social models that examined the effect of crowding on animal observation time (Supplemental Table S1), the simple model with the sole variable others present was strongly supported over models that included group size, attendance, or combinations of these variables (Table 2 and Supplemental Table S6). Among social models of group composition (Supplemental Table S2), the simple model with the sole variable group type received more support than models that included youngest, oldest, or portion male, or combinations of these variables (Table 2 and Supplemental Table S7). When all social models were compared, including variables in the best crowding and group composition models, the variable flow, and combinations of these variables (Supplemental Table S3), the simple model containing the sole variable others present was the most strongly supported (Table 2 and Supplemental Table S8). Among animal behavior models (Supplemental Table S4), the simple model with the sole variable visibility was supported relatively strongly (Table 2 and Supplemental Table S9). A more complex model of animal behavior that included activity level, visibility, and their interaction, also received some support. In contrast, other models with these variables, and models with the variable proximity, were not supported. Ultimately, the time a visitor spent on observing an animal once it was spotted was influenced by only one social factor—the size of the crowd when that visitor arrived. Other potential social factors such as the ages and the size or type of group the visitor arrived with were insignificant when compared to the role of the crowd size. Similarly, only one animal factor—visibility—played into observation time.

Full model

When full models containing all categories of variables—including social, animal behavior, environmental, and species variables—were compared (Supplemental Table S5), two models received strong support. The best model of animal observation time contained the social variable others present and the animal behavior variable visibility (Table 2 and Supplemental Table S10). An alternate model that was nearly as strongly supported contained both these variables and their interaction (Table 2 and Supplemental Table S10). Two other models, one with visibility and species and one with the sole variable visibility also received limited support (Table 2 and Supplemental Table S10). Further examination of the best full model indicated others present and visibility were both strong predictors of animal observation time (Table 3); with animal observation time increasing as others present and visibility increased. This suggests that when considering all potential social, animal, and environmental factors together, crowds and animal visibility play the greatest combined roles in influencing how much time a visitor spends observing an animal once it is initially spotted.

Further examination of the alternate models indicated additional findings. Although visibility plays a role in many of the best models, several other factors demonstrate a level of importance. For example, it seems that crowds influenced visitors to stay longer even when visibility was poor. In addition, species played a role in determining how long someone observed an animal, and observation times were higher for lions, Amur tigers, and spotted jaguars than for melanistic jaguars, pumas, and snow leopards.

Table 3. *Variable estimates for the top four full models for animal observation time*

Variable[a]	Model A5-8 (Best)			Model A5-19			Model A5-10			Model A5-3		
	Est	*t*	*p*	Est	*t*	*p*	Est	*t*	*p*	Est	*t*	*p*
Intercept	**4.077**	**46.982**	**< 0.001**	**4.249**	**40.794**	**< 0.001**	**4.527**	**31.887**	**<0.001**	**4.262**	**58.729**	**< 0.001**
Oth	**0.025**	**3.724**	**< 0.001**	0.001	0.175	0.862	—	—	—	—	—	—
V[high]	**0.322**	**3.439**	**< 0.001**	**0.571**	**4.525**	**< 0.001**	**0.277**	**2.746**	**0.006**	**0.386**	**−4.116**	**< 0.001**
Oth*V[high]	—	—	—	**−0.040**	**2.904**	**0.004**	—	—	—	—	—	—
Sp[Tiger-African_Lion]	—	—	—	—	—	—	−0.119	−0.068	0.946	—	—	—
Sp[Tiger-Mel_Jaguar]	—	—	—	—	—	—	**−0.491**	**−3.014**	**0.003**	—	—	—
Sp[Tiger-Puma]	—	—	—	—	—	—	**−0.437**	**−2.864**	**0.005**	—	—	—
Sp[Tiger-Snow_Leopard]	—	—	—	—	—	—	**−0.555**	**−3.458**	**<0.001**	—	—	—
Sp[Tiger-Spotted_Jaguar]	—	—	—	—	—	—	−0.268	−1.389	0.166	—	—	—

Note. Values in bold are statistically significant.
[a]Variables are: Oth = others present; V = visibility; Sp = species (difference from Amur tiger).

