Evaluating the effectiveness of live animal shows at delivering information to zoo audiences

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Live animal shows, which combine animal facts with trained behaviours, are commonly used to engage zoo visitors globally. However, such shows have been criticised for portraying a potentially unhelpful image of 'performing animals' and have raised issues of animal welfare ethics. Little is known about the educational effectiveness of these shows. Furthermore, the impact of 'tricks', used as attention grabbing hooks, has received limited research attention. We evaluated the impact of a sea lion and a mixed species bird show on audience knowledge of animal facts. Over a quarter of zoo visitors attended some form of live animal show, demonstrating quantitatively that they are a major potential source of knowledge transfer. Show audiences were questioned immediately before (n = 299) or after (n = 265) each performance about relevant show content knowledge. Additionally, a general zoo visitor survey (n = 160) investigated what information was recalled from shows post-visit. Audiences demonstrated significantly higher animal knowledge post-show compared to pre-show. Conservation action awareness showed weak positive change post-show. Audience education levels and weather conditions also had a weak positive effect on correct responses. However, animals performing trick-type behaviours were found to cause confusion regarding natural adaptations. We conclude that live animal shows should prioritise natural behaviours with a central message focused on conservation action.

Animal displays, sea lion show, bird show, visitor experience, animal training, public engagement

Introduction:

Modern zoos aim to fulfil a valuable role in society through the three pillars of education, research and conservation. These aims are prominent across zoo mission statements (Patrick, Matthews, Ayers, & Tunnicliffe, 2007) and are supported by international guidelines (Barongi, Fisken, Parker, & Gusset, 2015; WAZA, 2005). International studies have demonstrated that zoo visits are able to raise awareness of biodiversity and knowledge of actions to help conservation (Jensen, Moss, & Gusset, 2017; Moss & Esson, 2013; Moss, Jensen & Gusset, 2015, 2017). Despite internationally agreed targets and multiple education studies, the impact of individual zoo visitor experiences, such as live animal shows, on animal and conservation awareness is relatively unknown. Moss et al. (2015) study of WAZA institutions included 'attending an animal show' as one of their variables and found that shows were not a significant predictor of increased biodiversity literacy.

Interactive animal talks and shows are a key part of the zoo experience and are generally viewed positively by audiences (Fernandez, Tamborski, Pickens, & Timberlake, 2009). Visitors often plan their day around these interactions (Moss, Esson, & Bazley, 2010). Although enjoyment can enhance learning (Clayton, Fraser & Saunders, 2009, Clayton, Prevot, Germain, & Saint-Jalme, 2017), presenting animals solely for entertainment is widely viewed as unacceptable in modern zoos (Mann-Lang, Ballantyne, & Packer, 2016, Whitehouse-Tedd, Spooner, Scott, & Lozano-Martinez, 2018). This means that live animal shows must have educational value in order to be considered a legitimate contemporary zoo experience.

Globally, zoos and aquariums offer a wide variety of educational events involving animals from across the taxonomic spectrum. These activities can be divided into three broad

categories: Presentation (shows and displays of natural behaviours), Performance (including some unnatural behaviours e.g. comical activities), and Encounter (offering contact opportunities) (Whitehouse-Tedd, Spooner & Whitehouse-Tedd, 2020). Many experiences fall into multiple categories. Training methods vary including both positive and negative reinforcement and coercion. Sea lion shows and bird displays are one of the most frequently advertised animal events in zoos internationally. Approximately 30% of WAZA zoos offer some form of display or show, making them the third most popular animal-visitor interaction, after petting and walk-through exhibits, (D'Cruze, et al. 2019). Informal examinations of zoo online marketing material found that sea lion shows appear in every continent except Africa, and bird displays involving parrots, owls or birds of prey appear across all continents (Whitehouse-Tedd et al. 2020). This study focuses on these encounters, examining the impact of a single species iconic mammal versus a multispecies display.

Comparisons between the educational effectiveness of live animal shows, environment centres and museums, found that live animal shows were best for conveying species identification and for increasing ideas of stewardship (Kimble, 2014). Close encounters with animals can increase feelings of affiliation and emotional connections (Luebke, Watters, Packer, Miller, & Powell, 2016; Povey & Rios, 2002; Sherwood, Rallis, & Stone, 1989; Skibins & Powell, 2013). Sensory encounters, such as touching animals, can also increase positive attitudes towards species (Lindemann-Matthies & Kamer, 2006; Sherwood et al., 1989). Such connections are also important for developing concern about environmental issues (Hotchkiss, 1991; Luebke et al., 2016).

Visitors have been shown to stay significantly longer at zoo exhibits during animal keeper presentations and have a more positive view of the species seen, compared to those who view exhibits without staff present (Anderson, Kelling, Pressley-Keough, Bloomsmith, & Maple, 2003; Povey & Rios, 2002). Visitors often seek explanation regarding animal behaviour and, keeper interpretation can help visitors answer questions as they arise (Margulis, Hoyos, & Anderson, 2003). Providing interpretations of animal behaviours has been shown to be more effective than fact-only presentations at delivering information to audiences (Miller Zeigler-Hill, Mellen, Koeppel, Greer, & Kuczaj, 2013; Visscher, Snider, & Vander-Stoep, 2009). This is supported by Jensen (2014) who found significantly improved educational outcomes for school children visiting a zoo when they attended presentations led by zoo education staff compared to self-guided visits. Interpretation can also raise support for conservation issues. Swanagan (2000) found that when keeper talks were used at an elephant exhibit significantly more visitors signed a petition against ivory trade than when the exhibit was viewed without a keeper present.

