

Refinement in the literature: Searching for environmental enrichment

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Abstract

The term *environmental enrichment* became more common among animal caretakers in zoo and research settings after the passage of the 1985 amendments to the United States Animal Welfare Act which introduced the concept of psychological well-being of nonhuman primates and required exercise for dogs. The standards promulgated by the US Department of Agriculture in response to the new mandates placed an emphasis on individual facilities developing targeted exercise and enrichment programs based on an understanding of species-specific needs. Interestingly, although originally focused on nonhuman primates, the concept of environmental enhancement (or enrichment) spilled over into the housing of other species as well. This review will examine early research into environmentally enriched housing and how that same concept is applied in various management settings today. In addition to these new requirements, the 1985 amendments specified that pain and distress must be minimized in scientific research and that principal investigators much consider alternatives to procedures that may cause more than momentary or slight pain or distress. One method of examining potential alternatives is a comprehensive literature search for alternatives, defined as the 3Rs (reduction, refinement, or replacement). Often, the refinement portion of a literature search is either neglected or forgotten. This paper will also discuss methods of searching the literature to locate information on housing refinements, particularly the provision of environmental enrichment.

Keywords: environmental enrichment, literature search, databases, database comparison, refinement alternatives

Introduction

Studying the literature can provide a wealth of new data and speculation for those involved in animal care and use. This paper provides an overview of the literature on a specific animal care topic: environmental enrichment. Although experts still debate what "environmental enrichment" means, and many choose to use other terms to describe the same concept (including enriched housing, behavioral enrichment, and environmental enhancement), the idea of providing an animal with more complexity in their living situation with a goal of maintaining or improving physical and/or psychological well-being remains constant. In the United States, the concept of environmental enrichment (EE) became part of the care and management of captive animals after passage of the 1985 amendments to the Federal Animal Welfare Act (Kulpa-Eddy et al., 2005). Although originally directed towards only nonhuman primates in the law and regulations, the use of EE as a husbandry tool in animal care has now expanded to nearly every animal species maintained in captivity, including animals in zoos, aquariums, and research settings.

In 1925, R. Yerkes wrote that "the greatest possibility in our provision for captive primates lies with the invention and installation of apparatus which can be used for work or play." This idea of providing animals with additional structures in their environment was expanded upon by psychology researchers in the 1940s and 1950s who were interested in the effects of early experience on problem-solving and behavior at maturity. In 1947, D. Hebb brought laboratory rats home to be raised as pets by his children. He also maintained a colony of rats in standard, "non-stimulating" boxes in his laboratory. When the pet rats and lab rats were tested in the same problem solving task (a variable-pattern T maze), the pet rats performed much better. Hebb concluded that "the richer experience of the pet group during development made them better able to profit by new experiences at maturity" (Hebb, 1949).

Researchers of the late 1950s and early 1960s expanded Hebb's work by studying rats in "free-environmental" boxes or experiences (Forgays and Forgays, 1952; Hymovitch, 1952). These psychologists found that the provision of a "wider and richer environment" (Bingham and Griffiths, 1952) or

a "complex visual-proprioceptive experience" (Forgus, 1954) resulted in intellectually superior animals when tested in standard learning paradigms. Based on his research, Forgas (1954) concluded that "early experience and learning is an important determinant of the emotionality and cognitive ability of adult rats." Some researchers began referring to these complex environments as "enriched" environments as compared to "restricted" or "unstimulating" ones (Cooper and Zubek, 1958). This simple comparison provided a straightforward description of an enriched environment – one that included a larger space, frequently changed playthings and sometimes social partners. Studies of dogs also concluded that exposure to complex environments early in life resulted in animals with superior problem solving skills when compared to animals raised in "cages with no view of the surroundings and little contact with humans" (Clarke et al., 1951).

"Environmental enrichment procedures" in the laboratory not only led to behavioral changes and superior animals in discrimination and learning tasks, but also physically changed the animals, resulting in increased brain weight and changes in the central nervous system that affect cholinergic mechanisms (Tapp and Markowitz, 1963). Krech, Rosenzweig and Bennett (1960) found that provision of environmental complexity and training (ECT), including social groups, mazes, and wooden "toys," resulted in some regions of the cerebral cortex being heavier as compared to rats raised in restricted environments. Other scientists found that rats raised in enriched conditions had more dendritic branching of neurons in the visual cortex than those raised in impoverished conditions and that rats raised in pairs (social groups) were in between (Cummins et al., 1977; Rosenzweig et al., 1978). These studies of the effects of enrichment on the brain were not only early steps toward improved animal care, but they demonstrated that contrary to commonly held opinions of the time, the brain was affected not only by genetics, but also by environmental factors.