Table 4. *The best model and all other strongly supported models for attention to habitat time*

Level	Model type	Model #[a]	Model[b]	Δ_i[c]	w_i[d]
Subcategory	Crowding	S1-2	Oth	0	0.983
Subcategory	Group composition	S2-3	Old	0	0.737
Category	Social	S3-6	Old+Flow	0	0.802
Category	Animal Behavior	S4-6	AL+V+AL*V	0	0.678
		S4-4	AL+V	1.834	0.271
Full	Full	S5-3	AL+V+AL*V+Date	0	0.823
		S5-10	AL+V+AL*V+Sp+Date	3.343	0.155

[a]Model numbers are from Tables S1–S5.
[b]Variables are: Oth = others present; Old = oldest; AL = activity level; and V = visibility. Date = date (a random effect for observation date). Best models were selected on the basis of AICc.
[c]Δ_i is the difference in AICc between the best and the alternate models in each set. All models with a $\Delta_i \leq 4.0$ are shown.
[d]w_i is the Akaike weight, the weight of evidence for each model given the data (1.000 represents the highest likelihood of the model relative to the alternate model).

Attention to Habitat Time

Partial Models: Subcategory and Category Levels

Similar to animal observation time, the social models that examined the effect of crowding on attention to habitat time (Supplemental Table S1), the sole variable others present was strongly supported over models that included group size, attendance, or combinations of these variables (Table 4 and Supplemental Table S11). Among social models of group composition (Supplemental Table S2), the oldest group member seemed to be the only significant factor influencing attention to habitat time (Table 4 and Supplemental Table S12). When all social factors were compared together (Table S3 and Supplemental Table S13), the model containing oldest and flow was the most strongly supported (Table 4). Among animal behavior models (Supplemental Table S4), our data provided relatively strong support for a model with activity level, visibility, and their interaction (Table 4 and Supplemental Table S14). Thus, of the observed animal behaviors, animal activity level and visibility influence visitor attention to the habitat space. In contrast, other models with these variables, and models with the variable proximity, were not supported—which suggests that visitor attention to the cats in this study is not influenced by their proximity to the visitor but more so by their visibility and activity.

Full Model

When full models containing all categories of variables—including social, animal behavior, environmental, and species variables—were compared (Supplemental Table S5), one model received considerable support. This model of attention to habitat time contained the animal behavior variables activity level, visibility, and their interaction, along with the random effect of date (Table 4 and Supplemental Table S15). This suggests that the amount of time a visitor spends directing attention to a habitat is influenced most heavily by the animal activity and visibility. Our data also provided some limited support for the model with these variables and the additional variable species (Table 4 and Supplemental Table S15). Much like with the animal observation time, further examination of the best full model indicated that visibility was a

Table 5. *Variable estimates for the top two full models for attention to habitat time*

	Model S5-3 (best)			Model S5-10		
Variable[a]	Est	t	*p*	Est	t	*p*
Intercept	**4.066**	**23.379**	<**0.001**	**4.446**	**14.378**	<**0.001**
AL[0-1]	0.135	0.539	0.590	0.078	0.259	0.796
AL[0-2]	0.031	0.144	0.885	0.064	0.213	0.831
AL[0-3]	0.244	0.825	0.410	0.250	0.676	0.499
V[high]	**0.759**	**3.982**	<**0.001**	**0.626**	**2.125**	**0.034**
AL[0-1] * V[high]	−0.001	−0.003	0.998	0.008	0.025	0.980
AL[0-2] * V[high]	**−0.679**	**−2.565**	**0.011**	0.460	1.330	0.184
AL[0-3] * V[high]	−0.785	−1.654	0.099	0.766	1.445	0.149
Sp[Tiger-African_Lion]	—	—	—	−0.356	−1.461	0.145
Sp[Tiger-Melanistic_Jaguar]	—	—	—	−0.273	−1.328	0.185
Sp[Tiger-Puma]	—	—	—	**−0.389**	**−2.120**	**0.035**
Sp[Tiger-Snow_Leopard]	—	—	—	**−0.598**	**−3.420**	<**0.001**
Sp[Tiger-Spotted_Jaguar]	—	—	—	**−0.713**	**−3.161**	**0.002**

Note. Values in bold are statistically significant.
[a]Variables are: AL = activity level; V = visibility; Sp = species (differences from Amur tiger).

strong predictor of attention to habitat time, and that higher activity level increased attention to habitat time when visibility was relatively low (Table 5). Further examination of the alternate model indicated that both Visibility and Species were strong predictors of attention to habitat time (Table 5), and that two of the species patterns discussed in the partial model—with African lions and Amur tigers, receiving the most attention—held true in the full model. In the full model, however, the melanistic—not the spotted—jaguar appeared to have higher attention to habitat.

