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# Behavioral Changes of Brown Bears (*Ursus arctos*) during COVID-19 Zoo Closures and Further Reopening to the Public

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**Abstract:** Visitor effect studies have been of keen interest for decades, but there have been only anecdotal opportunities to investigate the impact of the prolonged absence of visitors on animal welfare in zoos. In some zoos, bears are actively involved in animal–visitors interaction through begging, which gives them some degree of control over gaining food rewards throughout the day when visitors are present. Prolonged visitor absence may, therefore, represent a loss of control and have a negative impact on the bears' welfare. In this study, we investigate the behavior of four brown bears (*Ursus arctos*) in three zoos to see how the animals' behavior changed depending on the presence and absence of the public during zoo closures in 2020 related to the COVID-19 pandemic. The bears' behavior was assessed using activity budget analysis and novel object tests. The results showed that the bears behavior varied between facilities and that there was no effect of visitor presence for the individuals who had access to indoor holding space. The results of the study are discussed in terms of choice and control and their impact on the wellbeing of bears in zoos.

**Keywords:** visitor effect; begging; choice/control; stereotypical behavior



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## 1. Introduction

Approximately 700 million guests visit zoos around the world every year, therefore visitors are almost a consistent feature of the zoo animal's environment [1]. The impact of visitors on animal welfare has been of considerable interest for decades [2]. Studies show that the effect of visitors can have negative, neutral, or positive influences on zoo animal behavior and welfare [3–11]. Visitors may provide social or feeding interactions for zoo-housed animals, and these interactions have a positive welfare impact on animals from different taxonomic groups. For example, public feedings were effective at decreasing stereotypes in elephants [12], prairie dogs move closer to larger visitor numbers [13], and chimps initiate animal–visitor contact to obtain food from visitors [14]. However, in 2020, zoos around the world were closed to the public for unusually prolonged periods due to the global COVID-19 pandemic, resulting in a drastic reduction in the animals' opportunities to interact with the public. The absence of the public may be especially important for species that used to be actively involved in animal–visitor interactions in zoos. Therefore, these unique conditions provided an exceptional opportunity to obtain new information on how these animals behave in the absence of visitors and to compare their behavior after the reopening of the zoos.

Bears are carnivoran mammals whose behavior can be especially impacted by the presence of the public, as the tendency to beg for food has been documented in several bear species in zoos, especially brown bears [15]. This ability makes this group important for studies on the impact of the visitor effect on their behavior. The response of bears to the presence of zoo visitors is mixed [16]. For example, visitors can act as both a disturbance factor that increases bears' vigilance and stereotypical behavior, or as a stimulus to encourage normal activity such as exploratory behavior [6,17]. However, there is only one published study on how bears behave during the prolonged absence of visitors, and it was during the global pandemic in 2020. A study at the Cleveland Metroparks Zoo showed

that the behavior of five bear species (“sloth bears ( $n = 3$ ), Andean bears ( $n = 2$ ), grizzly bears ( $n = 2$ ), American black bears ( $n = 2$ ), and a Malayan sun bear ( $n = 1$ )”, p. 541) did not change during the zoo closure of two months [16]. However, studies that include more individuals of one species and involve several institutions could shed light on general changes in bears’ behavior without visitors.

Begging is usually viewed in terms of frustrated appetitive activity [18]. However, exhibiting that undesirable activity may indicate that controlling the visitors’ behavior is rewarding to a bear itself [19]. When animals are begging, they are not always successful in gaining food rewards from visitors; moreover, the received rewards can remain untouched on the ground, yet the behavior persists [20]. Zoos provide enough food resources for animals and some of them may even be at risk of obesity [21,22], so it is unlikely to be a behavior driven by issues of satiety. The food rewards that are gained may be higher value for the animals due to variety, but the high unpredictability of the bears’ ability to elicit the rewards from the public might be expected to diminish the frequency of the behavior over time if the behavior did not provide another form of reward to the animals [23]. Therefore, begging is likely an indicator that the animals need to be given more complex stimulation [24] rather than additional food. It was suggested that animals could use visitors as a source of stimulation (Morris, 1964, as cited in [25]). Therefore, bears are probably begging to compensate for the lack of control by manipulating the public’s behavior in zoos. A decrease in the ability to control one’s environmental factors leads to an increase in abnormal behavior, as well as an increase in anxiety behavior in response to uncertainty [26–29]. Bears that were not allowed to beg for food (e.g., temporary absence of visitors or physical barriers for visitors) exhibited higher levels of stereotypical behavior [15,30], suggesting that begging may provide bears with a sense of control over their environments. Providing animals with opportunities for control has been shown to reduce stress and their sensitivity to stressors [26–29].

The sensitivity of animals to stressors can be assessed by an animal’s reaction during novel object tests. In an environment with a lack of opportunities for choice and control, animals may exhibit a decrease in exploratory behavior and an increase in stereotypical behavior [27,31]. Overall activity budgets also provided similar conclusions about the animal’s welfare when compared to the rapid novel object tests [31], so I decided to use these two alternative observation methods in this study to assess the impact of absence/presence of zoo visitors on bears’ behavior.

