Animal Behavior and Cognition
ABC 2025, 12(1):122-137
DOI: https://doi.org/10.26451/abc.12.01.06.2025

Examining The Visitor Effect In Zoo-Housed Semi-Aquatic Turtles

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Citation – Thomson, A. S., & O'Brien, S. L. (2025). Examining the visitor effect in zoo-housed semi-aquatic turtles. *Animal Behavior and Cognition, 12*(1), 122-137. https://doi.org/10.26451/abc.12.01.06.2025

Abstract – Zoo visitors constitute a major part of a zoo animal's environment and can have measurable impacts on their behavior and welfare, a phenomenon referred to as the visitor effect. The influence of visitors on animal welfare is generally categorized as positive, neutral, or negative, with most, but not all, studies reporting a negative or neutral relationship. However, most studies on visitor effects have been conducted with mammals, and therefore more research is needed to understand how zoo animals of other taxonomic groups, such as reptiles, are impacted by zoo visitors. At Lincoln Park Zoo (Chicago, IL, USA), a semi-aquatic turtle enclosure is located indoors next to a large children's play structure. This indoor environment can become busy and loud during peak hours, which could impact the turtles' welfare. To assess whether the turtles are collectively impacted by visitors, we recorded the turtles' space use within their enclosure with changing visitor presence and visitor activity. We found no evidence that the turtles' visibility or their propensity to seek coverage was affected by visitor presence or visitor activity. However, our data indicates that the turtles tended to be further from the visitor viewing glass as the number of people on the play structure increased and as visitor noise level increased. The other environmental variables measured -- crowd size in front of the turtle enclosure and tapping on the visitor viewing glass – did not significantly impact turtle space use.

Keywords – Animal welfare, Aquarium, Reptile, Turtle, Visitor effect, Zoo

Maintaining high standards of animal welfare within zoos and aquariums (hereafter referred to as zoos) requires insight into how animals are impacted by their environment. Zoo visitors constitute a major part of a zoo animal's environment and can have measurable impacts on their behavior and welfare (Williams et al., 2023; Sherwen & Hemsworth, 2019), a phenomenon referred to as the visitor effect (Hosey, 2000). The influence of visitors on animal welfare is generally categorized as positive, neutral, or negative, with most, but not all, studies reporting a negative or neutral relationship (Collins et al., 2023; Carter et al., 2021; Sherwen & Hemsworth, 2019). Avoidance behaviors are the most frequently used indicators of a negative response to visitor presence (e.g., Chiew et al., 2020; Learmonth et al., 2018). An animal that is negatively impacted by the presence of visitors is likely to move further from the visitor viewing area or out of sight completely (Collins et al., 2023). Other behaviors that suggest a negative reaction to visitor presence include decreases in the range of enclosure use (e.g., Lewis et al., 2020), increases in hiding (e.g., Sherwen et al., 2015), and decreases in species-typical behaviors (e.g., Spiezio et al., 2023). On the other hand, an animal that is positively impacted by visitors may exhibit approach to or engagement with visitors (e.g., Bloomfield et al., 2015; Cairo-Evans et al., 2022; Jones et al., 2016) or an increase in play behaviors in the presence of visitors (e.g., Williams et al., 2021). Finally, some animals may either not be impacted by visitors, or become habituated to their presence, such that their present response is best characterized as neutral (Sherwen & Hemsworth, 2019).

The negative effects of zoo visitor presence on animal welfare can be exacerbated by negative visitor behaviors, such as banging on parts of the enclosure, crossing the enclosure barrier, and shouting (Collins et al., 2023). Notably, one study found that children were responsible for 80% of these negative behaviors (Collins et al., 2023). In addition to being potentially visually upsetting, or even threatening to animals, these visitor behaviors generate auditory disturbances, with sound levels in captivity often greatly exceeding those found in natural environments (Morgan & Tromborg, 2006). High amplitude noise, especially that which is unpredictable, induces distress responses across multiple species (e.g., Larsen et al., 2014; Orban et al., 2016; Quadros et al., 2014). Additionally, past studies have shown that including measures of crowd activity is important for understanding the visitor effect (e.g., Birke 2002; Choo et al., 2011; Woods et al., 2019), as visitor count in front of an enclosure (i.e., crowd size) may not be a sufficient measure of the visitor influence on its own.

The strength and valence of behavioral responses to visitors has been shown to vary across species (e.g., Carter et al., 2021) and across individuals (e.g., Rose et al., 2020; Stoinski et al., 2012), while some studies have shown both species- and individual-level differences in animals' responses to visitors (e.g., Hashmi & Sullivan, 2020). Collectively, these studies illustrate the complexities of the visitor effect and highlight the need for more research on species- and individual-level responses in order to inform effective management strategies in zoos. Mixed-species exhibits are common in zoos and therefore, assessing how heterospecific groups are collectively impacted by visitors can help inform management strategies at the group level.