For zoo animals, H. Hediger (1964) expanded the EE concept by writing that the provision of quality space was more important than the quantity of space. Hediger believed that stereotyped behaviors, such as pacing, developed due to frustrations arising from the need to engage in particular activities unique to each species. Hediger stated that "the well-being of the captive animal doubtless depends on the possibility of satisfying those occasional activity needs that are essential to the species." During the 1960s, zoos began a more thorough consideration of the natural history of a species when developing new exhibits (Mellen and MacPhee, 2001). Traditional cages were replaced by sweeping landscapes with the animal habitats separated from zoo visitors by

cleverly camouflaged moats. Zoo designers studied the behavior of animals in their natural habitats and sought to re-create similar situations in exhibits. In the 1970s and 1980s, Hal Markowitz revolutionized zoo enrichment programs by emphasizing the role of choice in an animal's environment and used terms such as "behavioral engineering" or "behavioral enrichment" (Markowitz, 1982). Although many of his ideas and designs were later dismissed as being too unnatural for zoo settings, his concept of providing increased behavioral opportunities for captive animals remains an important goal of EE programs established in zoos and aquariums today.

Prompted in part by the media coverage of two animal care stories and subsequent public outcry (Kulpa-Eddy et al., 2005), the US Congress began holding hearings in 1981 and officially amended the Animal Welfare Act in 1985. These amendments directed the Secretary of Agriculture to establish regulations to provide for "exercise for dogs" and an "adequate physical environment to promote the psychological well-being of primates." The Secretary of Agriculture interpreted the meaning of psychological well-being as providing "environmental enhancement" and this was included in the final regulations (9CFR, Sec. 3.81). Once the new amendment was passed and regulations went into effect, general papers about enrichment provided to captive animals, including the type, ease of delivery, method of disinfection, and effect on the behavior or health of the animals to which it was provided, began to appear more frequently (de Azevedo, Cipreste, and Young, 2007). In addition, at least two books devoted to the subject (Shepherdson et al., 1998; Young, 2003) were published and a publication devoted entirely to enrichment called *The Shape of Enrichment* (<http://www.enrichment.org/>) mailed its first issue in 1992.

As EE became part of an institution's animal care program, the scientific community began asking for a more concise definition in order to measure the effects. Newberry (1995) states "We need clearly defined and biologically meaningful goals for enrichment research if progress is to be made in improving captive animal environments." A few approaches toward defining EE have been taken as demonstrated by the following examples.

- **Changing the animal's environment** in such a way that the animal voluntarily becomes more active than it was, and there is a measure of a reduction or elimination of abnormal behavior. (Spinelli in Rollin and Kessel, 1990)
- **An animal husbandry practice** that seeks to enhance the quality of captive animal care by identifying and providing the environmental stimuli necessary for optimal psychological and physiological well-being. (Shepherdson,

1998)

- **The provision of stimuli** that promote the expression of species-appropriate behavioral and mental activities in an understimulating environment. (Reinhardt and Reinhardt, 2002)
- **Environmental enrichment**, also called **behavioral enrichment**, refers to the practice of providing animals under managed care with environmental stimuli. The goal of environmental enrichment is to improve an animal's quality of life by increasing physical activity, stimulating natural behaviors, and preventing or reducing stereotypical behaviors. (Wikipedia, 2007)

Since it is difficult to determine an exact definition of EE, it is also common for authors and indexers to use a variety of terms to describe EE. Terms found in the literature are extensive and include: environmental enrichment, environmental enhancement, behavioral (behavioural) enrichment, enriched housing, enriched environment, complex environment, behavioral (behavioural) engineering, and structural enrichment. There are also terms for specific types of enrichment such as manipulanda, foraging enrichment, social grouping, and toys. With such a variety of terms, it is difficult to know how best to go about conducting a search of the literature for information on EE. Which terms will bring up the most relevant results and which databases index this type of information so that it is easily retrieved? A preliminary examination of EE information in five bibliographic databases provided some answers during this study.