Due to the spread of the COVID-19 pandemic, many Russian zoos were closed for three to four months during the spring and summer of 2020. This allowed us to conduct a brief study across three zoos in an attempt to answer the question of how brown bears (*Ursus arctos*, common species across Russian zoos) behave without visitors and to assess changes after the reopening of the zoos. I supposed that during the period of prolonged absence of zoo visitors, bears may experience a lack of control due to the reduced ability to beg from visitors. This could be expressed in the growth of indicators of poor welfare, both in their activity budgets and in their reactions during novel object tests.

The aim of this study was to evaluate changes in the activity budget of brown bears and their response to novel object tests under Zoo Closed/Zoo Open conditions. If visitor presence has measurable welfare impacts on the bears, I expected to see differences in their overall time budgets and responses to novel object tests between when the zoos were closed against when they reopened.

**Hypothesis 1 (H1):** *I expected more pacing in the absence of visitors and an increase in begging and less pacing under Zoo Open conditions.*

**Hypothesis 2 (H2):** *I expected that during Zoo Closed conditions, the bears would show a lower inclination to explore novelty, as measured by novel object tests. Specifically, I expected to see less time engaged in manipulation with a novel object, less time spent in the zone of a novel object,*

longer latency to approach the novel object, latency to extract a food reward, and more time spent on stereotypical behavior when the zoo was closed compared to after the zoo reopened.

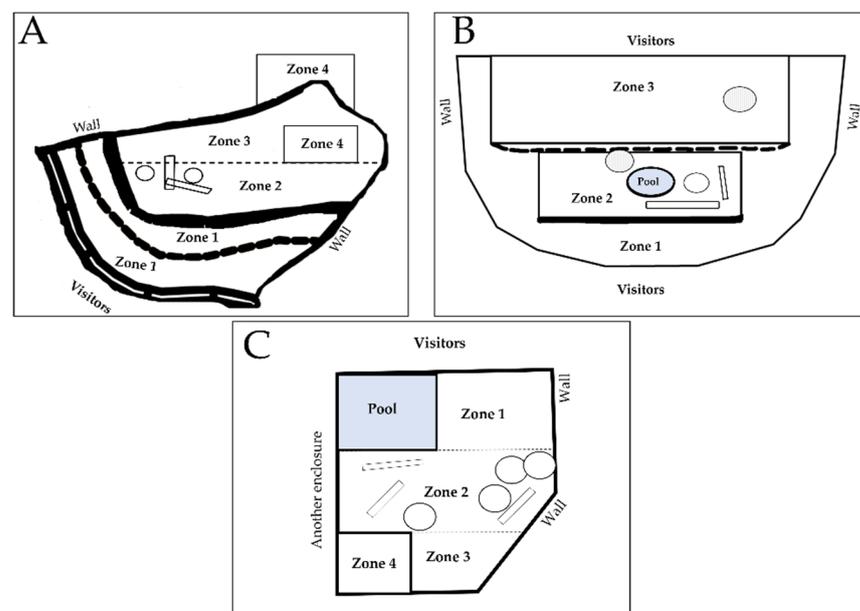
**Hypothesis 3 (H3):** I expected that during Zoo Closed conditions, the bears would use the exhibit spaces more equally and spend less time in the area close to visitors.

## 2. Materials and Methods

### 2.1. Sample Populations and Enclosure Zones

Four brown bears (*Ursus arctos*) were the subjects of this study. The data were collected on bears maintained in three zoological institutions in Russia: Kaliningrad Zoo (KZ), Moscow Zoo (MZ), and Yekaterinburg Zoo (YZ). These institutions were selected based on their staff's ability to collect behavior observations on their own. The study protocol was reviewed and approved by Moscow Zoo's Research Committees (MZ#2020-001).

Each bear was maintained separately, and the area of the enclosures varied from 65 m<sup>2</sup> to 300 m<sup>2</sup>. Both females from MZ and YZ had free access to indoor holding spaces, while the male and the female from KZ only had access to an indoor holding space at night or in bad weather conditions (Figure 1). The female from MZ had two shelters: an indoor enclosure and a den. The small den was inside the on-exhibit area (Figure 1). During the observations, both of these zones were marked as Zone 4 (see below).



**Figure 1.** Diagrams of bear enclosures. (A) Moscow Zoo, (B) Kaliningrad Zoo, (C) Yekaterinburg Zoo. Zone 1–3—the on-exhibit area, Zone 4—off-exhibit area. White circles symbolize the presence of a permanently established enrichment. The filled circle symbolizes the location of a large stone. The white rectangles symbolize a log. The dashed line symbolizes the boundary between the zones, while the thick line indicates a change in the height of the relief and the border between zones.

The MZ and KZ enclosures were separated from visitors by a metal fence and moats. The YZ enclosure was separated from visitors by a metal fence and by bars, and there was no moat. In the zoos, the visitors are asked not to feed the animals, referring to the fact that it can be dangerous for the animals. However, visitors do not always follow the rules ([30,32], personal communication from Maria Koziakova, KZ).

