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Cultivating Complexity:

A Meta-Analysis of Structural Enrichment for Macaques

Jenny Berrio, MD, PhD

Funded by CALAR





Genetic proximity
Similar physiology
Practicality



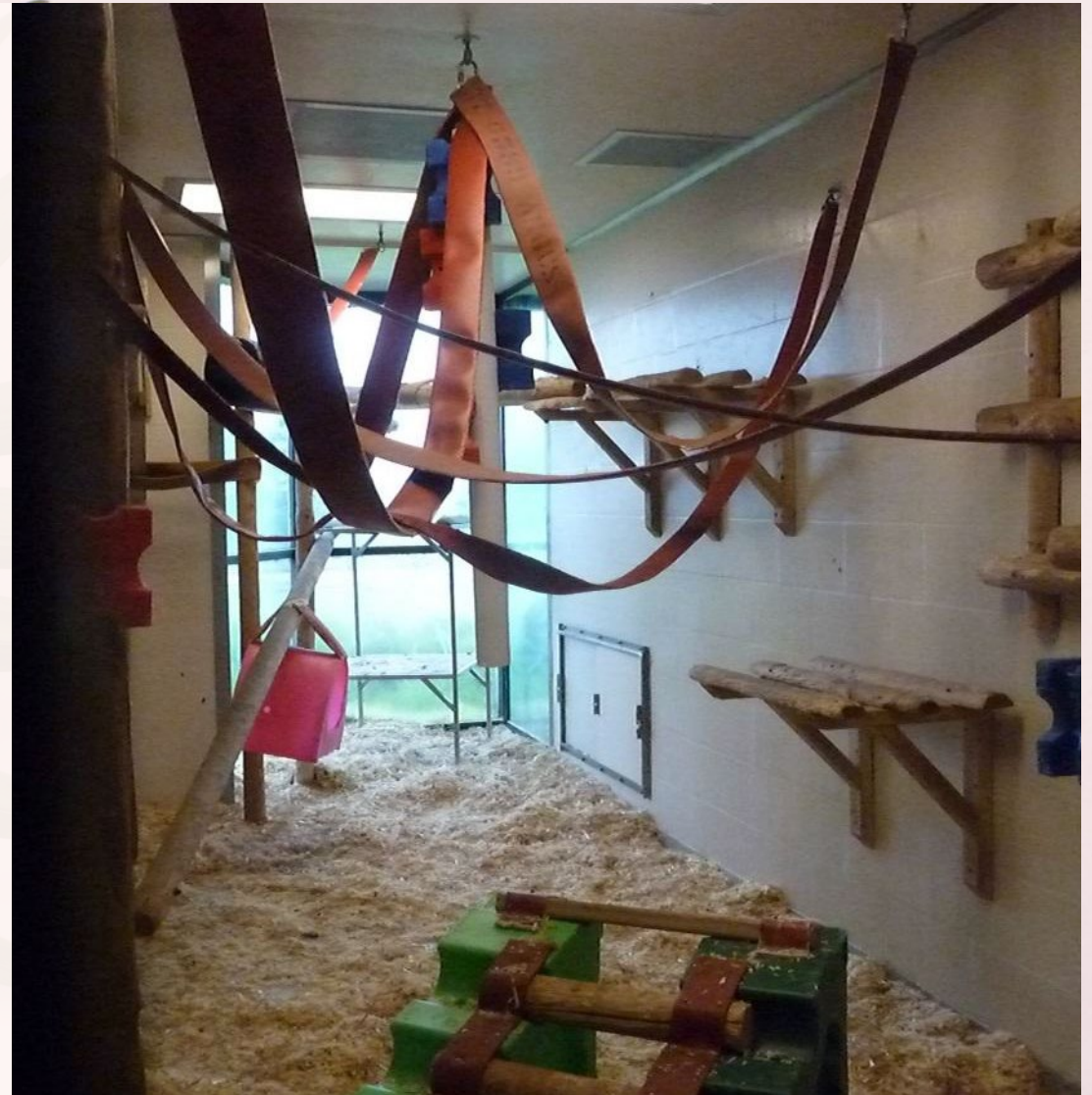
Genetic proximity
Similar physiology
Practicality

Social species with a complex filial and hierarchical structure



Structural enrichment

Any **structural item and/or space added** to the home cage that increases its complexity and/or its usable space.



