Environmental Enrichment for Captive Animals: The Past, Present, and Future

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Environmental Enrichment for the Maintenance of Psychological Well-being: What are We Doing, and Does It Work?

- A meta-analysis of decades of enrichment research.
- Co-authors: Eduardo Fernandez and Nathan Andrews

Where We've Been: A Meta-Analysis

- All studies with direct measure of behavior change from baseline.
- Included all captive environments, any species.
- Searched Web of Science, PsycINFO, BIOSIS, Google Scholar.
- RESULT: 150 articles, reporting 263 studies.

Defining Enrichment Types

TYPE	DEFINITION
Auditory:	Auditory stimulation (e.g., nature sounds, music, etc.)
Enclosure*:	Manipulating enclosure size, shape, immovable barriers, substrate, or transfer to another enclosure.
Foraging*:	Manipulating feeding schedule, food type, or food delivery method.
Neighbor:	Altering behavior by the presence of an adjacent heterospecific animal.
Olfactory:	Olfactory stimulation (e.g., prey scent, conspecific scent, heterospecific scent, etc.).
Social:	Providing physical social contact or adding conspecifics to the enclosure.
Toy:	Providing toys (without food).
Training:	Reinforcement training.
Visual:	Providing visual stimulation (e.g. movies).

Defining Psychological Well-being

BEHAVIOR	DEFINITION
Stereotypy (-)	Any repetitive behavior pattern.
Explore/Forage (+)	Non-stereotypic movement directed at target (i.e., towards food).
Inactivity (-)	Not moving, typically either sitting or lying down.
Enclosure Use (+)	Some measure of enclosure use variability.
Social/Affiliative (+)	Interaction identified as positive.
Agonistic (-)	Interaction identified as negative.
Abnormal (-)	Researcher-identified, non-stereotypic activity, for example, coprophagia or regurgitation and re-ingestion.
Other (change)	A behavior that does not fit into one of the above categories; for example, behavioral transitions or auto-grooming.

Results: Locations of Studies

SETTING	#STUDIES	STUDY%	#PAPERS	PAPER%
Zoo	132	50.2	63	42.0
Lab	72	27.4	47	31.3
Farm	32	12.2	19	12.7
Stable	8	3.0	6	4.0
Shelter	6	2.3	4	2.7
Circus	5	1.9	4	2.7
Sanctuary	5	1.9	4	2.7
Aquarium	3	1.1	3	2.0
TOTAL	263		150	