Most of the currently available research into the visitor effect within zoos is centered on mammalian species, with a particular focus on non-human primates (e.g., Williams et al., 2023; Cairo-Evans et al., 2022). To illustrate this point, a review of studies on the visitor effect that excluded primates was still composed of 56% mammalian species (Williams et al., 2023). However, zoos care for many non-mammalian species and would, therefore, benefit from research that examines the visitor effect across different taxonomic groups. For example, there are over one hundred thousand reptiles housed within zoos globally (Species360 Zoological Information Management System, 2024) and yet only 9% of visitor effect studies are focused on reptiles (Williams et al., 2023). Thus, there is a clear need for more reptilian-centered studies on the welfare impacts of visitors in zoos to inform taxa-specific care practices that help mitigate negative visitor effects.

The Pritzker Family Children's Zoo at Lincoln Park Zoo (Chicago, IL, USA) recently underwent construction to remove a large children's climbing structure that encouraged running and climbing near animal exhibits with a structure intended to encourage calmer engagement. The new play structure (installed in October 2022) was also situated further from and oriented away from animal enclosures than the previous structure. A semi-aquatic turtle enclosure is located indoors approximately 10 feet away from the new children's play structure. Five individuals from three species reside in the enclosure: one Blanding's turtle (*Emydoidea blandingii*), two wood turtles (*Glyptemys insculpta*), and two spotted turtles (*Clemmys guttata*). The ages of the turtles range from 5 – 21 years, with an average age of 12 years. To assess whether these turtles, collectively, are impacted by visitors, we recorded the turtles' space use within their enclosure with changing visitor numbers and visitor activity levels. We were interested in examining the collective response of the turtles to inform our management strategy, as the turtles share an enclosure and any management decisions resulting from this study would impact all the turtles. Considering that all the turtles have been housed within this enclosure for several years, and previous observations indicated that the turtles typically used various locations within their enclosure throughout the day (O'Brien et al., 2024), we hypothesized that the turtles would have a neutral relationship with visitor presence. More precisely, we predicted that the turtles would show no change in their visibility, coverage (i.e., under a hide structure or underwater), or distance from the visitor viewing glass with increasing visitor numbers or visitor activity levels.

Methods

Ethics Statement

This study was approved by the Lincoln Park Research Committee, the governing body that oversees all research conducted at the institution.

Enclosure

The turtles' enclosure was a semi-circle shape with viewing glass along the curved side (Figure 1A). Visitors were able to move around all sides of the enclosure, although the back side was blocked from visitor view by a large wall. The top of the enclosure was open and there were 0.5-inch gaps between the panes of glass of the viewing window. Overall, the enclosure was approximately 11 x 5 x 6 feet. Specifically, a pond that ran along the viewing window on the animal side measured approximately 132 x 30 x 16 inches at the surface. The land area in the back of the enclosure measured approximately 24 x 96 x 10 inches. The enclosure also included three large logs that sat across the water, a variety of plants (both real and synthetic), naturalistic hide structures (e.g., hollowed rocks), UV lamps (Exo Terra Solar-Glo Mercury Vapor Bulb, 160 Watts), and heat lamps (GE 27216 - 80PAR/HIR/SP10 - PAR38 HIR Halogen Light Bulb, Narrow Spot, 80 Watts). The UV and heat lamps collectively covered areas within the front, middle, and back of the enclosure, providing multiple basking areas. Anecdotally, the turtles were often observed basking in various areas of their enclosure, including next to the visitor viewing glass at the front of their enclosure. The enclosure was located indoors approximately 10 feet away from a children's play structure (Figure 1B).

Data Collection

Observations were recorded 3 – 4 times per day for a total of 31 days during the summer (Mondays – Fridays between 22 June – 4 August 2023), when visitor numbers tend to be high. The observations took place between the hours of 10:00-17:00, when the building is open to the public and after the turtles have been fed by animal care staff. Within a single day, all observations occurred at least one hour apart. Observations lasted approximately 5 min each. Data were collected by three trained observers who had previously established 100% agreement on turtle identification and a minimum of 85% inter-observer reliability for turtle space use. Turtles were identifiable based on their size, coloration, and shell patterns.

The National Institute for Occupational Safety and Health (NIOSH) Sound Level Meter Application downloaded on an iPhone was used to quantify visitor noise levels (LAeq: A-weighted, equivalent continuous sound level in decibels (dBA)). The iPhone used to measure visitor noise levels was placed approximately 5 in from the front, center of the viewing window for a 30 s duration at the start of the observation (NIOSH, 2019). The ZooMonitor application was used to record data (Wark, 2019). In addition to visitor noise level, the other variables collected were the number of visitors near the enclosure (crowd number), the number of visitors on/in the children's play structure (play structure number), and whether any tapping on the visitor viewing window was observed during the observation period (glass tapping). Noise level and glass tapping were considered measures of visitor activity, whereas the number of people in front of the turtle enclosure and on the children's play structure were considered measures of visitor presence. The number of people in front of the turtle enclosure and on the children's play structure were considered separately as these measures could impact the turtles differently based on their proximity to the turtle enclosure.

