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Introducing a Semi-Naturalistic Exhibit As Structural Enrichment for Two Brown Bears (Ursus arctos). Does This Ensure Their Captive Well-Being?

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In this study we used the daily activity pattern and use of space as indicators of change in the program of structural enrichment, implemented with 2 subjects of the species Ursus arctos in the Barcelona Zoo. We collected 930 sampling points in each study phase for each of the individuals: The samples were taken in a balanced way at different times of day. We observed a wider range of behavior in the male than the female. With respect to the indicators, we observed statistically significant differences in behavior in both individuals in the 2 study phases. Both individuals showed an increase in vigilance, maintenance, and inactivity when their enclosure was changed. In terms of the subjects’ well-being, we considered the percentage of stereotyped behavior within acceptable limits. The percentage of activity observed in the male was very similar to that of individuals of this species in the wild. In terms of the use of space, we observed homogeneity only in the male during the enrichment program. The 2 individuals responded in different ways to the structural enrichment.

One of the five types of environmental enrichment is structural enrichment (Bloomsmith, Brent, & Schapiro, 1991). Consequently, many zoo biologists have begun to collaborate with architects and engineers to design exhibits that enhance the lifestyles of captive, nonhuman animals (Maple & Perkins, 1996). Numerous environmental variables contribute both individually and collectively to the well-being of captive animals. Some of these variables have been classi-
fied as elements in the physical environment (Maple, 1979). Many of these elements have been used to improve the quality of life of captive bears: changing enclosure size and shape (Van Keulen-Kromhout, 1978; Winhall, 1998), building rest areas (Cowan, 1997; Poulsen & Price, 1997), and introducing some types of manipulable objects made with natural (Acuña, 1993) or artificial material (Cutting, 2002; Ford, 1995; Pfaff, 1999; Willms, 2001). The seminaturalization of exhibits and the increase in space for the bears were chosen to increase behavioral diversity and to provide a more educational and attractive enclosure for visitors (Murray, Waran, & Young, 1998).

The term *postoccupancy evaluation* (POE) is used in architectural language to mean the evaluation of a building once the facility is in use (Zimring & Reizenstein, 1980). POE has been described as a procedure that enables managers to make effective decisions about planning and designing environments (Ross & Lukas, 2003). Maple and Finlay (1987) described it as “the practice of using systematic methods to find out exactly what makes designed environments work well for their users.” When a new animal facility is designed, many different users must be involved.

The main users are the animals (Riddle, Keeling, Alford, & Beck, 1982; Ross & Lukas, 2001). However, there are also other types of users (care staff, visitors, and researchers) who must be considered in the design of the environment. Care staff are probably second to the animals in terms of the length of time they spend in building. Zoo visitors expect a pleasant, agreeable, and entertaining experience (Wilson, Kelling, Poline, Bloomsmith, & Maple, 2003). Finally, other users (veterinarians, educators, and support staff) have important design needs for the facility. Ignoring care staff’s needs will be detrimental to the animals’ well-being (Shettel-Neuber, 1988).

Studies that have examined the effect of increasing the size of the enclosure on behavior (Chang, Forthman, & Maple, 1999; Goerke, Fleming, & Creel, 1987; Line, Markowitz, Morgan, & Strong, 1991; Little & Sommer, 2002; Spendrup & Larsson, 1997b), on the use of space (Kessel & Brent, 1996), or on a combination of both factors (Brent, Lee, & Eichberg, 1991; Hebert & Bard, 2000; Ogden, Finlay, & Maple, 1990; Price, 1992) have mainly focused on the primate order.

No previous studies have examined the effect of an increase in enclosure size on the behavior and use of space in the *Ursidae* family. Articles on this species that discuss entertainment mainly dealt with the effect of food enrichment on the behavior of brown bears (Grandia, Van Dijk, & Koene, 2001; Hare, 1995; Larsson & Tove, 1995; Morimura & Ueno, 1999) and on the relationship between the size of the enclosure and stereotyped behavior in these animals (Spendrup & Larsson, 1997a).

Therefore, this study is the only one on the effect of an increase in enclosure size on the *Ursidae* family. In addition, it is the only one that analyzed both behavior and use of space as indicators of the animal’s well-being, using the calculation of an index of spatial homogeneity.
The aim of this study was to analyze the effect of structural enrichment on two captive bears in the Barcelona Zoo in Spain. The daily activity pattern and the use of space were used as indicators of change.