There is, however, concern that these same shows can also present species as domesticated and reinforce concepts of humanity's dominance over animals (Acampora, 2005; Finlay, James, & Maple, 1988 Whitehouse-Tedd et al., 2018). International guidelines stress that zoo animals should not perform 'unnatural behaviours' or 'become humanised' (EAZA, 2008). Nevertheless, many live animal shows still use trick-like, unnatural, behaviours (e.g. balancing balls, animals talking and solving puzzles) for entertainment or as 'educational hooks'. Educational hooks are elements of presentations which are designed to attract and focus audience's attention on a particular message. In the context of a live animal show these hooks are often employed prior to explaining how the animal's capabilities are used in the wild (Whitehouse-Tedd, et al. 2020). There is currently no evidence to indicate whether using these trick-like hooks helps or hinders retention of educational messages and limited research into the educational benefit of live animal shows more generally.

Zoo visitors represent a wide range of socio-economic groups and backgrounds. This is further broadened when zoos are co-situated with other leisure activities such as theme parks. Zoo visits are often primarily a leisure experience, therefore, achieving a learning outcome with potentially pro-environmental behaviour implications can be viewed as an education success that would not have been achieved during most other forms of leisure time.

With rising concerns over animal welfare and the appropriateness of live animal shows in the modern zoo, some organisations have examined alternatives. Spooner et al. (2019) examined the impact of animal-free performances which used puppets and costumed actors to present animal facts. They found that these performances were highly successful at conveying their message to adults and children. Understanding whether these animal-free performances are as effective as live animal shows is yet to be tested.

This paper aims to determine the effectiveness of live animal shows at educating zoo visitors, with the following objectives:

1. Do entertainment-focussed live animal shows meet institutional learning objectives among audiences?
2. How effective are unnatural, trick-like behaviours in facilitating conservation action?
3. What information from shows is recalled at the end of a zoo visit regarding animal facts and conservation?
4. How do other expected environmental and socio-economic drivers of learning influence the effectiveness of live animal shows?
5. How does learning from live animal shows compare to learning from animal-free alternatives?

This research is approached from an environmental education perspective. Based on the previously published empirical literature, the authors believe that zoos have great potential for educating audiences about conservation action in addition to information on animal adaptation and general zoology. We seek to establish whether 'show' style presentations, which are popular both in terms of audience numbers and apparent enjoyment, are effective ways of conveying information. In understanding what is and what is not conveyed to their audiences we hope to inform best practice.

Materials and Methods:

Study site and shows

The research was undertaken at Flamingo Land Resort Ltd., UK, a combined zoo and theme park. Flamingo Land is privately owned and entertainment-orientated (Flamingo Land Ltd., 2016) and thus, provides a genuine case for whether education is achievable in an entertainment-focused setting. Given that theme park-based zoos represent the entertainment end of the spectrum it can be assumed that any learning outcomes achieved in this context can be achieved to a similar or greater extent in zoo-only environments. The zoo is a member of the European Association of Zoos and Aquariums (EAZA) and hence officially signed up to promoting biodiversity, conservation and environmental education.

We examined two types of live animal show, a sea lion show and a multi-species bird show. Both shows were written and delivered by an independent entertainment and animal training team, and developed over several decades at the zoo. These were the only live animal

shows on offer at the site. The shows used trick-like behaviours as entertaining hooks for information (see descriptions below). The training team felt that 'education is much more easily absorbed if delivered with a mixture of humour and entertainment' and that their shows 'always aim for some educational content' (APAB Ltd., 2009). The overarching objectives of the shows were to entertain and convey basic features and behaviours of animals to their audience. The secondary objective was to indicate how the audience could help in wildlife conservation (pers. comms.). Whilst different trainers and animals performed in each show, a consistent set of facts were mentioned in every performance.

Sea lion show

The sea lion show was a 15-20-minute-long, single species display, featuring between one and four Californian sea lions (*Zalophus californianus*). The show took place in a combined pool and platform area in front of a seated audience (capacity 400 people). The stage area was themed like a fishing harbour. Although the individual sea lions varied across performances, the show always contained a sea lion balancing objects (balls, bowling pins, etc.) on its nose. This was used as a hook to teach about whisker sensitivity to movement and their use in sensing fish. Other behaviours included walking on land, flipper stands, catching hoops and leaps into and out of the pool, all of which were used to convey the animal's flexibility and agility on both land and water. The differences between seals and sea lions was shown by the sea lion pretending to be a seal (sliding on the ground). Contrasts were made with a sea lion's ability to walk, clap and shake hands because of their much larger flipper size. Show content mentioned how Californian sea lions have previously been hunted for their fur and how litter is a major threat for aquatic species. At the end of the show presenters suggested that visitors could donate to conservation charities such as the Monk Seal Trust (which had a donations box at the show, held by the presenter at the end).

