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Lion, Ungulate, and Visitor Reactions to Playbacks of Lion Roars at Zoo Atlanta

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Felids in captivity are often inactive and elusive in zoos, leading to a frustrating visitor experience. Eight roars were recorded from an adult male lion and played back over speakers as auditory enrichment to benefit the lions while simultaneously enhancing the zoo visitor experience. In addition, ungulates in an adjacent exhibit were observed to ensure that the novel location and increased frequency of roars did not lead to a stress or fear response. The male lion in this study roared more in the playback phase than in the baseline phases while not increasing any behaviors that would indicate compromised welfare. In addition, zoo visitors remained at the lion exhibit longer during playback. The nearby ungulates never exhibited any reactions stronger than orienting to playbacks, identical to their reactions to live roars. Therefore, naturalistic playbacks of lion roars are a potential form of auditory enrichment that leads to more instances of live lion roars and enhances the visitor experience without increasing the stress levels of nearby ungulates or the lion themselves, who might interpret the roar as that of an intruder.

Most modern zoos, in a desire to enhance nonhuman animal well being and improve visitor experience, exhibit their animals in naturalistic habitats (Finlay, James, & Maple, 1988). However, these exhibits may be disappointing for
visitors if they cannot locate the animals because of natural camouflage or hiding spots (Bashaw & Maple, 2001). This problem may be exacerbated by animals’ inactivity during peak visitor hours (Bitgood, Patterson, & Benefield, 1988), particularly for species who do not follow diurnal activity patterns. Thus, a conflict may exist between ensuring animal welfare and zoo visitor satisfaction.

Zoo personnel have used various approaches in an attempt to increase the activity levels of animals in the zoo during visitor hours given that increased activity enhances the potential educational and entertainment value of the zoo experience (Altman, 1998; Bitgood et al., 1988; Margulis, Hoyos, & Anderson, 2003). One way to increase the activity levels of zoo animals during peak visitor hours is to schedule the provisioning of environmental enrichment during those hours. Environmental enrichment is a term for anything used to improve the psychological and physiological welfare of animals in captivity (Shepherdson, 1998). This definition usually refers to devices and objects placed into an exhibit, but it can also include training and events that may induce arousal, such as brief threatening events, assuming they are determined to be enriching and not detrimental to welfare (Moodle & Chamove, 1990). Thus, naturalistic playbacks can be a useful form of enrichment (e.g., Shepherdson, Bemment, Carman, & Reynolds, 1989). The impact of enrichment on welfare can be examined through usage time; stress hormone levels; and behavioral change, notably decreases in stereotypic or other abnormal behaviors and increases in species-typical behaviors (Crockett, 1988). Recent research has explored the effects of various sensory modalities of environmental enrichment on the well being of zoo animals (see Mellen & MacPhee, 2001, for a discussion), but considerably less attention has been devoted to evaluating how these programs affect the zoo visitor experience.

The African lion is a captive animal who provides an excellent opportunity to examine the effects of environmental enrichment programs on zoo visitors and lions. African lions are typically nocturnal animals; exhibiting activity peaks after 17:00 and before 08:00 (Schaller, 1972). However, Schaller (1972) reports that lions will hunt throughout the day, suggesting that increasing daytime activity should not be detrimental to welfare. Although captive lions may exhibit somewhat altered activity peaks that reflect husbandry routines, they often spend a large portion of time resting during zoo operating hours. This pattern of activity could have a definitive impact on the zoo visitor experience. Margulis et al. (2003), for instance, determined that the average number of visitors to the lion exhibit and visitor interest were significantly greater at a lion exhibit when the cats were active as opposed to inactive. There is evidence that environmental enrichment programs can increase activity levels of captive lions. Bashaw, Bloomsmit, Marr, and Maple (2003) demonstrated that the provisioning of bones to lions on exhibit resulted in decreased resting and increased activity levels on the day of bone presentation and an increased amount of time spent in
areas visible to zoo visitors. However, care must always be taken to ensure that alteration of behavior does not result in detriments to animal welfare. Lion behavior is obviously greatly altered by captivity, but even in the wild, felids will willingly hunt throughout the day (Schaller, 1972), suggesting that increasing daytime activity may be beneficial, especially if it is achieved through an increased variety of behaviors.