The MZ and YZ enclosures are closed from the public on three sides. The enclosure from KZ is open to visitors from two sides and was the only enclosure where the area was partially covered with natural soil. All outdoor areas of the enclosures were equipped with logs attached to the floor. In MZ, a 70 cm food ball (AA-B2a, Zooprofis) was tied to one

of the logs with a rope. The enclosure at YZ was permanently equipped with food-based and physical enrichment items (wooden puzzle feeder, fire hose SquareKnot browser, tires, Christmas trees, hay). The moat in MZ was occasionally filled with water, while the KZ moat was covered with pine mulch bark. The KZ and YZ outdoor enclosures contained a small tank in an area close to visitors. All animals regularly received food-based, physical, olfactory, and cognitive enrichment.

Each enclosure was divided into three or four zones, reliably discriminable by sight, depending on the distance to visitors, with Zone 1 closest to visitors. In MZ and KZ, this is the moat and the area closest to it, while in YZ, this area was on the same ground level as the rest of the zones. Zone 2 was the central area, Zone 3 was farthest from the visitor area, and Zone 4 was the indoor enclosure.

## 2.2. Collecting Data

For each animal, we collected activity budget data during two phases: Zoo Closed, and Zoo Open (after reopening). After the completion of each phase, the animals received a novel object test with a feeding enrichment.

### 2.2.1. Collecting Activity Budgets Data

Since the bears' care staff had a limited amount of time for behavioral data collection, the animals were observed using a "multi-point scan" method, which is comparable to intensive sampling regimes [33]. Two or three observers at each facility conducted 6 to 10 scans per day to record the behavior and the zone number of the animal in the exhibit when they passed the exhibit during their daily routines. The number of days' observations collected varied among the zoos (Table 1), but within each zoo, the number of observation days were balanced across the Zoo Closed and Zoo Open phases.

**Table 1.** Details of study sites and periods of data collection at each facility.

Study Site	Number of Individuals	Period of Data Collection	Number of Observation Days		Date of Closure	Date of Reopening
			Closed	Opened		
KZ	1 M 1 F <i>Ursus arctos</i>	May–July 2020	14	14	28 March 2020	17 June 2020
MZ	1 F <i>Ursus arctos beringianus</i>	May–July 2020	8	8	17 March 2020	16 June 2020
YZ	1 F <i>Ursus arctos</i>	May–August 2020	11	11	28 March 2020	25 July 2020

All observations were conducted during the hours the zoos used to be open to the public, from 9:00 to 17:00. The day when zoos were closed to the public due to the COVID-19 pandemic and then reopened depended on the local government rules for each zoo (Table 1). The keepers recorded specific behaviors during their observations, and these behaviors were subsequently assigned to a behavioral category for analyses (Table 2). Four categories, namely, activity, inactivity, abnormal activity, and out of sight, were recorded during this study (Table 2). Additionally, we documented the location of the animals in the exhibit (see below for separate information on each animal) and the average daily temperature approximated from the weather data from the closest major city. A level of at least 85% agreement between observers was reached (percent agreement for multiple raters).

**Table 2.** Ethogram of captive brown bears’ behavior observed in the study.

Behavior Category	Behavior	Description
Inactivity	Inactive	Individual is lying down with eyes open or closed, or sitting or standing, performing no other behaviors
Activity	Locomotion	Individual is walking from one place to another on land or in water, performing no other food-related or abnormal behaviors
	Foraging	Individual is consuming food (visible jaw movement), sniffing or manipulating the environment or object.
	Behavior directed at non-food enrichment	Individual is sniffing or/and manipulating an enrichment object
	Self-directed behavior	Subject is scratching or licking itself, rubbing against an object, and/or auto-grooming.
Undesirable behavior	Begging	Animal is sitting (sometimes waving its front paws) or standing (in the proximity zone to visitors) staring at them (more than 5 s) as they walk past the exhibit, or standing on its hind legs (sometimes waving its front paws) in any other zone and staring at visitors.
Abnormal behavior	Pacing	Individual is performing a repetitive movement (with no apparent goal or function) during which the animal repeats the exact movement for greater than three cycles
	Invisible *	Individual is out of view because the bear is in the indoor enclosure.

\* Note: indoor enclosures were only registered for MZ and KZ bears.

### 2.2.2. Collecting Novelty Object Test Data (Tests)

After the end of each phase, the bears were tested with novel objects with food inside [31]. A non-edible novel object is used as a tool to assess animal reactivity as a personality trait [34], but also as a fear-eliciting stimulus to assess alteration of the emotional reactivity in animals under different conditions [26,27]. Additionally, it has been shown that fear-level alterations can be assessed by latency to touch a favorite food in the presence of novel, non-edible objects [35]. In the current study, a food reward was hidden inside the test objects, which provided an opportunity to measure an additional indicator of the alteration of the emotional reactivity (latency to extract a familiar food reward). In all test objects, only one slice of meat of the same type and size (length about 15 cm) was hidden from a typical diet in each facility.

Since zoo-housed bears, as long-lived animals, have been exposed to various enrichments, there are difficulties in creating truly novel objects for adult animals. Previously, it was shown that the reaction of animals to “semi-novel” objects (modifications with the shape of the objects or/and new combinations of familiar materials) also depended on the type of housing conditions [31], as in studies with truly novel objects [26,27]. Therefore, hereafter, “novel objects” will refer to items that have a mixture of novelty and non-novelty.