OBJECTIVE



Despite regulatory pressure, the actual effectiveness of these interventions in improving the welfare of captive macaques has **not** been **systematically** assessed



Conduct a systematic review and meta-analysis to assess the **effect** that different structural enrichment interventions, introduced within the home cage, have on the welfare of macaques kept in captivity.



Behavior as the primary **outcome**

Increase of species typical behaviors

Decrease in behaviors associated with negative welfare

Long-tailed macaques



Rhesus macaques



Stump-tailed macaques



Pig-tailed macaques

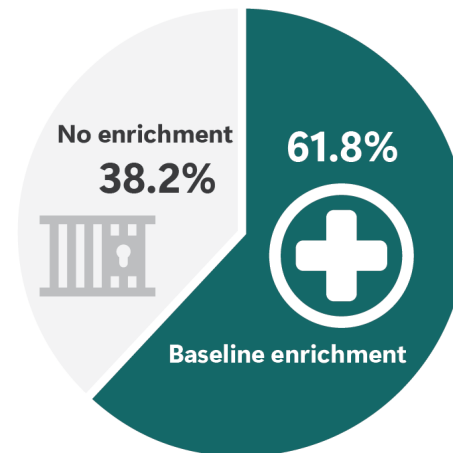
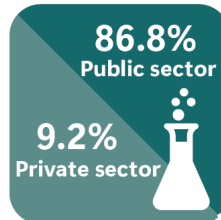
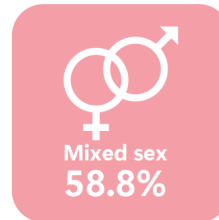
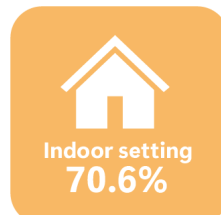
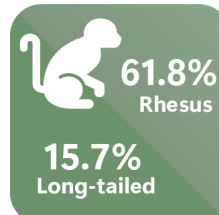




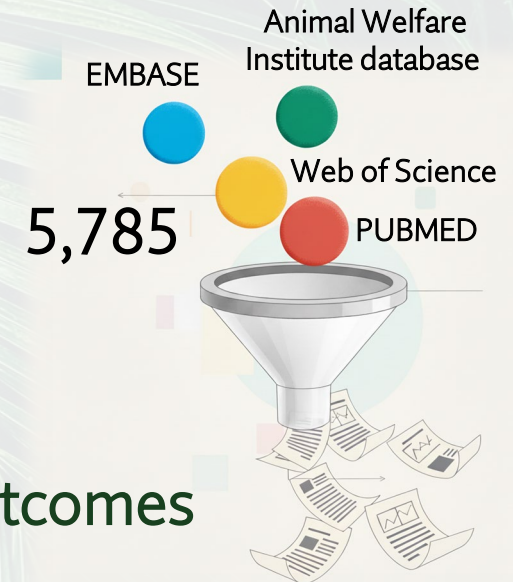
Europe (13.1%)



USA (80.3%)



Studies published between 1963 and 2024 with the majority being published in the 90s.