DISCUSSION

Factors Influencing Stay Time and Comparison of Stay Time Measures

Only a few of the 13 variables investigated in this study had a strong overall influence on visitor stay times. Specifically, the degree of visibility of an animal was an important driver of stay time in all cases when animals were able to be seen. The visibility variable was part of every overall (full) model with substantial support, regardless of which stay time metric was employed (Table 2 and Table 4). Further, when variables within models were examined further via regression analysis, this variable was significant in all cases and always positively correlated with stay time (Table 3 and Table 5). Thus our results for visibility are highly robust and suggest the particular importance of visibility for promoting visitor interest.

Other variables were dependent on the particular stay-time metric employed. For instance, crowds around an exhibit combined with visibility to influence animal observation time (i.e., how long a visitor remains at an exhibit once the animal is identified in the habitat; Table 2 and Table 3) but not attention to habitat time (i.e., how long a visitor directs his or her attention towards the habitat viewing window; Table 4 and Table 5). On the other hand, Animal activity level combined with visibility to influence attention to habitat time (Table 4 and Table 5) but not animal observation time (Tables 2 and 3). This last finding on animal activity corroborates Johnston's

(1998) study which found animal activity to be one of the key factors (of 50) to impact visitors' stay times. Furthermore, given this study uniquely monitored four levels of animal activity, the significance of the animal activity variable itself demonstrates that greater activity (not just the presence of activity) leads to lengthier visitor stays devoted to observing the exhibit space.

One other variable—animal species, within their respective exhibits—may also play a role in influencing both metrics of stay time. However, support for this conclusion is less robust: Models with this variable were less supported than models without it for both metrics of stay time (Table 2 and Table 4). Nonetheless, these models did have some support and indicated that species (or the habitat in which the species was presented) affected stay time.

In contrast, the other variables—the total attendance at the zoo and the high temperature on the day the visitor arrived, the age and gender of the members of the group with which the visitor arrived, the size and type of the visitor's group, the type of interpretive activities ongoing at the exhibit, and the proximity of the animal to the viewing window during the visit—were all relatively unimportant as predictors of overall visitor interest, under both measures of stay time.

Implications

Measurement of Visitor Interest

Although more research is needed to understand the strength of correlation between stay time and visitor interest, this study helps to illuminate some basic questions about what influences visitors' attention within particular exhibits. Explicit definitions of different stay time measures enabled us to provide greater specificity about how particular variables influenced visitor interest in zoo exhibits. Further, the differences we observed in the two measures suggest that the particular definition used has a bearing on the factors identified as important in influencing stay time. Thus, researchers should carefully define the measure of stay time used in each study and consider using more than one measure to evaluate the responsiveness of their results to the particular definition used. Readers should carefully interpret stay time studies, paying special attention to ensuring that the measure used in a study is relevant to their interests and directly comparable to other studies they consult.

Environmental Variables

It is often assumed by zoo staff that temperature has a profound impact on visitation and visitor stay times (personal observation). This assumption is supported by data suggesting that stay times decrease on hot days (Johnston, 1998). In contrast, model-based inference from our data did not identify temperature as an important influence on visitor stay times. This contrast may result from seasonal variation; previous studies examined only the summer months (Johnston, 1998), whereas our study examined a much wider range of variation across three seasons (high temperatures of 5–37°C). Alternatively, other factors than temperature may simply have a more powerful influence on stay times than temperature or season.

Exhibit Design

Our findings about the importance of animal visibility should be particularly useful to exhibit designers, who have strived to reduce the space between animals and humans over the past few decades (see www.designingzoos.com). According to our research, however, it is not proximity to the big cats that increases interest, but rather how visible the animal is within the habitat. For example, in our observations, visitor stay times were often low at exhibits showing snow leopards. This appeared to be because snow leopards were particularly inclined to perch in places high above the ground and far from the viewing window, and thus were difficult to see. After controlling statistically for visibility, visitor stay time was similar to that of other smaller species of big cats. Thus, once design teams have addressed the husbandry and welfare needs of animals, they might consider how all three dimensions of space, in conjunction with exhibit features and characteristic animal behaviors, interact to influence the visibility of animals to visitors.