Bird show

The bird show was a 15-20-minute-long mixed species display, which presented birds both in front of and flying over a sheltered, seated audience (capacity 120 people). In every show there was a parrot, an owl and a vulture, although individuals varied and other species were occasionally presented. The parrots performed two main tasks: (1) a shape sorting puzzle to demonstrate their ability to see in colour; and (2) a 'talking' demonstration (human voice and animal call mimic), to show their intelligence and entertain the audience. The owl and the vulture were both trained to fly over and amongst the audience for a closer experience. The presenter described each species, its features and behaviours as well as some of the threats they face in the wild including habitat loss. At the end of the show, audiences were encouraged to see the animals up close. Audiences were able to hold a parrot and have a photo taken or give a coin to a parrot who would then post it into a donations box. The audience were informed that money collected would go to the Hawk and Owl Conservation Trust.

All animals used in the shows were trained using positive reinforcement and given food rewards for performing the desired behaviours.

Data collection

Show level impact evaluation:

Show-level impact evaluation was conducted using questionnaire surveys (collected 1st May to31st October 2015), which tested audiences understanding of show-related content knowledge and ability to state conservation actions before the show (pre-) and immediately

after viewing the show (post-). The survey included questions based on the learning objectives of each show most relevant to the zoo mission.

Pre-show responses were collected from audiences queuing to watch the show by asking every 4th adult to complete a survey. These data provided a measure of audience baseline knowledge. Questionnaires were collected from respondents five minutes before the show started to ensure that no answers were completed once the show had begun. Respondents were informed that surveys investigated audience knowledge about species and that research findings would be used to improve show content. Although there was a potential that this may have primed respondents to look for information within the show, they were unaware that we were collecting post-show responses and that there was a potential for re-testing. Consequently, the potential for priming responses was minimised.

Post-show responses were collected from audience members as they filtered out of the show (approx. every 4th adult). This provided a sample of pre-show (n=299) and post-show (n=265) responses (85 of these responses were 'paired samples' where the same individual was questioned pre- and post- show) (Table 1). Recent research has shown that paired and unpaired samples yield similar results regarding zoo education effectiveness (Spooner et al., 2019). Therefore, we analysed the samples as an aggregate and did not spend additional effort to ensure equal paired and unpaired sample sizes, which would have required bespoke paired sampling.

Responses to show content knowledge questions were coded as either correct or incorrect using a pre-defined coding table based on the information given in the show following standard content analysis methods (Jensen & Laurie, 2016) (Table 2). Overall audience 'knowledge' was calculated based on the total number of correct answers given across show content knowledge questions. The impact of the show on audience's wildlife conservation awareness was measured by comparing the number of conservation actions respondents could state pre- and post-show.

To test whether trick-like behaviours aid or distract from presented animal facts we examined one open-ended knowledge question from the sea lion show in detail: 'Why are sea lion's whiskers so important?'. This question was chosen because the show used the sea lion's ability to balance balls as an educational hook to teach about whisker sensitivity when finding fish. As the question did not specify whether we were looking for a natural or unnatural use of whiskers, we initially coded responses very broadly, scoring correct any response which defined a plausible use for sea lion whiskers. This included responses which were unnatural such as balancing objects. We then took all 'correct' responses and coded them again into two sub-categories, namely 'natural behaviours', including finding fish, feeling spaces and vibrations, and 'false learning' for responses that misinterpreted the intended meaning behind the message, including non-natural behaviours such as 'balancing objects' and also 'balancing'.

General visitor impact evaluation

A second, separate survey assessed the impact of shows on the general visitor population post-visit (collected 1st May to 31st October 2016). Visitors completed a short registration questionnaire at the entrance to the site or when booking online prior to a visit. A post-visit survey was then sent the evening after the visit, with three reminder emails sent 10 days apart. This examined: (1) whether the individual had attended a live animal show [yes / no]; (2) which show they had seen [sea lion / bird]; (3) their level of satisfaction with the show [7 point Likert scale from 'highly dissatisfied' to 'highly satisfied'] and (4) general recollections regarding what they could remember from the show [open-ended]. In all, 160 visitors

responded to the post-visit e-mail survey. Of these follow up surveys, 38 stated they had attended a show and 25 provided show-related comments.

Responses to general open-ended recollections of the show were coded into the following categories: (1) educational; (2) entertainment; (3) tricks; (4) individual animal details; (5) show conditions; and (6) conservation. The sentiment behind the statements (whether positive, negative or neutral) was also classified. Overall satisfaction was classed as positive if respondents stated they were somewhat satisfied to highly satisfied.

For all surveys, respondents gave consent to be included in the study. Ethical approval was granted by the University of York Environment Department Ethics Committee.

Statistical Analysis

For both shows and general surveys, all response coding (correct/incorrect, content and sentiment analysis) was completed by two researchers independently, blind to the test condition (100% overlap). Disagreements were resolved through discussion. Intercoder reliability was calculated using Cohen's kappa where values above 0.80 indicate a strong agreement and therefore reliability in coding (Field, 2013).

Statistical analysis was performed using R version 3.2.3 (CRAN, 2014). Variables used for analysis included questionnaire responses as stated above, plus various socio-economic and environmental predictor variables that could potentially have affected learning ability or attention spans. Data were transformed to remove skew: number of adults viewing the sea lion show [$\log_{10}$]; temperature at sea lion show [cube]; number of adults viewing the bird show [square root].