Based on the natural history of the lion and on the results of studies of free-ranging lions, the playback of lion vocalizations as a form of auditory enrichment emerged as a potential means to both increase the vocal behavior of lions in captivity and to stimulate visitor interest. Informal observations of visitors by the authors of this study indicated that, upon hearing roaring, there was a tendency of visitors in other parts of the zoos to orient to roars and to subsequently relocate to the lion exhibit. The use of auditory playbacks during peak visitor hours thus offered the potential to enhance visitors’ perception of lion visibility and their educational experience. Additionally, the frequency of lion roars vary greatly each day, with averages reported as high as 29 for a nomadic male (Schaller, 1972). Approximately 25% of these roars were preceded by distant roars. Therefore, playback of a few roars per day was not expected to result in animal welfare detriments, and on the contrary, it had the potential to be enriching.

The lion is the most social of the big cats, living in prides that consist of several females, subadults and cubs, and one or more males. Schaller (1972) found that although all pride members willingly interact with each other, they tend to avoid members of other prides despite overlapping territories. Territories are vital for reproduction, and pride members occasionally must defend these territories. Lion roars function as advertisements of territories and to maintain communication with pridemates (Grinnell & McComb, 2001; Heinssohn, 1997; McComb, Packer, & Pusey, 1994; Schaller, 1972). These loud, low-frequency vocalizations “are delivered in bouts, which typically last 30–60 s and consist of several soft introductory moans, a series of full-throated roars and a terminating sequence of grunts” (Grinnell & McComb, 2001, p. 94). It has been shown that roaring is a flexible behavior governed by the conflict of communicating with coalition companions versus potentially advertising their location to resident males whose territories they are in, with males often remaining silent, even after playbacks of roars, if they are outside their territory (Grinnell & McComb, 2001).

Studies in the wild have demonstrated that the lion reactions and frequency of lion roaring may be influenced by auditory playbacks. Research has found that lions can use roar playbacks to adapt their frequency and mode of approach based on the number of intruders featured in the playback and number of pride members, approaching three intruders less often (females) and more cautiously (males and females) than a single intruder (male lions: Grinnell, Packer, & Pusey, 1995; female lions: McComb et al., 1994). The differences suggest that roaring could serve different purposes for males and females. The previous studies all
took place in Tanzania in either Serengeti National Park or Ngorongoro Crater; thus there is a lack of studies of roar playbacks in captivity.

The effects of roar playbacks on potential listeners must be taken into consideration. Zoos typically house a number of ungulate species who when free-ranging serve as a prey base for the lion. Although it is likely that these animals in zoos may already be habituated to the roaring of exhibited lions (e.g., Stanley & Aspey, 1984), it is possible that an increased frequency of roars, via speakers and as a potential lion response to playbacks, might elicit antipredator behavior in these animals. Though this response would likely constitute a species-typical one, Shepherdson (1998) points out that some behaviors performed by animals in the wild, such as predator avoidance, do not seem consistent with enhanced well being in captivity. This issue is a difficult matter to reconcile because although the prolonged effects of stressors may induce pathological processes, the initial psychobiological activation to stressors allows for the adjustment of an organism to changes in its environment (Maschke, Rupp, & Hecht, 2000). Therefore, it seems that judicious exposure to natural stressors may confer an advantage on the captive wild animal, particularly in those populations who may be part of reintroduction programs. It is especially important that the exposure of ungulates to predator vocalizations, incidental or otherwise, include an evaluation of behavioral response and psychological well being. Furthermore, a male lion naïve to the sound of his own roar via a remote source may interpret the sound as that of an intruder. Therefore, even the lion from whom the roars were recorded must be observed closely for any behavioral changes indicative of welfare detriments.