For each turtle, their locality was recorded as land, water, log, or not visible. When on land, turtle localities were recorded as 'covered' if the turtle was underneath a hide structure or plant or 'uncovered' if the turtle was not underneath anything. When in water, turtle localities were additionally recorded as 'surface' if they were swimming at the surface of the water (i.e., part of their body exposed) or 'submerged'

Figure 1

Turtle Enclosure

Note. A. Image of the top-down view of the turtles' enclosure including markers to denote approximate distance from viewing glass used to classify turtle locations. The size of the enclosure is approximately 11 x 5 x 6 feet. B. Image of the children's play structure, which is ~10 feet away from the turtles' enclosure.

if they were swimming underwater (i.e., full body underwater). If a turtle could not be located after examining all sides of the enclosure, then "not visible" was recorded. Turtles that were not visible were likely hidden underwater, beneath logs. Additionally, each visible turtle's distance from visitor viewing glass was estimated as the number of body lengths each turtle was away from the viewing glass (<1, 1, 2, 3, >3 body lengths; Figure 1A).

Data Analysis

Statistical analyses were performed in R version 4.2.1 (R Core Team 2021). Prior to conducting statistical analyses, visitor noise levels were transformed to a linear scale using the formula 10^(dBA/10). Generalized linear mixed-effects models were used to assess if the turtles were impacted by visitors using the 'lme4' package (Bates et al., 2009). Separate sets of models were constructed for each response variable: turtle visibility (binomial distribution: visible vs. not visible), turtle coverage (binomial distribution: covered on land/submerged underwater vs. uncovered on land/surface swimming), and turtle distance from the visitor viewing glass (Poisson distribution: <1, 1, 2, 3, >3 body lengths). The predictor variables tested were: crowd number (count per observation), play structure number (count per observation), visitor noise level (per observation), and glass tapping (yes/no per observation). The predictor variables were included as fixed effects in all models and were each tested separately in comparison to a reduced model that contained only random effects. The random effects in all models were: turtle ID, observer ID, and time of day. The best-fit model was identified using the Akaike information criterion (AIC) and significant factors within the best-fit model were identified using the 'summary(model)' function in the 'lme4' package (Bates et al., 2009). Models with ≤ 2 AIC values difference were compared using likelihood ratio tests ('lrtest' function in the 'lmtest' package, Hothorn et al., 2015) to determine the best fitting model for each response variable. Due to the limited sample size per species (e.g., 1 Blanding's turtle), we did not attempt to quantify potential species-level effects.

Results

A total of 90 independent observations were collected over 31 days (with a maximum of five turtles observed during each observation). Individual turtle visibility ranged between 65 – 100%. The number of visitors at the turtle enclosure ranged from 1 – 14 individuals (mode = 2). The number of visitors at the children's play structure next to the turtle enclosure ranged from 0 – 35 individuals (mode = 2). Visitor noise levels ranged from 55.9 – 83.0 dBA (mode = 69.5 dBA). Glass tapping was observed during 46.7% of observations.

Turtle Visibility

There was no effect of crowd number, play structure number, visitor noise levels, or glass tapping on turtle visibility. Turtle visibility was best predicted by the reduced model which included only the random effects (AIC =246.20, df = 4). The intercept was significant for this model ($p < .01$). For a full model summary of turtle visibility, see Supplementary Table S1.