Predictor variables were checked for inter-correlation and pairs of variables with a Pearson correlation coefficient $r \geq 0.7$ and Variance Inflation Factor > 2 were not included in the same model (Zuur, Ieno, & Elphick, 2010). Poisson and binomial Generalised Linear Models (GLM) were used to evaluate the effect of viewing the show on correct response to animal knowledge and conservation action questions relative to other predictor variables. Variables were classified as show, socio-economic or external predictors as follows: Show characteristics included variables which could be controlled by the show such as time, presenters and audience size. Socio-economic predictors included demographic characteristics of the visitors; understanding the influence of these factors was important to ensure that the show did not exclude or favour particular groups. External predictors included climatic variables such as cloud and temperature. Although climate variables cannot be directly controlled, understanding whether they had an impact can be important for designing show areas and determining whether weather conditions were a potential learning distraction. The variables were successively assigned to alternative models, firstly based on their classification, then based on intercorrelation with other variables (variables that were intercorrelated were not modelled together; Zuur et al 2010), until all variables were included in at least one model. We used multiple models to ensure that unmeasured intercorrelation between predictor variables did not bias outcomes (Burnham, Anderson, & Huyvaert, 2011; Murtaugh, 2009; Whittingham, Stephens, Bradbury, & Freckleton, 2006). Table 3 shows the eight models that were applied to sea lion show data and the six models that were applied to bird show data. There were more sea lion models than bird models to test the effect of different individual animals used in the single species sea lion show. Akaike Information Criterion (AIC) was used to rank models and those with the lowest AIC and within two AIC of each other were selected as best representing the data (Anderson & Burnham, 2002; Thomas, 2017). Although p values were generated for each variable, they were considered

less important than the effect size (% deviance explained) and model ranking (Burnham et al., 2011).

Overall audience knowledge, the number of stated conservation actions and the effect of trick-like behaviours, were compared pre- and post-show using Wilcoxon signed rank tests and GLMs. The effect sizes were calculated using Cohens' d with a pooled standard deviation of pre- and post-groups (Field, 2013; Higgins, Katsipataki, Kokotsaki, Coe, Major & Coleman, 2013). An effect size of below 0.01 was assumed to indicate no effect on learning, between 0.02-0.18 a low effect, 0.19-0.44 moderate, 0.45-0.69 high and above 0.70 a very high effect (Higgins et al., 2013). Comparing effect sizes allowed the impact on audience' knowledge to be examined across shows regardless of sample sizes.

Results

Inter-coder reliability was high (sea lion show: kappa = 0.83; bird show: kappa = 0.91).

Conveying learning objectives

Across the two shows, increases in the number of questions correctly answered post-show compared to pre-show were seen across all learning objectives (Table 4). The shows had a high to very high effect on overall learning (sea lion show: pre- show s.d. =1.65, post-show s.d. = 1.69, effect size (d) = 0.61, w = 9822, $p < 0.001$; bird show: pre- show s.d. =1.59, post-show s.d. = 1.69, effect size (d) = 0.73, w = 3697.5, $p < 0.001$)

For sea lion shows, the comparison of alternative models found that seeing the live animal shows was consistently placed as the most influential and positive predictor of correct response to animal questions, explaining 5.9 - 8.4% of the deviance (Table 5). Having seen the live animal show before was a common variable in two of the three selected models but only explained minimal deviance (< 2.0%). A single model was found for bird show knowledge responses, again indicating that the strongest influence was seeing the show, with 10.2% deviance explained (Table 5).

Models selected for the number of stated conservation actions for the sea lion show placed seeing the show as the most consistent predictor or correct answers (deviance explained 0.6-1.2%). However, p-values were not all significant and none of the variables selected by the models explained more than 1.7% deviance, which was explained by cloud cover in one model (Table 6). For the bird show, models consistently placed seeing the show as the main predictor of stated conservation actions. Yet, seeing the show only explained between 1.7 and 2.1 % of the model deviance (Table 6).

Effectiveness of trick-like behaviours

The question *'Why are sea lion's whiskers so important?'* was answered correctly by 63.3% of respondents pre-show (using initial, broad coding inclusive of responses relating to balancing and balancing objects), indicating a high level of existing knowledge, but further increased to 69.0% of respondents post-show. However, when the question was examined in closer detail (second coding: coding for natural behaviours versus false learning) post-show responses demonstrated a non-significant but weak, negative effect on audiences' understanding of natural behaviours and a significant increase in false learning (Table 7).

Information recall post zoo visit

The post-visit surveys found that over a quarter of zoo visitors (28.4%) attended at least one live animal show. Specifically, 24.6% attended the sea lion show and 7.5% attended the bird show.

Audience satisfaction with the shows was high for both shows (80% for the sea lion and 100% for the bird show). The most common themes recalled post-visit were specific facts about individual animals, and expressions of being entertained (Table 8). Recalled information supported the shows learning objectives (Table 4), however, responses were very general.

Trick behaviours were recalled in three instances post-visit for both the sea lion show and the bird show (Table 8). No specific comments were mentioned about conservation learning.

Other environmental and socio-economic drivers

Respondents' education had a positive influence (explaining 2.4 - 2.5% deviance) on correct responses to the sea lion related questions. In contrast, increasing cloud cover had a negative influence (2.8% deviance).

