Original Article

Environmental enrichment and the behavioral effects on captive Beluga whales (*Delphinapterus leucas*)

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Abstract

Environmental enrichment methods are meant to encourage animals to display their complete ethogram while under human care in zoos and aquariums. In this study, we sought to characterize the effectiveness of environmental enrichment (involving the inclusion of toys in the living environment) on captive beluga whales in the National Museum of Marine Biology and Aquarium. Our results indicate that belugas with toys spend less time floating and swimming repetitively than do belugas without toys. The presence of toys was also shown to enhance social interactions among captive belugas. Overall, our findings indicate that the provision of toys can enrich the living condition of beluga whales in a captive environment.

Keywords: Marine mammals, Beluga whales, Environmental enrichment, Toys

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Introduction

Marine mammals are found in zoos, aquariums and conservation breeding centers around the world. Common examples include pinnipeds, such as the California sea lion (*Zalophus californianus*), Steller sea lion (*Eumetopias jubatus*), seals, walruses (Clark, 2013; Small, 1995), as well as cetaceans, such as bottlenose dolphins (*Tursiops truncatus*), killer whales (*Orcinus orca*) and beluga whales (*Delphinapterus leucas*) (Clark, 2013; Clark *et al*., 2013; Jiang *et al*. 2007; Small, 1995). The captivity of marine mammals provides a rare opportunity to explore their hematology (Tsai *et al*., 2016) and immunology (Chen *et al*., 2016; Tsai *et al*., 2017), which is simply not possible when observing animals in the wild. The information obtained through the study of captive animals provides a solid reference to improve protection and conservation strategies for all animals (Li *et al*., 2015; Swimmer, 2000).

The welfare of all captive animals is a growing concern (Holst, 1997; Shepherdson *et al*., 1998). Mason *et al*., (2007) reported that man-made environments tend to promote abnormal behavior in captive animals. It also appears that impeding the expression of stereotype behavior can impacts the welfare of the animals (Defran and Pryor, 1980). Captive animals are often bored due to confinement and the predictability of their lives (Neto *et al*., 2016). These concerns have led to the development of environmental enrichment programs aimed at encouraging animals to display their complete ethogram while under human care in zoos and aquariums (Delfour and Beyer, 2011; Hill *et al*., 2015a, Kuczaj *et al*., 2002; Shepherdson, 1994).

Enrichment often involves modifying the proximate circumstances of captive animals in the form of more natural-appearing surroundings (Held and Špinka, 2011; Newberry, 1995; Shepherdson *et al*., 1998). Other methods include sensory stimulation, interacting with humans and providing novel objects (i.e. toys) or complex structures (Hill *et al*. 2015b; Melfi, 2013; Swaisgood and Sheperdson, 2005; Wells, 2009). Play behavior is an indicator of a desirable environment and/or the effectiveness of methods used to stimulate the interest of the captive animals (Paulos *et al*., 2010; Young, 2004). Neto *et al*., (2016) reported that play behavior can be promoted by manipulating the objects surrounding captive as well as wild cetaceans.

The positive impact of environmental enrichment can be seen in terrestrial creatures, such as ursine animals, which include the sloth bear (*Melursus ursinus*), the American black (*Ursus arnericanus*) and the brown bear (*Ursus arctos*) (Carlstead *et al*., 1991), as well as the kinkajou (*Potos flavus*) (Shepherdson *et al*., 1990) and domestic animals (Newberry, 1995). Environmental enrichment is also used for marine mammals, such as pinnipeds (Smith and Litchfield, 2010) and cetaceans (Clark *et al*., 2013; Delfour and Beyer, 2011; Galhardo *et al*., 1996). However, there has been far less research on the environmental enrichment of captive belugas than on other cetaceans or marine mammals. Moreover, the influence of enrichment may differ among individual animals within the same species, particularly when using objects for stimulation (Delfour and Beyer, 2011; Newberry, 1995).