This study examined the effects of lion roar playbacks on zoo visitors, captive lions, and captive ungulates at Zoo Atlanta. It was hypothesized that the lions would roar more frequently in response to playback because it acts as auditory enrichment and thus enhances species-typical behavior. Additionally, stereotypic behavior was not expected to increase. It was also hypothesized that the ungulates have already habituated to the male lion’s roar, demonstrated through little or no reaction to the playbacks of roars or to an altered frequency of live roars. Finally, it was expected that zoo visitors would prefer the lion exhibit during playbacks of lion roars and during live lion roars, as evidenced by higher ratings and longer stay times.

METHODS

Stimuli and Equipment

Eight separate roars, ranging from 36 to 48 s, were collected from the adult male lion (hereafter “Farasi”) to allow randomization for up to three roars per session.
and to avoid pseudoreplication (Kroodsma, 1989). The roars were recorded while the male lion was on exhibit with an Earthworks TC20K microphone, which has a frequency response from 10 Hz to 20 kHz and was used to capture ranges lower than available to human auditory perception. Audacity, the recording software, was used along with HarierSoft’s Amadeus II for acoustical analysis. Playback equipment consisted of two midhigh range speakers, Sony SSMB-150H, accompanied by a Sony SAWM-500 subwoofer attached to a Sony STR-DE597 stereo receiver. The total response of the playback system was 24 Hz to 50 kHz, and thus it was restricted on the lower range. Recording and playback were accomplished using a laptop computer connected to a Phillips Aurilium external sound card. All equipment, except for the laptop, was stationed at the exhibit on a mobile cart.

Settings and Participants

This study was conducted at and around the African Lion and Masai Mara exhibits at Zoo Atlanta. Behavioral data were collected on the 1.1 (1 male, 1 female) African lions (Panthera leo) and the ungulates in the Masai exhibit, including 1.1 Masai giraffe (Giraffa camelopardalis tippelskirchi), 0.2 Grant’s zebra (Equus burchellii boehmi), 2.1 waterbuck (Kobus ellipsiprymnus ellipsiprymnus), and 2.0 Thomson’s gazelles (Gazella thomsonii). The African Lion exhibit consists of two areas, an outdoor area (hereafter “on exhibit”) that consists of a grassy hill, a large rock structure that provides shade, a visual barrier, and opportunities to lie in the sun and a pool near the glass separating the exhibit from the public. The public could either view lions from underneath a shade structure at a glass viewing area in front of the pool (hereafter “glass”) or at a fence directly off the main path that overlooks the large rock structure (hereafter “rock”). On alternate days, lions were housed either on exhibit or in a smaller, concrete-floored indoor/outdoor area surrounded by mesh fencing and with no public access (hereafter “off exhibit”). The Masai Mara exhibit area used for data collection was a seminaturalistic exhibit with rocks, logs, and a stream that separates the exhibit from the public, who can view the exhibit from several vantage points.

A total of 546 individuals who were visitors to the African Lion exhibit between April and May 2005 and September and November 2005 participated in this study. To ensure independent sampling, only 1 visitor per group was selected, with only every 3rd visitor or visitors separated by 1 min selected for participation. Visitors who met these criteria and appeared to be 15 years of age or older were selected for either stay time (N = 370) or questionnaire data (N = 176). The minimum age criterion was established to ensure that each individual had a choice of when to leave the exhibit area and could answer our questions without interpretation. Lion exhibit stay time recordings began once
the visitor was within 3 ft (0.914 m) of the lion exhibit viewing areas and began
to attend to the exhibit, meaning that they were facing the exhibit and making
visual contact with it. Visitors selected for questionnaire data were approached
as they left the exhibit area.

Questionnaire
The questionnaire consisted of two forms, one for baseline data (see Appendix A)
and the other for use during the playback phase (see Appendix B). Both consisted
of five classification questions and questions to rate the visitor’s overall zoo
and lion exhibit experiences. The baseline condition questionnaire consisted
of questions related to whether visitors would enjoy lion roar playbacks. The
playback condition questionnaire replaced these questions with ones to determine
how the visitor perceived the roar and if they would like to hear roars played
back in the future.