Turtle Coverage

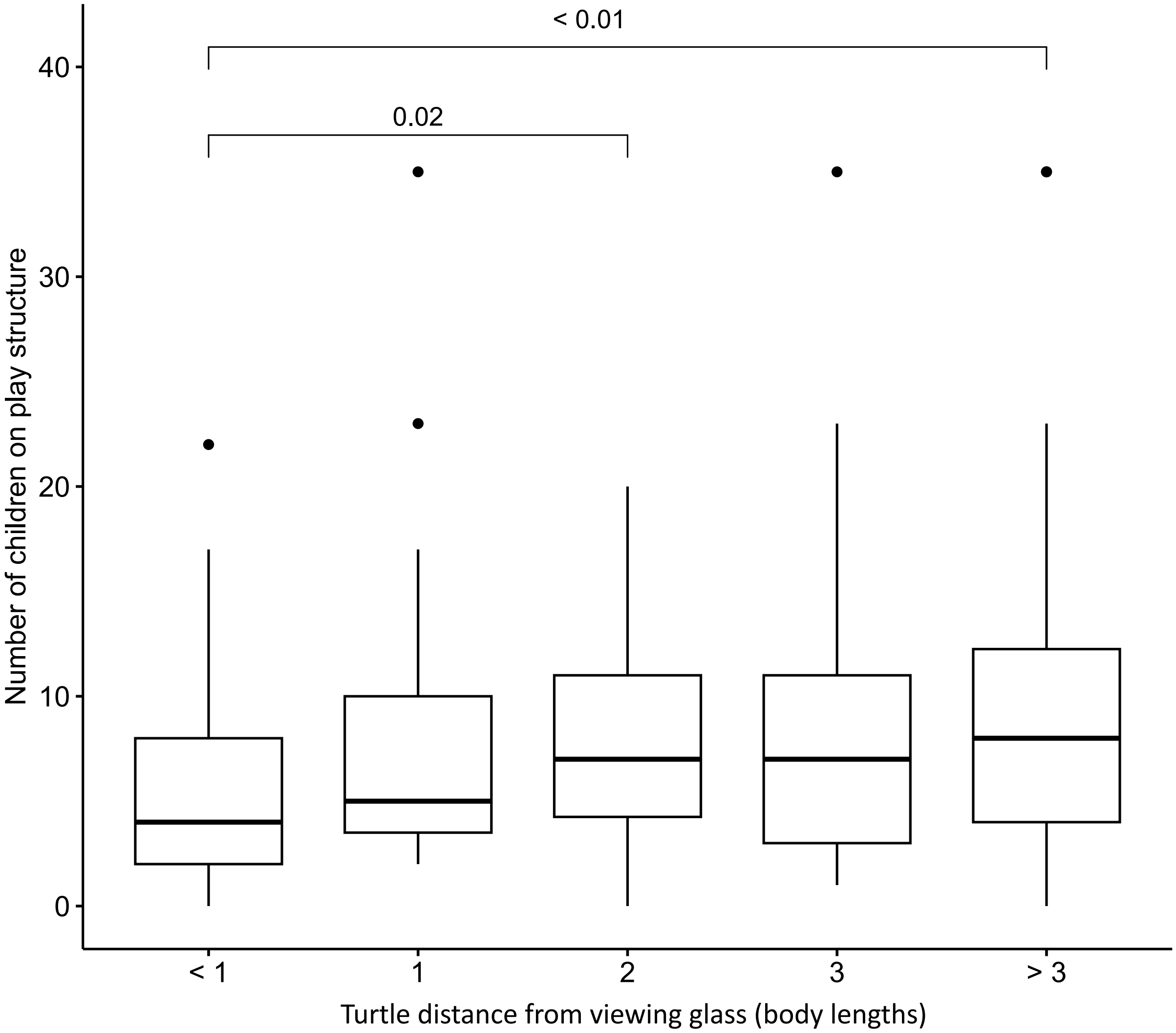
There was no effect of crowd number, play structure number, visitor noise levels, or glass tapping on turtle coverage. Turtle coverage was best predicted by the reduced model which included only the random effects (AIC = 484.90, df = 4). The intercept was significant for this model ($p < .01$). For a full model summary of turtle coverage, see Supplementary Table S2.

Turtle Distance From Visitor Viewing Glass

For models related to visitor presence, turtle distance from the visitor viewing glass was best predicted by the model that included play structure number as a fixed effect (AIC = 1488.40, df = 5). Play structure number ($p = 0.02$) and the intercept ($p < 0.01$) were significant for this model. Specifically, turtle distance from the visitor viewing glass increased as the number of people on the play structure increased (Figure 2). For models related to visitor activity, turtle distance from the visitor viewing glass was best predicted by the model that included visitor noise level as a fixed effect (AIC = 1490.73, df = 5). Visitor noise level was significant for this model ($p = .01$). Specifically, turtle distance from the visitor viewing glass increased as visitor noise level increased (Figure 3). For a full model summary of turtle distance from the visitor viewing glass, see Supplementary Table S3.