Our objective in this study was to assess the efficacy of environmental enrichment (in the form of toys) on captive beluga whales housed in an aquarium. We also sought to characterize the toy preferences of these captive animals.

Materials and Methods

Animal Ethics: Our observation of beluga whale behavior in this study was approved by the institutional animal care and use committee (IACUC) of the National Museum of Marine Biology and Aquarium (NMMBA) (Approval number: 2017003). The display of captive beluga whales for educational purposes was approved by the Pingtung County Government (Approval number: 0950137173).

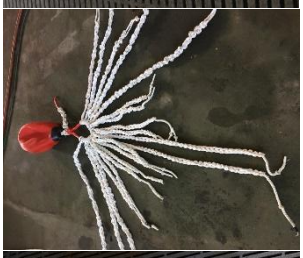
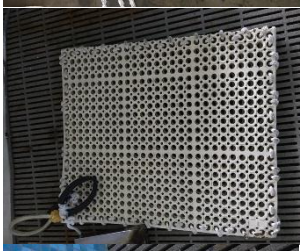
Location and Study Subjects: The housing facility of the belugas consists of one main exhibit pool, two holding pools and two medical pools. The exhibit pool measures approximately 43 meters long, 13 meters wide and 7 meters deep. The holding pool is about 8 m long, 8 m wide and 3.5 m deep. Regarding the medical pools, one medical pool, with a lifting bottom facility, measures 8 m long, 8 m wide and 3.5 m deep, the other one is 5 m long, 5 m wide and 2 m deep. The belugas have access to all pools. The female beluga was routinely housed together with one male beluga to avoid fighting accidents between animals. The lighting of the housing facility was controlled to provide 10 h of daylight daily (08:00 to 18:00 h). Regarding the feeding times, all the belugas were fed four meals daily (09:00, 11:00, 13:00 and 15:00 h). The belugas were fed various kinds of fish, mainly mackerel, atlantic horse mackerel, pacific saury and bonito, combined with vitamins and mineral supplementation. The observation of the behavior of beluga whales (*D. leucas*) was conducted during a period of 14 consecutive days in August of 2017 at NMMBA in Pingtung, Taiwan. The indoor pools used to house the animals were filled with filtered and ozone-sterilized natural seawater at a temperature of less than 17 °C. The three beluga whales in the current study (Table 1) had been captured off the coast of Russia at the age of 3 (Tsai *et al*., 2016). Since 2002, they have been housed in the aquarium and are in regular contact with humans; i.e., breeders, veterinarians, technicians and trainers.

Data Collection: Seven types of toy were assessed in this study (Table 2). The whales at NMMBA had become familiar with all of the available toys over a period of at least 2 years. The animals freely interacted with the toys without the need for training. The behavior of the animals was observed in the absence of toys for 7 days and then in the presence of toys for another 7 days. Every day, the trainers usually introduced the toys into the pools at 9 - 10 am, where they remained until 3 pm. The focal observation of the beluga behavior was conducted once a day for 30 min. (9.30 am - 10.00 am) using the scan sampling method (Clegg *et al*., 2017; Mann, 1999). The behavior of the three animals was scanned at 1-min., intervals by the observers behind a blind. Analysis was based on the ethogram (Table 3) described by Anderson *et al*., (2017) and Hill *et al*. (2015a; 2015b).

Table 1 Demographics of three captive beluga whales (*D. leucas*) at the National Museum of Marine Biology and Aquarium in Pingtung, Taiwan. "Age" indicates the age of the belugas during the year of study (2018).

Name	Sex	Estimated Weight (kg)	Age	Body Length (cm)
Angel	Female	1,200	19	385 – 395
Babu	Male	1,400	19	410 – 420
Ginbo	Male	1,350	19	430 – 440

Table 2 Characteristics of seven toys used by belugas housed at NMMBA.