Data Collection Procedure
Data were collected in an ABA design consisting of preplayback baseline,
playback phase, and postplayback baseline. Data were collected Monday through
Friday and were balanced by day of week and for time of day (morning and
afternoon). Data were not collected on weekends to maintain greater consistency
of visitor levels. For lions, frequency and duration data were collected on
nonstereotypic behavior (rest, stand, orient, and locomote/explore, consume,
autogroom, object directed, object play, solitary play, and not visible) and stereo-
typic behavior (pace). Frequency data were collected on vocalizations (roar
and nonroar). A large variety of behaviors were observed to ensure that any
behavioral indices reflecting changes to welfare would be discovered. Lion data
were collected on one male (Farasi) and one female (Masai), who were separated
during the study based on incompatibility. Because of the separation, the lions
were watched simultaneously, with one on exhibit and the other off exhibit, but
still within auditory range of playbacks or roars of other lions. Preplayback
baseline data were collected from April to May 2005, playback data were
collected from September to October 2005, and postplayback data were collected
from October to November 2005. There were 20 half-hour sessions during pre-
playback, 20 half-hour sessions during playback, and 10 half-hour sessions of
postplayback data. Animal management changes, specifically the addition of a
juvenile male and female to the collection, precluded the collection of 20 sessions
of postplayback data and served as an early end to data collection. In order to
examine seasonal effects, temperature was recorded using a thermometer placed
in the off exhibit area.

For the playback sessions, pseudorandomly selected roar(s) were played
one to three times in each half-hour session at randomly selected times. The
number of roars per half-hour session was predetermined to provide variance between sessions so that the lions could not habituate to a set number of roars. All-occurrence data were collected on lion vocalizations and behavior (Altmann, 1974). The ungulates were observed to determine if they exhibited any reaction, especially any signs of stress. During the preplayback baseline and playback phase, the ungulates were observed and their levels of reaction to roars or playbacks were rated on a scale from No Response to Seek Refuge (see Appendix C; e.g., Blumstein & Armitage, 1997). Because the ungulates never had a reaction stronger than an orient response, which was seen both after the roars and playbacks, ungulate data collection was discontinued after the first five playback sessions.

Data Analysis

The ungulate data were not analyzed given the lack of variance in response observed. Because data did not appear to be normally distributed and the number of participants was small, nonparametric statistics were employed for the evaluation of the lion data (Runyan & Haber, 1980). For the lion data, Kruskal-Wallis analysis of ranks, the nonparametric equivalent of an ANOVA, was used to evaluate differences in frequencies and durations of behaviors across phases. Temperature differences were analyzed using Spearman correlations. Mann-Whitney U tests, the nonparametric equivalent of an independent t test, were used to evaluate differences in frequencies and durations of behaviors between locations or lions. Because of the categorical nature of survey data and heterogeneity of variance, survey and stay time data were analyzed using Kruskal-Wallis analysis of ranks and then Mann-Whitney U tests to determine the directions of the differences, or only Mann-Whitney U tests were used if there were only two levels of the independent variable. Survey responses and stay time data were analyzed for differences by phase, age group, gender, day of the week, a.m. or p.m., lion visibility, frequency of previous visits, and if they had heard a roar before or that day. In order to preserve a familywise Type I error rate of $\alpha = .05$ in the survey and stay time data, significance levels were corrected using a Bonferroni-Dunn procedure. The familywise error rate was divided by the number of pairwise comparisons conducted to determine the alpha value for each post hoc test.

RESULTS

Ungulates

The ungulates were observed for 23 sessions, with 12 roars, during the preplayback baseline phase and 5 sessions, with 9 playbacks, during the playback
phase. No animal visible during and after a roar or playback exhibited a response greater than orient and the most frequent response was no change in behavior (71.4% of visible scans during preplayback baseline and 76.9% during playback).

