CABI

Animal Behaviour and Welfare Cases – Case template

Brown Bear Cognition and Welfare

Contents

Summary/Abstract

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The welfare of bears in captivity has been of longstanding concern. Species with complex cognitive requirements often face difficulties when placed in artificial environments. Cognitive enrichment, however, may work to ameliorate this by providing stimulating challenges for individuals living in zoological settings.

Abstract

The welfare of large-brained wide-roaming carnivores in captivity has been of longstanding public and professional concern. Bears are one such example. Ursids have unexpectedly large relative brain sizes, indeed showing brain size increases similar to those observed in canids. Bears also have considerable space requirements, with extensive home range sizes seen in the wild. Species with complex requirements often face difficulties when placed in artificial environments. Cognitive enrichment, however, may work to ameliorate this by providing stimulating mental challenges for individuals living in zoological settings. This case study explores the proposed benefits of cognitive trials. To do so, we exposed seventeen captive European brown bears (*Ursus arctos arctos*) housed in UK zoos to two experimental tasks 1) a puzzle box and 2) an object-manipulation set-up. Fourteen of the bears voluntarily engaged with the puzzle box, whilst fifteen individuals interacted with the object-manipulation set-up. The bears that failed to interact with the tests were likely dissuaded due to the collective nature of testing, a lack of motivation or fear of novel objects. Cognitive stimulation, such as that provided in our study, offers one means of improving the welfare of captive bears. We advocate the use of cognition studies for zoo-housed bears to enrich their lived-experiences when housed in zoological settings.

Why is this case of value?

Six of the eight species of bear are endangered or vulnerable. Although the brown bear is listed as least concern, it is locally vulnerable to extirpation across many parts of its range. To protect bears from extinction, they are often kept in zoological collections for conservation, education, captive breeding, rehabilitation and public viewing purposes. Bears are renowned for being highly intelligent species, with substantial home range and complex cognitive demands. Species with such complex cognitive demands, for example, wide-roaming carnivores, face mental challenges when kept in captive environments. The use of zoo-based cognition studies can reveal insights into the lived-experiences of those individuals housed in zoological settings. These can further inform enrichment activities provided to captive bears, in efforts to meet their complex cognitive needs. Additionally, and importantly, these captive individuals require our utmost attention in ensuring they live the most fulfilled lives possible.

Learning outcomes

On completion of this study the learner should be able to:

1. Explain the reasons why bears face difficulties when placed in captivity.
2. List five abnormal behaviours a captive bear may perform.
3. Articulate the benefits of cognitive enrichment for captive bears.
4. Assess the engagement levels of enrichment tasks by calculating the mean, standard deviation and range of values for each task.
5. Construct a reasoned argument as to why cognitive stimulation is beneficial for the welfare of zoo-housed bear species.

Background and context

The subject

Bears have unexpectedly large brain sizes, even after taking their body size into account. When brain size is larger than expected for given body size, this is referred to as '*encephalisation*'. Encephalisation is thought to grant certain advantages such as superior cognitive abilities. Examples of these include behavioural flexibility in primates (Amici et al., 2018), learning in fish (Kotrschal et al., 2013) and innovation in carnivores (Benson-Amram et al., 2016), including picture recognition in sloth bears (Tabellario et al., 2020). Simply, an individual with a big brain (after accounting for body size), is thought to perform better on tasks involving complex *mental* processes, when compared to an individual with a smaller brain (for body size).

Coupled with big brains, bears are known to have extensive space requirements, with substantial home range sizes seen in the wild (Knight, 1980). For example, in one study, European brown bears *Ursus arctos arctos* were found to have an average annual home range of 1055km^2 for males and 217km^2 for lone females (Dahle & Swenson, 2003). The home ranges of this wide-ranging species is influenced by many factors including the spatial distribution of food resources, the seasonality of food resources, and the social environment including the availability of females and territoriality (Edwards et al., 2013; Koehler & Pierce, 2003; Mitchell & Powell, 2007; Moyer et al., 2007).