Analysis from the bird show found that awareness of conservation actions was influenced by prior exposure to a show either at the site (0.2% deviance) or at another zoo (1.5% deviance); the presenter (0.3 - 0.8 % deviance); the number of adults viewing the show (0.4% deviance) and the percentage of cloud cover (1.9% deviance).

Discussion

Over a quarter of zoo visitors questioned watched at least one live animal show, highlighting their continued popularity in a modern zoo. Given that 1.17 million visits were made to Flamingo Land in the year of the survey (Flamingo Land Annual Audit 2016) this equated to approximately 332,000 visits to on-site live animal shows. If we assume similar numbers of visitors attend live animal shows on a global scale, acknowledging that around 30% of zoos have some form of show, and apply this to the typical 700+ million visits to zoos each year, we suggest that over 50 million visits may be made to live animal shows globally. While these figures are very crude, our observations clearly suggest the huge importance of live animal shows to visitor engagement in zoos.

Overall, live animal shows had a positive impact on audiences' animal knowledge in line with their first intended learning outcome; to convey basic features and behaviours of animals. The significant, positive impact of seeing a show on visitor's knowledge echoes the findings of Moss et al. (2015). Since active animals tend to increase engagement in learning, it is possible that seeing the animal up close aided in knowledge transfer (Moss et al., 2010). Whilst the shows did convey knowledge, this alone is insufficient to impact behaviour and conservation action (Clayton et al., 2017; Hines, Hungerford & Tomera, 1986; Hughes, 2013; Myers, Saunders, & Birjulin, 2004). Accordingly, the very low deviance explained suggests that seeing a live animal show had limited impact on conservation action awareness. This supports findings from other zoo studies which indicate that visitors are unsure of conservation actions which they can personally undertake (Clayton et al., 2017; Esson & Moss, 2014). Whilst the show did mention conservation actions such as donating after the show, these appear to have been missed by most audience members.

The observation that more than a quarter of respondents could correctly recall animal facts prior to both shows, suggests that current show content may not be pitched at a high enough level to fully extend audience knowledge. Increasing the amount of learning content does not detract from enjoyment (Mann-Lang et al., 2016). Entertainment-focused live animal shows could therefore consider targeting their content beyond simply conveying animal facts. Allowing audiences to interact directly or ask questions to interpreters can increase learning (Povey & Rios, 2002). As seeing live animals elicits 'learning-talk' (Allen,

2004) encouraging audience discussions, on topics such as conservation, may enable live animal shows to extend learning beyond fact recall. Additionally, talking about conservation is known to improve perceived self-efficacy towards pro-environmental behaviours (Clayton et al., 2017) and may consequently aid uptake of conservation actions.

The finding that bird post-show audiences were able to identify and explain more adaptations, and threats facing species compared to pre-show, and compared to sea lion show audiences, indicates that this multi-species show may have a greater impact on audiences' biodiversity and environmental awareness. The sea lion show also conveyed some species adaptation information. However, our observation regarding false learning indicates that the show's use of non-naturalistic behaviours as educational hooks is causing misconceptions. We only examined one question to test the impact of trick behaviours, but our finding of an increase in non-natural and a decrease in natural behaviours being mentioned post-show poses a concern. This, combined with the fact that trick behaviours were recalled post-visit but conservation messages were not, raises questions as to the effectiveness of using non-natural behaviours to demonstrate adaptations. Other studies have suggested that messages can become confused when a conservation or biodiversity storyline is too complex (Mann-Lang et al., 2016). As such, the more removed the trick is from the natural behaviour, the more likely that audiences will misinterpret the message. Tricks may have entertainment or animal enrichment value (Whitehouse-Tedd et al. 2020) therefore are not likely to be removed entirely from animal shows. However, modifications can make these on-cue behaviours more naturalistic. For example, since this study, the show we tested has changed from ball balancing to using a model fish in the hope it will reinforce the concept that sea lions' whiskers are used to sense fish.

Respondents recalled specific information about individual animals better than overall concepts post-visit. Developing emotional bonds to individual animals has been found to be important in committing to conservation actions (Clayton et al., 2017; Myers et al., 2004; Skibins & Powell, 2013). Knowing this, live animal shows should make clear links between the individual animals in their shows and wider conservation issues affecting the species.

Post visit comments confirm the strong entertainment value of live animal shows. This is important as the show must appeal to the leisure seeking audience who are visiting the zoo. However, caution must be exercised to ensure that the entertainment value of the show does not mask important conservation messages.

External factors such as weather conditions were found to be a significant variable in correct response. This indicates that in order for learning potential to be maximised audience's needs should be met. Concern over the impending weather or issues over sound quality may distract audience attention and lead to reduced learning. These issues can be easily avoided with good display arena design.

Whilst this study did not experimentally compare live animal shows with animal-free alternatives, its findings can be reviewed against those of Spooner et al (2019) who undertook research at the same site using a very similar survey design. Spooner et al. (2019) found a significant knowledge gain post-viewing an animal-free, family-oriented puppet and costumed actor performance which featured speech, song, dance and a large digital screen with supporting images. This animal-free show had a similar effect size as the live animal bird show we tested in this study and a stronger impact than for the sea lion show. This suggests that animal-free alternatives are potentially just as effective as live animal shows for conveying animal information to a zoo-going audience. Using animal-free alternatives could be particularly beneficial for animals which are difficult to train, critically endangered or who

do not respond well to large audiences. Caution must be exercised in comparing these shows, however, as the animal-free show in Spooner et al (2019) was designed in conjunction with the zoos education department and targeted a slightly different demographic to the shows tested in this study.