The study subjects received two novel objects on different days for each phase, therefore four objects per study (Table 3). To maintain a similar level of novelty and avoid habituation to the tests, in each trial, the bears were presented with a different object. The objects had a similar level of difficulty (it was easy and fast to obtain food from all items) and a balanced level of destructibility between phases. In each phase, there was one low-destructible item (one of the plastic objects) and a more destructible food enrichment (a slotted box or a wooden frame). The sizes and materials of the novel objects were similar across the zoos). Novel items had the shape and combination of materials the animals had not encountered before or had not been exposed to during the last two months. These objects were placed in the central area of the enclosure where they would be visible to the subject as soon as they entered the outdoor enclosure. The order between the two objects

within each phase was randomized across facilities. During the tests, the bears were not offered any other form of enrichment other than those left over from the day before. At the end of the tests, the novel object was removed from the enclosure, and the animals were offered familiar enrichment items.

**Table 3.** Description of objects for testing the bears during the novel object tests.

Phase	Novel Object
Zoo Closed	Food was placed in a plastic bucket (volume 25 L) that was turned upside down.
	Food was placed inside a slotted box with a double wall (L 70 × W 70 × H 110 cm <sup>3</sup> ) where all flaps were folded. The slotted box was placed vertically.
Zoo Open	Food was hung from a wooden frame (70 × 70 × 70 cm) that was covered with a burlap sack. The frame was made from sticks tied together with a rope.
	Food was placed in a plastic barrel without a lid (volume 51 L). The barrel was turned upside down.

L—length, W—width, H—height.

The novel object tests were videotaped for 30 min. In total, the video data included 480 min across all facilities. The video recording began from the moment the gate was opened into the outdoor enclosure. From the video recordings, a single observer coded the bears' behavior using the Behavioral Observation Research Interactive Software [36]. Two latencies related to an object (first physical contact; extracting the food) were recorded. I divided each 30 min video into 10 sub-divisions of three minutes each and one sub-division became a unit of analysis. This allowed the creation of a total of 40 samples (sub-divisions) for each bear to analyze their behavior separately. The duration of normal activity (all behaviors except pacing, begging, and invisible), pacing, begging, time spent in an area with a novel object (one bear body), and time spent in an indoor enclosure was calculated (where applicable).

### 2.3. Data Analysis

There were small variations in the average temperature across facilities (3.5–4.5 °C) between phases. Subsequently, the factor "Temperature" was excluded from further analysis.

All data were checked for normality using the Shapiro–Wilk test and the data were not normally distributed. To compensate for the small sample size, as the statistics for one animal may contribute to the pooled data results, I avoided pooling the data from all bears. Therefore, the statistics were investigated separately for each bear [37]. Due to the small sample size and the data not being normally distributed, permutation nonparametric tests were applied. Permutation tests provide an alternative to the well-known standard statistical procedures, especially where a single case or small N studies are common [38]. Permutation tests were performed using the exact two-sided Wilcoxon–Pratt Signed-Rank Test (package 'coin' [39]) to compare changes in the bears' behavior between conditions in both the activity budget and novel object tests.

The statistical analysis of the latencies of bears to make contact with and extract food from the novel objects during the novel object tests was not carried out, due to the small size. Therefore, only descriptive statistics of the results are represented.

Additionally, a Spread of Participation Index (SPI) was calculated for each bear in each of the phase conditions [40]. The formula for the Spread of Participation is:

$$\text{SPI} = [M(\text{nb} - \text{na}) + (\text{Fa} - \text{Fb})]/2(N - M) \quad (1)$$

where N = total number of observations of the subject; M = mean frequency of observations in all of the enclosure sites (N divided by number of sites); nb = number of sites with

frequencies less than M; na = number of sites with frequencies greater than M; Fa = total number of observations in sites with frequencies greater than M; Fb = total number of observations in sites with frequencies less than M. An SPI value of this index is in the range from 0 to 1, where 0 indicates all zones were used equally, and 1 indicates minimum space utilization. Differences between the SPI values under the conditions were assessed using the exact two-sided Wilcoxon–Pratt Signed-Rank Test where one day of observation became a unit of analysis. We calculated an SPI for each day of observation for each individual bear, and we used the exact two-sided Wilcoxon–Pratt Signed-Rank Test to assess the differences under the two conditions for each individual separately.

Statistical analyses were carried out with R, version 4.0.3 [41]. Due to the small sample size, a significance level of 0.10 was chosen in all analyses [42].

### 3. Results

Changes were found in overall activity budgets (Table 4), enclosure usage (Table 5) and space utilization (SPI) (Figure 2), and reaction to novel object tests (Tables 6 and 7); however, these changes were wide-ranging across facilities and individuals.

#### 3.1. Activity Budgets

After facility reopening, both bears from KZ significantly decreased the time spent active due to the increased time they spent on begging (Table 4). The bear from MZ showed no difference in activity budget between conditions, while the YZ female spent less time inactive after facility reopening (Table 4). The YZ staff registered the same level of pacing behavior in the bear between conditions. Thus, while using the “multi-point scan” method, begging was observed for both bears in KZ, and pacing was only recorded for the bear at YZ, while for the bear from MZ, begging and pacing were not observed.

**Table 4.** Comparison of median % ± IQR of changes in the overall activity budget of individual bears by pairing the permutation Wilcoxon test during facility closure and open periods based on keeper observations. Light gray indicates a significant difference between conditions.