Brown bears also demonstrate great dietary breadth, with foraging strategies ranging from highly specialised to high mixed ones (Costello et al., 2016; Lafferty et al., 2015; Mangipane et al., 2018; 2020). Their diets are heavily influenced by the changing seasons, due to the often-ephemeral nature of those food resources. In addition, those food resources often need extraction from the environment and require problem-solving or other forms of processing. For example, grizzly bears break into logs to eat insects (Servheen, 1983). These behaviours require cognition and brain-hand-eye coordination to succeed. Thus, brown bears are thought to display high levels of behavioural flexibility especially in terms of foraging strategies (Van Daele et al., 2012).

Brown bears are the most widespread bear species, found across Europe, Asia and North America, and occupy a wide range of habitats (Belant et al., 2010; Hilderbrand et al., 2018; Servheen et al., 1999). They live in these seasonal and unpredictable environments – subsequently facing many challenges in their daily lives. Moreover, brown bears are long-lived species, with a typical lifespan of 28 years (Bartareau et al., 2011; Pearson, 1975). Thus, brown bears face many challenges *over time*. This likely has implications for the cognitive requirements placed on bears and in turn selects for superior cognitive abilities in order to meet these demands, thereby making brown bears a highly adaptable and behaviourally flexible species.

The problem

Their big brains and wide-roaming nature mean bears possess complex cognitive requirements. Species with such complex requirements are known to often struggle when placed in artificial environments, i.e., zoological collections (e.g., Clubb and Mason (2003)). In fact, bears are now considered to be an extremely difficult and challenging species to manage in captivity (Law & Reid, 2010). This has implications for the welfare of zoo-housed species. This is of particular concern as zoological collections strive to offer excellent care and conditions. However, even the finest zoological collections, with the leading resources and best intentions, provide bears an environment thatis *different* to the wild. This ultimately leads to a different existence (although that is not to say a lesser existence) when compared to their wild counterparts.

One particular welfare concern is the presence of abnormal behaviours in captive bears. When kept in captive collections, many individuals start to produce abnormal or '*stereotypic*' behaviours and ursids are not immune to this. Rees (2013, pp. 1094-1095) defines stereotypic behaviour as a "*repetitive behaviour which has no apparent purpose which often appears when an animal is under stress*" and he highlights how stereotypic behaviour is "*often used as a measure of its welfare*".

Bears are known for being extremely susceptible to behavioural abnormalities and stereotyping when kept in captivity, and this is a matter of both public and professional concern. In fact, these behaviours are perhaps one of the biggest problems facing captive bears today. Stereotypic behaviours can develop for a variety of reasons; however, they are most commonly displayed by captive animals lacking suitable behavioural and environmental stimulation (Shepherdson et al., 2013). Examples of stereotypic behaviour in bears include bar-biting, route tracing, pacing and head-swinging (Table 1).

Table 1. The prevalence of abnormal repetitive behaviours in captive bear species (after Mason et al. (2007)).

Species	**Prevalence expressed as % (and as a fraction of the individuals sampled)**	**Examples of known stereotypies (list not exhaustive)**
Brown bears (*Ursus arctos*)	48% (89/185)	Pacing, circling, head-tossing, swaying (Montaudouin & Pape, 2004, 2005; Waroff et al., 2017)
Asiatic black bears (*Ursus thibetanus*)	54% (34/63)	Pacing (Vickery & Mason, 2004)
American black bears (*Ursus americanus*)	43% (6/14)	Pacing (Bruno et al., 2023; Carlstead & Seidensticker, 1991)
Sun bears (*Helarctos malayanus*)	74% (21/29)	Pacing, self-licking/biting, bar biting (Izzat-Husna et al., 2021; Tan et al., 2013; Vickery & Mason, 2004)
Spectacled bears (*Tremarctos ornatus*)	60% (9/15)	Pacing, head-twisting and head-tossing (Correa et al., 2022; Fischbacher & Schmid, 1999; Maslak et al., 2013)
Sloth bears *Melursus ursinus*)	60% (9/15)	Pacing, head-tossing, swaying (Bauer et al., 2013; Pastorino et al., 2017; Veeraselvam et al., 2013)
Polar bears (*Ursus maritimus*)	57% (101/176)	Pacing, circle swimming, pace swimming, head-tossing (Fernandez,