Results: Types of Enrichment

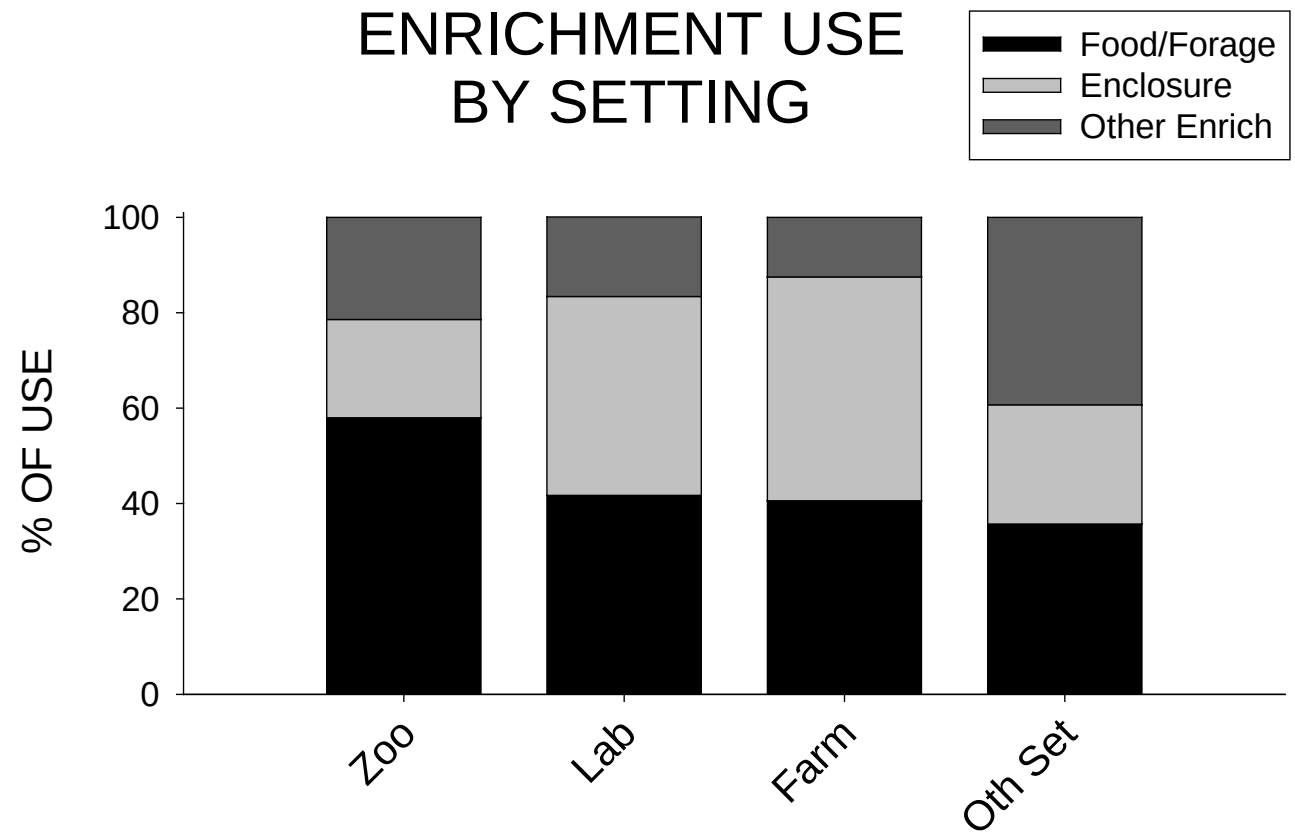
ENRICHMENT	#STUDIES	STUDY%	#PAPERS	PAPER %
Food/Forage*	129	49.0	92	61.3
Enclosure*	79	30.0	70	46.7
Olfactory	20	7.6	11	7.3
Toy	10	3.8	7	4.7
Social	6	2.3	6	4.0
Training	6	2.3	5	3.3
Visual	6	2.3	5	3.3
Auditory	4	1.5	3	2.0
Neighbor	3	1.1	3	2.0

Results: Behaviors Addressed

BEHAVIOR	#STUDIES	STUDY%	#PAPERS	PAPER%
Explore/Forage	207	78.7	119	79.3
Stereotypy	139	52.9	74	49.3
Inactive	137	52.1	88	58.7
Social/Affiliative	82	31.2	54	36.0
Aggression	61	23.2	43	28.7
Abnormal	40	15.2	26	17.3
Enclosure Use	37	14.1	23	15.3
Other Behavior	47	17.9	31	20.7

