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Unpredictability, Controllability, and Optimal Arousal/ Stimulation Level as Applied to Zoo Environment Enrichment Theory and Practice

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Abstract

Success of zoo environmental enrichment, in spite of its widespread use and high significance for animals' welfare, depends mainly upon keepers' experience or the application of other zoos' examples of daily practice. That's why an algorithm based on some theoretical premises may be very useful for choosing the exact method of enrichment.

We define the term "zoo environmental enrichment" as any impact resulting in improvement of the animals' psychological state, so it may include not only increasing, but sometimes decreasing, stimulation.

Psychological welfare comes from the ability to display specific activities (with necessary releasers), and from the optimal level of nonspecific arousal (according to Yerkes-Dobson' law). Therefore, we may improve animal welfare by adequate manipulations of the arousal level through varying either the intensity of stimulus or the animals' sensitivity to stimulation. Such sensitivity dramatically increases when the stimulus is unpredictable and decreases if the animal can control the stimulation. The lack of animals' psychological welfare may be detected by such signs as a decrease in exploratory behavior and locomotion activity, a vacuum/lack of instinctive activity, aggressive and destructive activity, stereotypies, apathy, a change in fur condition, weight loss, etc.

Based on these observations, we suggest an algorithm to determine the level and quality of stimulation needed for the animals. Besides, we discuss the universal classification of environmental enrichment tools and recommendations on optimal choices depending on the situation.

In the concluding remarks, we illustrate the application of our principles, analyzing some examples of the successful impact of our tools on the psychological state of Moscow Zoo's mammals.

Key Words: Environmental Enrichment; Environmental Optimization; Unpredictability; Controllability; Optimal Arousal/Stimulation Level

Environment enrichment has been a major topic in mainstream zoo research during the last two decades but the situation is such that the theoretical background of this topic is complicated and unclear up until now. The main source of zoo enrichment practice is still the insight of curators and keepers or the experience of other zoos. So, some theory, which may be effective for the working out rules for the choice or elaboration of zoo enrichment tools, may be reasonable.

The psychological state of an individual depends on two general variables: the stimulation and sensitivity level for these stimuli. Therefore, we have two possibilities to affect our animals: to change the stimulation itself or manipulate an individual's sensitivity.

As to the level of stimulation, it's obvious that it may be too high, too low, or optimal; as well, it is a product of both specific and unspecific stimuli. We define the term "zoo environmental enrichment" as any impact resulting in an improvement of the animals' psychological state (Neprintseva, et al., 2006), it may include not only increasing, but sometimes decreasing, stimulation. So, the term "environmental optimization" seems more exact than "environmental enrichment".

According to the concepts of classic ethology, some external stimuli are releasers which are necessary for the performance of specific instinctive activities. We have to provide animals in captivity with these stimuli or their substitutes. The only problem is to identify the exact stimulus for every case. The absence of some instinctive behaviors or "vacuum activity" may indicate a lack of releasers. For example, a hollow entrance is a releaser for the nesting activity of parrots and some other birds. As another example, in the middle of the twentieth century some species of geese did not display courtship behavior or breed in Moscow Zoo until

piles of stones were placed in their enclosures.

More common, is the situation where we try to change the arousal level of our animals. Sometimes this level seems to be too low and our efforts will be directed to give the animals some additional stimulation. Most zoo environmental enrichment with its "increasing of novelty" is addressed to such situations.

In other cases, we think the animal is extremely excited and is trying to decrease its arousal level. Then we, for example, temporarily isolate this animal from the public. It is not enrichment in a traditional sense, but it contributes to the improvement of the animals' psychological state through the optimization of the arousal level.

There is an optimal arousal level for each activity for each animal according to Yerkes-Dobson law (1908). Hebb (1955) wrote that the stimulation level, which produces optimal arousal, is optimal too. Obviously any arousal or stimulation produces some stress. The stress from the optimal arousal/stimulation level may be defined as the "optimal level of stress".

If the actual stimulation is significantly lower than this optimum level, and it produces eustress for a long period of time, then it may lead to apathy, a lack of activity, or the seeking of additional stimulation through behaviors such as destructive behavior directed to the enclosure components, self-biting, or amotivational aggression directed towards keepers or conspecifics. Otherwise, if the arousal/stimulation is too high, then distress and frustration come with all their pathological features that include physiological (weight loss, bad coat, decreased reproductive function, gastric lesions) and behavioral (stereotypy, refusing to eat, depression) manifestations.

It is often difficult or even impossible to regulate effectively the level of specific stimulation in captivity, but there are some reasons to look for the possibility to regulate the level of an animal's arousal/stress through their sensitivity to external stimulation.