		2021; Ross, 2006; Shepherdson et al., 2013; Wechsler, 1991)
Giant pandas (*Ailuropoda melanoleuca*)	Not included	Pacing, head-tossing, self-licking/biting, swaying (Swaisgood et al., 2001)

Although primarily solitary in the wild, bears kept in captivity are typically housed socially (Table 2). The implications of imposed sociality are poorly understood since the social dynamics of captive bears has seldom been considered (although see Cavalleri et al. (2022)). It is possible that placing a predominantly solitary species with conspecifics could be problematic as it should not be living in a group setting; however, it is possible individuals may benefit from these social interactions, as highlighted by Ottewell (2016). In any case, this has implications in terms of bear welfare, the presence of behavioural abnormalities and requires further investigation.

The solution

One way to ameliorate this concern is to provide captive bears with an environment which is mentally stimulating. A major part of this includes the provision of '*environmental enrichment*', defined as "*an animal husbandry principle which seeks to enhance the quality of captive animal care by identifying and providing the environmental stimuli necessary for optimal psychological and physiological wellbeing*" (Rees, 2013; Shepherdson et al., 1998). Examples include scatter feeds, scent trails, log piles and frozen ice blocks (Law & Reid, 2010). However, what is particularly important is the mental or cognitive *stimulation* provided by these enrichment activities, drawing upon bear behaviours which would be present in their wild conspecifics.

Of a similar nature is the practice of '*cognitive testing*', which is commonplace in the field of cognitive research. Cognitive research investigates the "*mental process of knowing*" (Rees, 2013). Cognitive tests usually involve a cognitive challenge, which requires reasoning, problem-solving ability etc. in order to solve the task. An assortment of equipment can be used to study this, including touchscreens (e.g., (Vonk & Beran, 2012)) and puzzles boxes (e.g., (Benson-Amram et al., 2016)). Whilst these tests are usually driven by a wider goal of broadening understanding of '*mental states*' or complex cognitive behaviours, these activities can prove beneficial under the correct circumstances. By mentally stimulating the individuals that participate, these exercises become forms of *cognitive enrichment*.

The test

In efforts to further explore the proposed benefits of cognitive trials, the cognitive abilities of captive European brown bears were tested. Experimental trials were implemented at seven zoological collections in the United Kingdom (UK): Five Sisters Zoo, Wildwood Trust, Camperdown Wildlife Centre, Wildwood Escot, Welsh Mountain Zoo, Scottish Deer Centre and Port Lympne Reserve. Our study involved seventeen bears: eight adult females, one juvenile female, five adult males, and three juvenile males (Table 2).

Table 2. Information on the brown bears involved in the study.

Location	Name (ID)	Sex (m/f)	Age (years)	Relation	Number of bears in group (#)	Captive born (C) or wild caught (W)
Five Sisters Zoo	Eso	F	7	N/A	1	W
Wildwood Trust	Fluff	M	23	Not related	2	C
	Scruff	M	23	Not related	2	C
Camperdown	Brumm	M	6	Siblings	3	C
	Maja	F	6	Siblings	3	C
	Brumma	F	6	Siblings	3	C
Wildwood Escot	Mish	M	2	Siblings	2	W
	Lucy	F	2	Siblings	2	W
Welsh Mountain Zoo	Athena	F	17	Siblings	2	C
	Fivi	F	17	Siblings	2	C
Scottish Deer Centre	Loki	M	9	Offspring	2	C
	Nelly	F	17	Dam	2	C
Port Lympne	Enciam	F	19	Dam	5	C
	Julio	M	15	Sire	5	C
	Neu	F	5	Offspring + Siblings	5	C
	Rojo	M	1	Offspring + Siblings	5	C
	Tornillo	M	1	Offspring + Siblings	5	C

The trials involved a) a puzzle box, and b) an object manipulation set-up. The puzzle box was a small, baited steel box, which has a simple latch on the front that required the bears to slide laterally to open the door, allowing access to the food reward inside. It was designed similarly to those used in previous studies that have proven useful in testing mammalian problem-solving ability (Benson-Amram et al., 2016; Benson-Amram & Holekamp, 2012; Benson-Amram et al., 2013; Borrego & Gaines, 2016).