Zoo	Animal	Behavior Category	Condition		Wilcoxon
			Zoo Closed	Zoo Open	
KZ	F	Inactivity	33.33 ± 16.67	33.33 ± 21.43	Z = 0.79, p = 0.44
		Activity	66.67 ± 16.67	42.86 ± 16.67	Z = 3.21, p < 0.001
		Undesirable behavior	0.00 ± 0.00	16.67 ± 11.91	Z = -3.29, p < 0.001
	M	Inactivity	16.67 ± 16.67	16.67 ± 16.67	Z = -1.18, p = 0.27
		Activity	83.33 ± 16.67	50.00 ± 16.67	Z = 3.05, p < 0.001
		Undesirable behavior	0.00 ± 0.00	29.17 ± 16.67	Z = -3.33, p < 0.001
MZ	F	Inactivity	15.47 ± 33.33	37.50 ± 23.33	Z = -1.26, p = 0.25
		Activity	16.67 ± 23.82	6.25 ± 16.67	Z = 0.84, p = 0.44
	Invisible	69.05 ± 58.33	55.00 ± 29.17	Z = 0.91, p = 0.41	
YZ	F	Inactivity	43.75 ± 33.00	30.00 ± 15.28	Z = 1.69, p = 0.10
		Activity	33.33 ± 19.41	50.00 ± 26.67	Z = -1.51, p = 0.15
	Abnormal behavior	11.81 ± 22.22	11.11 ± 12.50	Z = 0.62, p = 0.56	
	Invisible	0.00 ± 12.71	12.50 ± 16.67	Z = -1.27, p = 0.24	

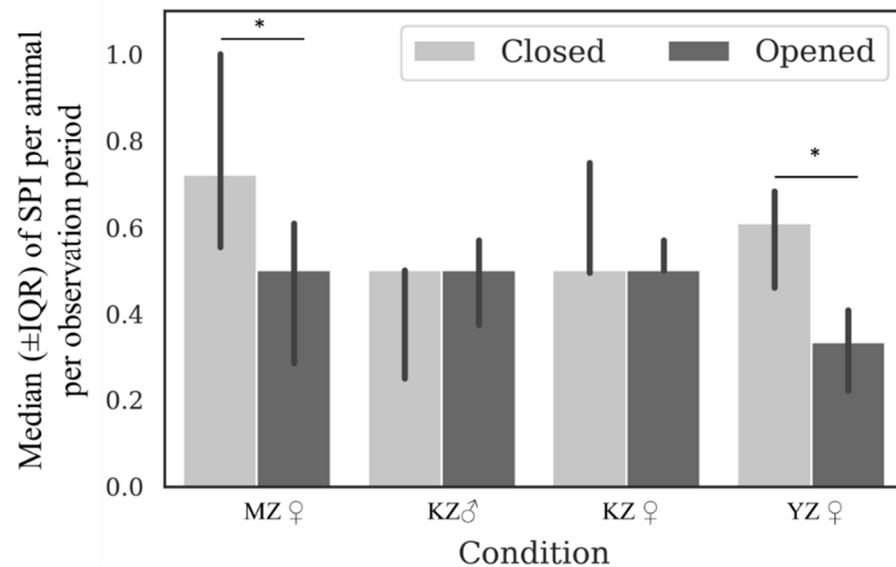
### 3.2. Space Use

During the Zoo Closed conditions, the MZ female spent almost 70% of her time in the indoor enclosure and did not use Zone 1 (closest to visitors) (Table 5). During the Zoo Open conditions, the SPI index significantly decreased ( $Z = 1.91, p = 0.05$ , Figure 2), which means the bear began to use the space zones more equally. The MZ bear spent significantly more time in Zone 1 after the zoo reopened, and these changes were due to a decrease in the time spent in Zone 2 (central area) and an increase in the time spent in Zone 3 (farthest from visitors); however, the results for each zone were not individually statistically significant (Table 5).

**Table 5.** Comparison of median %  $\pm$  IQR of changes in individual bears' time spent in different areas of the exhibit by pairing the permutation Wilcoxon test during facility closure and open periods based on keeper observations. Light gray indicates a significant difference between conditions.

Zoo	Animal	Enclosure Zone	Condition		Wilcoxon
			Zoo Closed	Zoo Open	
KZ	F	Zone 1	16.67 $\pm$ 16.67	14.29 $\pm$ 16.67	$Z = 0.39$ $p = 0.77$
		Zone 2	16.67 $\pm$ 16.67	16.67 $\pm$ 19.05	$Z = -1.31,$ $p = 0.21$
		Zone 3	66.67 $\pm$ 33.33	66.67 $\pm$ 4.76	$Z = -1.11,$ $p = 0.29$
	M	Zone 1	16.67 $\pm$ 33.33	16.67 $\pm$ 16.67	$Z = 0.39,$ $p = 0.77$
		Zone 2	25.00 $\pm$ 16.67	16.67 $\pm$ 16.67	$Z = 0.80,$ $p = 0.45$
		Zone 3	50.00 $\pm$ 16.67	66.67 $\pm$ 14.29	$Z = -1.66,$ $p = 0.13$
MZ	F	Zone 1	0.00 $\pm$ 0.00	12.50 $\pm$ 9.20	$Z = -2.35,$ $p = 0.03$
		Zone 2	16.67 $\pm$ 30.95	0.00 $\pm$ 0.07	$Z = 1.63,$ $p = 0.13$
		Zone 3	8.33 $\pm$ 16.67	31.25 $\pm$ 25.59	$Z = -1.26,$ $p = 0.23$
		Zone 4	69.05 $\pm$ 58.33	55.00 $\pm$ 29.17	$Z = 0.91,$ $p = 0.41$
YZ	F	Zone 1	66.67 $\pm$ 49.21	37.50 $\pm$ 27.78	$Z = 1.69,$ $p = 0.10$
		Zone 2	22.22 $\pm$ 35.71	25.00 $\pm$ 19.05	$Z = 0.22,$ $p = 0.87$
		Zone 3	0.00 $\pm$ 16.67	20.00 $\pm$ 20.83	$Z = -2.13,$ $p = 0.03$
		Zone 4	0.00 $\pm$ 12.71	12.50 $\pm$ 16.67	$Z = -1.27,$ $p = 0.24$

