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RESEARCH ARTICLE

Making a Tiger's Day: Free-Operant Assessment and Environmental Enrichment to Improve the Daily Lives of Captive Bengal Tigers (*Panthera tigris tigris*)

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Abstract
There are more captive tigers in the United States than there are wild tigers in the entire world. Many animals under human care engage in problem behaviors such as excessive grooming and aggression, although the origin of these behaviors is typically unknown. Environmental enrichment may mitigate these issues in captive animals of all kinds. In order to individualize enrichment experiences, the current study used a free-operant assessment procedure to establish a menu of most preferred play items and scents among 7 Bengal tigers (*Panthera tigris tigris*) housed at a sanctuary in southwest Missouri. Each tiger was tested 3 times with scents (cinnamon and Calvin Klein Obsession perfume) and play items (boxes, balls, leaves, and pumpkins). The importance of rigorous assessment of presumed reinforcers among captive wild animals, as well as the difficulty of effectively assessing tigers while ensuring the safety of both the participants and researchers, is discussed.

Keywords Environmental enrichment · Free operant · Preference assessment · Tigers

There was once an abundance of tigers (*Panthera tigris*) in the wild, including eight subspecies (three of which are now extinct), spread across 13 countries ("Tigers," n.d.). A century ago, 50,000 to 80,000 roamed India alone. By 1998, an estimated 7,000 tigers remained in the wild, and by 2010 the population had decreased to 2,154. Today, it is estimated that there are 3,159 wild tigers remaining in the world and 5,000 in captivity in the United States ("More Tigers," 2014). These population declines are due to high levels of poaching and habitat destruction (Karmacharya et al., 2018), and tigers are now considered endangered, with imminent extinction in the wild likely (Narayan et al., 2013). Therefore, captivity is vital to preserving tigers as a species—and necessary if reintroduction into the wild becomes feasible. Given the necessity of keeping tigers in captivity, it is important to do everything necessary to ensure their health and well-being if eventual extinction is to be avoided.

One motive for keeping wild animals in captivity is for entertainment and profit (Fudge, 2005). Another motive is to protect what is left of a species on the brink of extinction (e.g., rhinoceroses, tigers). Zoos that are accredited by the Association of Zoos and Aquariums facilitate breeding in support of species conservation and use applied population biology to ensure the adequate genetic diversity of captive populations. One consequence of this practice is that many animals in human care engage in problem behaviors such as excessive grooming and aggression to some degree (Carlstead, 1996; Vaz et al., 2017). Historically, captive wild animals have been kept in enclosures that are restrictive and without sufficient stimulation as found in nature (Mench & Kreger, 1996). One way to possibly mitigate problem behavior is to enrich the animals' lives with physical and mental stimulation (Márquez-Arias, Santillán-Doherty, Arenas-Rosas, Gasca-Matías, & Muñoz-Delgado, 2010).

Environmental, or behavioral, enrichment is defined in part as

> "a process for improving or enhancing zoo animal environments and care within the context of their inhabitant's behavioral biology and natural history . . . with

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> the goal of increasing the behavioral choices available to animals and drawing out their species-appropriate behaviors and abilities. (Shepherdson, 2003, p. 119)."

In practice, this definition covers a multitude of practices aimed at "providing adequate social interaction, keeping animals occupied, allowing an increased range and diversity of behavioral opportunities, and providing more stimulating and responsive environments." Mellen and MacPhee (2001) suggested five general goals for enrichment: (a) enhancing animal welfare, (b) ensuring successful reproduction, (c) reducing stress, (d) decreasing aberrant behavior and increasing species-typical behavior, and (e) ensuring successful reintroduction. Examples of common enrichment techniques range from naturalistic foraging tasks to the introduction of objects for manipulation, play and exploration, novelty, and sensory stimulation (Márquez-Arias et al., 2010; Skibiel, Trevino, & Naugher, 2007).

Enrichment is now considered a critical component of animal care programs designed to maximize animal welfare (Barber, 2009) using a wide variety of strategies (Maple, 2007). The most common strategy involves a foraging challenge where a novel food item is introduced (Mcphee, 2002) or its access is made more complex (Burgener, Gusset, & Schmid, 2008). In order to increase activity levels and decrease stereotypic behaviors of tigers and lions, Bashaw, Bloomsmith, Marr, and Maple (2003) provided live fish and horse leg bones, with positive changes being maintained 48 hr afterward. Jenny and Schmid (2002) used feeding boxes to restrict access to food and require that the tigers work to attain their food. Results showed a decrease in stereotyped pacing and an increase in sleep time. Food items have also been temporally and/or spatially dispersed in order to decrease stereotypic behaviors. Quirke and O'Riordan (2011a) introduced temporal and spatial feeding variation along with olfactory enrichment using cheetahs and found a significant increase in exploratory behaviors and a significant decrease in pacing behaviors (see also Quirke & O'Riordan, 2011b).