Figure 2

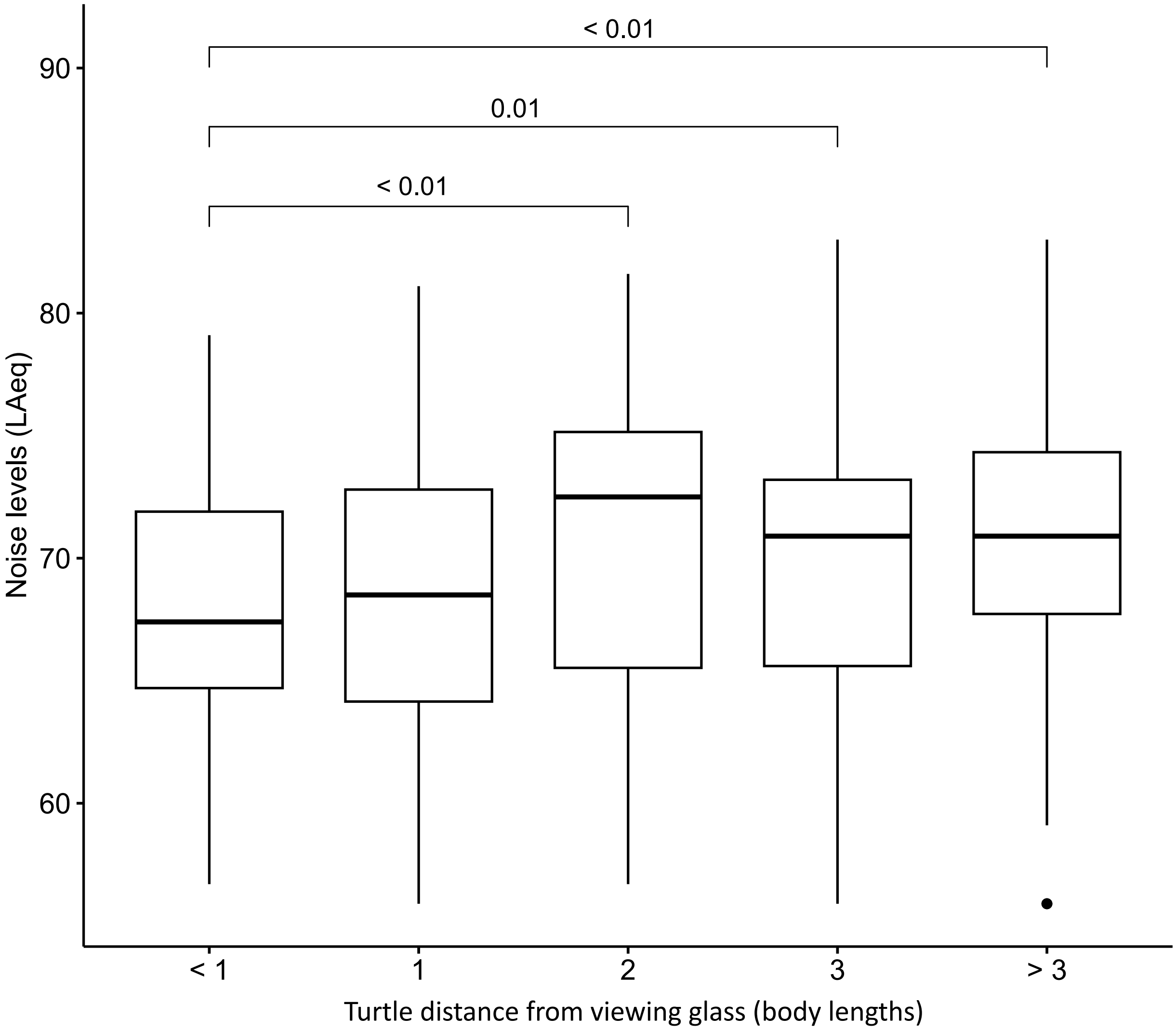
Boxplots of the Number of Children on the Play Structure in Relation to Turtle Distance from the Visitor Viewing Glass



Note. Significant differences between means are denoted.

Figure 3

Boxplots of Visitor Noise Level in Relation to Turtle Distance from the Visitor Viewing Glass



Note. Significant differences between means are denoted.

Discussion

We set out to determine whether zoo-housed semi-aquatic turtles were impacted by visitor presence (crowd size at the turtles' enclosure or at the children's play structure) and visitor activity (noise levels or glass tapping). We found no evidence that the turtles' visibility or their propensity to seek coverage was affected by zoo visitor presence or activity. However, our data suggest that the turtles' distance from the visitor viewing glass was impacted by visitor presence (the number of people on the children's play structure) as well as visitor activity (noise level). Specifically, the turtles tended to be further from the visitor viewing glass as the number of people on the children's play structure increased and as visitor noise level increased. The other variables measured – crowd size in front of the enclosure and tapping on the visitor viewing glass – did not impact the turtles' distance from the visitor viewing glass.

Increased environmental noise in zoos has been repeatedly shown to impact zoo animal behavior and welfare across many species. For example, as visitor noise levels increased, koalas increased vigilance behavior (Larsen et al., 2014), multiple bird species in a free flight aviary stayed further from the visitor pathway (Blanchett et al., 2020), and tamarins showed decreased foraging activity (Steinbrecher et al., 2023). These changes in behavior suggest that these animals find visitor noise levels to be aversive (Quadros et al., 2014). Similarly, visitor presence has also been shown to impact zoo animal behavior (e.g., Carter et al., 2021; Collins et al., 2023; Sherwen & Hemsworth, 2019). Therefore, the change in space use of the semi-aquatic turtles in this study could result from an aversive response to loud visitors, an aversive response to visitor presence, or both, as the turtles tended to be further away from the visitor viewing glass during periods of high noise and high numbers of people on the children's play structure. A high energy crowd, regardless of size, will likely have different impacts on animal welfare than a calm crowd (e.g., Birke, 2002; Ramont et al., 2021; Woods et al., 2019), therefore measuring visitor noise, as an indicator of visitor activity, may be a more informative measure of the visitor effect than crowd size alone. Unlike visual stimuli, auditory stimuli are perceived regardless of whether the animal is paying attention (Quadros et al., 2014), and therefore could be more distressing to animals. Differences in animal sensory modalities (e.g., sight, hearing, vibrational sensitivity) are also expected to impact their response to stimuli, such as zoo visitors near their enclosure.