During the Zoo Closed conditions, the YZ female spent 66.7% of her time in Zone 1 (closest to visitors). During the Zoo Open conditions, the SPI index significantly decreased ( $Z = 2.96, p < 0.001$ , Figure 2). The bear began spending significantly more time in Zone 3 (farthest from visitors) and decreased her time spent in Zone 1; the time spent in the indoor enclosure increased, but this was not significant (Table 5).



**Figure 2.** An overview of SPI per individual bear during facilities' closure and open periods. Note: \*— $p$ -level < 0.05. MZ—Moscow Zoo, KZ—Kaliningrad Zoo, YZ—Yekaterinburg Zoo.

For both KZ bears, the use of enclosure zones and, accordingly, the SPI index values did not change between conditions (in particular, female:  $Z = -0.17$ ,  $p = 0.91$ , male:  $Z = -1.08$ ,  $p = 0.33$ , Figure 2).

### 3.3. Novel Object Tests

During the novel object tests under Zoo Open conditions, both KZ bears significantly decreased their normal activity (female:  $Z = 1.76$ ,  $p = 0.08$ , male:  $Z = 2.48$ ,  $p < 0.05$ ), including time spent near the novel object area (female:  $Z = 1.75$ ,  $p = 0.08$ , male:  $Z = 2.64$ ,  $p < 0.001$ ) and increased time spent on begging (female:  $Z = -2.44$ ,  $p < 0.05$ ) and pacing (female:  $Z = -1.55$ ,  $p = 0.10$ , male:  $Z = -2.50$ ,  $p < 0.05$ ) compared to the Zoo Closed conditions (Table 6).

**Table 6.** Comparison of median total duration ( $\pm$ IQR) of changes in individual bears' reactions to novel objects (seconds) by pairing the permutation Wilcoxon test (two-sided) during facility closure and open periods. Light gray indicates a significant difference between conditions.

Zoo	KZ				MZ		YZ	
Animal	F		M		F		F	
Condition/ Behavior	Zoo Closed	Zoo Open	Zoo Closed	Zoo Open	Zoo Closed	Zoo Open	Zoo Closed	Zoo Open
Manip	15.07 $\pm$ 56.94	22.12 $\pm$ 92.29	23.90 $\pm$ 95.07	0.00 $\pm$ 90.32	0.00 $\pm$ 23.05	0.00 $\pm$ 9.96	0.00 $\pm$ 3.00	0.00 $\pm$ 19.98
Near enrich	106.26 $\pm$ 164.53	28.95 $\pm$ 133.48	139.52 $\pm$ 114.71	0.00 $\pm$ 112.78	0.00 $\pm$ 90.93	0.00 $\pm$ 46.59	0.00 $\pm$ 25.14	49.78 $\pm$ 96.34
Normal	180 $\pm$ 51.33	143.80 $\pm$ 84.73	180 $\pm$ 0.00	154.96 $\pm$ 92.52	113.12 $\pm$ 180	24.50 $\pm$ 166.14	180 $\pm$ 0.00	180 $\pm$ 0.00
Begging	0.00 $\pm$ 0.00	0.00 $\pm$ 2.31	0.00 $\pm$ 0.00	0.00 $\pm$ 0.00	0.00 $\pm$ 0.00	0.00 $\pm$ 0.00	0.00 $\pm$ 0.00	0.00 $\pm$ 0.00
Pacing	0.00 $\pm$ 18.81	12.13 $\pm$ 84.73	0.00 $\pm$ 0.00	0.94 $\pm$ 92.52	0.00 $\pm$ 0.00	0.00 $\pm$ 0.00	0.00 $\pm$ 0.00	0.00 $\pm$ 0.00
Invisible	NA				66.88 $\pm$ 180	155.50 $\pm$ 166.14	0.00 $\pm$ 0.00	0.00 $\pm$ 0.00

There were no significant differences in the MZ bears' reactions to novel object tests between conditions. However, the median time spent in Zone 4 (particularly in the small den) increased statistically insignificantly by 2.3 times ( $Z = -0.67$ ,  $p = 0.52$ ), where the female moved both novel objects, therefore the time spent near novel objects could be higher because of the small size of the den (Table 6).