76 studies
102 experiments
427 behavioral outcomes

Types of enrichment

Physical



Cage size increase
Furniture
Manipulable objects

Feeding



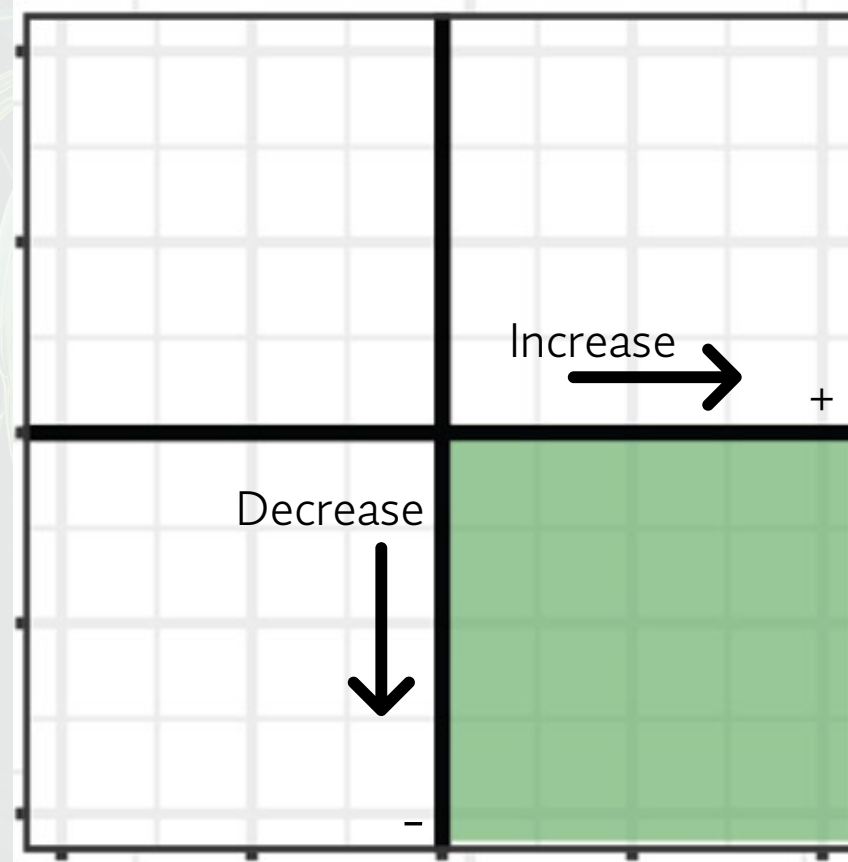
Foraging tools

Mixed



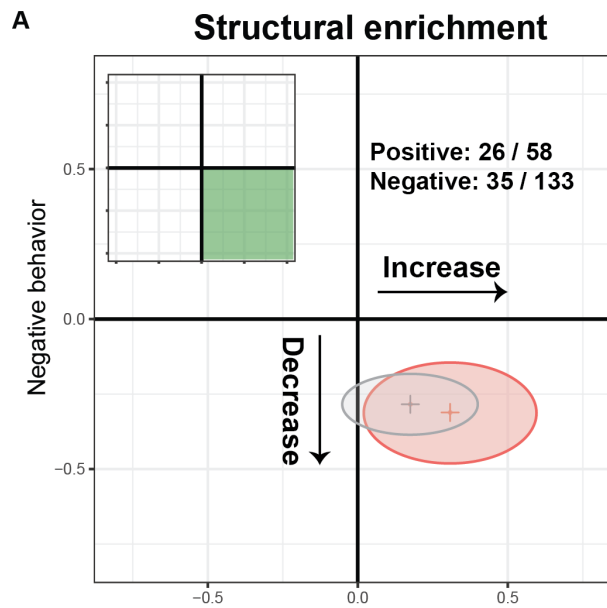
Both types

Negative-welfare-related