METHOD

The subjects were two bears (Ursus arctos) housed at the Barcelona Zoo. Bubu was a 10-year old female (in January 1997), who was captive born and mother reared. Keiko was a 1.5-year-old male (in January 1997), who was wild born and hand reared.

Baseline Phase

**Housing and husbandry.** During the baseline phase (BL), Bubu was housed with her mother, and Keiko was housed alone in 100-m² and 130-m² enclosures, respectively (see Figure 1). These animals went out into their exterior enclosures every day, as did the Tibetan bear and the American black bear who occupied the two adjacent bear enclosures. The bears were housed in concrete pits with various uneven exhibits and had a water area for drinking and bathing. Furnishings consisted of several large stones and trees in both exhibits and a large, felled log in Keiko’s exhibit. Bubu and Keiko had auditory and olfactory contact with each other because their exhibits were contiguous. Indoor cages were out of view of visitors, as was the drinking trough and concrete substrate (approximately 10 m²). The

![FIGURE 1](https://example.com/figure1.png)

*FIGURE 1* A plan of the old bear enclosures. 1 = *Selenarctos thibetanus* enclosure; 2 = *Ursus americanus* enclosure; 3 = *Ursus arctos arctos* enclosure; 4 = *Ursus arctos* enclosure; s = stone; T = tree; L = log; dashed line (- -) = uneven surface.
brown bears were housed individually because there was no interest in reproduction, as Bubu was a hybrid subject. They were on exhibit during daylight hours (9:00 a.m. to 8:00 p.m.). Bubu and Keiko were released into the outdoor enclosure daily. They were fed fruit, vegetables, and meat once a day in the afternoon when they were let into the indoor cages. These animals received a daily session with enriching items in the form of food.

Procedure. César González and collaborators from the ethology group Veterinarian Association for the Attention of Exotic and Wild Animals of the Autonomous University of Barcelona conducted the baseline observations. The bears were observed in the old exhibit in July and August 1997. The observation sessions began at 10:00 a.m. and ended at 8:00 p.m. Data were collected by different observers at different times of day. Observers had previously passed a reliability test, in which a concordance index was calculated (Martin & Bateson, 1986). Focal sampling methods and instantaneous scans were made at 10-min intervals over 22 days for each individual. In total, 75 hr of observation were undertaken for each of the subjects. Sessions were coded according to the time of day: mornings (10:00 a.m. to 1:00 p.m.), afternoons (1:00 p.m. to 4:00 p.m.), and evenings (4:00 p.m. to 8:00 p.m.); the location; and the activity each bear presented.

The study of use of space was carried out according to two different criteria in the division of the enclosure. First, the enclosures were divided into two similar parts in terms of the proximity of animals to the visitors (see Figure 2). Second, the location codes were “right location” when the animals occupied the right half of the enclosure and “left location” when the animals occupied the left half of the enclosure (see Figure 3). The activity categories that were coded are listed in Table 1.

FIGURE 2 A plan of the enclosure showing the division into front and back areas. S = stone; T = tree; L = log; BL = back location; FL = front location; dashed line (---) = uneven surface.
Postoccupancy Evaluation Phase

**Housing and husbandry.** The changes to the brown bears’ enclosures in the Barcelona Zoo were carried out from October 2000 to March 2001. Each of the two new enclosures was formed by joining two of the existing four enclosures (see Figure 4). Therefore, the size of Keiko’s enclosure increased by 150m²; the size of Bubu’s enclosure increased by 230m². In addition to doubling the surface available for the animals, different areas were made to increase the number of different surfaces. In addition to the cement floor, the new enclosure had areas with beach sand, gravel, and pine bark. New stones and logs were introduced as additional furnishings. The pump system was improved to prevent water from becoming stagnant, as it had been in the BL phase. For the animals’ well-being, permanent enriching items were added, such as a honey dispenser and some fixed PVC tubes.
TABLE 1
The Definition of Each One of the Behavioral Categories and Their Classification Into Three Macrocategories