Another strategy involves enclosure design modifications to enrich previously barren housing for big cats (Mallapur, Qureshi, & Chellam, 2002). Moreira, Brown, Moraes, Swanson, and Monteiro-Filho (2007) evaluated the effects of different housing conditions on the reproductive cyclicity and adrenocortical activity of three adult female leopards. Moving from large, enriched housing to small, unenriched housing decreased reproductive health and increased stress hormones, and yet subsequent enrichment of small enclosures was insufficient for restoring reproductive cyclicity. Relatedly, enclosures designed with easy visual access to other social partners tend to increase stereotyped pacing, but the addition of a visual barrier was an ineffective treatment (Bashaw, Kelling, Bloomsmith, & Maple, 2007). However, pacing also differs by species. Bashaw et al. (2007) found that tigers differentially paced depending on exhibit, whereas lions paced more when off-exhibit that when on.

The presence of other animals has also been shown to be of benefit to tigers and lions. Social enrichment has been shown to decrease stress and associated pacing by simply housing cats either with, or nearby, other cats (De Rouck, Kitchener, Law, & Nelissen, 2005; Macri & Patterson-Kane, 2011; Miller, Bettinger, & Mellen, 2008). Interestingly, the introduction of recorded lion roars increased the live roars and playfulness of lions (Kelling, Allard, Kelling, Sandhaus, & Maple, 2012). It has been suggested that even human contact meets some of the criteria that traditional methods of environmental enrichment aim to satisfy (Claxton, 2011). Whereas human contact is widely studied in farm animals, there is a paucity of research on exotic animals. Therefore, the value of human contact may depend on the species of exotic animal.

In general, enrichment that seeks to approximate the natural environment of the target species will be of benefit to animals, but often overlooked is the fact that the natural environment of common zoo animals is actually very stressful. Sajjad, Farooq, Anwar, Khurshid, and Bukhan (2011) tracked behavioral indicators of stress and corticosteroids and found that stress hormones were similarly elevated in both a traditional zoo exhibit and in a seminatural environment within a wildlife park, but the time spent pacing and resting was greater in captive animals than in those housed in the wildlife park.

Finally, a neglected and contested area of enrichment is the effect of positive reinforcement training on the well-being of animals. Westlund (2014b) suggested four criteria for deciding whether an intervention should be considered enrichment. Enrichment should (a) give an animal more control over its environment, (b) add behavioral choices, (c) promote species-specific repertoires, and (d) empower the animal to deal with challenges. Formal training using operant conditioning techniques can satisfy all of these criteria and could be considered environmental enrichment (Westlund, 2014a).

Although animal welfare is the primary motivation for environmental enrichment, positive changes in an animal's behavior as a result of enrichment has other benefits as well. Captive wild animals are more likely to exhibit playful and naturalistic behaviors than aggressive or stereotypic behaviors when they are sufficiently engaged (Makecha & Highfill, 2018). These behavior changes enhance guest experiences at zoos, sanctuaries, and in recorded documentaries as well, and help educate visitors on how these animals might act in the wild (Shepherdson, 1998). Visitors to zoos and animal parks are happier with their decision to visit when they feel the animals are being properly cared for and look relatively happy to be in captivity (Mellen, Stevens, & Markowits, 1981). In addition, Miller (2012) found that visitors' perception of animal care and interest in supporting zoos both declined after visitors noticed a tiger pacing in its exhibit. In recent years, there have been calls for more behavior-analytic methodology and participation in environmental enrichment research (Alligood, Dorey, Mehrkam, & Leighty, 2017; Maple & Segura, 2015).

Although there has been a lot of research on implementing environmental enrichment programs with captive animals, evaluation of these programs has been less common. Subjective assessment is not adequate, but systematic evaluations have been more the exception than the rule. Mellen and MacPhee (2001) developed a six-step framework for effective enrichment programs that includes setting goals, planning, implementing, documenting, evaluating, and readjusting (SPIDER). Barber (2006) noted, though, there are still "three-legged SPIDERs" and emphasized the importance of all six components to ensure effectiveness. Therefore, a fruitful area of research would be filling out the rest of the SPIDER framework. In addition to documenting, it is necessary to carefully evaluate the effectiveness of enrichment strategies and to readjust them based on the results of the evaluation (Alligood & Leighty, 2015).

An important component for evaluating enrichment strategies is establishing the most preferred items or experiences. Items and experiences that are only mildly reinforcing are obviously less effective than more highly preferred items and experiences (Fernandez, Dorey, & Rosales-Ruiz, 2004). The use of preference assessments has proven to be an effective and generally simple way to establish preferred items in both humans and animals. Procedures that incorporate the results of preference assessments have also been shown to reliably reduce abnormal or unwanted behavior in humans (Ringdahl, Vollmer, Marcus, & Roane, 1997).

And yet interest in preference assessments with captive animals is a relatively recent phenomenon. Fernandez et al. (2004) used a two-choice food preference assessment with Tamarin monkeys and found great variation between animals but a general trend in preference for specific items within animals. Mehrkam and Dorey (2014) studied the relationship between preference and enrichment efficacy in Galapagos tortoises (*Chelonoidis nigra*) and found that preference was an accurate predictor of enrichment efficacy. Finally, Shreve, Mehrkam, and Udell (2017) investigated domestic cat preferences at the individual and population levels using a free-operant preference assessment. These authors found clear individual variability in cat preference, but that social interaction with humans was the most preferred stimulus category for the majority of cats, followed by food.