Visitors

The results for visitor data demonstrated higher satisfaction with the exhibit and longer stay times with playback. Familywise error correction led to an alpha value of .008 for stay times. Visitor stay times were collected based on equally timed observations leading to 97 visitors in preplayback, 90 in playback, and 183 in postplayback. Visitors stayed longer in the playback phase ($M = 1:59.72$ min:s, CI$_{95} = 1:37.78–2:21.67$, $H(2) = 15.561$, $p < .0001$; see Table 1) than in the preplayback baseline ($M = 1:18.38$, $U = 2,986.5$, $p < .0001$) or postplayback baseline ($M = 1:26.31$, $U = 6,525.0$, $p = .005$). There was no significant difference in mean stay times between preplayback and postplayback baselines ($U = 7,633.0$, $p = .054$). For the rest of the stay time results, data were collapsed across conditions. Visitors stayed longer if they reported hearing a roar ($M = 1:58.78$, CI$_{95} = 1:40.78–2:16.79$, $U = 10,328.5$, $p < .0001$). Visitors also stayed longer if the lion was reported as visible ($M = 1:34.41$, CI$_{95} = 1:26:18–1:42.65$, $U = 2,044.5$, $p = .002$) than if the lion was not visible ($M = 56.40$ s). In addition, visitors stayed longer at the glass viewing area ($M = 1:36.51$, CI$_{95} = 1:27.65–1:45.32$, $U = 6,041.0$, $p = .003$) than the rock viewing area ($M = 1:06.35$).

For the survey data, lower values indicate more agreement. Alpha values were adjusted to .005 for Kruskal-Wallis tests and .006 for Mann-Whitney $U$ tests using a Bonferroni correction. Again, visitors surveyed were based on equal times, resulting in 58 in preplayback, 50 in playback, and 68 in postplayback.

In terms of wanting roar playback to continue, more zoo visitors agreed in the playback phase (CI$_{95} = 1.10 \pm .09$, $H(2) = 11.49$, $p = .003$) than in

<table>
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<tr>
<th>TABLE 1</th>
<th>Mean Visitor Stay Times (in min) at the Lion Exhibit by Condition</th>
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<tr>
<td>Condition</td>
<td>Preplayback BL ($n = 97$)</td>
</tr>
<tr>
<td>Mean stay times</td>
<td>1:18.38</td>
</tr>
<tr>
<td>95% Confidence Interval</td>
<td>1:04.15–1:32.61</td>
</tr>
</tbody>
</table>

Note. BL = baseline.
REACTIONS TO LION ROAR PLAYBACKS

the preplayback baseline \((M = 1.38)\) or postplayback baseline \((M = 1.32)\). More zoo visitors also agreed that they would like to hear future playback if they reported hearing a roar, live or played over speakers \((\text{CI}_{.95} = 1.10 \pm .07, H(2) = 18.310, p < .0001)\) than if they reported not hearing a roar \((M = 1.40)\). Additionally, more females reported that they wanted to hear playback in the future \((\text{CI}_{.95} = 1.18 \pm .07, H(2) = 15.968, p < .0001)\) than males \((M = 1.47)\). Other questions on the survey were rated on a 5-point scale from Very Dissatisfied to Very Satisfied. These values tended to trend toward satisfaction, with only 1 being significant. On the questions evaluating how satisfied the zoo visitors were with the lion exhibit, visitor satisfaction ratings of the lion exhibit were higher in the playback phase \((\text{CI}_{.95} = 4.00 \pm .24, U = 1,005.0, p = .003)\) than the preplayback baseline \((M = 3.41)\). However, playback phase values were not significantly higher than the postplayback baseline \((M = 4.18)\). Postplayback baseline values were significantly higher \((\text{CI}_{.95} = 4.18 \pm .14, U(1) = 1,089.5, p < .0001)\) than the preplayback baseline but not playback values \((U(1) = 1,454.0, p = .507)\).