behaviors



Species-typical behaviors

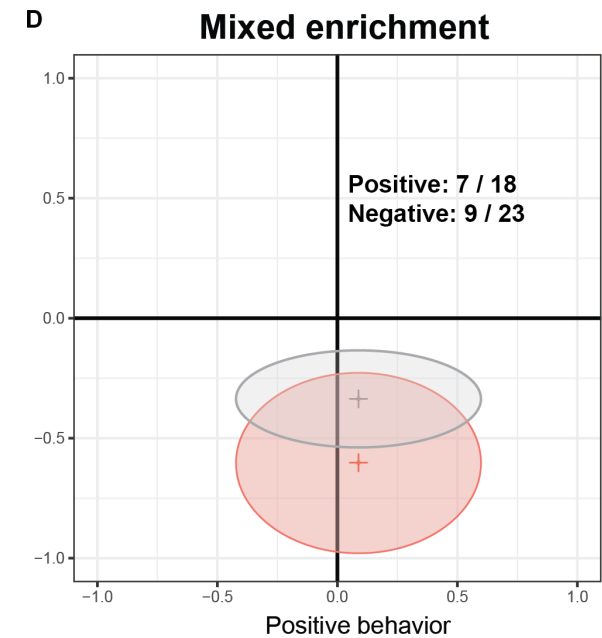
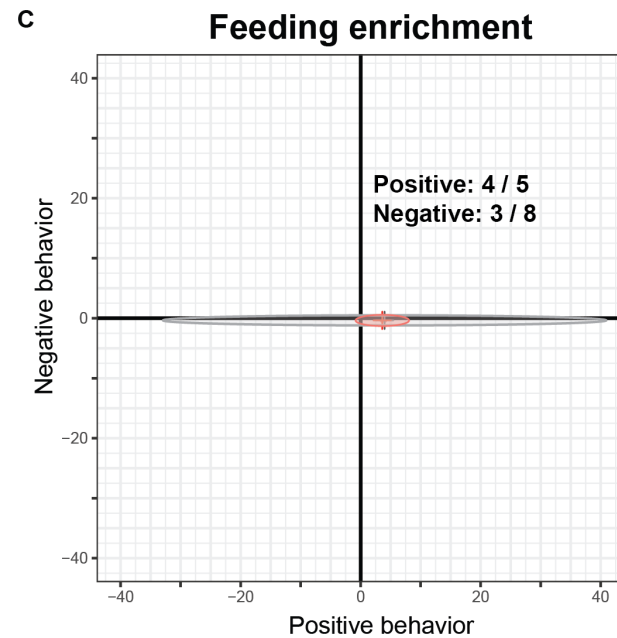
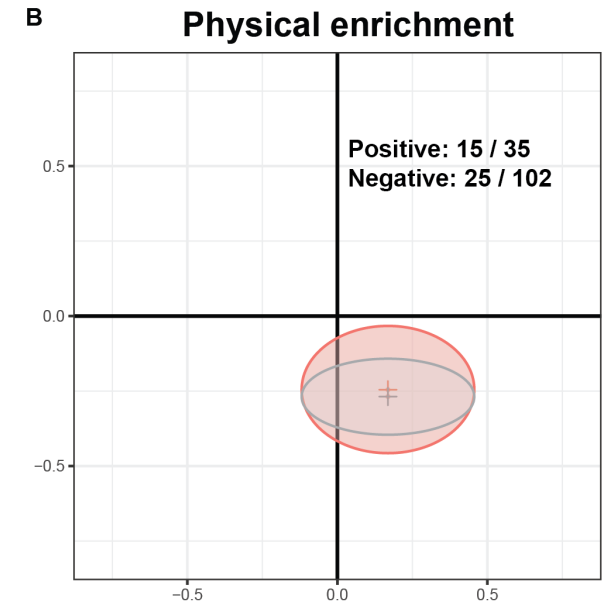
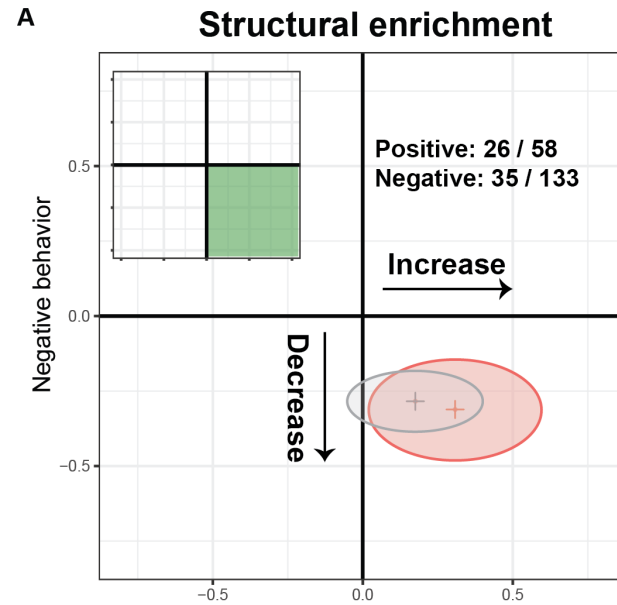
Beneficial effect!
Even when enrichment was added



Complexity!