The Role of Species

There was some limited support for the influence of the species identity of the cats observed on both measures of stay time. In particular, after controlling for visibility (and activity level in the time attention to habitat model), alternate models suggested that the larger and more well-known species (Amur tigers and African lions) were observed for longer durations than were smaller, less well-known ones (pumas and snow leopards, and sometimes spotted jaguars and melanistic jaguars). There is also some evidence that jaguars have similar appeal as the lions and tigers. Thus, it may be that more familiar animals or larger animals have greater draw. However, because species were always observed in the same habitat, we cannot exclude the possibility that the exhibit itself or the order in which species were visited, rather than cat species identity, was the key underlying factor influencing visitor stay time. In particular, the Amur tiger and African lion exhibits are the largest ones, and (because visitors can only enter *First Niagara Big Cat Falls* through the Amur tiger or African lion exhibits) the first ones that visitors will see. Thus, the effect we have labeled as a species effect may instead result from visitor response to larger exhibits or from visitor satiation (Johnston, 1998) after viewing the first cat in the series. Further research is needed to disentangle these potentially confounding effects. The design of *Big Cat Falls* allows for some species to be interchanged, and recent renovations have made it easier to observe the same species in a variety of habitats. These design features could facilitate the future study of species-level variation while controlling for the role of habitat to a greater extent.

Animal Behavior Management

Because our results suggest that animal visibility and activity were central factors influencing overall stay times, animal keepers—not just exhibit designers—play important roles in influencing visitor interest. For instance, the increased activity of exhibit animals may help to explain the increased stay times of visitors observing keeper chats and training sessions (Anderson et al., 2003). Our results suggest that keepers interested in maximizing visitor stay times may want to engage animals or place food or enrichment tools in particular locations at times and in manners that will facilitate animal activity and visibility, rather than proximity.

Crowds

Of the eight social variables included in the models we tested, the number of other people present at an exhibit at the time of arrival was the most significant variable influencing animal observation time. This is similar to the findings of Moss et al.

(2008), who found that zoo visitors approach crowds more than avoid them. Both studies suggest that a crowd draws a crowd; in other words, the attention paid by others may increase the stay time of a visitor newly arriving at an exhibit. They may also suggest that visitors are encouraged to continue watching a difficult-to-observe animal when other visitors are also investing the time to do so. Support for the latter idea comes from the alternate model for animal observation time—nearly as well supported by the data as the best model—which suggested the number of others present was a particularly important factor when visibility is relatively low. It is worth noting that the others present variable was not important at the full model level for time attention to habitat; this difference between the two response variables may further suggest that there is an inverse relationship between time seeking an animal (including crowd obstruction) and time spent observing it, perhaps because visitors have limited total time available to spend at an exhibit or because of a desire to shorten observations as a means to politely defer to the many others waiting to observe the animal. These possibilities need further study.

Flow and Interpretation

Our results suggest that the presence of an interpreter or guide did not affect overall stay times. One limitation of this study is that breadth and intensity of visitor interpretation were not measured, but these factors could play an important role in the effectiveness of these interventions. It would be interesting to address the relative influence of more active or deliberate interpretive techniques in future studies.

Nonetheless, even though a direct impact on visitor stay times was not observed at the full model level after controlling for other factors such as crowding, interpretive staff could facilitate an indirect impact on visitor stay time through various forms of crowd management. Because our results suggest crowds at an exhibit increase stay times, it might be beneficial to use interpretive staff to help draw crowds towards particular habitats and species where low visibility or low animal activity levels might otherwise lead to short stay times (as in the snow leopard example noted in the Exhibit Design section above). Staff could model visitor *seek and find* behaviors in their messaging and stimulate visitor interest in these species. Such interpretive placement could be particularly beneficial to highlight exhibits or species with themes related to central educational or conservation missions (Weiler & Smith, 2009). Although these ideas are not new, their implementation is still not common practice in many locations.

CONCLUSION

Our findings suggest animal visibility in particular, but also visitor crowding and animal activity, play the greatest roles in driving visitor stay time at big cat habitats. Some evidence also suggested particular species have greater innate appeal to visitors than others, though this effect may be due to the exhibit design or the order in which the exhibits were encountered. Together, these results suggest key factors for exhibit designers to consider when developing future big cat exhibits and may inform the continued development of behavioral management, enrichment, and interpretive strategies at big cat exhibits. Although more research is needed to replicate these findings in exhibits featuring other taxonomic groups and at other zoological parks and aquariums, we make the following suggestions to zoo stakeholders (e.g., education departments, exhibit design teams, animal collections, and keepers) and others wishing to maximize the potential of zoos to serve and attract zoo visitors and promote their role in environmental education and conservation:

- Design exhibits for animal visibility over proximity. Although exhibit designs that encourage animals to move to a window within inches of visitors are surely exciting opportunities, animals are easily obstructed by a handful of visitors. This finding validates the practice, at least in the setting of big cat exhibitry, of designs that emphasize viewing areas that maximize visibility by all visitors within a space regardless of proximity, such as longer viewing windows, raised vantages, multiple viewpoints, or, for climbing species, platforms and portals that enable viewing of vertical spaces. Modern design trends align with this finding, but more research is needed to help parcel out the roles of species, animal size, and other potentially confounding variables in visibility.
- Regulate crowds by directing visitor traffic, creating tools to highlight certain exhibits, or facilitating seeking behaviors that may promote longer stay times to help draw attention to habitats or species that are of particular importance to zoo missions.
- Design exhibits to allow and promote animal movement and—where consistent with animal welfare—engage in programming, feeding activities, and other activities to enhance animal enrichment at times and in ways that enable visitors to observe natural animal activities.

More study of the factors influencing visitor stay times are needed, but it is clear that such studies can provide key information that improves understanding of the experiences of zoo visitors. We would suggest future research pairing visitor interviews with observed stay time within a single study to create deeper understanding of what visitors are experiencing during this time and to evaluate the extent that stay time correlates with self-perceived interest and how visitors' perceptions of their own behavior correlate with measured behaviors. The understanding resulting from such studies can allow zoos to capitalize on their strengths and resources to meet visitor interests while promoting their conservation and education missions.

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SUPPLEMENTAL MATERIAL

Supplementary materials are available for this article. Go to the publisher's online edition of *Visitor Studies* (www.tandfonline.com/uvst) for the following free supplemental resource: Candidate Models.

REFERENCES

Akaike, H. (1973). Information theory and an extension of the maximum likelihood principle. In B. N. Petrov & F. Csáki (Eds.), *2nd International Symposium of Information Theory* (pp. 267–281). Budapest, Hungary: Akadémia Kiadó.

Anderson, U. S., Kelling, A. S., Pressley-Keough, R., Bloomsmith, M. A., & Maple, T. L. (2003). Enhancing the zoo visitor's experience by public animal training and oral interpretation at an otter exhibit. *Environment and Behavior*, *35*, 826–841.

Bitgood, S., & Patterson, D. (1987). Principles of exhibit design. *Visitor Behavior*, *2*(1), 4–6.

Bitgood, S., Patterson, D., & Benefield, A. (1988). Exhibit design and visitor behavior: Empirical relationships. *Environment & Behavior*, *20*, 474–491.

Borun, M., Dritsas, J., Johnson, J., Peter, N., Wagner, K., Fadigan, K., … Wenger, A. (1998). *Family learning in museums: The PISEC perspective*. Philadelphia, PA: The Franklin Institute.

Daly, M., & Wilson M. I. (1999). Human evolutionary psychology and animal behaviour. *Animal Behaviour*, *57*, 509–519.

Derwin, C. W., & Piper, J. B. (1988). The African Rock Kopje exhibit: Evaluation and interpretive elements. *Environment and Behavior*, *20*, 435–451.

Falk, J. H., & Adelman, L. M. (2003). Investigating the impact of prior knowledge and interest on aquarium visitor learning. *Journal of Research in Science Teaching*, *40*, 163–176.

Falk, J. H., & Dierking, L. D. (1992). *The museum experience*. Washington, DC: Whalesback Books.

Falk, J., & Storksdieck, M. (2010). Science learning in a leisure setting. *Journal of Research in Science Teaching*, *47*(2), 194–212.

Gusset, M., & Dick, G. (2011). The global reach of zoos and aquariums in visitor numbers and conservation expenditures. *Zoo Biology*, *30*, 566–569.

Hocking, M. D., & Reynolds, J. D. (2011). Impacts of salmon on riparian plant diversity. *Science*, *331*, 1609–1612.

Johnston, R. J. (1998). Exogenous factors and visitor behavior: A regression analysis of exhibit viewing time. *Environment and Behavior*, *30*, 322–347.

Kellig, A. S., & Gaalema, D. E. (2011). Postoccupancy evaluations in zoological settings. *Zoo Biology*, *30*, 597–610.