Most relevantly, Mehrkam and Dorey (2015) studied the utility of preference assessments across six common zoo animals and found that, regardless of experience, zoo personnel were more accurate at predicting least preferred stimuli than most preferred stimuli across species and tended to make the same predictions for all individuals within a species. Significantly, they tended to generalize preferences from individuals to all members of a species when preference is actually highly individual (Mehrkam & Dorey, 2015). Preference for an item during assessment does not necessarily lead to increased animal welfare, but clear item preferences during assessment may be a prerequisite for assessing behavior-change procedures that do.

The current study used a free-operant preference assessment paradigm to establish a menu of most to least preferred play items for seven captive Bengal tigers. In addition to being large, dangerous animals, the tigers were residents of an animal sanctuary and had suffered significant deprivation and mental/physical abuse prior to being surrendered to the sanctuary. The safety and comfort of the tigers were of paramount concern in carrying out the preference assessments in a way that was efficient, effective, and enjoyable to the tigers.

Method

Subjects

Seven adult Bengal tigers (*Panthera tigris tigris*) living at a sanctuary in southwest Missouri were subjects in the study. The tigers ranged in age from 6 to 16 years old and consisted of five females and two males. All of the subjects experienced significant neglect and/or punishment as performing tigers that had been surrendered to the sanctuary.

Harry, a 6-year-old male orange Siberian (*Panthera tigris altaica*) and Bengal (*Panthera tigris tigris*) hybrid, weighed approximately 550 pounds and was a sanctuary resident of 5 years. Harry was previously a part of the cub-handling or "pay for play" industry. Harry lived in his own enclosure with another tiger on one side and several lions on the other side.

Farah, a 15-year-old female white Bengal tiger (*Panthera tigris tigris*), weighed approximately 350 pounds and was a sanctuary resident of 18 months. Farah was previously part of a breeding program that leased tigers to circuses. She lived in her own enclosure with other tigers on either side.

Dakar, a 6-year-old male white Bengal tiger (*Panthera tigris tigris*), weighed approximately 500 pounds and was a sanctuary resident of 18 months. Dakar was previously part of a breeding program that leased tigers to circuses. Dakar lived in his own enclosure with another tiger on one side of his enclosure.

Carma, a 10-year-old female white Bengal tiger (*Panthera tigris tigris*), weighed approximately 350 pounds and was a sanctuary resident of 1 year. Carma was also previously part of a breeding program that leased tigers to circuses.

Princess, a 13-year-old female white Bengal tiger (*Panthera tigris tigris*), weighed approximately 350 pounds and was a sanctuary resident of 4 years. She had been a performer in a magic show and lived in a basement prior to arriving. When she was rescued, it was the first time she had seen the sun or felt grass. Princess lived in a shared enclosure (with Precious and Stripey) and was the dominant animal in the enclosure. Due to their previous history, the three tigers (Princess, Precious, and Stripey) were unable to live separately without significant distress.

Stripey, a 16-year-old female orange Bengal tiger (*Panthera tigris tigris*), weighed approximately 275 pounds and was a sanctuary resident of 4 years. As with Princess, she had been a performer and experienced significant environmental deprivation. Stripey lived in a shared enclosure (with Precious and Princess) and was the least dominant animal in the enclosure. She was very friendly toward both other tigers and humans.

Precious, a 13-year-old female white Bengal tiger (*Panthera tigris tigris*), weighed approximately 350 pounds and was a sanctuary resident of 4 years. As with Stripey and Princess (her sister), she had been a performer and experienced significant environmental deprivation. Precious lived in a shared enclosure (with Stripey and Princess) and had chronic strabismus esotropia (cross-eyes) that resulted in a loss of depth perception. She was very friendly toward both other tigers and humans.

Setting

All of the tigers were housed at the National Tiger Sanctuary in southwest Missouri. Princess, Precious, and Stripey were housed together, whereas the rest of the tigers were housed in their own enclosures. Enclosures ranged in size from 5,000 to 15,000 square feet. The sanctuary was located on 130 acres and included dozens of other rescued animals, including 18 additional tigers, 9 lions, 4 leopards, 2 mountain lions, 12 wolf hybrids, and 1 alligator.

Preference Assessments

Free-operant preference assessments were completed for each of the tigers. There were three phases for each subject, 5 min in length, and each phase was video recorded using partial-interval recording in 5-s blocks (PI-5"). There was a total of 15 min of observation for each tiger, or 5 min for each phase.

Three of the subjects—Princess, Precious, and Stripey—were assessed together due to the fact that they lived in the same enclosure and were not able to be separated.

Phase 1 The first phase of assessments was used to identify the most highly preferred scent of two scents used for enrichment at the sanctuary: cinnamon and Calvin Klein Obsession perfume. For convenience, pumpkins were used during this phase because they were plentiful during the time of year that Phase 1 took place and the tigers enjoyed them. The trial consisted of two pumpkins placed in the center of the enclosure with clear visual identification by the observer(s). One pumpkin was scented with Obsession, and the other with cinnamon. To be judged as "choosing" a scent, the tiger had to touch the pumpkin with its nose, tongue, or paw. Simply smelling the pumpkin while standing above it did not count. The most preferred scented pumpkin during Phase 1 determined the scents used in Phase 2.

For the enclosure that held three tigers, there were a total of six pumpkins, three of each scent, so that each of the tigers had access to the same number of items as the individually housed tigers did.