Lions

All values are given in mean duration for the 30-min sessions except for roars that were coded without duration and therefore are reported as mean frequencies per 30-min session. The male lion (Farasi) roared significantly more in the playback phase \((\text{CI}_{.95} = 1.95 \pm .6 \text{ roars per 30-min observation}; \text{Kruskal-Wallis } H(2) = 12.56, p = .002; \text{see Table 2})\) than in the preplayback \((M = 0.61, U = 74.5, p = .001)\). However, it was not significantly different from postplayback baseline \((M = 1.44, U = 80.0, p = .275)\). However, this includes a day in which the veterinarians were present in the vicinity and Farasi was agitated, as indicated by pacing and door-directed behavior, and roared more. Removing that day reduces the mean frequency to .88 times per 30-min session. There was no significant difference between preplayback and postplayback baseline

<table>
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<th>TABLE 2</th>
<th>Roar Frequencies and Mean Roars per Session by Condition</th>
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<tbody>
<tr>
<td></td>
<td>Preplayback BL</td>
</tr>
<tr>
<td>Farasi</td>
<td></td>
</tr>
<tr>
<td>Total number of roars</td>
<td>11</td>
</tr>
<tr>
<td>Mean frequency (95% CI)</td>
<td>0.61 (.22–1.00)</td>
</tr>
</tbody>
</table>

Note. BL = baseline.
(U = 58.5, p = .106). Overall, Farasi roared a total of 63 times: 11 times in preplayback baseline, 37 in playback, and 15 in the postplayback baseline. The female lion (Masai) roared less frequently overall, with no significant differences by condition (playback CI\(_{95}\) = .67 ± .39 roars per 30-min observation, H(2) = 2.07, p = .354; preplayback baseline \(M = .37\), postplayback \(M = .50\)).

In addition to the findings by playback condition, there were also differences by location. Pacing was never seen on exhibit, but Farasi paced off exhibit (CI\(_{95}\) = 9.58 ± 3.38, U = 62.5, p < .0001). Off exhibit, Farasi made more nonroar vocalizations (CI\(_{95}\) = 2.04 ± 1.22, H(2) = 9.56, p = .002) versus on exhibit (mean frequency = .16). Farasi also spent more time locomoting and exploring off exhibit (CI\(_{95}\) = 2.89 ± .87, U = 136, p = .003) than on exhibit (\(M = .45\)).

Even though there were differences in mean temperatures by conditions, there were no significant temperature effects. Preplayback baseline (\(M = 65.35^\circ F [18.53^\circ C], SD = 9.88\)) and postplayback baseline (\(M = 68.80^\circ F [20.44^\circ C], SD = 6.17\)) temperatures did not differ from each other (\(U(1) = 288.0, p = .168\)), but both differed from playback temperatures (\(M = 75.81^\circ F [24.39^\circ C], SD = 7.02, U(1, preplayback) = 326.0, p < .0001\), and \(U(1, postplayback) = 194.0, p = .001\)).

**DISCUSSION**

Naturalistic playbacks of male lion roars increased live lion roars, acting as a form of auditory enrichment for the lions and increasing visitor interest, while not increasing stress levels of ungulate species in adjacent exhibits. Playbacks lead to an increase in live roars; thus there was an increase in species-typical behaviors. Conclusions of this study are limited with such a small sample size, but the findings are promising, and lion roar playbacks should be further investigated. Playbacks of roars are an excellent option to expand enrichment to another sensory system, diversifying the possibilities for enrichment for lions and similar species that use vocal communication. Variety is essential to the psychological well being of captive animals. Diversity in enrichment is crucial because enrichment items can be prone to extinction and habituation based on decreases in use (see Tarou & Bashaw, 2007). Published studies of captive felid enrichment frequently focused on food (e.g., Bashaw et al., 2003; McPhee, 2002), objects (e.g., Hare & Jarand, 1998; Poulson & Miller, 1996), or olfaction (e.g., Baker, Campbell, & Gilbert, 1997; Schuett & Frase, 2001). These forms of enrichment are essential, but roars are critical aspects of lion communication (Grinnell & McComb, 2001) and should also be used as a form of auditory enrichment, especially because they were found to increase species-typical behaviors in Farasi.
McComb et al. (1994) observed that female lions roared infrequently in response to playbacks, similar to the finding of this study. In McComb et al. (1994), females roared significantly more often when pride members were absent and were joined by missing members in almost half of the roaring instances. Therefore, McComb et al. (1994) concluded that roaring after playbacks for lionesses is a signal to the pride members not present rather than to the intruders. In addition, separation from pridemates did not have an effect on the frequency of roaring after playbacks in the male lions in the study by Grinnell et al. (1995). Thus, responding to roars may function differently for male and female lions. Increasing roars of the male lion in this study may function as an increase in communication and thus may be enriching given that it indicates an increase in species-typical behavior. The forced separation of lions in this study may have had an effect on the roaring of Masai. Future studies should examine the responses of lions that are usually housed together but are separated for research purposes.