The YZ female was the only one who significantly increased time spent near the novel object area ( $Z = -2.03$ ,  $p < 0.05$ ) after the zoo opened. All other behavior did not change between conditions.

Descriptive analysis of the bears' latency to touch the novel object and to extract a food reward shows that the responses varied greatly between animals (Table 7). However, for both MZ and YZ bears, the latency to touch the novel object was higher after the zoo opened.

**Table 7.** Changes in the bears' latencies to novel objects during the novel object tests under the two conditions (two novel objects for each phase).

Zoo	Animal	Zoo Closed	Zoo Open	Zoo Closed	Zoo Open
		Latency to touch the novel object		Latency to extract a food reward	
KZ	F	34.00 ± 40.00	13.50 ± 7.00	66.50 ± 17.00	82.00 ± 80.00
	M	16.00 ± 4.00	13.50 ± 1.00	154.50 ± 23.00	103.00 ± 20.00
MZ	F	23.00 ± 223.00	204.00 ± 268.00	198.50 ± 343.00	227.50 ± 235.00
YZ	F	18.50 ± 21.00	65.00 ± 82.00	378.50 ± 559.00	378.00 ± 524.00

#### 4. Discussion

The results of the study showed that the bears' behavior during the zoo closures was different from their behavior after the zoos reopened. However, these changes varied across institutions and individuals. The hypothesis about an increase in the level of begging and time spent in the area close to visitors after the zoos opened again was only partially confirmed for three out of four bears. The bears from MZ and KZ either increased their begging levels after the zoos reopened or spent more time in the zone closest to visitors. Thus, after the reopening of the zoos, the bears from KZ began to beg both in the near and far zones of the enclosure, and only the female from MZ increased the time spent in the closest zone to the public, but begging was not observed in her activity budget. Previous research shows that this female only begged from the front zone of the enclosure [32] and the proportion of this behavior was no higher than 20%, so the increase in the time spent in this zone during Zoo Open conditions may be due to the bear's preference for additional stimulation from the public. The absence of the act of begging itself may be due to the "multi-point scan" method limitations, which does not register behaviors that occupy less than 15% of the activity budget. All of these three enclosures share an important detail in common that an enclosure in YZ does not have: they do not contain bars, and this probably allowed these bears to develop begging or other forms of visitor-animal interaction.

Only one enclosure, YZ, was separated from the visitors by bars, which creates obvious obstacles for visitors to reinforce the bear's begging behavior with food rewards. This appears to result in the bear not developing this undesirable activity. During Zoo Open conditions, this female was the only one who reduced her time in the area close to the public, showed no signs of begging, and began spending more time in the area farthest from the visitors' area. This increase is consistent with the study by Soriano et al. [6], where the brown bears increased both their time spent in the back location as well as stereotypies in the presence of visitors. However, in this study, after the reopening of the zoo, the YZ bear's level of pacing remained the same. On the contrary, all three of the other bears that were noted to display begging in this study or the earlier one [32] did not show pacing or other abnormal repetitive behaviors in their activity budgets. Begging and pacing both indicate a

lack of control over one's environment. This sense of control or agency is important for animal welfare, in order for them to function effectively [43]. Even though begging is an undesirable behavior, it may provide bears with a sense of control and thus improve their welfare, resulting in fewer abnormal behaviors such as stereotypy. Thus, the presence of pacing in the activity budget of the YZ female is consistent with observations that bears that do not have the opportunity to beg have a higher level of stereotypical behavior than those who do have this opportunity [15], and this highlights how the facility conditions can shape the manifestation of signs of poor welfare. However, providing species-appropriate methods to experience control, such as environmental enrichment, can provide benefits for bears' wellbeing, and these benefits do not rely on the public [32].

One unexpected result was the changes in the SPI index across facilities. Two bears from MZ and YZ during the Zoo Closed period used the enclosure areas unevenly and preferred to be in one area: the MZ female preferred the indoor area, and the YZ female preferred the closest zone to where visitors would be when the zoo was open. After the reopening of the zoos, these bears began to use the zones more equally. Neither bear from KZ changed their usage of space between the conditions. The lack of observed differences in space use across conditions by the KZ bears can be explained by several factors. First, the bears from MZ and YZ had free access to indoor holding spaces, in contrast to the bears from KZ, in which the space preference did not change between conditions. Second, visitor access to the exhibits differed across the zoos. The MZ and YZ enclosures are only accessible from one side by visitors, while the KZ exhibits were open on two sides (front and back). This combination of conditions may have resulted in a greater ability of the MZ and YZ bears to regulate their stimulation levels, both in the presence or absence of visitors, compared to the KZ bears. Under Zoo Closed conditions, the MZ and YZ bears could seek out interaction with zoo staff or keepers indoors if they were under-stimulated, and when the zoos reopened, the bears could choose to use an indoor area to avoid visitors if they became over-stimulated. The KZ bears were exposed to visitors on two sides of their exhibit and lacked the ability to move indoors at their choosing. Therefore, the MZ and YZ individuals could have had a generally stronger sense of control over their stimulation level, while the KZ bears are doubly out of control in that they are exposed on two sides and also have no opportunity to go inside to regulate their stimulation levels. It is worth noting here that the KZ bears who were locked in the outdoor enclosure during the day exhibited the highest levels of begging among the bears, which was most likely their alternative method of exerting control over their environment. Then, when the zoos reopened, all bears had more stimulation from the visitors' area, but only two of them had the opportunity to regulate the level of stimulation via the more equal use of space zones and using indoor spaces.