Materials and methods

Although there are a number of appropriate bibliographic databases in which to search for literature on EE, the five databases selected for this study are commonly available to researchers in United States institutions, including scientists at the US Department of Agriculture. The databases and dates covered are as follows: Agricola (1970-present), Biosis Previews (1969-present), CAB Abstracts (1910-present), Zoological Record (1978-present), and Medline (1950-present). While these databases overlap in coverage to some extent, they index different subject matter and publication types. Agricola, the USDA National Agricultural Library's catalog, covers materials in all formats (including books, conference proceedings, journals, and audiovisual material) and encompasses all aspects of agriculture and allied disciplines, including animal and veterinary sciences, entomology, plant sciences, forestry, aquaculture and fisheries, farming and farming systems, agricultural economics, extension and education, food and human nutrition, and earth and environmental sciences. Biosis Previews is

provided by Thomson and indexes life science information from journals, meeting and conference reports, books and patents. CAB Abstracts, a product of CABI, is a leading abstracts database for agriculture, plant sciences, animal and veterinary sciences, microbiology and parasitology, and human health. It indexes materials from journals, books, and conference proceedings. Zoological Record is another Thomson product and covers information from every field in animal biology, including biodiversity, habitat, taxonomy, and veterinary science, from a variety of publication types. Finally, Medline is a product of the National Library of Medicine. It indexes journals only and covers biomedical science and research.

Based on the papers identified during a pilot study, four terms were selected to search for literature on EE. The four terms searched were: environmental enrichment, environmental enhancement, enriched housing, and enriched environment. These terms were searched in all record fields, including the title, abstract, and keyword fields. All terms were searched in the same way across all databases. No publication year limits were imposed. Since terms were searched in all record fields, there is a possibility that some non-related citations are included (for example, papers on CO₂-enriched environments).

During the second part of the study, which aimed to identify the most appropriate database or databases in which to search, only the term "environmental enrichment" was searched in the title field. This provided a smaller subset of data with which to work. The same 5 databases identified above were searched again. The data from each database was downloaded into a bibliographic software program (Procite v5) and citations were sorted, identified by database, and then duplicates were removed, both from within and between databases. Each duplicate record was counted fully as belonging to each database in which it was indexed. If a particular record was found in a given database, that database was assigned a 1 (yes). Conversely, if a particular record was not found in a given database, that database was assigned a 0 (no).

Results

What terms do I use to find citations about environmental enrichment?

Fig. 1 shows the total number of citations containing each of the 4 terms in each database. Since these are total numbers, readers are reminded that a citation containing the term "environmental enrichment" may also have included the terms "enriched environment" or "enriched housing" or "environmental enhancement." The data provided are totals.

Biosis Previews contained the highest number of citations (1865) containing at least one of the four terms in either the title, abstract or descriptor field.

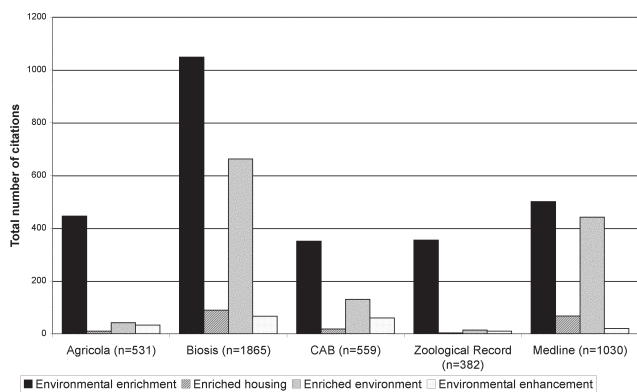


Fig. 1. The total number of citations by database containing each of the four EE terms. This figure provides total numbers. There may be more than one term in each citation.

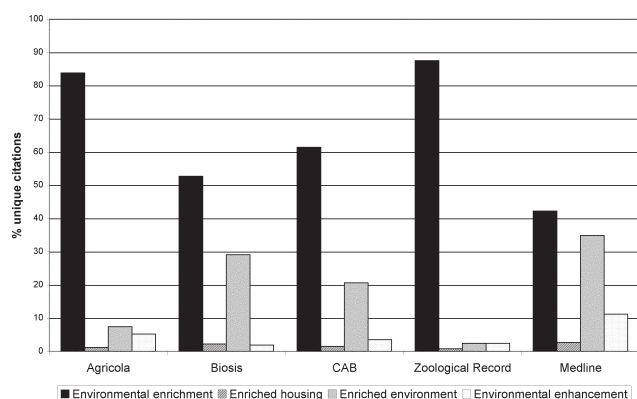


Fig. 2. The percentage of unique citations containing each term by database. For example, in the Agricola database 84% of the identified records contained only the term "environmental enrichment."

The majority of citations for all databases contained the term "environmental enrichment." Medline and Biosis Previews also indexed a high number of citations with the term "enriched environment."

Fig. 2 demonstrates as a percentage, the number of citations in each database that only contained one of the four phrases searched. For example, in Biosis Previews, 53% of the citations contained the phrase "environmental enrichment" but not "enriched housing" or "enriched environment" or "environmental enhancement." Similar to the previous Figure, the highest percentage of citations contained the term "environmental enrichment" in all five databases. However, in Medline, the term "enriched environment" was found in 35% of the records while "environmental enrichment" was found in 42% of the records.