A lot of physiological research during the last half of the twentieth century has clearly showed that even a weak stressor has a worse effect if it is (a) unpredictable and/or (b) uncontrolled (Weiss, 1971; Davis and Levine, 1982; Herbert, 1987; Hennessy and Foy, 1987). Predictability means the probability of the individual's correct prevision of the future situation. Controllability has been defined by Weinberg and Levine (1980) in relation to studies using aversive stimuli, as "the ability to make active responses during an aversive stimulus" and in a more common case by Videan, et al. (2005) as "the ability of animals to alter aspects of their environment".

The idea to use the stress-protective effect of predictability and controllability for the improvement of animal welfare has been discussed recently (Videan, et al., 2005; Neprintseva, et al., 2006; and the last comprehensive review by Bassett and Buchanan-Smith, 2007).

For these purposes, we suggest combining the data on the effect of predictability and controllability on stress with the psychological concept of the optimal arousal/stress level. For this, we have provided a scheme for achieving the optimal arousal level (Neprintseva, et al., 2006). This model shows the interactions between the unpredictability of the environment and the available level of control and their impact on the arousal level.

If the level of unpredictability is high, the arousal increases and exceeds the optimal level. Arousal may be decreased by decreasing unpredictability or by increasing controllability. On the other hand, the arousal level drops below the optimum when the environment is highly predictable. In this case, we can optimize the arousal level if we increase the unpredictability of the environment. We would like to note that according to Yerks-Dobson and Hebb "arousal" in this scheme may be easy substituted by "stress."

It is a useful fact that manipulations with predictability and controllability can change the level of arousal through the animals' sensitivity to the same stimuli and, thus, provide us with the possibility to optimize the arousal level in situations when stimulation is obligatory. For example, cheetahs and tigers were found to choose different locations in their enclosures depending on the number of visitors (using control), and as a result were not distressed even when under hard pressure from the public (Popov and Zubchaninova,

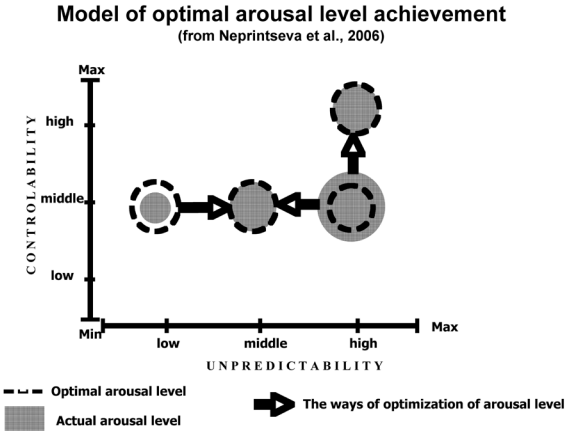

Figure 1. Model for the achievement of optimal arousal level.

Symptoms	Conclusions
Absence of some instinctive behaviors or vaccuum and redirected instinctive activity	The lack of special stimuli releasing instinctive behavior patterns
Timidity, hysterical behavior, stereotypes with high speed of performance, hypertrophied defensive behavior, decrease of exploratory acticity and grooming, decrease of sleep, activity circle fickleness,, bad coat, diarrhea, and weight loss	Arousal/Stress level is too high The lack of control combined with high environmental unpredictability
Decrease of total activity level and behavioral diversity, apathy (passive coping strategy) or looking for additional stimulation, hyperactivity, destructive activity, a lot of activities towards keepers, self-directed activity (active coping)strategy	Arousal/Stress level is too low The lack of control combined with too low environmental unpredictability

Table 1. Diagnostic table for assessment of state of animal with abnormal behavior.

1995). As a second example, according to Grandin, et al. (1995), animals are not as nervous during aversive blood sampling if they have been acquainted with the procedure and have had a previous signal (high predictability), on the other hand, the input of novelty, the main part of many enrichment techniques, decreases the predictability and so increases the arousal level.

So, when we are faced with the task of environmental enrichment we need to see what types of problems are presented by particular individuals: (1) lack of specific stimuli; (2) chronic arousal level below the optimum; or (3) chronic arousal level over the optimum, resulting in distress. Every state has its own distinctive symptom data (Table 1).

In the first case, such stimuli or their substitutes would be needed and a special investigation may be necessary. In other cases, the problems may be solved through manipulating the level of stimulation or the animals' sensitivity to stimulation. Then, the subdivision of enrichment tools according to their ability to deal with these problems may become the foundation for the classification of available tools and for the development of new ones.