A Few Conclusions

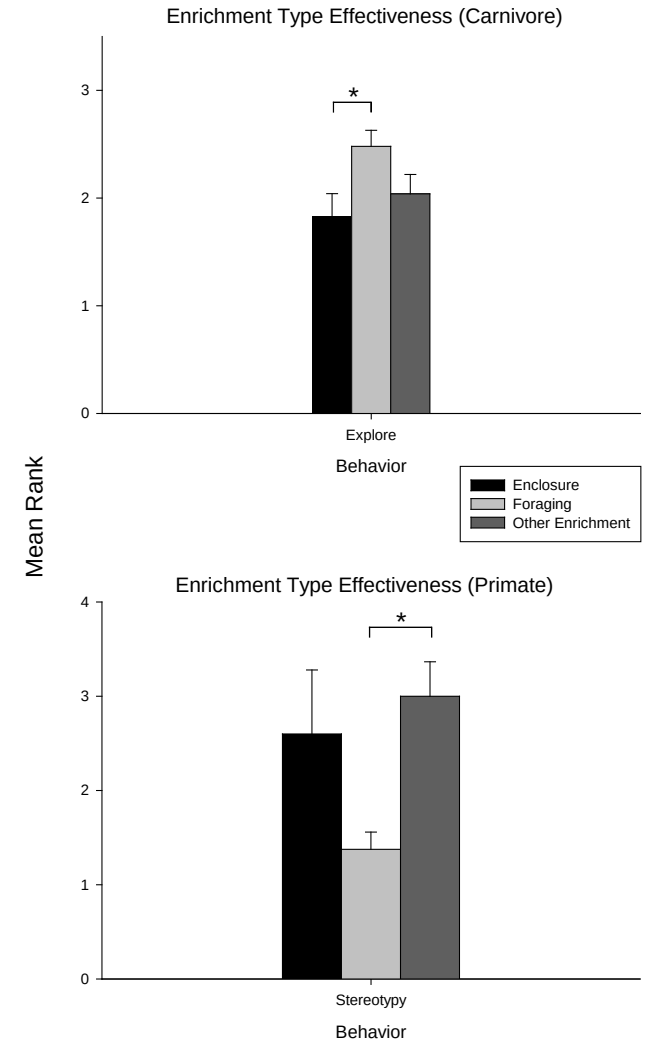
- Almost 80% of all studies involved Foraging or Enclosure enrichment, with nearly half of these studies using Foraging enrichment.



A Few Conclusions

- Foraging enrichment worked best for Carnivores
- Enclosure manipulations worked best for Stereotypy in Ungulates
- “Other” types of enrichment worked best for Primates

“Other” includes Auditory, Neighbor, Olfactory, Social, Toy, Training, Visual.



A Few Conclusions

- Unexpected result: while specific enrichment types worked best for specific taxa, the facilities housing these taxa often used different strategies.
- Out of all three groups:
  - Carnivores received the lowest percentage of Foraging enrichment,
  - Ungulates received the highest percentage of Foraging enrichment and the lowest average percentage of Enclosure enrichment, and
  - Primates received the second most amount of “Other” enrichment.

A Few Conclusions

- Overall, enrichment was surprisingly ineffective at modifying the behavior of captive animals, with generally only modest changes at best.
  - Often statistically significant, but of limited real effect.
  - We need to do better: how?

An increasingly popular hypothesis: individual differences

- Animals have individual, genetically-determined, experience-shaped temperaments (or personalities).
- Therefore, individuals should respond differently to enrichment.
- Enrichment should be tailored to temperament types to be most effective.

Definitions

- *Temperament*: stable, biologically based individual patterns of behavior
- *Personality*: traits that may vary with age and environmental factors
  - In humans, personality develops from an innate temperament
- *Behavioral syndrome*: a suite of correlated behaviors across different contexts, such as aggressiveness in foraging and mate seeking

Measuring personality in animals

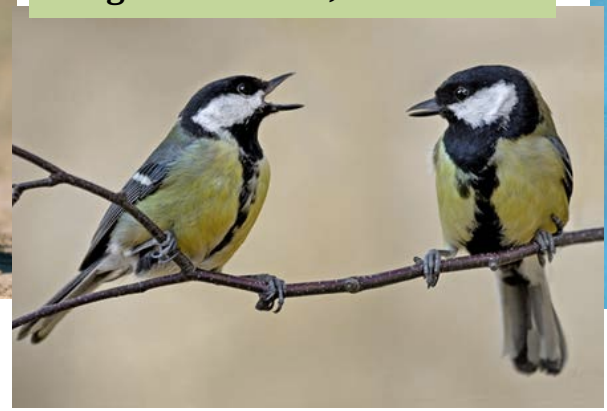
Dominance
Extraversion
Neuroticism
Agreeableness
Weiss et al., 2012