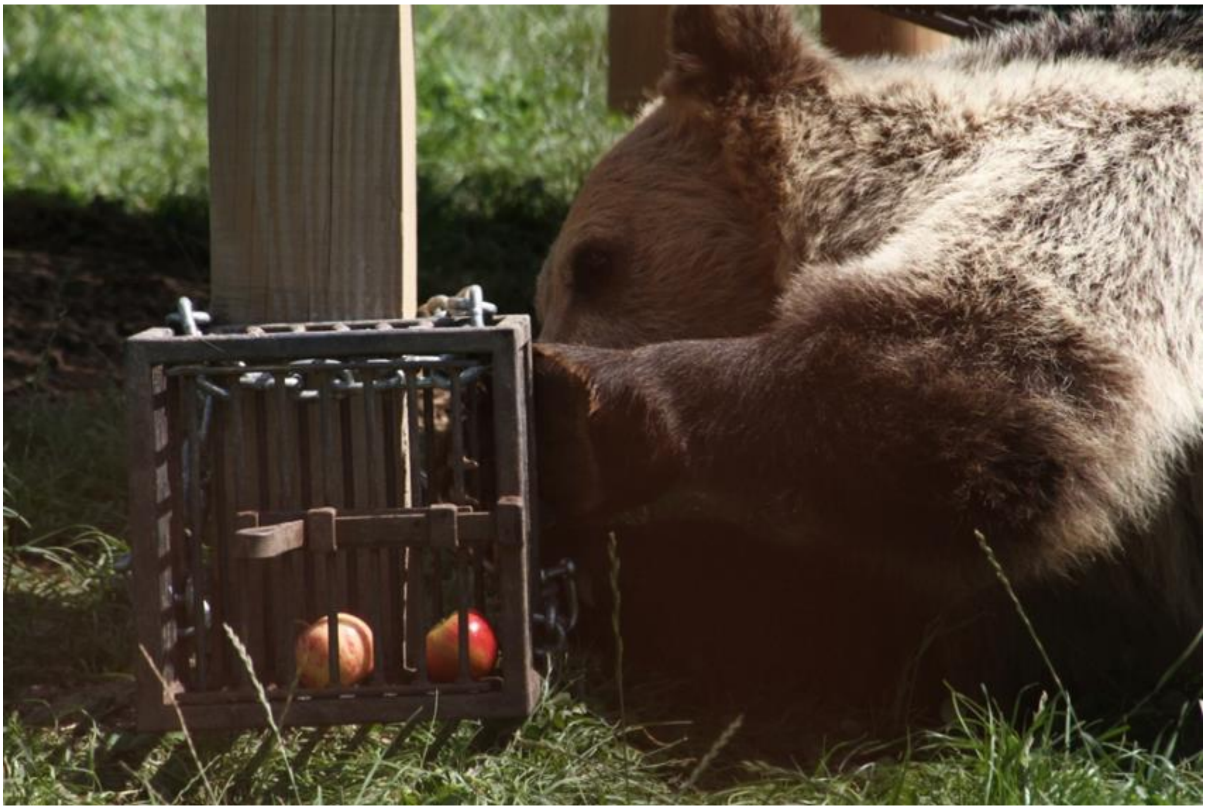

Figure 1. Mish, a brown bear, from Wildwood Trust interacting with the puzzle box. Photo credit: Page, 2021.

The object manipulation set-up involved suspending a food reward out of reach and providing trees stumps for the bears to manipulate so as to retrieve the reward. This task required the bears to understand that the food item could be accessed by repositioning the stump under the suspended item so as to stand on to reach it.

Previously, bears have been trained or provided with cues in order to be successful (Amici et al., 2019; Waroff et al., 2017); here, this task was divided into stages. First, tree stumps were placed directly underneath the food reward, so all the bear had to do was stand on the stumps to be successful. If successful, in the next trial, the stumps were placed on their side, so the bear needed to push the stumps flat and stand on them to be successful. If successful, in the next trial, the stumps were placed flat, but they were placed away from the food reward, so the bear had to actively manipulate and manoeuvre the stumps to reach the food reward.