Phase 2 The second phase consisted of three new enrichment items being presented at the same time using the preferred scent chosen by each tiger in Phase 1. The enrichment items were a cardboard box, a pile of leaves, and a favorite toy. Each tiger had a favorite toy in its enclosure, and these were balls that ranged from 10-pound bowling balls to 75-pound hard plastic balls, depending on the tiger and its degree of destructiveness. In Phase 2, each of the three enrichment items was placed in a central area of the tiger's enclosure.

As in Phase 1, the enclosure that held three tigers included a total of six enrichment items. There were two scented items for each of the three tigers.

The stimuli were lined up in a row, where the observer(s) could observe each easily, and had the scent chosen by the tiger in Phase 1 applied to them. If the tiger touched the item with its nose, tongue, or paw, then that was scored. Simply smelling the item while standing above it did not count. The most frequently selected item during the PI-5" observation period was assigned most preferred status.

Phase 3 In the third phase, the most highly preferred items were presented again using both scents, along with an unscented item to confirm that the scent from Phase 1 was indeed the most preferred, thereby controlling for the smell of the pumpkin itself. As in the previous phases, the tiger had to touch the item with its paw, tongue, or nose. Standing over the object and smelling it but not touching it did not count.

For the enclosure that held three tigers, for whichever enrichment items were chosen by each tiger, there were three of each of those items in the enclosure during Phase 3 to account for each tiger.

Stimuli

Stimulus objects consisted of olfactory scents (cinnamon, Calvin Klein Obsession) and physical objects (leaf piles, balls, cardboard boxes, pumpkins). The scents were used in conjunction with the objects to enhance their attractiveness to the tigers based on the trainer's accumulated experience.

Piles of leaves were created by gathering fallen leaves and collecting them in 55-gallon barrels. The barrel was emptied into an enclosure, and piles were made about 2 feet high and 3 feet long.

There were several different types of balls used, depending on the tiger. The smaller, gentler tigers (i.e., Farah, Princess, Precious, and Stripey) used 10-pound bowling balls that were 8.5 in. in diameter. Carma used a 25-pound, 1-in. thick, 18-in. diameter, hard plastic ball. Harry used a 65-pound, 2-in. thick, 24-in. diameter, hard plastic ball, and Dakar used a 75-pound, 2.5-in. thick, 26-in. diameter, hard plastic ball.

Cardboard boxes also varied in size, ranging in size from 16 in. × 12 in. × 12 in. to 24 in. × 18 in. × 24 in. All packing tape was completely removed from the boxes before they were placed into the enclosures. If not, the tape could become stuck in the tiger's stomach and cause injury and/or death.

Pumpkins were donated to the sanctuary by local farmers and grocery stores and ranged in size and weight from 12 to 20 pounds.

Stimuli were lined up, 3 feet apart and 6 feet from the enclosure's perimeter fence, in order to facilitate the observation and recording of the assessment session. In the enclosure with three tigers, there were always three rows of stimuli. The second group of three stimuli was placed 4 feet behind the first group, and the third group was 4 feet behind the second group.

Procedure

All sessions with the tigers took place with the researcher outside of the enclosure and a fence separating the tiger from the researcher. The researcher present during each phase of the assessments videotaped all sessions. The researcher also took data (PI-5") during the assessments and recorded each instance of a tiger touching a stimulus object.

Each assessment phase lasted 5 min and ended immediately if the tiger moved an item from the observation area and returned to its sleeping area, as it was no longer visible to the researcher. During preparation for an assessment phase, there were up to six staff present, depending on the enclosure size and time since the last cleaning. During the assessment phase, there were three people present: the researcher and two staff members.

Stimulus placement prior to assessment was the most time-consuming and closely monitored portion of the process. In order to place the stimuli inside an enclosure, the tiger(s) had to be moved to an adjacent area of the enclosure using food and/or attention. A staff member at the fence line of the tiger's sleeping area called the tiger's name and provided a treat and/or attention when the tiger responded appropriately. Once the tiger was in the adjacent area of the enclosure, senior staff used a series of tools and pulleys to close off that area from the rest of the enclosure before opening the main enclosure for human access. The main enclosure was then cleaned, stimuli were lined up, and the application of scents (if needed in the phase) completed as quickly as possible. During this time, the tiger was in the adjacent bedroom area of the enclosure watching the process take place. Shifting the tigers between areas took between 5 and 10 min, depending on participants' cooperativeness that day. The goal was always to complete the setup procedure in 20 min or less.

Once the enrichment items had been placed in the enclosure and the proper scent(s) applied, everyone exited the enclosure so that the senior staff could shift the tiger(s) back into the observation area, using the same pulleys and tools used to shift them into the bedroom area previously. Scent application involved sprinkling 500 mg of ground cinnamon (1/8 teaspoon) or spraying 500 mg of Obsession (three to four pumps) onto the surface of the stimulus object. The tiger was then released back into the observation area and Phase 1 commenced.

Tigers are very sensitive to weather and air pressure fluctuations; therefore, temperature and barometric pressure were recorded during each session but did not appear to affect the tigers' activity level and associated behaviors.