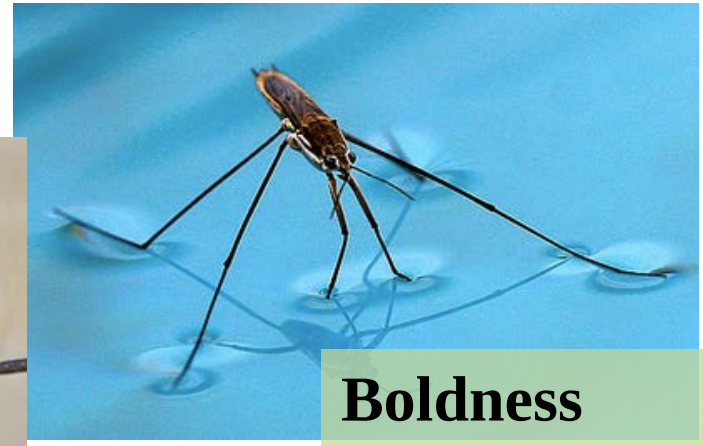
Boldness
Aggressiveness
Activity
Dingemanse et al., 2007

Boldness
Activity
Reactivity
Sinn & Moltschaniwskyj, 2005

Excitability
Sociability
Curiosity
Assertiveness
Gosling, 1998

Boldness
Exploration
Dingemanse et al., 2002





Boldness
Aggressiveness
Sih & Watters, 2005

Individual variability and stability

- Measurable individual differences in behavior, from squid to chimpanzees
- Genetic and hormonal mechanisms
  - –Highly heritable, .30 to .50+
  - –Associated with levels of nor-epinephrine, 5-hydroxy-indoleactic acid, and monoamine oxidase
- Recent directions: possible evolutionary and ecological explanations for their persistence

Quantification of temperament

- In humans: Five Factor Model
  - –Conscientiousness
  - –Openness
  - –Neuroticism
  - –Agreeableness
  - –Extraversion
  - –In animals, possibly a sixth trait: Dominance

Sussman, Ha, et al. (2013) *American Journal of Primatology*

In laboratory macaque monkeys:

Confidence

Front of cage
Back of cage (negative)
Reach to observer

Cautiousness

Ignore
Quiet face
Lipsmack to observer (negative)
Approach observer

Aggressiveness

Open mouth
Lunge
Cage shake

Fearfulness

Shriek
Grimace

In companion cats:

6 significant temperament dimensions:

- Curiosity
- Attentive
- Excitability
- Cat Sociability
- Human Sociability
- Human Aggressive

Jones & Gosling (2005)

In domestic dogs:

- Revealed 7 traits:
  - –Reactivity
  - –Fearfulness
  - –Activity
  - –Sociability
  - –Responsiveness to Training
  - –Submissiveness
  - –Aggression

Evidence for the “individual differences” hypothesis

- Neophobia and enrichment in mice
  - Walker and Mason 2012
- Extraversion and feather plucking in parrots
  - Cussen and Mench 2015
- Personality and environment in domestic pigs
  - Bolhuis, Schouten, Schrama, and Wiegant 2006
- Neophobia, cynomolgus macaques
  - Ha and Nelson, in prep

Evidence: “individual differences” hypothesis

- Neophobia and enrichment in mice
  - Walker and Mason 2012
- Assessment degree of neophobia (fear of novel objects or situations)
  - female mice *(Mus musculus)*
  - placing novel objects into their home cages
  - calculating how long it took them to make contact with the object
- Enrichment: free access to an enriched cage environment
  - running wheel, objects to chew on, nesting materials, complex surfaces for the mice to climb on and around, and a variety of manipulable toys
- Measurement:
  - amount of food consumed in the enriched cage compared to their standard laboratory cages, and
  - quantity of two "consumable" forms of enrichment (a cardboard planter pot, which the mice shredded, and a length of string that they could pull into the cage to chew or use for nesting materials)
- Found: mice with higher levels of neophobia ate (1) less food in the enriched cage and (2) less of the available enrichment.
- Supports hypothesis that **enrichment items may actually be frightening for individuals that are more fearful**