Activity is any behavior that is not classified as inactive, which includes:
- Exploration: The animal sniffs the air, substrate, food or objects
- Vigilance: The bear is alert with head up and eyes open
- Locomotion: The animal moves around the enclosure
- Scent marking: The bear rubs against logs
- Feeding: The bear consumes food items, this also includes drinking
- Solitary play: This mainly involves individual movement, such as vigorous, rigorous, exaggerated-like jumping
- Maintenance: The animal self-grooms with mouth and/or paws, scratches, urinates, defecates, or shakes
- Manipulation: The bear claws at, swipes at, nibbles at, picks up food, and nonfood items with mouth and/or paws
- Human interaction: The bear sits or stands up while looking at humans; this includes different forms of begging, for example while the bear is sitting or standing up it may open its mouth and wave its head from side to side; the animal tries to communicate with the humans
- Stereotyped behavior: This behavior has no goal and is repetitive, lasting for a constant time and occurring in the same places
- Social interaction: This includes affiliation or agonistic behavior

Inactivity
- Stationary: The bear rests lying or sitting with their musculature relaxed
- Not Visible
- Not visible: The bear or its behavior is not visible

FIGURE 4  A plan of the new bear enclosures. 1 = Keiko’s enclosure; 2 = Bubu’s enclosure; S = stones; T = tree; L = logs; BS = bark substrates; CRS = crushed stone substrates; SS = sand substrates; COS = concrete substrates; AU = honey dispenser; P = PVC tube.
Both Bubu and Keiko were housed individually during this phase. Again there was no interest in reproduction because Bubu was a hybrid subject. The times at which the bears entered and left the exterior enclosures (they remained outside from 9:00 a.m. to 8:00 p.m.), the diet, and the interior enclosures were kept constant in all phases. However, there was a change in the Barcelona Zoo’s collection plan. It was decided that, because of infrastructure considerations, only the species *Ursus arctos* would be maintained. Therefore, the Tibetan bear was removed from the collection, and a young female brown bear was introduced.

As a result, Keiko went into her exterior enclosure on Tuesdays, Thursdays, and Saturdays. On the other days, the young female brown bear went into the exterior enclosure. However, this female was not included in the study because there were no BL data available for her. Bubu also went into the exterior enclosure on alternate days. He used the enclosure on Mondays, Wednesdays, Fridays, and Sundays. On the other days, the enclosure was used by the male American black bear. In this case, the animals did not undergo any enrichment program.

**Procedure.** Ana I. Soriano conducted all the behavioral observations in this present phase. Observations were made during June and July 2001. In this case, the observation sessions were 1 hr long and were carried out according to a monthly schedule in which 5 hr of monthly observation had to be carried out for each individual and for each one of the established time bands (mornings, 10:00 a.m. to 1:00 p.m.; afternoons, 1:00 p.m. to 4:00 p.m.; and evenings, 4:00 p.m. to 8:00 p.m.). Focal sampling methods and instantaneous scans were made at 2-min intervals over 15 sessions of 1 hr each for each individual. A total of 30 hr of observation was undertaken for each one of the individuals in the 2 months of the study while the animals were in the exterior enclosures (9:00 a.m. to 8:00 p.m.). Sessions were coded according to the same variables described in the BL phase.

The method of recording and sampling varied in the two study phases because the established objectives were initially different. However, it was decided that the data could be used to assess structural enrichment.

To compare the two study phases, the BL recording points were matched with those of the POE phase for each of the established time bands. In total, 930 recording points were obtained in each one of the phases and for each individual in the study.

**Data Analysis**

Using contingency tables, we analyzed the categorical data for behavior and use of space obtained in this study. These tables enabled us to determine whether there were statistically significant differences in the two study phases for the two dependent variables, by means of Pearson’s chi-square calculation. This test sta-
tistic was used to determine in exactly which categories (behavior or location) the statistically significant differences could be found. This statistic has an absolute value of 2.96 for a normal distribution, assuming that the significance level is .05 (Haberman, 1978).

To analyze the effect of the enrichment program on a more homogeneous use of the space, a spread-of-participation index was used. A value of 1 indicated minimum use of the facility; a value of 0 indicated that the use of the space was totally homogeneous (Dickens, 1955; Shepherdson, Carlstead, Mellen, & Seidensticker, 1993).

RESULTS

Activity Differences Between BL and POE phases

Statistically significant differences in the two phases of the study for the two individuals are shown in Table 2. The detailed behavioral categories in which there were statistically significant differences (their values were either above or below the test statistic) are shown in Figure 5. Bubu spent more time engaging in the following behaviors: not visible, vigilance, locomotion, maintenance, manipulation, and inactivity; and spent less time engaging in explore, feeding, and social interaction in the POE observations than in the BL observations. Keiko spent significantly more time engaging in vigilance, maintenance, and inactivity and less time engaging in the following behaviors: not visible, explore, locomotion, feeding, solitary play, manipulation, and human interaction in the POE phase than in the BL phase (see Figure 6).