Interobserver Agreement

Interobserver agreement was assessed by having a second observer watch 35% of the recorded experimental sessions. Records were compared on an interval-by-interval basis, and an agreement was scored on any interval in which both observers scored either the occurrence or the nonoccurrence of behavior with respect to each item. Agreement percentages were calculated for each phase by dividing the number of agreement intervals by the number of agreements and disagreements and multiplying by 100%. Mean interobserver agreement scores were 97% (range 96%–100%), 98% (range 97%–100%), and 99% (range 98%–100%), for Phase 1, Phase 2, and Phase 3, respectively.

Results

The data for the first four individually tested tigers are shown in Fig. 1. During Phase 1, Harry (Fig. 1, top left) touched the cinnamon-scented pumpkin (42%) more than the Obsession-scented pumpkin (20%). During Phase 2, he touched the cardboard box with cinnamon the most, spending 95% of his session time with it. During Phase 3, he touched the unscented cardboard box for most (98%) of the observation period, to the exclusion of the other two (scented) boxes. He seemed to prefer both scents when paired with pumpkins and the cinnamon-scented box in Phase 2, but the unscented cardboard box was the preferred enrichment item during Phase 3.

Data for the second tiger, Dakar, are also shown in Fig. 1. During Phase 1, Dakar (Fig. 1, top right) touched the Obsession-scented pumpkin (22%) but not the cinnamon-scented pumpkin. During Phase 2, he touched the

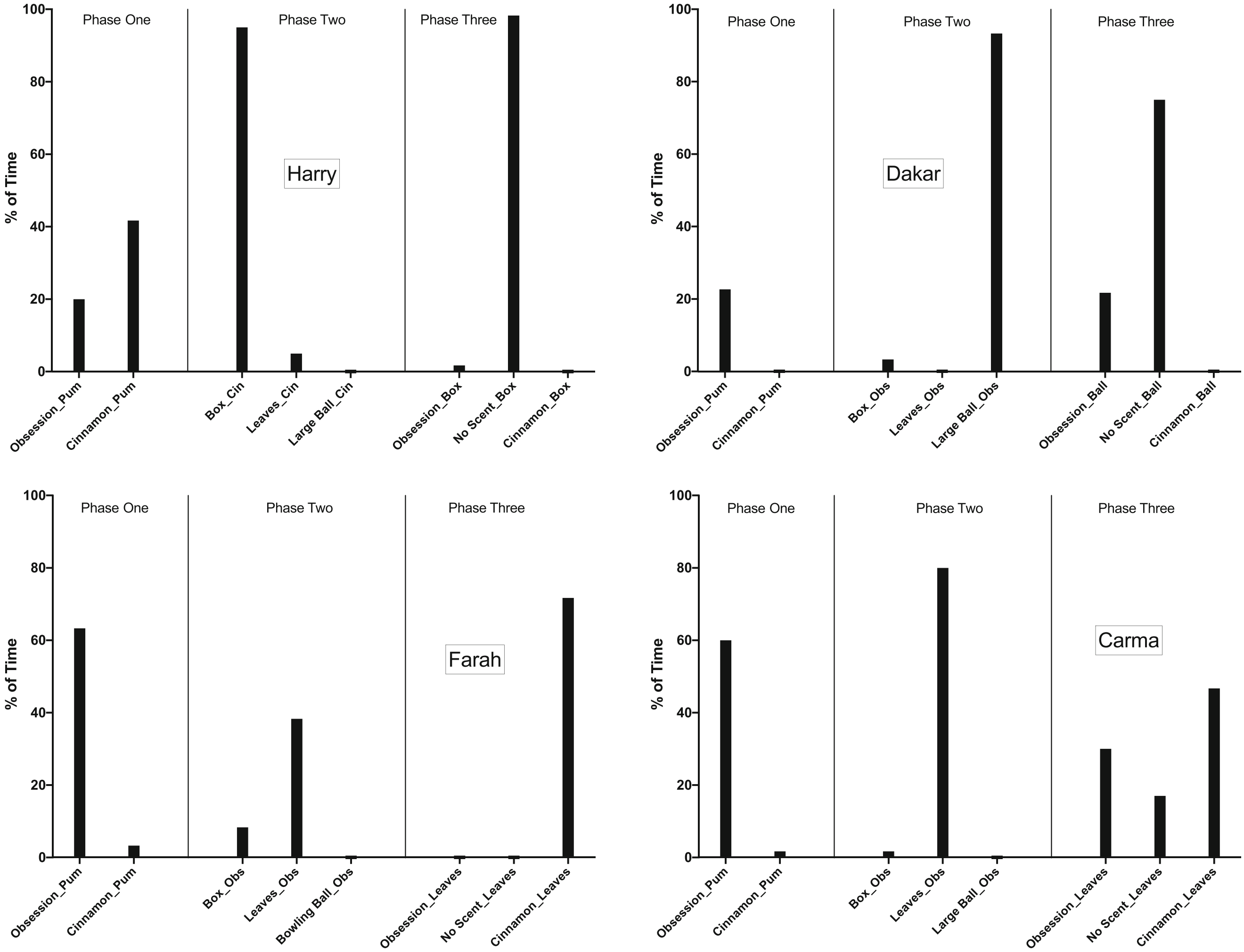

Fig. 1 Percentage of session time touching each stimulus item during preference assessments

Obsession-scented plastic ball the most, spending 93% of his observation time with the ball. During Phase 3, he touched the unscented ball for most (75%) of the observation time and the Obsession-scented ball 22% of the time.