Evidence: “individual differences” hypothesis

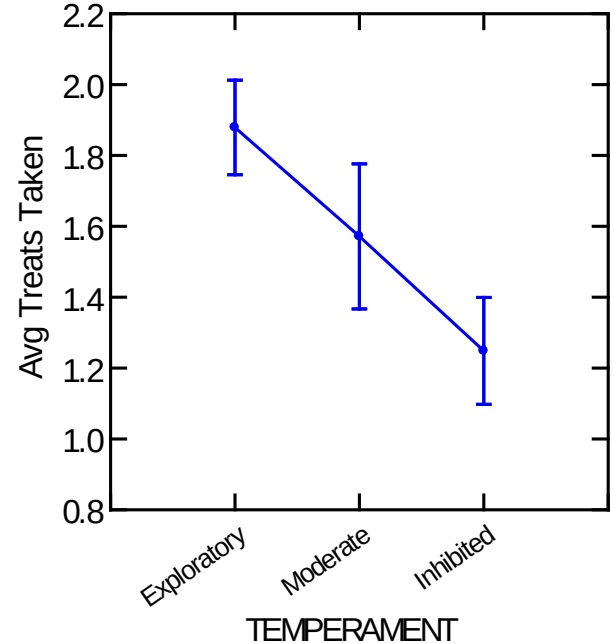
- Extraversion and feather plucking in parrots
  - Cussen and Mench 2015
- Measured feather plucking and locomotor stereotypies following 20 weeks of barren housing in orange-winged Amazon parrots
- Previously been rated on what the authors labeled "extraversion" and "neuroticism” (two independent dimensions).
- Birds rated **more "neurotic"** had **poorer feather condition**
- Birds **higher on extraversion** showed **smaller increase in stereotypy** after the barren environment and after re-enrichment
- **“Effective” enrichment varied with personality traits.**

Evidence: “individual differences” hypothesis

- Personality and environment in domestic pigs
  - Bolhuis, Schouten, Schrama, and Wiegant 2006
- Personality assessed using "Backtest“
  - 10 days old, piglet held on their backs for sixty seconds
  - Counted number of times they struggled
  - Repeated at 17 days old
  - Categorized as **high resisting (HR)** or **low resisting (LR)**
- Studied responses of both groups to different housing environments: barren floors versus straw bedding
- **HR pigs** tended to be **more aggressive** than LR pigs, and the **LR pigs** tended to be **more sensitive to the environment** and its changes
  - LR pigs reared in barren environments spent more time chewing on their penmates
  - LR pigs also played more on straw bedding than on barren floors

Evidence: “individual differences” hypothesis

- Neophobia, cynomolgus macaques
  - Ha and Nelson, in prep
- Neophobia temperament assessed, Coleman, et al. 2005
  - Latency to approach, touch, manipulate novel objects
- Three categories: **Exploratory, Moderate, and Inhibited**
- Each group received:
  - Control, Low-Enrichment, and High-Enrichment environments
  - Human-interaction, Non-food, and Food-search
- No effect of level of enrichment
- Dramatic effect of temperament
  - Only Human-interaction treats
  - Not turfboard foraging, or non-food enrichment
- **Human-interaction EE may be stressful to to many animals.**



Conclusions

- Better psychological well-being for captive animals would benefit from:
  - Use of more diverse forms of EE
  - Use of more species-significant forms of EE
  - Consideration of individual differences in response to EE
    - Routine quantification of temperament
    - Adapting EE to temperament types

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