Figure 2. Object-manipulation set-up: a rope secured between two trees with a food item hung in the middle and tree stumps provided underneath. Photo credit: Chambers, 2021.

Trials were run between June and October 2021. Two to four trials were run per day, typically one in the morning and one in the afternoon. This consisted of either one puzzle box trial or one object manipulation trial; the setups were not implemented at the same time. Trials were run collectively with the bears, meaning all bears had access to, and could interact with, the setups presented. This experimental procedure is further discussed below.

The results

In total, fourteen of the bears voluntarily engaged with the puzzle box, and fifteen individuals interacted with the object-manipulation set-up. Engagement with the trials was completely voluntary and bears were only encouraged to become involved via baiting of the set-ups with food rewards. Bears were not starved nor restricted prior to the trials in any way (which is sometimes the case in cognitive trials to ensure motivation is high). In addition, they received the same amount of food whether they engaged with the set-ups or not. Each bear was presented with at least three trials of each set-up; however, this was dependent on which bear engaged with the trials and whether one bear monopolised the trials, as there was no way to guarantee which bear was going to interact with the trial (see 'Collective nature of testing').

The fact that almost all the bears in the study engaged with the set-ups at least once – and they did so voluntarily – demonstrates that these cognitive trials piqued the curiosity of the bears (Video 1, 2). Admittedly, they were likely driven to the set-ups by the food items involved; however, it is also probable that the novelty of the trials drove them to investigate the set-ups. By engaging with the trials, this likely added a cognitive challenge to their time which may not have been otherwise present. This engagement and time spent trying to solve the challenges seemingly stimulated the bears and came to act as a form of *cognitive enrichment* – for example, *Mish* and *Lucy* from *Wildwood Trust* spent 434 and 485 seconds (respectively) interacting with the puzzle box the first time it was introduced (Video 3, 4, Figure 3). Similarly, the first puzzle box trial at *Port Lympne Reserve* attracted considerable bear engagement (Video 5). This was further reinforced by the repeated engagement with the trials across time – with some bears engaging with over five trials; for example, *Rojo* and *Tornillo* from *Port Lympne Reserve*, each had 13 successful object manipulation trials – which work towards improving the welfare standards of the bears involved (Table 3, 4). Notwithstanding, interaction times per individual in cognitive trials tend to be short (in terms of overall time budgets). The resulting positive valence, however, may extend to long after interactions with the stimulus has ceased. Further work is required to measure and fully evaluate the extent to which cognitive stimulation influences subsequent behaviour to better understand the overall benefits brought about by cognitive enrichment.

Video 1 – Puzzle box video.

Video 2 – Object manipulation video.

Video 3 – Mish first puzzle box trial.

Video 4 – Lucy first puzzle box trial.

Video 5 – Port Lympne Reserve first puzzle box trial.

Figure 3. Mish, a brown bear, from Wildwood Trust interacting with the puzzle box. Photo credit: Page, 2021.

Table 3. The results of brown bear engagement with the puzzle box.

Location	**Name (ID)**	**# of successful trials**	**# of bears present during trials**	**1st trial – engagement time* (s)**	**1st trial – latency to approach (s)**
Five Sisters Zoo	Eso	4	1	57	9
Wildwood Trust	Fluff	3	2	304	19
	Scruff	0	2	0	0
Camperdown	Brumm	2	3	43	43
	Maja	1	3	33	45
	Brumma	6	3	44	10
Wildwood Escot	Mish	9	2	421	12
	Lucy	1	2	213	19
Welsh Mountain Zoo	Athena	3	2	33	25
	Fivi	0	2	0	0
Scottish Deer Centre	Loki	1	2	15	35
	Nelly	5	2	58	3
Port Lympne	Enciam	2	5	92	45
	Julio	1	5	87	16
	Neu	0	5	0	0
	Rojo	3	5	65	18
	Tornillo	9	5	217	36

** Engagement time = time engaged in solving the trial until success. Some bears further interacted with the set-up after success.*

Table 4. The results of brown bear engagement with object manipulation task.