Data for the third tiger, Farah, are also shown in Fig. 1. During Phase 1, Farah (Fig. 1, bottom left) touched the Obsession-scented pumpkin frequently (63%), but less so with the cinnamon-scented pumpkin (3%). During Phase 2, she touched the pile of leaves the most, spending 38% of her observation time with the leaves and less time with the cardboard box (8%). Finally, during Phase 3, she touched the cinnamon-scented leaf pile for most (72%) of the observation time and ignored the other two piles of leaves.

Data for the fourth tiger, Carma, are also shown in Fig. 1. During Phase 1, Carma (Fig. 1, bottom right) touched the Obsession-scented pumpkin (60%) but not the cinnamon-scented pumpkin (2%). During Phase 2, she touched the Obsession-scented pile of leaves the most, spending 93% of her observation time with the leaves and much less time with the other two enrichment items. During Phase 3, she touched all three piles of leaves. The two scented leaf piles were touched the most (cinnamon: 47%; Obsession: 30%), whereas the unscented leaves received less attention (17%). These data suggest that Carma preferred the pile of leaves as her enrichment item, regardless of what scent was on them.

The last three tigers, Precious, Princess, and Stripey, were tested together in the same enclosure and thus their phases were slightly different from those of the previous four subjects. In each phase, there were enough enrichment items (six to nine) for all three tigers. In this way, all three tigers would have access to all of the enrichment items available during that phase. For example, if one of the tigers was playing with a cardboard box, there were still two other boxes available to the other two tigers.

Data for the fifth tiger, Precious, are shown in Fig. 2. During Phase 1, Precious (Fig. 2, top left) touched the cinnamon-scented pumpkin the most, spending 62% of the observation time with one of the three cinnamon-scented pumpkins; she did not touch any of the Obsession-scented pumpkins during Phase 1. During Phase 2, Precious touched

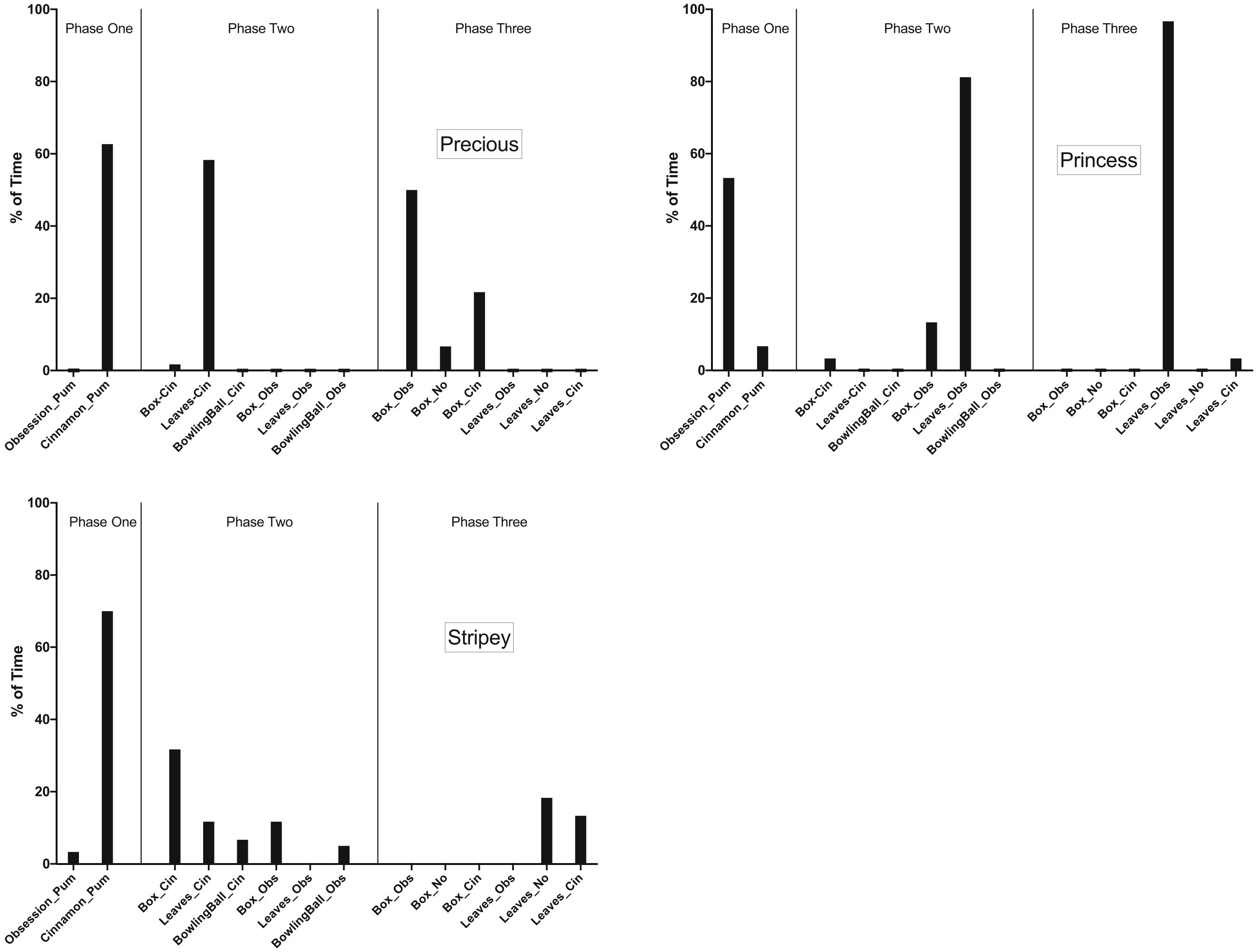

Fig. 2 Percentage of session time touching each stimulus item during preference assessments