Kuhar, C. W. (2008). Group differences in captive gorillas' reactions to large crowds. *Applied Animal Behaviour Science*, *110*, 377–385.

Luebke, J. F., & Grajal A. (2011). Assessing mission-related learning outcomes at zoos and aquaria: Prevalence, barriers, and needs. *Visitor Studies*, *14*, 195–208.

Marcellini, D. L., & Jenssen, T. A. (1988). Visitor behavior in the National Zoo's reptile house. *Zoo Biology*, *7*, 263–269.

Margulis, S. W., Hoyos, C., & Anderson, M. (2003). Effect of felid activity on zoo visitor interest. *Zoo Biology*, *22*, 587–599.

Mason, P. (2000). Zoo tourism: The need for more research. *Journal of Sustainable Tourism*, *8*, 333–339.

Mitchell, G., Obradovich, S., Sumner, D., DeMorris, K., Lofton, L., Minor, J., … Foster, F. (1990). Cage location effects on visitor attendance at three Sacramento Zoo mangabey enclosures. *Zoo Biology*, *9*(1), 55–63.

Moss, A., Francis, D., & Esson, M. (2008). The relationship between viewing area size and visitor behavior in an immersive Asian elephant exhibit. *Visitor Studies*, *11*(1), 26–40.

Moss, A., & Esson, M. (2010). Visitor interest in zoo animals and the implications for collection planning and zoo education programmes. *Zoo Biology*, *29*(6), 715–731.

Moss, A., Esson, M., & Bazley, S. (2010). Applied research and zoo education: The evolution and evaluation of a public talks program using unobtrusive video recording of visitor behavior. *Visitor Studies*, *13*, 23–40.

National Research Council. (2009). *Learning science in informal environments: People, places and pursuits*. Washington, DC: The National Academies Press.

Patrick, P., Matthews, C., Ayers, D., & Tunnicliffe, S. (2007). Conservation and education: Prominent themes in zoo mission statements. *Journal of Environmental Education*, *38*(3), 53–60.

Phillpot, P. (1996). Visitor viewing behavior in the Gaherty Reptile Breeding Centre, Jersey Wildlife Preservation Trust: A preliminary study. *The Dodo, Journal of the Jersey Wildlife Preservation Trust*, *32*, 193–202.

Ross, S. R., & Gillespie, K.L. (2009). Influences on visitor behavior at a modern immersive zoo exhibit. *Zoo Biology*, *28*, 462–472.

Sekar, M., Rajagopal, T., & Archunan, G. (2008). The influence of zoo visitor presence on the behaviors of captive Indian Gaurs (*Bus gaurus gaurus*) in a zoological park. *Journal of Applied Animal Welfare Science*, *11*(4), 352–357.

Serrell, B. (1998). *Paying attention: Visitors and museum exhibitions*. Washington, DC: American Association of Museums.

Serrell, B. (2001). In search of the elusive bimodal distribution. *Visitor Studies Today*, *4*(2), 4–9.

Serrell, B., (2010). *Paying more attention to paying attention*. Retrieved from http://informalscience.org/perspectives/blog/paying-more-attention-to-paying-attention

Shettel-Neuber, J. (1985). *The Whittier Southeast Exhibits: A post-occupancy evaluation and comparison with older exhibits*. Jacksonville, AL: Center for Social Design, Jacksonville State University.

Sugiura, N. (1978). Further analysis of the data by Akaike's information criterion and the finite corrections. *Communications in Statistics, Theory and Methods*, *A7*, 13–26.

Weiler, B., & Smith, L. (2009). Does more interpretation lead to greater outcomes? An assessment of the impacts of multiple layers of interpretation in a zoo context. *Journal of Sustainable Tourism*, *17*(1), 91–105.

Wilson, M., Kelling, A., Poline, L., & Bloomsmith, M. (2003). Post-occupancy evaluation of zoo Atlanta's Giant Panda Conservation Center: Staff and visitor reactions. *Zoo Biology*, *22*, 365–382.

The Zoological Society of Philadelphia. (2014). *Financial statements and report of independent certified public accountants in accordance with OMB Circular A-133*. Retrieved from http://www.philadelphiazoo.org/About-The-Zoo/Audited-Financial-Statements/auditedfinancialstatements.aspx

Zuur, A. F., Ieno, E. N., Walker, N., Saveliev, A. A., & Smith, G. M. (2009). *Mixed effects models and extensions in ecology*. New York, NY: Springer.

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