In which databases should I search for "environmental enrichment"?

A total of 799 individual citations were found across the five databases containing the term "environmental enrichment" in the title field. Table 1 shows the number of unique records by database and identifies the amount of overlap between 2 databases.

The chart does not take into account 3 and 4 way duplicates, when a record was found in more than 2 databases. Biosis Previews contained the highest number of unique records (187) with "environmental enrichment" in the title. Medline contained the fewest number of unique records (31).

Table 2 indicates the percentage of coverage by database. These numbers were calculated by counting the total number of citations found in each database, including those that overlapped with other databases, dividing that number by 799 (the total number of citations found across all databases), and then multiplying by 100. Biosis Previews indexed 82% of the total number of citations containing "environmental enrichment" in the title field. Zoological Record (28%) and Agricola (35%) indexed the fewest citations.

Discussion

Based on the data obtained from each database when searching for the four specific EE terms, "environmental enrichment" should not be the only term included in search. In most of the databases in this study, "environmental enrichment" is not part of the thesaurus or controlled vocabulary. Agricola is an exception and provides a definition as well as a list of synonymous terms for environmental enrichment in its thesaurus (see <http://agclass.nal.usda.gov/agt/agt.shtml>). Along these same lines, EE is considered a refinement alternative in animal care and housing procedures. However, data indicate that terms for refinement, the 3 Rs, or alternatives are rarely linked to EE concepts by either authors or indexers. When the 4 EE concept terms were combined with "animal testing (use) refinement" or "animal testing (use) alternative" using the Boolean operator AND, there were only 20 records retrieved from Agricola and 3 from CAB Abstracts. There were no records with both of these terms in Biosis, Zoological Record, or Medline.

While each of the 4 selected terms brought up unique records, "environmental enrichment" and "enriched environment" were the most common. A search for EE should at the very least include both of these terms. The use of proximity operators should be considered and encouraged when available. Proximity operators allow a user to locate one word within a certain distance (proximity) of another. For example, using the proximity commands WITH (W) or NEAR (n) in Dialog, a user can specify that they would like to locate the words environment (or environmental) within a specified number of words of enriched (or enrichment).

The importance of searching multiple databases is also highlighted by this study. Each database contains a high percentage of unique citations for EE. At this time, there does not appear to be one all-

Table 1. Number of records (citations) containing the term "environmental enrichment" in the title field only by database (n=799). The total number of citations unique to each database are italicized across the bottom diagonal. The number of overlapping citations between 2 databases is also indicated.

	Agricola	Biosis	CAB	Zoological Record	Medline
Agricola	<i>69</i>	83	79	30	35
Biosis		<i>187</i>	102	51	228
CAB			<i>51</i>	28	43
Zoological Record				<i>99</i>	16
Medline					<i>31</i>

Table 2. This table indicates the number of citations found in each database expressed as a percentage of the total number of records from all databases containing the term "environmental enrichment" in the title field. For all databases combined, the total number of records was 799.

Zoological Record	28%
Agricola	35%
CAB	36%
Medline	44%
Biosis	82%

encompassing database. Researchers must continue to search across multiple databases to access the broad amount of relevant literature. Additional information on environmental enrichment can be found in online web sites, databases, and discussion groups. The following list provides some examples (all sites accessed online, December 28, 2007).

- *Animal Welfare Information Center (AWIC) Web site*, <http://awic.nal.usda.gov>
- *Refinement and Environmental Enrichment for all Animals Kept in Laboratories*, <http://www.awionline.org/SearchResultsSite/laball.aspx>
- *Enrichment Online*, <http://www.enrichmentonline.org/browse/index.asp>
- *PrimateLit*, <http://primatelit.library.wisc.edu/>
- *Primate Enrichment Forum (PEF)*, <http://pin.primate.wisc.edu/infoserv/forums/pef/>
- *Laboratory Animal Refinement and Enrichment Forum (LAREF)*, http://www.awionline.org/lab_animals/LAREF.htm#forum

Searching the literature using multiple terms and across multiple databases provides a thorough way in which to identify potentially useful information for animal care or research, including information about

environmental enrichment. Authors of papers about environmental enrichment should consider carefully the terms that they use in the paper and identify alternate, synonymous keywords when submitting the article to a journal or indexing database. Indexers may also want to use terms for refinement alternatives to identify papers on environmental enrichment. Information seekers would then be able to locate useful papers on the same topic more easily.

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