Previous research has shown that animals may have species- and individual-level responses to visitors (e.g., Hashmi & Sullivan, 2020). Examining potential species-level differences in the turtles' responses to visitors was not possible in this study. Rather, for this study we sought to examine how the semi-aquatic turtles at the Pritzker Family Children's Zoo at Lincoln Park Zoo were collectively impacted by visitors to inform group-level management strategies. The individuals in this study consist of three different semi-aquatic species, all are native to North America and their native ranges include the Great Lakes region of the United States and Canada (Harding & Bloomer, 1979; Litzgus & Mousseau, 2004; Refsnider & Linck, 2012). Despite similar natural history, it is possible that each species may have different responses to visitors; this could be examined in the future by researching the visitor effect with these species across multiple institutions. The ZooMonitor app (Wark et al., 2019)—used to record data for this study—now has multi-institutional capabilities that make this research possible for the future. Broadly speaking, multi-institutional studies may help elucidate whether certain species are more likely to be negatively impacted by visitors, which could inform broad species-specific mitigation strategies. For example, decisions could be made across multiple institutions to house animals that are sensitive to visitors in areas with low visitor traffic, and/or in areas that have off-exhibit access so that the animals may retreat from visitors when they choose.

Collectively, little research exists that investigates how visitor presence and visitor activity impact reptiles specifically. However, some studies have shown that zoo-housed reptiles do respond behaviorally to visitors. One study from the Detroit Zoo during pandemic closures found variable behavioral changes across six reptile species upon renewed visitor presence: decreased social behaviors in Catalina Island rattlesnakes and beaded lizards, decreased visibility in European glass lizards and Sonoran spiny-tailed iguanas, and decreased activity levels in Arrau turtles and dwarf caimans (Hamilton et al., 2022). Another study noted increased aggressive encounters between captive giant Galapagos tortoises during times of higher noise levels (Fieschi-Méric et al., 2022). Together with recent work, our findings further highlight that reptiles are impacted by their environmental conditions and, more specifically, that they react to zoo visitors.

As turtles have been historically considered the least vocal group of reptiles and their hearing has not been well tested (Willis, 2016), it has often been presumed that they have very limited hearing capabilities. Newer technologies that measure brain activity have been used to suggest that turtles are generally able to hear low-frequency sounds between 0.5 to 1 kHz at 60 dB (Mancera & Phillips, 2023), a range that would allow them to hear frequencies well within regular human speech (Quam et al., 2012). Noise levels measured within this study ranged from 55.9 – 83.0 dBA and the turtles tended to be further away as noise levels increased. For context, the sound emitted by a household refrigerator is around 55 dBA (the low range experienced by the turtles in this study), normal conversation is typically between 60-70 dBA, and the sound of city traffic is typically around 85 dBA (the high range experienced by the turtles in this study) (Yale Environmental Health and Safety, 2024). Thus, the turtles in this study likely hear visitors talking and shouting, as well as the lower frequency sounds made by running and climbing on the nearby children's play structure. Ears cannot be simultaneously highly effective in air and water; therefore, turtle ears have been described as constrained to a middle-ground optimization (Willis, 2016). There is some evidence from red-eared sliders that semi-aquatic turtles have evolved better hearing for underwater than for airborne sound (Christensen-Dalsgaard et al., 2012). As for the turtles of this study, it is possible that visitor noise generates surface vibrations within the turtles' pond, which then enhances this noise when the turtles are in the water. The turtles' pond is nearest to the visitor viewing glass (Figure 1A), which could explain why the turtles tended to move away from the viewing glass as sound levels (and presumably vibrations) increased. Turtles may perceive auditory stimuli as threatening because it is likely, but not yet evidenced, that turtles use hearing to avoid predation (Willis, 2016). It has been suggested that anthropogenic sound tends to be more distressing for species that are targets of predators in nature, as auditory signals are frequently used to alert potential danger, and these animals are more easily aroused as a result (Morgan & Tromborg, 2006).