These playbacks enhanced the visitor experience, with visitors reporting more positive impressions of playbacks and staying at the exhibit for a longer period of time during the playback phase of the study. Therefore, naturalistic playbacks of male lion roars or the roars they elicit as a response are a viable solution to the disappointment experienced by many visitors to felid exhibits when the animals are hidden or inactive. There were some demographic details, such as ethnicity and income level, which were not included in the surveys and stay time data that may have affected the results. Future studies may want to expand demographic data given the difference between men and women.

Additionally, these playbacks and the more frequent live roaring did not increase fear or stress-related behaviors in nearby ungulates or the lions themselves. Ungulates were observed reacting to both playbacks and live roars by continuing their current behavior or perhaps orienting. Thus, these animals did not exhibit behaviors characteristic of fear, mainly including a startle response, freezing to avoid detection, or fleeing (Blumstein & Armitage, 1997). Lions also did not exhibit negative responses to playbacks of roars; increased rates of stereotypic behavior or behaviors indicating anxiety were not observed.

CONCLUSION

This study provides several other suggestions for future research. Overall, this type of research should be replicated with lions at other zoos. As discussed previously, future studies should examine lions usually housed together to maximize the likelihood that female lions would respond to playbacks. For this study, the focus was on roaring, a species-typical behavior, but other methods to determine the psychological and physiological benefits should be used. Other
lions who engage in more frequent pacing should be observed to determine if roar playbacks would function as auditory enrichment and decrease stereotypic behavior in those animals. Cortisol values could also be included for a more thorough method to analyze the psychological benefits of a new modality of enrichment. It may also be useful to examine the long-term effectiveness of auditory enrichment in a future study.

Studies in which playback experiments were conducted have found that a variety of species do not appear to recognize their own vocalizations when they are played back to them. Gibbons did not react differently when self, neighbor, or stranger duets were used for playback (Mitani, 1985). Male sparrows also do not differentiate their responses to either self or stranger vocalizations when they are presented as playbacks (Searcy, McArthur, Peters, & Marler, 1981). Species who must learn species-specific vocalizations and use their own vocal output as a way to regulate their learning, such as songbird species, may be an exception rather than the rule. Male red-winged blackbirds reacted more strongly to playbacks of strangers than to playbacks of their own vocalizations (Yasukawa, Bick, Wagman, & Marler, 1982).

A distinction should be made regarding the recordings used in this study. Frequency ranges occurring naturally in lion roars, sub 20 Hz, were not played back due to equipment limitations. This cropping would be similar to hearing a voice on an answering machine. Although the vast majority of sound is similar, leading to a complete understanding of the message, the sound is not exactly reproduced as the telecom system removes some frequency ranges in transmission. This difference is distinct enough to alter the perception of the sound. Lions lack the cognitive knowledge to comprehend this effect, much like young children do not recognize their voices when they are recorded. This effect is further magnified by the fact that an individual’s own perception of his or her own voice is not based on the sound as directly heard by others, but it is altered by cranial vibrations, as evidenced by covering one’s ears while talking. These effects result in a perceptual distinction between lions. The lion from whom recordings were made, Farasi, would regard the played roars as coming from a strange lion. However, other lions would recognize the played roars as similar enough to be from the familiar neighbor lion. Previous research has found that birds respond more to playbacks of unknown calls than to playbacks of birds who have an adjacent established territory (see Hopp & Morton, 1998). For this study, the resident male lion roars were used to examine if his roars would have an effect and because the lions usually respond when one roars. Similar to roar use in the wild (see Grinnell & McComb, 2001), captive lions may roar to connect with pridemates and defend territories from neighbor lions. It would be informative to play back roars from both a resident lion and an unknown lion to act as novel roars to examine if the roar of an unfamiliar stranger would also be enriching.
Finally, although the equipment used in this study was not designed to satisfy the maximal vocal qualities of this species, it still resulted in increased roaring. These results are supported by research on African elephants (*Loxodonota africana*) that analyzed how calls degrade, finding that the 115-Hz region decayed less than other frequencies (McComb, Reby, Baker, Moss, & Sayialel, 2003). Thus, the frequency component essential for long-distance communication in some species may exceed infrasonic range. Therefore, removing only the lowest frequency portions would not be expected to eliminate all responding. However, it would be difficult for many zoological institutions to acquire equipment of this quality, and it is not practical for repeated use outdoors. Therefore, it would be constructive to repeat this experiment with equipment that did not include the subwoofer to investigate if a more feasible equipment arrangement would still be enriching for the lions and enhance the visitor experience.