The results of the bears' reaction during novel object tests led to similar conclusions about the changes in the animals' welfare as the monitoring of the bears' activity budgets. During the Zoo Open phase, both bears from KZ exhibited undesirable behavior (begging) in their activity budgets, and during the tests, both animals again showed undesirable or stereotyped activity (begging was only seen in the female, but pacing was observed in both bears during the novel object tests). The activity budgets of the MZ and YZ bears did not show significant changes, and during the tests, the MZ female also showed no change between conditions. The YZ female only showed an increase in the time spent near the novel object zone, and exhibited no additional signs of poor welfare in her activity budgets. Thus, the overall welfare of the KZ bears declined during the Zoo Open conditions, and that was recorded by both observational methods, while no significant changes in the MZ/YZ bears' overall welfare were shown using these methods.

However, the predictions about the reaction of the animals in the tests was not confirmed. All four bears successfully solved the problems in all tests (extracted food rewards from novel objects), and the time of getting the reward did not depend on visitor presence, but rather varied among individuals. I expected that during the Zoo Closed period, the bears would experience a decrease in control (no opportunity to control visitors' behavior),

so they would show more signs of abnormal behavior and lower levels of exploratory behavior. However, I observed the opposite response in at least two bears. Specifically, after the Zoo Open period, both bears from KZ sharply decreased their time spent in the zone near novel objects and both increased their time spent pacing.

To avoid the factor of habituation to novelty, the time of the tests between the conditions (Zoo Closed/Open) was approximately one month for all bears, therefore the observed pacing during the tests during the Zoo Open period was unlikely to be associated with the frequent provision of novel objects. The presence of pacing and a decrease in the time spent in the zone near novel objects in the KZ bears may indicate an increase in the level of their anxiety during this period, and may reflect the opposite picture: that the animals perceive their environment after the zoos reopened as an environment with less opportunities for choice and control [31]. After the Zoo Open phase, the female from YZ increased the time spent in the zone near novel objects, and the female from MZ increased the time spent in the small den in the outdoor space, where she moved novel objects, and accordingly, also increased her time spent in the zone near novelty.

The differences in the animals' reactions to novelty between the bears from KZ and the other two could be understood through the animal exhibit features. As I mentioned, both bears from KZ had no free access to the indoor space. Providing choices is a critical element for improving animal welfare, and free access to indoor spaces can decrease the risk of abnormal behavior and increase normal activity in bears [44,45]. Novelty is a psychological stressor [46–48], and the ability of an animal to successfully react to novelty can be shaped by the conditions that provide an animal with the opportunity for choice and control [26,29,31]. Therefore, exposure to novel objects during the Zoo Open period could be perceived by the bears from KZ as being more stressful than by the bears from MZ and YZ due to the lack of choice and control they experienced. Moreover, probably because of this choice, the level of pacing in the YZ female did not change between the periods in her activity budget, because she could freely choose the most comfortable zone. Thus, the presence of visitors and the ability to control their behavior did not buffer the exploration of novelty, and a significant contribution to the results, most likely, was made by the opportunity of choice through free access to the indoor spaces.

The methodology for this study has a limitation in that the novel objects for the tests were a combination of truly novel and not-recently-used objects. Traditionally, animals are presented with completely novel objects for the novel object tests, which, as noted above, is a difficult task when studying zoo-housed long-lived animals. This imposes certain restrictions on the interpretation of the results obtained, since it is likely that the provision of completely novel objects would lead to even greater alteration in the behavior of the bears toward the objects. However, the trend of changes in the behavior of the bears is consistent with the literature mentioned above, where conditions with fewer opportunities for choice increase the risk of abnormal behavior.

## 5. Conclusions

In our brief study, the bears demonstrated changes between the conditions (Zoo Closed/Open) and the changes varied greatly, depending on the characteristics of the exhibits across institutions. Due to the different characteristics of the zoos, a new hypothesis about the role of visitors on the behavior of the brown bear was put forward. Bears that did not have free access to indoor spaces were more sensitive to the appearance of the public. During the Zoo Closed period, these bears had more normal activity levels, and demonstrated no abnormal behavior during the novelty object tests. I expected the reopening of the zoos to increase the ability of the bears to control their environment through begging. However, the increase in pacing during the novel object tests suggests the bears without indoor access were more sensitive to novelty after the zoo visitors returned than while they were absent. The two bears who had constant free access to indoor enclosures exhibited no significant changes in their activity budgets between the conditions, which is consistent with data from a study in Cleveland Metroparks Zoo [16]

in which no differences between the Zoo Closed/Open conditions were found for brown bears, either.

This study demonstrates that the prolonged absence of visitors may have no effect on bear behavior if the animals have free access to indoor holding spaces, and highlights the importance of providing bears with access to off-exhibit spaces as well as other opportunities for choice and control to avoid negative visitor effects on their behavior.

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**Data Availability Statement:** The data presented in this study are available on request from the corresponding author. The data are not publicly available due to institutional policy.

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