This study focuses on the findings from a single UK study site and adds to existing literature. More studies are required to create a broader understanding of the conservation education impact of live animal shows on zoo visitors globally. Our findings, highlight both the benefits of live animal shows and the potentially damaging effects of trick behaviours to audience understanding.

In conclusion, the mass potential audience and continued popularity of live animal shows mean they are a valuable platform for conveying information to visitors during a leisure outing to the zoo. Conveying the right message to promote conservation is crucial, and must be guided by evaluation evidence (Jensen & Gerber 2020). Live animal shows are effective at conveying facts, but these alone will not impact visitor behaviour or desperately needed pro-environmental social change (Moss et al. 2017). A key strength of live animal shows is their ability to create an emotional connection to an individual animal. Conservation educators can build on this emotional connection with messaging that engages audiences with wider conservation issues. Live animal shows should concentrate on presenting behaviours as naturally as possible to avoid false learning. Additionally, shows could consider whether the information they provide adds to audiences' existing knowledge or whether alternative presentation styles could be adopted to provide a stronger connection to conservation issues.

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Declaration of Interest

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Data Availability

Data are available at UK Data Service ReShare 10.525/UKDA-SN-853214

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Table Captions

Table 1: Participant sample characteristics for sea lion and bird show audiences surveyed under live animal show impact evaluation (pre- and post-show) and general visitor surveys. CI = Bootstrapped confidence interval.

Table 2: coding table used to mark open ended responses to knowledge questions.

Table 3: Generalised Linear Models applied for explaining variance in knowledge and conservation action awareness, for a) sea lion show, and b) bird show.

Table 4: Comparison of achievement of learning objectives (a) and (b) as demonstrated through visitor knowledge identified from pre- and post-show surveys and through general visitor surveys.

Table 6: Estimated parameters, p values in brackets, and percentage deviance %D, for each predictor variable in the most optimal models of stated personal conservation actions (based on AIC).

Table 5: Estimated parameters, p values in brackets and percentage deviance %D, for each predictor variable in the most optimal models of animal show audience knowledge (based on AIC).

Table 7: Impact of watching a sea lion show on specific responses to the question 'why are sea lions' whiskers so important?'. Coding based on natural behaviours, e.g. sensing vibrations, finding fish, versus false learning, e.g. balancing and balancing objects. p = significance; w = test statistic; d = effect size.

Table 8: Themes recalled from live animal shows post-visit, including example statements and the percentage of visitors mentioning each theme.

Table 1: Participant sample characteristics for sea lion and bird show audiences surveyed under live animal show impact evaluation (pre- and post-show) and general visitor surveys. CI = Bootstrapped confidence interval.

	Sea lion show	Bird show
Live animal show impact evaluation		
Sample size	188 pre-show 155 post-show (47 repeat tested)	111 pre-show 110 post-show (38 repeat tested)
Mean age (and 95% CI)	31.5 (29.8 - 33.2)	32.8 (30.7 - 35.0)
Gender: Percentage of females	89.1	64.8
Mean (and 95% CI) household income before taxes (£)	29,317.00 (27,525.00 - 31,053.00)	25,708.68 (23,697.14 - 27,679.92)
Modal highest education achieved	GCSE or equivalent	GCSE or equivalent
General visitor surveys		
Total surveys completed	160	
Number of overall visitors who visited the zoo	134	
Number (and %) of zoo visitors who attended at least one live animal show	38 (28.4%)	
Number (and %) of zoo visitors who attended each live animal show	33 (24.6%)	10 (7.5%)
Number who provided comments on the show seen	18	7
Mean age (and 95% CI) of those viewing the show	41.2 (35.9 - 46.4)	42 (36.1 - 48.7)
Gender: Percentage of show viewers who were female	66.7	71.4

Mean household income before taxes (£); all post-visit respondents	26,714.48 (24,242.66 - 29,200.23)	
Mean household income before taxes (£) of those viewing a show	30,312.50 (24,375.0 - 36,041.67)	31,500.00 (22,750.00 - 40,000.00)
Modal highest education achieved of those viewing a show	Vocational level	Vocational level

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653 Table 2: coding table used to mark open ended responses to knowledge questions.