The first class of enrichment tools relates to the stimuli necessary for releasing instinctive activities.

The second class is composed of different techniques for changing the current level of stimulation. A good example of this class is the restriction of the public's access to enclosures, or sound-suppressing barriers. It is important that, in this case, we manipulate only the level of current stimulation but do not change its qualitative attribute. This class may be subdivided according to different modals of stimulation: visual, acoustic, and so on.

The third cluster of enrichment tools combines different means of increasing the animals' control of the environment. It includes:

- Disposable objects for manipulation, material for developing individual space, and special toys, playing machines, and problem boxes;
- Enclosure design which allows the animals to choose the mode and level of stimulation;
- Human-animal interactions, both with the keepers and visitors; and
- Social enrichment.

The last big cluster involves the enrichment tools which will change the predictability of environment:

- To increase it through a stable husbandry regime or warning signals before routine procedures; or
- To decrease the predictability through providing the animals with new objects;

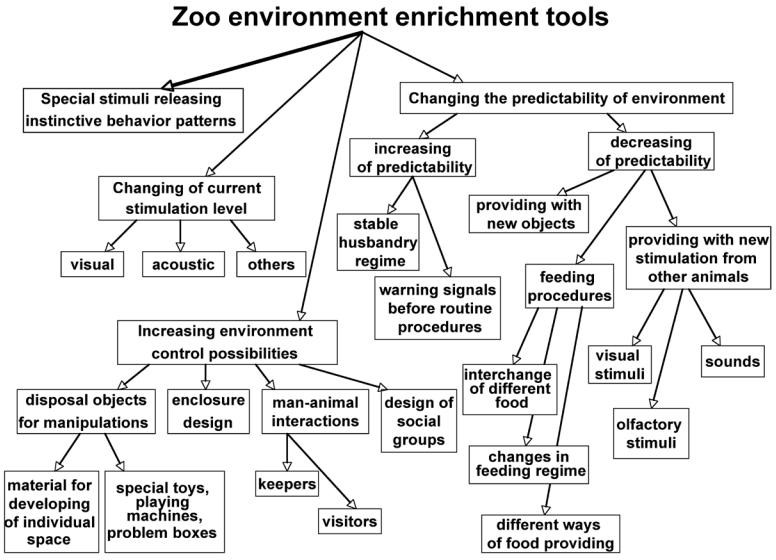

Figure 2. Zoo environmental enrichment tools.

- Feeding procedures: alternating different foods, changing the feeding regime, or implementing different methods of providing food;
- Providing stimulation from other animals, such as visual, acoustic and olfactory stimuli.

Our experiences with the optimization of the behavior of two sloth bears may serve as an example of the application of such an approach. These animals arrived at Moscow Zoo in 2003, and were at first kept separately in small enclosures without any enrichment during their quarantine period. Some unfavorable symptoms were observed after a short time.

The male became hyperactive and jumped in place when he saw keepers nearby and began self-directed biting after the keepers would leave.

The female's symptoms were the opposite. She lost weight, had a bad coat, and refused to eat. Her behavior was very poor and she displayed stereotyped pacing, which was transformed into going around when she met with unpredictable stimuli, such as a loud noise or the appearance of a keeper.

According to the algorithm which was described above, the male was diagnosed as an individual with an arousal and stimulation level that was too low, and the female was diagnosed with an arousal and stress level that was too high. We increased the unpredictability of the male's environment by giving him a lot of new objects. For the female we tried to increase her sense of controllability: she received objects for manipulation (including destruction) and experienced special "responsive" techniques of keeper-animal interactions. After that manipulation, the male sloth bear stopped self-directed biting and became more independent from the presence of people, and the female reduced the time she spent engaging in stereotypic behaviors, she began to eat normally, and her behaviors became more diverse.

Some other examples of successful behavior optimization, based on the scheme under consideration, were collected at Moscow Zoo during the last years (Neprintseva, et al., 1999 and 2000; Neprintseva, 2004 and 2005). So we conclude that the idea of the optimization of arousal level may be regarded as a useful foundation for improving the welfare of animals in captivity.

The environment in the wild is much more unpredictable but, at the same time, it presents animals with more possibilities of control when compared with the situations present in zoos. One can expect that a predictable environment will promote a passive-coping strategy and a high degree of control should make active-coping more adaptive. As a result, involuntary selection in zoos may work against natural selection. This takes on special significance for the development of conservation programs with reintroduction as a goal. Special training in highly unpredictable conditions for the animals prepared for reintroduction may solve this problem.

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