two of the six enrichment items in the enclosure, the cinnamon-scented box (2%) and the cinnamon-scented pile of leaves (58%). She did not touch anything scented with Obsession. During Phase 3, Precious touched all three cardboard boxes but did not touch any of the three piles of leaves. She touched the Obsession-scented box the most (50%), followed by the cinnamon-scented box (22%) and then the unscented box (7%).

Data for the sixth tiger, Princess, are also shown in Fig. 2. During Phase 1, Princess (Fig. 2, top right) touched the Obsession-scented pumpkin, spending 53% of the observation time with one of the three Obsession-scented pumpkins and less than 7% of her time with any of the cinnamon-scented pumpkins. During Phase 2, Princess touched three of the six enrichment items in the enclosure: the Obsession-scented pile of leaves (82%), the Obsession-scented box (13%), and the cinnamon-scented box (3%). During Phase 3, Princess touched only two of the six items in her enclosure. She touched the Obsession-scented pile of leaves (97%) and the Obsession-scented cardboard box (3%). These results suggest that Princess preferred both the scent of Obsession and the pile of leaves.

Data for the seventh subject, Stripey, are also shown in Fig. 2. During Phase 1, Stripey (Fig. 2, bottom left) touched the cinnamon-scented pumpkins the most, spending 70% of the observation time with one of the three cinnamon-scented pumpkins and 3% of her time with any of the Obsession-scented pumpkins. During Phase 2, Stripey touched all but one of the enrichment items. She touched the cinnamon-scented cardboard box the most (32%), followed by the cinnamon-scented leaves (12%) and the Obsession-scented box (12%). The two items she touched the least were the cinnamon-scented toy (8%) and the Obsession-scented toy (5%). During Phase 3, Stripey touched only two of the six items in her enclosure: the cinnamon-scented pile of leaves (18%) and the unscented pile of leaves (13%).

Touching, in each of the aforementioned cases, was most often a more complex response than the term suggests. The tiger would, indeed, begin by touching an item with its nose and/or paw, but it would then proceed to play with the object using teeth, claws, and limbs. This would still count as a "touch" for the sake of data collection but was much more vigorous than simply touching. Even the bowling balls were unable to endure too much "touch" before requiring replacement.

Discussion

This study sought to establish a most preferred scent and object for each of seven Bengal tigers using two frequently used scents (Obsession and cinnamon) and familiar play items. Most of the seven tigers showed a preference for one of the olfactory stimuli during Phase 1. Some did so clearly, whereas others were less interested in either scent in Phase 1 (Harry and Dakar). During Phase 2, the preferred scent from Phase 1 was applied to three of the tiger's favorite enrichment items. The items themselves were specific to each tiger and ranged from bowling balls to piles of leaves. Six out of seven tigers showed a strong preference for one of the available enrichment items during Phase 2. Stripey touched most of the items to some degree, although she touched the cinnamon-scented cardboard box the most. During Phase 3, three of the most preferred items from Phase 2 were used as enrichment items, and scent was reintroduced as a component of the assessment. One item had cinnamon applied to it, the second item had Obsession, and the third was left unscented. This phase was used to confirm that the scent from Phase 1 and the item from Phase 2 were, in fact, most preferred.

The staff at the sanctuary indicated that scents (i.e., Obsession and cinnamon) were very important to the tigers and necessary for maximizing the effectiveness of the enrichment items. The staff had scented play items in the past and felt strongly that this was a necessary condition for environmental enrichment. Our results suggest that added scents may not always be necessary, depending on the individual tiger. Some of the tigers had a strong scent preference (Princess, Precious, and Dakar), and others did not (Harry, Farah, Carma, and Stripey). One implication of these results is that scented and unscented items could be rotated, increasing the variety of possible enrichment items while at the same time reducing costs.

The enclosure that housed three tigers (Princess, Precious, and Stripey) necessarily complicated assessment procedures during this study. The social dynamics and safety issues involved when working with tigers are very different from those involved when working with Galapagos turtles (Mehrkam & Dorey, 2014). First, we had to include more enrichment items in each phase. Second, we had to ensure that each of the tigers had the full 5 min of observation time. Third, additional staff members were required during their assessments to ensure the safety of the tigers if a fight began over the enrichment items. An additional consideration with the triad was issues relating to dominance and rank within the group, which may have affected the results. For example, if Stripey had been housed separately, she may have been more engaged and touched the enrichment items more during the observation periods than she did. Princess was the dominant animal of the three, and neither Stripey nor Precious would venture near her when she was playing with any enrichment items. So, although scent can be a strong determinant of animal behavior, it is not the only determinant of what enrichment items are chosen.