Location	**Name (ID)**	**# of successful trials**	**# of bears present during trials**	**1st trial – engagement time* (s)**	**1st trial – latency to approach (s)**
Five Sisters Zoo	Eso	6	1	105	13
Wildwood Trust	Scruff	0	2	0	0
	Fluff	0	2	0	0
Camperdown	Brumm	7	3	71	10
	Maja	1	3	99	10
	Brumma	1	3	35	11
Wildwood Escot	Mish	8	2	160	14
	Lucy	1	2	85	23
Welsh Mountain Zoo	Athena	3	2	52	49
	Fivi	2	2	14	9
Scottish Deer Centre	Loki	0	2	0	0
	Nelly	2	2	53	4
Port Lympne	Enciam	2	5	19	198
	Julio	4	5	12	136
	Neu	0	5	0	0

	Rojo	13	5	83	51
	Tornillo	13	5	9	15

** Engagement time = time engaged in solving the trial until first success. Some bears further interacted with the set-up after first success.*

The outliers

One male bear did not engage with any of the trials. Similarly, one female only briefly engaged with one trial and motivation was very low. A second female failed to engage with the puzzle-box but engaged with the object manipulation trials. The reasoning behind this lack of engagement can be explained by multiple factors, each of which has welfare implications.

Collective nature of testing

Individual testing is seen as a gold-standard in cognition trials. However, bear welfare was at the heart of our investigation and consultation with keepers revealed that separating group-housed bears would likely result in increases in indicators of behavioural anxiety and stereotypic behaviours in the bears. In order to reduce the risk of this occurring, we modified our experimental procedure. Therefore, trials were run with all bears in the group having access to the set-ups at the same time. This collective nature of testing, however, resulted in certain bears often taking over trials, and those bears which were more dominant, i.e., males, would often monopolise trials due to the food reward and competition present.

This indicates that social dynamics are very important when caring for group-housed captive bears. This is especially important when implementing enrichment devices or food-related tasks, as these social interactions may influence engagement with both cognitive trials and behavioural enrichment activities. In cognitive research, while running trials individually is preferred, this may perhaps neglect the influence of social dynamics on cognitive processes. In addition, attempting to implement individual trials may increase the risk of stereotypic or abnormal behaviours, which would negatively impact the welfare of the captive bears involved.

Motivation

Problem-solving abilities are often found to result from motivational differences rather than complex cognitive processes (Cooke et al., 2021; van Horik & Madden, 2016). Indeed, here, latency to approach in the trials was an important factor influencing success times. Simply, it indicated that as time to engage with the task increased, the time taken to solve the task also increased. The result here is most likely the consequence of motivational differences in terms of the food reward present. This suggests that individual variation in motivational levels in an important factor influencing engagement with cognitive trials and enrichment devices.

Motivation is an essential factor to consider when implementing cognitive trials and deploying enrichment devices, as securing engagement with the activity is of utmost importance, especially to ensure the welfare benefits of the activities are maximised. This is of particular consequence for species such as bears which engage in torpor, a time during which activity levels are noticeably affected by the changing seasons. Targeting enrichment and cognitive trials when bear activity levels are at their peak – such as the summer months – is favourable to ensure the welfare benefits of such activities are fully realised.

Fear of novel objects

When designing and implementing cognitive trials or enrichment activities, another important factor to consider is the potential for fear of novel objects (*neophobia*). One male bear in our study did not react well to the introduction of the puzzle box. This was likely due to a mixture of factors, including those already mentioned but, fear of novel objects was also a likely cause. This was probably due to the difficult background history of this bear – he had been rescued from a canned hunting facility in Bulgaria, where he had been born and kept in a barren concrete pit his whole prior life – the aftereffects of which are still present.

This bear failed to interact with the set-ups and on one occasion exhibited anxiety related behaviours when presented with the puzzle box. Therefore, it is important to consider both the *background history* and the *personality type* of the bears which are being presented with the cognitive trials or enrichment devices. Fear of novel objects or anxiety with changing environments may result in abnormal or stereotypic behaviours which has implications for the welfare of such individuals.