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Question	**Code as correct (1)**
SL1 a) What is special about a sea lion's eyes?	Binocular vision / forward-facing / like binoculars / like goggles underwater / special layer of cells / film layer / protective layer / can see in the dark / can survive if blind
SL1 b) How does this help them in the wild?	To catch prey / to catch fish / to hunt / to judge speed and distance / depth perception / helps with light refraction / to protect eye / stops stuff getting into eyes / to help with vision in the dark or murky water / see in low light levels
SL2) Why are sea lion's whiskers so important?	Balance / balance objects / sense prey / sense vibrations / find fish / contain nerve endings / very sensitive / to feel /touch / to feel fish / to sense if go blind / hunt if murky / detect food / detect prey / detect size of space, don't bump into things
B1) What threats do owls face in the wild?	Cars / pesticides / poisoned / lack of barns or nest sites / deforestation / habitat loss
B2 a) What is special about a parrot's sight?	See in colour / peripheral vision / side view / eyes on side of head
B2 b) How does this help them survive in the wild?	Colour vision: identify ripe fruits / don't eat poisonous berries / peripheral vision: escape predators
	Code as follows:
What body features and behaviours help [species/animal name] survive in the wild?	0 = no features / behaviours identified 1 = one behaviour / feature identified 2 = two or more features / behaviours identified 3 = one behaviour / feature identified and explained 4 = two or more behaviours / features identified and explained
What if anything could you do personally to help conservation?	0 = no action 1 = generic action stated 2 = specific / personal action stated

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Table 3: Generalised Linear Models applied for explaining variance in knowledge and conservation action awareness, for a) sea lion show, and b) bird show.

a)

Model	Predictor variables
Personal factors (M1)	Show seen + respondent income + visit in the last 12 months + show seen before + respondent education
Personal factors (M2)	Show seen + respondent age + respondent income + respondent education + show seen at another zoo + gender (female)
Show factors (M3)	Show seen + number of adults viewing the show (log) + presenter + time of show + sea lion used (Miguel)
Show factors (M4)	Show seen + number of adults viewing the show (log) + presenter + sea lion used (Clive) + show seen at another zoo
Show factors (M5)	Show seen + presenter + time of show+ sea lion used (Marvin)
Show factors (M6)	Show seen + number of adults viewing the show + presenter + time of show+ sea lion used (Merlin)
External factors (M7)	Show seen + show seen before + cloud cover (0-25%, 26-50%, 51-75%, 76-100%)
External factors (M8)	Show seen + presenter + temperature

b)

Model	Predictor variables
Personal factors (M1)	Show seen + respondent income + visit in the last 12 months + show seen before + respondent education
Personal factors (M2)	Show seen + respondent age + respondent income + respondent education + show seen at another zoo + gender (female)
Show factors (M3)	Show seen + number of adults viewing the show (sqrt) + presenter + time of show
Show factors (M4)	Show seen + number of adults viewing the show (sqrt) + presenter + show seen at another zoo
External factors (M5)	Show seen + show seen before + cloud cover (0-25%, 26-50%, 51-75%, 76-100%)
External factors (M6)	Show seen + presenter + temperature (^3)

Table 4: Comparison of achievement of learning objectives (a) and (b) as demonstrated through visitor knowledge identified from pre- and post-show surveys and through general visitor surveys.

(a) To convey basic features and behaviours of animals to their audience

	Pre-/ post- live animal show survey	**General visitor survey Post- visit responses**
Sea lions have very sensitive whiskers, they act as a detection system to allow them to feel changes in the water and use these to find fish.	Correct answer: 63.3% pre-show, 69% post-show (+5.7% change) 'False learning': pre-show: 13.3%, post-show 25.8% (+12.5% change)	1 out of 18 respondents recalled '*the whisker facts*' but provided no further detail. 1 out of 18 respondents recalled '*balance balls*'
Sea lions have binocular vision which helps them judge speed and depth. This is used when hunting prey. Sea lions' eyes also have a special layer of cells to protect the surface of the eye.	Correct answer: 11.2% pre-show, 68.4% post show (+57.2% change)	Not mentioned
Difference between seals and sea lions including that- seals have smaller flippers, sea lions can walk on land whilst seals slide, and that sea lions have visible ear flaps.	Not asked in survey	4 out of 18 respondents were coded as mentioning differences between seals and sea lions. These differences were not explained.
Parrots see in colour and that this allows them to select ripe fruits and avoid poisonous ones.	Correct response: 21.6% pre-show, 50.0% post-show (+28.4% change)	Not mentioned
Parrots are intelligent and can talk.	Not asked in survey	1 out of 7 statements recalled birds as being '*intelligent*' 1 out of 7 recalled the '*parrot talking*'.
Owls have several features to help them hunt prey these include their facial disk, sharp talons and beak, ability to turn their neck three quarters of the way around and sensitive hearing.	Not asked in survey	Not mentioned

Vultures have bald heads to keep them clean when eating carcasses. Vultures glide on thermals to conserve energy. They need to conserve energy as they scavenge for food and food sources are unreliable.	Correct response: 39.6% pre-show, 48.9% post show (+9.3% change)	Not mentioned

(b) To indicate how the audience could help in wildlife conservation

	Pre- / post-live animal show survey	**General visitor survey – post- visit responses**
The public can help protect seals and sea lions by donating to the Monk Seal Conservation Trust and by not littering at the beach.	One or more conservation actions stated: 52.1% pre-show, 61.3% post-show (+ 9.2% change)	Not mentioned
Flamingo Land raises money for the Hawk and Owl trust to protect native species. Donations made at the bird show go to this trust.	One or more conservation actions stated: 63.1% pre-show, 66.4% post-show (+ 3.3% change)	2 out of 7 statements recalled general conservation efforts with no specific information
Barn Owls are threatened in the UK primarily by habitat loss from barn conversions, traffic collisions, and pesticides killing prey species.	Correct response: 46.8% pre-show, 55.5% post-show (+8.7% change)	Not mentioned