	Toy	Description
A		Small white buoy with rope (*L* = 90 cm, sink)
B		Small red ball with bundle of ropes (*L* =253 cm, float and sink)
C		Mat with handles (75 cm × 91 cm, sink)
D		Basketball (*D* = 22 cm, float, rounded in shape)
E		Big ball (*D* = 50 cm, float, rounded in shape)
F		White-blue buoys and small white buoys with rope (*L* = 330 cm, float, elongated in shape)
G		Medium-sized balls with rope (*L* = 56 cm, partial float, elongated in shape)

L, length; *D*, diameter

Table 3 Ethogram of beluga whales in current study.

Behavior	Description
Float	Remain stationary on the water surface for 5 – 10 seconds
Swim – Repetitive	Solitary swimming in a fixed pattern (in circles)
Swim – Exploratory	Solitary swimming in an irregular pattern
Social Interaction	Interaction between two beluga whales or collective behavior (e.g., swimming together)
Courtship display	Male beluga whale prolapses its genital organ or moves its genital organ along the toy
Lean	Contact between head of beluga whale and gate separating front and back pools
Play with toys	Contact between beluga whale and toy (indicative of their desire to play)

Analysis: The efficacy of the enrichment methods was assessed by analyzing the frequency with which the animals performed various behaviors. We calculated the frequency with which each animal came into contact with the various toys in order to estimate the toy preferences of each animal. Statistical analysis was performed using the Windows version of the SPSS statistical package v.18.0 (SPSS Inc., Chicago IL). Data was analyzed using the non-parametric Whitney U-test to compare among-group differences (non-enrichment and enrichment) (Hocking *et al.*, 2015). For all tests in this study, p values of less than 0.05 were recognized as indicators of statistical significance.

Results and Discussion

We first observed the frequency with which the animals performed various behaviors under two living conditions: without any toys (non-enrichment) and with toys (enrichment), as shown in Figure 1.

Overall, our results indicate that belugas with toys spent less time floating and swimming repetitively than did belugas without toys, as follows: without toys (floating 35.18% and swimming repetitively 36.85%) and with toys (floating 11.16% and swimming repetitively 1.91%). We also observed a significant difference in social interactions between belugas in the presence or absence of toys, as follows: without toys (0.00%) and with toys (1.49%).

No significant differences were observed in the behavior of the animals in the absence or presence of toys in terms of solo exploratory behavior, estrus or head leaning behavior (explained later). Nonetheless, a number of subtle differences were observed. Solo exploratory swimming occurred less frequently in the presence of toys (8.12%) than in the absence of toys (15%). The introduction of toys appeared to have prompted courtship displays in male belugas (1.66%). It also prompted the animals to lean their heads against the gate separating the front and back pools, as follows: without toys (12.96%) and with toys (18.47%). Overall, when toys were given to the belugas, they spent 57.17% of their time playing with the toys.

We also observed the frequency with which each of the animals touched the various toys, as shown in Figure 2.