Turtles have well-developed visual structures (Granda & Dvorak, 1977), with the ability to see colors (Corredor et al., 2022; Loew & Govardovskii, 2001). Additionally, there is evidence from black-breasted leaf turtles that at least some species of turtles may be able to focus their eyes independently (similar to chameleons) (Henze et al., 2004). Collectively, these studies illustrate that turtles have advanced eyesight and therefore it should be assumed that the turtles in this study perceive the visitors within their field of view. Interestingly, this study did not find evidence that the turtles were impacted by the visitors in front of their enclosure, rather they were impacted by the visitors on the children's play structure which is approximately 10 feet away from the turtle exhibit. This may indicate that the turtles were not distressed by the visual stimuli of the visitors, but rather the disturbances associated with the children's play structure (e.g., sounds and vibrations). It is possible that the turtles used methods such as turning away or closing their eyes to avoid distressing visual stimuli in a way that is not possible with distressing sounds (other than physical movement away from the noisy source). The back of the turtles' enclosure had an opaque solid wall, which may limit noise and/or provide the turtles with a sense of cover or relief from visitor activity compared to the visitor viewing area at the front of their enclosure, which had 0.5-inch gaps in between the glass windowpanes. These differences between the front and the back of the turtles' enclosure may explain why the turtles tended to be further away from the visitor viewing glass during periods of high noise and high numbers of people on the children's play structure.

The turtle enclosure in this study had various hide structures and plants both on land and underwater that provided the turtles the opportunity to hide from visitors. However, the turtles in this study did not have off-exhibit space that would have allowed them to retreat from visitors, therefore providing turtles with more sound-protected hiding spaces could be an option to enhance their welfare on exhibit. Additionally, altering enclosures to be sound protected could also support better welfare. As an example, a loud HVAC (heating, ventilation, and air conditioning) unit near an anteater enclosure at Disney's Animal Kingdom was surrounded by a sound-reducing barrier, which resulted in a return to positive baseline welfare for the anteaters (Orban et al., 2017). Additionally, measures could be taken to cover the top of open enclosures to help mitigate visitor noise. The addition of well-placed signage (e.g., "please keep your hands to yourself, we're sensitive to vibrations") or a barrier that prevents visitors from coming in direct contact with the turtles' enclosure could also help mitigate visitor effects. Further, the addition of padded rubber flooring (or similar material) in and around the play structure could help dampen sounds and vibrations. Measures taken to sound-proof the turtles' enclosure and to dampen external sounds and vibrations caused by visitors may help address the visitor effects observed in this study. Notably, only the turtles' space use was impacted by visitors, whereas the turtles' general visibility and their propensity to hide were not impacted by visitor presence nor visitor activity. Collectively, these results suggest that the turtles were generally tolerant of visitors, but additional actions taken to mitigate the visitor effect could positively impact the turtles' welfare. Future research could replicate the methods of this study once mitigation strategies are in place to assess their effectiveness and determine whether the mitigation strategies positively impact the turtles' behavior and welfare. In lieu of off-exhibit areas, future research could examine whether the addition of a sound-proof hide structure impacts the turtles' behavior. For example, if the turtles utilize a sound-proof hide during periods of high visitor noise and/or utilize a sound-proof hide more than a regular hide, this could provide strong evidence that the turtles find noise aversive and will seek refuge from noise when provided the opportunity. Further, future research could utilize remote sound loggers and vibrometers placed in various locations throughout the turtles' enclosure to measure the sound and vibrational gradients the turtles are exposed to and whether the turtles preferentially use areas with lower noise or vibrational levels.

There are limitations to acknowledge in this study. First, the sample size of this study prevented us from examining potential species-level effects. However, as mentioned, multi-institutional studies may be able to assess broad species-level patterns in the future. Second, this study lacked a control treatment in which there were no visitors and no visitor-associated noise. Instead, our study compared periods of low visitor and noise levels to periods of high visitor and noise levels, which reflect the naturally fluctuating zoo environment. Third, the social dynamics between the turtles and individual preferences for substrates and enclosure features—which could have impacted their space use—were not directly assessed in this study. Finally, because the turtles do not have off-exhibit access, the turtles may have lacked opportunities to effectively seek refuge in response to visitors, therefore this study was limited to interpreting the turtles' behaviors while on exhibit in the presence of visitors.

Understanding how animals are impacted by visitors is an important part of assessing their welfare in a zoo setting. One simple definition of animal welfare posits that animals have good welfare when they are healthy and have what they want (Dawkins, 2021). Visitors are part of a zoo animal's environment that they have little control over. Examining how zoo animals behave in response to visitors can inform management and care decisions that allow animals to express choice and agency within their environment so that they can respond in desired ways when visitors are present. When animals have appropriate ways to retreat from visitors, it can help provide animals with opportunities to express what they want (e.g., Owen et al., 2005; Wark et al., 2022;), which can help promote good welfare. More generally, this study emphasizes the need for further research into the impact of zoo visitors on reptile welfare and the effectiveness of strategies to mitigate these effects.