Both pumpkins and leaves have their own scent, which makes analysis of the two targeted scents (Obsession and cinnamon) more difficult. Cardboard boxes also have a scent that could have impacted the tigers' selection of most preferred items. There were several other limitations to this study. First, the process of doing assessments with tigers was necessarily cumbersome and time-consuming. The sanctuary is a private, nonprofit organization, dependent on donations and entrance fees. Therefore, 6 days each week are dedicated to visitors, and for 1 day each week, the animals rested. In order to not interfere with the visitors' park experience, we only ran assessment sessions on the day each week when the park was closed to the public. Thus, only one assessment session could be run with a cat (or group of cats) each week. In order to begin a session, we had to move the tiger to a separate area of the enclosure before the enrichment items could be placed into the enclosure. This procedure required multiple staff members and a series of pulleys and tools to move the tiger. Experimenters had to be acutely aware of the immediate environment and the location of the tiger(s) while completing this procedure. Further, the process of moving the tiger(s) and the presence of humans in their enclosure would agitate the tiger(s), and therefore this was kept to a minimum.

Second, the nature of the participants themselves made assessment particularly difficult. There were always two overriding concerns of the staff and trainers when doing the assessments: (a) the safety and comfort of the tigers and (b) the safety of the people. The tigers were surrendered and rescued by the sanctuary because they were living in very difficult settings. They had previously been housed in small cages and subject to frequent physical punishment. The cats were remarkably resilient and thrived at the sanctuary. It is possible that they recovered so well because they quickly learned that actual contact with humans would be very limited in their new homes.

Finally, the array of enrichment items available for assessment sessions was limited. Some were only available seasonably (pumpkins and leaves), and others were expensive and difficult to obtain. Acceptable play items had to be (a) safe for the tiger to play with and (b) very robust. Bengal tigers can effortlessly bite through bowling balls and often do so, so the sanctuary relied on the generosity of local bowling alleys for frequent donations. The large plastic balls were very expensive to acquire because they had to be stronger than bowling balls and safe for the tigers. The pumpkins and bowling balls were donated to the sanctuary, and thus necessarily limited, and the leaves were limited but free. The two scent items and the large plastic balls were purchased at significant ongoing expense by the sanctuary, which had to feed an additional 18 tigers, 9 lions, 4 leopards, 2 mountain lions, 12 wolf hybrids, and 1 alligator.

Future research would benefit from the use of more scents and a larger selection of play items (Macri & Patterson-Kane, 2011; Quirke & O'Riordan, 2011b). One variable that was left unanswered was the degree to which humans could serve as enrichment items (Claxton, 2011). Anecdotal reports from staff and experimental observations suggested that some of the tigers preferred to be at the fence line, as close as they could get to the observer(s). The tiger(s) would rub against the fence and frequently "chuff." Due to the flexibility of their larynx bone, tigers are unable to "purr" like smaller cats, but they do chuff. Chuffing serves the same function as purring in smaller cats. A revised assessment procedure that includes human attention would extend the findings of Vitale and Udell (2019; see also Shreve et al., 2017) with domestic house cats and would have to account for both the sex of the tiger and that of the human but would be a valuable next step.

Another future research area would be to focus more on novelty when choosing enrichment items or experiences. One conclusion that can be drawn from the current results is that some of the tigers were responding more to novelty than to a preference for one or two particular items. Except for Princess and Stripey, the rest of the tigers seemed to show a preference for novelty (Stansfield & Kirstein, 2006) instead of showing a consistent preference for a specific scent or play item. Although animal trainers tend to generalize across and within animals when providing enrichment (Mehrkam & Dorey, 2015), incorporating more novelty would probably result in greater benefit to the animals.

The goal of the preservation of any species, including tigers, should be to protect remaining wild animals and rehabilitate captive animals for possible reintroduction into the wild. Selection pressures in the wild are stressful, as are the conditions for most wild animals in captivity. Environmental enrichment attempts to mitigate the amount of stress on captive animals. Frequent preference assessments of captive wild animals are a necessary component when designing enriched environments. Further, wild animal trainers tend to rely on word of mouth and guesswork as to what animals "want." The current results suggest that one size fits all does not apply with Bengal tigers and that frequent preference assessments would probably provide better enrichment experiences for all captive wild animals.

Improving the experiences of captive wild animals could be more easily accomplished if zookeepers and behavior analysts work together (Alligood et al., 2017; Maple & Segura, 2015). Both domains bring a unique set of skills and experiences to the task of improving animal welfare. Recently, the idea that most animals are more intelligent (de Waal, 2016) and have far richer emotional lives than anyone had previously imagined has gained wider acceptance (de Waal, 2019). If protecting a species is important and doing so means keeping members in captivity for their protection or until they can potentially be released back into the wild, their time in our care should be as humane as possible. Animals that are thriving in captivity will live longer, reproduce more often, and generate more public support for their protection and conservation. Bringing together the considerable technology of behavior analysis and the experience and wisdom of zookeepers and animal trainers would be a valuable collaboration.

Compliance with Ethical Standards

Conflict of Interest The authors declare no known potential conflicts of interest with respect to this research project.

Ethical Approval The Institutional Animal Care and Use Committee provided a waiver for this research project and did not require that informed consent be obtained.

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