The majority of the bears in our study engaged with the trials and exhibited positive or neutral reactions to the set-ups present. However, the isolated case of the one male leads us to note, it is important to remember that not all bears will react in a positive way to activities. This requires careful consideration when designing proposed trials and subsequent monitoring following implementation.

Bear behaviour

The object-manipulation set-up (i.e. the tree stump problem) was not solved in the intended way by the bears – instead they used alternative techniques to solve the problem. This outcome was unexpected since bears have previously proved successful at such a task (Waroff et al., 2017). The result highlights a crucial aspect of the trials was potentially missing and likely influenced engagement levels and trial success. Our scenario, whilst useful in testing object-manipulation and potential tool-using ability, potentially fails to hold ecological relevance to bears. It neglects to draw on typical bear behaviours and as such, the bears either failed or used alternative techniques to solve the problem.

This informs us on good welfare as one ought to always strive to enact normal behaviours from the subjects, especially important when dealing with captive individuals. This ultimately goes back to the Five Freedoms (FAWC, 2013), and the '*Freedom to Express Normal Behaviour*'. Therefore, when designing and implementing enrichment activities or cognitive trials, even if the concept is abstract, the behavioural solution should attempt to draw on natural behaviours, ensuring welfare standards are maintained and to increase the likelihood the subjects will engage well with the scenario.

Discussion points

1. Why do bears have complex cognitive requirements?
2. What challenges do bears face when kept in captive collections?
3. How can we alleviate the potential problems faced by captive bears?
4. What factors influenced engagement with the cognitive trials used in our study?
5. Follow-up question: what factors should be considered when designing and implementing cognitive trials and/or enrichment activities?
6. What benefits are provided by the use of cognitive trials?
7. What limiting factors are present when using cognitive trials as enrichment activity for bears?
8. Does the implementation of cognitive trials and/or enrichment devices always initiate neutral or positive reactions from the targeted individual?

Questions for the researcher/keeper

When designing and implementing any type of enrichment or cognitive trial, the following should be considered:

1. Which bear behaviour is this cognitive task/enrichment device drawing upon?
2. How can you provide the cognitive task/enrichment device in a novel way?
3. Can you provide a cognitive task/enrichment device that draws across multiple senses?
4. Are you presenting the cognitive task/enrichment device individually or in a group setting? What measures are you putting into place to ensure the chosen mode of delivery does not have negative connotations on the welfare and overall wellbeing of the bear(s)?
5. How long do you think the bear(s) will engage with this cognitive task/enrichment device?

Discussion questions

Ask students to write a short essay titled "What sorts of difficulties do bears face when placed in captive environments and what are the potential solutions to ensuring they are able to live fulfilled lives?" The essay (or discussion) should adopt the viewpoint that sometimes bears *will* need to be housed in captivity, for example, for rescue and rehabilitation purposes. Given that this is the case, what are the pros and cons of housing them socially, for example? What can be done to ensure they receive suitable stimulation to occupy them? Pay careful consideration to intervention measures that draw on the natural history and behavioural ecology of bears in your answer.

Courses of action

Cognitive trials have proven beneficial in terms of enrichment purposes when carefully implemented. It is evident that bears face difficulties when housed in captive environments, likely due to their large brain sizes and wide-roaming nature, which results in complex cognitive requirements. An improved approach is crucial to ensure that the welfare of captive bears does not suffer. Many factors must be considered when designing cognitive trials to ensure that the tasks do not initiate abnormal or behavioural anxiety indicators, but instead encourage engagement and mentally stimulate the individuals involved.

Conclusions

The presence of stereotypic behaviours in captive bears highlights the need to mentally enrich the lives of bears in zoos. Here, our study demonstrates that cognitive trials can be used as enrichment activities and offers one solution to improve the mental wellbeing of captive bears, thereby aiming to improve the overall welfare of zoo-housed bears. Out of seventeen, fourteen of the bears voluntarily engaged with the puzzle box, and fifteen interacted with the object-manipulation set-up. Our study highlights several factors to consider when designing and implementing both cognitive trials and other enrichment devices, in order to maximise the benefits of such activities while minimising the potential for negative impacts to welfare.

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Further reading

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