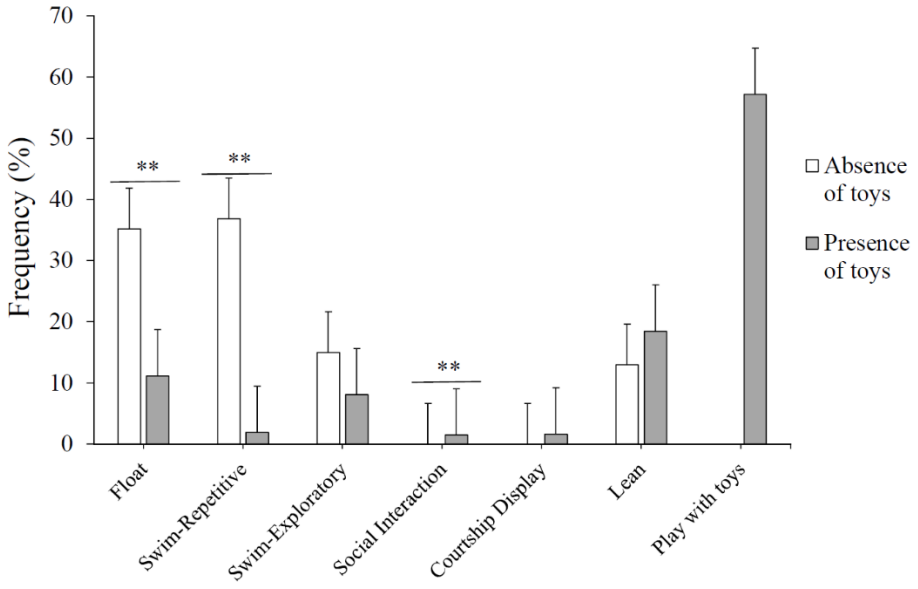


Figure 1 Mean frequency of beluga whale behaviors in the absence of toys (in white) and in the presence of toys (in grey) in a captive environment. Asterisks (**) indicate a significant difference at $p < 0.05$ while vertical bars show the standard error of mean (SEM).

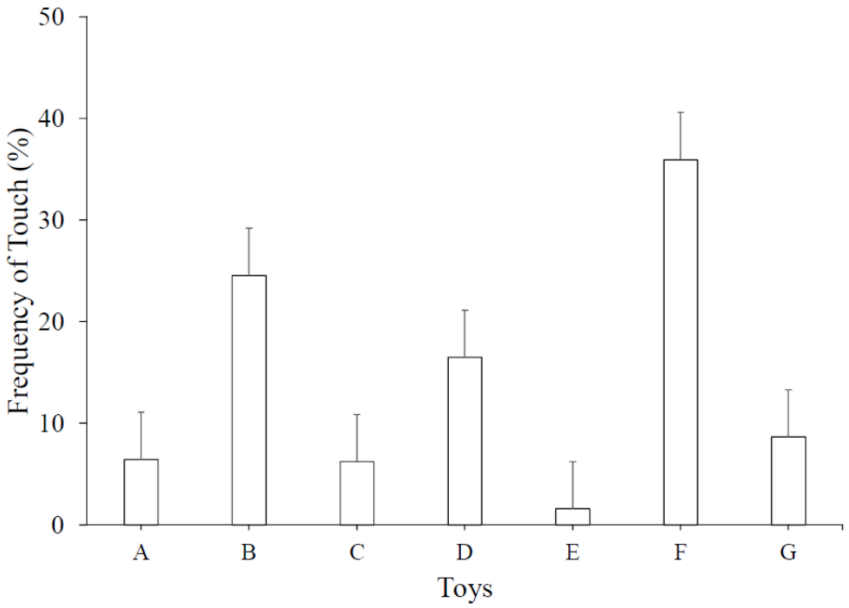


Figure 2 Mean frequency of touching various toys by captive belugas (%).

Toy F (an elongated toy consisting of white-blue buoys, small white buoys and a rope capable of floating) received the largest number of touches (35.96%), which included biting, tossing/catching, contacting with the head, carrying on the back, pulling and interactive play. Toy B (a small red ball and bundle of ropes) also received many touches (24.57%) as did toy D (a basketball) (16.51%). Toy B partially floated on the surface, whereas toy D fully floated. The methods used when playing with toy B included biting; pulling; contacting with pectoral fins, caudal fin or head; rubbing of epidermal skin; and interactive play. The methods used when playing with toy D included biting, pulling, contacting with the head and genital organ and tossing/catching.

Captive belugas spent much less time playing with the other devices: toy G (8.67 %), toy A (6.46%), and toy C (6.23%). Playing with toy G (elongated device consisting of two medium-sized balls connected by a rope with partial floatation) involved biting or pulling. Playing with toy A (small white buoy that would sink) involved biting, pulling, and contacting with pectoral fins. Playing with toy C (a mat with handles that would sink) involved biting and balancing on the head. Toy E (a larger floating version of toy D) received the least contact (1.60%), which included only biting.