Acknowledgements

We would like to thank Spencer Koenig and Allison Ritter who helped collect data for this study and to Dr. Katherine Cronin and Dr. Ignacio Escalante for providing valuable feedback on earlier versions of this manuscript. We would also like to thank the Animal Care staff at Lincoln Park Zoo, especially Maureen Leahy, Dave Bernier, Dan Boehm, Lou Keeley, Lauren Carlson, Annette Van Der Grind, Brittany Childs, and Kelsey Lots. Additionally, we thank The University of Chicago Metcalf Internship Program for funding the internship during which this study took place.

Author Contributions: SLO designed the study. AST collected data. SLO and AST analyzed data and wrote the initial version of the manuscript. SLO revised the manuscript following reviewer feedback.

Conflict of Interest: The authors declare no conflict of interest.

Data Availability Statement: Data are available upon request.

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Supplementary Materials

Table S1

Full Summary of Models Conducted for Turtle Visibility, Including the AIC and df Values for Each Model

Response variable	Predictor type	Model	AIC	df
Turtle visibility	Crowd size	glmer(Turtle Visibility ~ Climber + (1|Turtle) + (1|Observer) + (1|Hour), data=turtlevisitor, family = binomial)	247.64	5
		glmer(Turtle Visibility ~ Crowd + (1|Turtle) + (1|Observer) + (1|Hour), data=turtlevisitor, family = binomial)	247.69	5
		glmer(Turtle Visibility ~ 1 + (1|Turtle) + (1|Observer) + (1|Hour), data=turtlevisitor, family = binomial)	**246.20**	**4**
	Crowd activity	glmer(Turtle Visibility ~ Noise + (1|Turtle) + (1|Observer) + (1|Hour), data=turtlevisitor, family = binomial)	247.86	5
		glmer(Turtle Visibility ~ Tapping + (1|Turtle) + (1|Observer) + (1|Hour), data=turtlevisitor, family = binomial)	248.07	5
		glmer(Turtle Visibility ~ 1 + (1|Turtle) + (1|Observer) + (1|Hour), data=turtlevisitor, family = binomial)	**246.20**	**4**

Note. The best fitting model (based on AIC value) is bolded.

Table S2

Full Summary of Models Conducted for Turtle Coverage, Including the AIC and df Values for Each Model

Response variable	Predictor type	Model	AIC	df
Turtle coverage	Crowd size	glmer(Turtle Cover ~ Climber + (1|Turtle) + (1|Observer) + (1|Hour), data=turtlevisitor, family = binomial)	486.51	5
		glmer(Turtle Cover ~ Crowd + (1|Turtle) + (1|Observer) + (1|Hour), data=turtlevisitor, family = binomial)	486.18	5
		glmer(Turtle Cover ~ 1 + (1|Turtle) + (1|Observer) + (1|Hour), data=turtlevisitor, family = binomial)	**484.90**	**4**
	Crowd activity	glmer(Turtle Cover ~ Noise + (1|Turtle) + (1|Observer) + (1|Hour), data=turtlevisitor, family = binomial)	486.90	5
		glmer(Turtle Cover ~ Tapping + (1|Turtle) + (1|Observer) + (1|Hour), data=turtlevisitor, family = binomial)	486.73	5
		glmer(Turtle Cover ~ 1 + (1|Turtle) + (1|Observer) + (1|Hour), data=turtlevisitor, family = binomial)	**484.90**	**4**

Note. The best fitting model (based on AIC value) is bolded.

Table S3

Full Summary of Models Conducted for Turtle Distance from Viewing Glass, Including the AIC and df Values for Each Model

Response variable	Predictor type	Model	AIC	df
Turtle distance from viewing glass	Crowd size	**glmer(Turtle Distance ~ Climber + (1|Turtle) + (1|Observer) + (1|Hour), data=turtlevisitor, family = poisson)**	**1488.40**	**5**
		glmer(Turtle Distance ~ Crowd + (1|Turtle) + (1|Observer) + (1|Hour), data=turtlevisitor, family = poisson)	1492.68	5
		glmer(Turtle Distance ~ 1 + (1|Turtle) + (1|Observer) + (1|Hour), data=turtlevisitor, family = poisson)	1491.62	4
	Crowd activity	**glmer(Turtle Distance ~ Noise + (1|Turtle) + (1|Observer) + (1|Hour), data=turtlevisitor, family = poisson)**	**1490.73**	**5**
		glmer(Turtle Distance~ Tapping + (1|Turtle) + (1|Observer) + (1|Hour), data=turtlevisitor, family = poisson)	1493.33	5
		glmer(Turtle Distance ~ 1 + (1|Turtle) + (1|Observer) + (1|Hour), data=turtlevisitor, family = poisson)	1491.62	4

Note. The best fitting model (based on AIC value) is bolded.