**REFERENCES**


APPENDIX A

Lion Roar Survey I: No Playback, Baseline Data

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Number of lions on exhibit</th>
<th>Farasi</th>
<th>Masai</th>
<th>Both</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Age group:</td>
<td>15–25</td>
<td>26–35</td>
<td>36–45</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sex</td>
<td>Male</td>
<td>Female</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Number at exhibit</td>
<td>0–5</td>
<td>6–10</td>
<td>10+</td>
</tr>
</tbody>
</table>

1. How satisfied were you with your zoo visit today?  
   - Very Dissatisfied  
   - Dissatisfied  
   - No opinion  
   - Satisfied  
   - Very Satisfied

2. How satisfied were you with the lion exhibit today?  
   - Very Dissatisfied  
   - Dissatisfied  
   - No opinion  
   - Satisfied  
   - Very Satisfied

3. How frequently do you visit this or any other zoo?  
   - Never  
   - 1/Year  
   - 2–4/Year  
   - 1/Month  
   - 2+/Month

4. Have you heard a lion, including Farasi, roar before?  
   - Yes  
   - No

5. Would you have spent longer at the exhibit if you heard lions roaring?  
   - Yes  
   - No

6. Would you like to hear roars played back in the future?  
   - Yes  
   - No

7. Additional Comments?

APPENDIX B

Lion Roar Survey II

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Number of lions on exhibit</th>
<th>Farasi (male)</th>
<th>Masai (female)</th>
<th>Both</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Age group</td>
<td>15–25</td>
<td>26–35</td>
<td>36–45</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sex</td>
<td>Male</td>
<td>Female</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Number at exhibit</td>
<td>0–5</td>
<td>6–10</td>
<td>10+</td>
</tr>
</tbody>
</table>

1. How satisfied were you with your zoo visit today?  
   - Very Dissatisfied  
   - Dissatisfied  
   - No opinion  
   - Satisfied  
   - Very Satisfied
2. How satisfied were you with the lion exhibit today?
   Very Dissatisfied  Dissatisfied  No opinion  Satisfied  Very Satisfied

3. How frequently do you visit this or any other zoo?
   Never  1/Year  2–4/Year  1/Month  2+/Month

4. Have you heard Farasi roar before?  Yes  No
   • Today?  Yes  No

5. Did you notice the lion sounds?  Yes  No
   • If Yes, Did you realize it was playback?  Yes  No
   • If Yes, Did it enhance your experience?  Yes  No
   • If Yes, Did you spend longer at the exhibit because of the roars?  Yes  No

6. Did you see any reaction to the roaring?  Yes  No

7. Would you like to hear roars played back in the future?  Yes  No

Additional Comments?

APPENDIX C

Ungulate Behavior Rating Scale (after Blumstein & Armitage, 1997)

1 = No Response—animal does not change orientation or behavior in the first 5 s after playback.

2 = Orient—animal moves his or her head in response to playback and looks around; body posture remains the same.

3 = Startle—animal looks up suddenly and immediately after playback.

4 = Cluster/Flee—animal seeks out other animals in exhibit or moves to the portion of the exhibit farthest from playback.

5 = Seek Refuge—animal attempts to hide or moves to holding area doors.