Location Differences Between the BL and POE Phases

Table 3 shows where there were statistically significant differences in the two study phases, the two area division systems, and the two individuals in this study.

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Bubu</th>
<th>Keiko</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson chi-square</td>
<td>443.306</td>
<td>297.219</td>
</tr>
<tr>
<td>df</td>
<td>9</td>
<td>10</td>
</tr>
<tr>
<td>p</td>
<td>0*</td>
<td>0*</td>
</tr>
</tbody>
</table>

*Statistically significant difference.
ACTIVITY PATTERN

FIGURE 5  Bubu’s percentage of activity observations in the two study phases.

FIGURE 6  Keiko’s percentage of activity observations in the two study phases.

TABLE 3
The Value of Pearson’s Chi-Square, the Degrees of Freedom and the Significance Level for the Two Brown Bears’ Use of Space

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Bubu</th>
<th>Keiko</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson chi-square</td>
<td>0.581</td>
<td>54.368</td>
</tr>
<tr>
<td>df</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>p</td>
<td>.446</td>
<td>0*</td>
</tr>
</tbody>
</table>

*Statistically significant difference.
Bubu’s use of the front and back location did not differ significantly in the two phases (see Figure 7). However, her use of the right and left location differed significantly (see Figure 8). Keiko’s front and back location differed significantly in the new enclosure (see Figure 7), although he spent significantly more time in the right location during the POE phase (see Figure 8).

The values of the spread-of-participation index for the two classifications of use of space and for the two subjects studied are shown in Table 4. There were no differences in terms of the homogeneity of Bubu’s use of the front–back locations. However, homogeneity in the use of the right–left spaces was lost with enrichment. In the case of Keiko, an increase in homogeneity was seen only in the right–left locations.

![Figure 7](https://example.com/bubu_keiko_front_back.png)

**FIGURE 7** Bubu and Keiko’s use of the front and back locations in the two study phases.

![Figure 8](https://example.com/bubu_keiko_right_left.png)

**FIGURE 8** Use of right and left location by Bubu and Keiko in old and new exhibit.
DISCUSSION

More behavioral categories (solitary play and stereotyped behavior) were observed in the male brown bear than in the female. This may have been due to several factors, such as sex, age of the individuals, and the type of birth (in the wild or in captivity).

Despite the time elapsed between the BL and POE evaluation periods and the death of Bubu’s mother, the results show that brown bears spent more time engaged in vigilance, maintenance, and inactivity. The objective of structural enrichment was to attain increases in exploration, manipulation, maintenance, and solitary play.

Increases in exploration and manipulation were due to increased enclosure size and the introduction of new furniture and different substrates. An increase in the manipulation behavioral category was observed only for Bubu. The explore category was not increased with the new enclosure design.

Maintenance is an indicator of well-being because it contributes to controlling physiological functions. This indicator increased in the POE phase for the two subjects.

Solitary play contributes to the development of motor capabilities. The appearance of solitary play could be due to the youth of the male and the link between play and learning (Bekoff & Byers, 1998; Fagen, 1981). This behavior was observed in Keiko only during the BL phase.

The objective of physical enrichment was to attain decreased the following: not-visible behavior, stereotyped behavior, and human interaction.

Not-visible behavior is an indicator of an animal’s adaptation to environmental factors such as architectural design and visitors’ influence. Keiko’s not-visible category was not observed during the POE evaluation because the new exhibit had no places in which Keiko could be out of sight. This was not the case for Bubu.

Stereotyped behavior is an indicator of well-being. Its presence indicates that the physical and physiological necessities of the animals are not fulfilled (Mason, 1991). It is the only behavior that did not change when Keiko’s environment was

<table>
<thead>
<tr>
<th>Location</th>
<th>Bubu BL</th>
<th>Bubu POE</th>
<th>Keiko BL</th>
<th>Keiko POE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Front–back</td>
<td>0.48</td>
<td>0.53</td>
<td>0.10</td>
<td>0.560</td>
</tr>
<tr>
<td>Right–left</td>
<td>0.06</td>
<td>0.29</td>
<td>0.35</td>
<td>0.006</td>
</tr>
</tbody>
</table>

*Note.* BL = baseline; POE = postoccupancy evaluation.
enriched. It was not observed in Bubu’s behavioral repertoire. Shepherdson (1989) stated that more than 10% of stereotyped behavior is not acceptable. In this study, stereotyped behavior was observed only in the male, and the level was within acceptable values.