The study demonstrated the effectiveness of environmental enrichment in enhancing the behavior of three captive beluga whales. The introduction of toys into the captive environment was shown to reduce the incidence of swimming repetitively and floating as well as increase social interactions to a small extent among the animals. Frequent contact with toys F, B and D indicate that beluga whales were more attracted to floating toys overall and, particularly, to those of greater complexity.

Many previous studies have reported that environmental enrichment can help captive marine mammals to express species-specific behavior and enhance overall welfare (Clark 2013, Clark *et al*. 2013, Delfour and Beyer 2011, Held and Špinka 2011, Hill *et al*. 2015a, Hocking *et al*. 2015, Jiang *et al*. 2007 and Kuczaj *et al*. 2002). Solitary swimming and floating/resting are behaviors commonly observed among captive beluga whales, even in enriched environments (Hill *et al*., 2015b). Nonetheless, the frequent occurrence of these behaviors is an indication of a poor captive environment that could undermine animal welfare (Hill *et al*., 2015b; Swaisgood and Sheperdson, 2005). Repetitive pattern swimming is a stereotypical behavior commonly observed in captive marine mammals (Hocking *et al*., 2015; Lott and Williamson, 2017). In this study, the captive belugas without toys spent most of their time floating and swimming repetitively. The introduction of toys greatly reduced the prevalence of this behavior in favor of interactions with the toys in the form of playing. Our observations support the findings in previous studies (Delfour and Beyer, 2011; Hocking *et al*., 2015).

Previous studies also reported that captive adult belugas tend to spend most of their time engaged in solitary activities (Burghardt, 2005; Fagen, 1981; Hill and Ramirez, 2014). In the absence of toys, we observed no social interactions between the whales. However, in the presence of toys, we observed some interactions in the form of swimming in pairs and playing together with toys, although the interactions were limited. This is an indication that the provision of toys could perhaps be used to promote interactions between captive beluga whales. In the natural environment, wild belugas form into groups to hunt and migrate (Balsiger, 2003; Leatherwood *et al*., 1988). The unexpectedly high frequency of gate leaning in the presence of toys was also a sign of increased social interaction. According to beluga breeders, leaning behavior can probably be attributed to a desire to engage in interactive play involving the passing of toys over the gate separating the pools. Leaning on the net gates allows the animals to observe other animals in the next pool. The primary cause of leaning could perhaps be elucidated in future research on underwater acoustics.

Our results indicate that the preference for specific toys can be characterized according to three main factors: the number play styles, the size of the toy and the potential for interactive play. The whales in this study preferred to manipulate toys that float, similar to the behavior of captive bottlenose dolphins in a previous study (Delfour *et al*., 2017). It is possible that the whales enjoyed pulling the floating toys under the water and watching them rise to the surface. Most of the activity, such as feeding and health routines, occurred near the surface, which may have brought them into more frequent contact with floating toys. It also appeared that toys of greater complexity stimulated the interest and curiosity of the whales. Toy F and toy B remained afloat and consisted of a number of components, which appeared to have attracted the attention of the animals. Complex toys allowed for a greater variety of play styles, including biting, tossing/catching, pulling, rubbing, carrying on the head and interactive play as well as contact with the head, pectoral fin or caudal fin. It was observed that only toy F and toy D could be tossed over the gate separating the pools. This may explain the frequency with which these toys were used to conduct interactive play between animals in separate pools. The preference for toy D (a basketball) over toy E (a ball twice the size of a basketball) may be explained by its size.

This study revealed that novel objects (toys) can be used to enrich the behavior of captive beluga whales, as indicated by the reduction in the amount of time spent floating and swimming repetitively. The introduction of toys was also shown to promote social interactions among these animals in a captive environment. The toy preferences identified in this study could be used as a baseline reference to guide the selection or creation of toys for captive beluga whales.

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