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684 **Table 5**

	Sea lion show			Bird show
	Personal factors M2	Personal factors M1	External factors M7	External factors M5
AIC	1344.0	1345.1	1345.7	741.3
Show seen	0.308 (<0.001) %D = 5.9	0.307 (<0.001) %D = 5.9	0.360 (<0.001) %D = 8.4	0.465 (<0.001) %D = 10.2
Respondent's age	-0.001 (0.602) %D = 0.1	-	-	-
Respondent's income	-0.025 (0.047) %D = 0.9	-0.026 (0.039) %D = 0.1	-	-
Respondent's education	0.070 (< 0.001) %D = 2.4	0.072 (< 0.001) %D = 2.5	-	-
Gender	0.090 (0.161) %D = 0.5	-	-	-
Visit in the last 12 months	-	0.045 (0.505) %D = 1.0	-	-
Show seen before	-	0.038 (0.568) %D = 0.1	0.042 (0.483) %D = 0.1	0.150 (0.088) %D = 1.1
Show seen at another zoo	0.080 (0.188) %D = 0.4	-	-	-
Cloud cover	-	-	0.005 (<0.001) %D = 2.8	-0.063 (0.638) %D = 2.8

685 *Table 6: Estimated parameters, p values in brackets, and percentage deviance %D, for each*
686 *predictor variable in the most optimal models of stated personal conservation actions (based*
687 *on AIC).*

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	Sea lion show		Bird show		
	External factors	Personal factors	External factors	Show factors	External factors
	M7	M1	M6	M4	M5
AIC	464.3	464.5	263.7	263.8	265.0
Show seen	0.531 (0.019) %D = 1.2	0.394 (0.084) %D = 0.6	0.001 (0.002) %D = 2.0	0.064 (0.034) %D = 1.7	0.707 (0.020) %D = 2.1
Respondent's income		-0.095 (0.042) %D = 0.9	-	-	-
Respondent's education		0.160 (0.048) %D = 0.9	-	-	-
Visit in the last 12 months		0.334 (0.186) %D = 0.4	-	-	-
Show seen before	0.380 (0.087) %D = 0.6	0.298 (0.215) %D = 0.3	-	-	-0.201 (0.511) %D = 0.2
Show seen at another zoo	-	-	-	0.544 (0.077) %D = 1.5	-
Presenter			-0.005 (0.357) %D = 0.3	-0.229 (0.220) %D = 0.8	-
Number of adults viewing the show	-	-	-	<0.001 (0.570) %D = 0.4	-

Cloud cover	0.015 (0.005) %D = 1.7	-	-	-	-0.458 (0.372) %D = 1.9
Temperature	-	-	0.001 (0.208) %D = 0.6	-	-

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692 *Table 7: Impact of watching a sea lion show on specific responses to the question 'why are*
693 *sea lions' whiskers so important?'. Coding based on natural behaviours, e.g. sensing*
694 *vibrations, finding fish, versus false learning, e.g. balancing and balancing objects. p =*
695 *significance; w = test statistic; d = effect size.*

Analysis	Sample		N	Mean	S.D.	p	w	d
Natural behaviour	Sense vibration / find fish / spaces	Pre	146	0.91	0.29	0.441	4309.5	-0.1
		Post	144	0.88	0.33			
False learning	Balancing	Pre	146	0.17	0.37	0.015	6062.5	0.29
		Post	144	0.29	0.45			
	Balancing objects	Pre	146	0.01	0.08	0.007	765	0.28
		Post	144	0.06	0.25			

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704 *Table 8: Themes recalled from live animal shows post-visit, including example statements*
705 *and the percentage of visitors mentioning each theme.*

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	Sea lion show audience		Bird show audience	
Theme	**Example statements**	**% responses (n = 18)**	**Example statements**	**% responses (n = 7)**
Individual details	*'Clive weighed 42 stone last time they weighed him. He's the oldest sea lion they have.'* *'We absolutely loved Merlin the sea lion, such a clever sea lion.'*	33.3	*'Charlie the parrot, the wading bird and the vulture.'*	28.6
Educational	*'Great, educational and very engaging.'* *'Really informative.'*	22.2	*'Really informative and fun to watch.'*	14.3
Entertainment	*'We have seen it many times and love every minute of it.'* *'Loved it, as did the children.'*	22.2	*'It was funny.'* *'My daughter had fun and enjoyed it.'*	57.1
Tricks	*'The animals do repetitive 'tricks'.'* *'How they balance balls.'* *'The tricks that the sea lion performed.'* *'Sea lions can clap. Seals can't.'*	22.2	*'Parrot talking was funny.'* *'The tricks.'*	28.6
Show conditions	*'The volume of the trainer's microphone could have been louder to accommodate for the large, and noisy, crowd.'* *'Only people at the top could hear the attendant speaking, so we felt we wasted our time.'*	11.1	-	0

Conservation	-	0	*'Conservation efforts.'* *'The work they do to conserve local owls.'*	28.6
Positive sentiment	-	44.4	-	85.7
Neutral sentiment	-	38.9	-	14.3
Negative sentiment	-	16.7	-	0
Visitor satisfaction (somewhat satisfied to highly satisfied)	-	80% (n = 22)	-	100% (n = 8)