Human interaction is not desirable because it contributes to unbalancing the animal diet and is not part of the typical behavioral repertoire for this species. It is the only behavior that did not change after Bubu’s environment was enriched. This behavior pattern decreased after Keiko’s physical enrichment.

The seminaturalization of the exhibit was not enough to provide for both brown bears’ well-being. Bubu’s levels of inactivity increased only slightly (9.2%). This value was still far from wild brown bears’ values. Keiko’s well-being increased with the seminaturalistic exhibit because he was less active (42.2%) in the POE than in the BL phase (94.4%). Wild European brown bears have active behavior around 45% to 60% of the time in the summer period (Roth, 1983; Roth & Huber, 1986). Therefore, the physical enrichment program brought the male, captive brown bear’s pattern of activity–inactivity closer to patterns of subjects in the wild.

Spendrup and Larsson’s (1997a) studies of brown bears and Ames’s (1999) studies of polar bears showed the importance of the size of the enclosure to these species. Both studies concluded that habitat size is linked to stereotyped behavior. The increase in the size of the enclosure in the Barcelona Zoo was not sufficient because the male continued to present stereotyped behavior. Therefore, as Spendrup and Larsson (1997a) indicated, other kinds of enrichment programs need to be implemented (food, sensory, and occupational) to improve the well-being of these animals.

Studies of structural enrichment in primates (Brent et al., 1991; Chang et al., 1999; Little & Sommer, 2002; Price, 1992) and its influence on behavior generally revealed a decrease in inactivity and an increase in feeding. In contrast, the exact opposite occurred with the Barcelona Zoo brown bears. Inactivity values were very low during the BL phase. These values increased in the POE phase. Feeding decreased in the POE phase, because the animals were submitted to a program of food enrichment during the BL phase.

The use of space during the two study phases was different for each individual, except in the case of Bubu’s front and back locations during enrichment sessions. Keiko increased the use of the back area of her enclosure during the POE phase. There could be several reasons for this:

1. This location is at the greatest distance from the public.
2. It is close to the interior enclosure where the carers are and where there is more food.
3. It is the highest place in the enclosure, where the animal has the best view of the macroenvironment in which she lives.
A more homogeneous use of the space was observed only in the macho for the right–left location during the POE phase. This shows that increasing the size of the Barcelona Zoo’s brown bear enclosure led to a decrease in spatial homogeneity, indicating that the bears have preferential areas within their habitat.

Renner and Lussier’s (2002) study of the species *Tremarctos ornatus* indicated that structural enrichment increased the diversity of behavior and the use of space in this bear species. However, in our study the structural enrichment program caused an increase in behavioral diversity only in the female. In addition, spatial homogeneity was achieved only for the male in one of the uses of space divisions. This demonstrates that there is a different individual response to environmental enrichment programs, probably due to the sex, age, origin, and rearing conditions of subjects (Hare et al., 2003).

Readers should take into account that the brown bears’ old and new exhibits are pits. This type of design influences the bears’ well-being because their position is always subordinate to the visitors’ position (Coe, 1985). Mammal exhibits must never be designed as pits because captive brown bears dislike a terraced and uneven floor enclosure. In their natural habitat of forests and mountains—where the view is blocked by many obstacles—this would tend to encourage the use of hearing and scent rather than sight (Van Keulen–Kromhout, 1978).

Having a seminaturalized exhibit with increased space is not enough to make a real improvement in captive brown bears’ well-being (Beattie, Walke, & Sheddon, 1996). In addition, these two bears were in indoor cages several days a week. Therefore, the results demonstrate that they could not satisfy their daily needs. This type of management decreases the positive effects of structural enrichment. Achieving captive animal well-being is a combination of correct architectural exhibit design and correct daily management (Shettel-Neuber, 1988).

A limitation of this study that could have influenced the results was an excessive delay between the BL and POE phases. In addition, the objectives of the study were different in each of the two phases, so the recording and sampling methods were different. Moreover, the female was initially housed with her mother and subsequently was housed alone.

Future studies on this type of species in captivity should be aimed at improving the animals’ well-being through introducing a daily routine that brings the behavioral indicators as close as possible to those of the same species in the wild. Thus, the objective is to boost the typical behavior of the species and to design a diet as similar as possible to the seasonal nature of the same species in a natural habitat.

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