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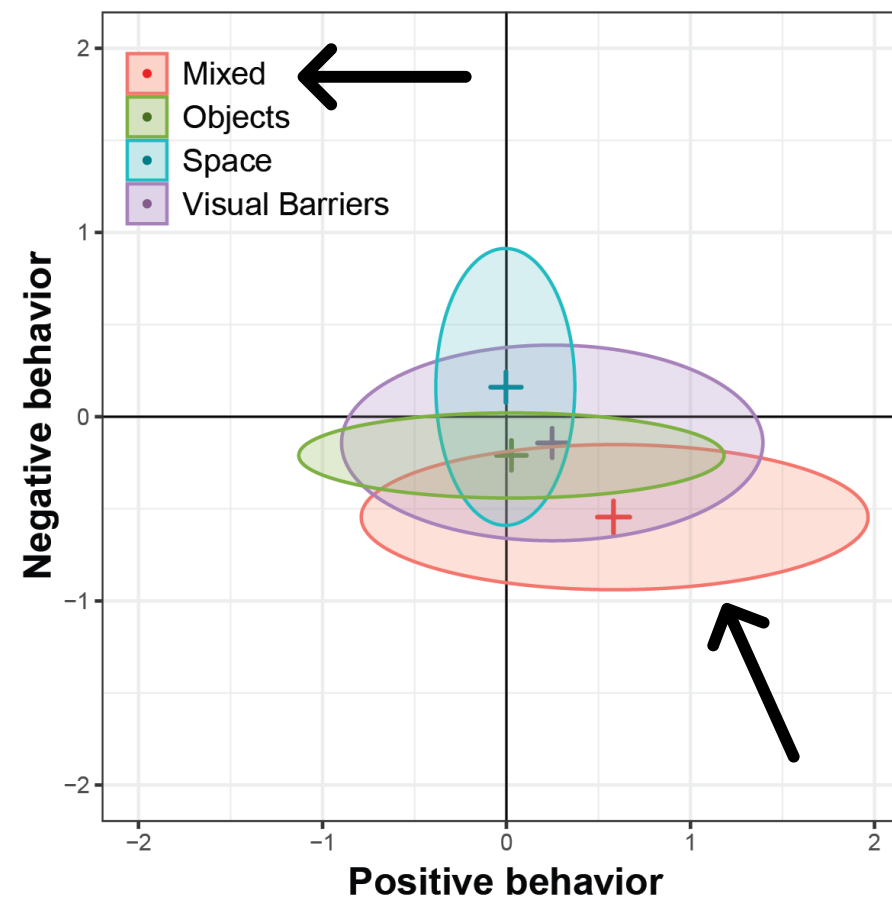


Complexity!

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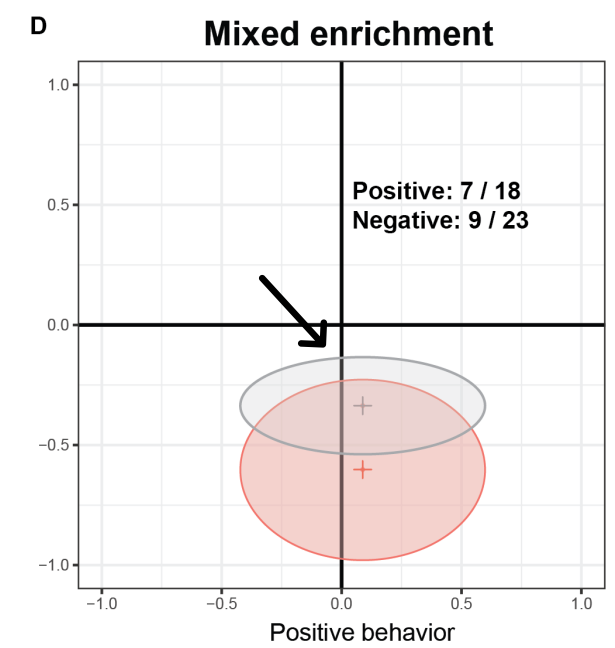
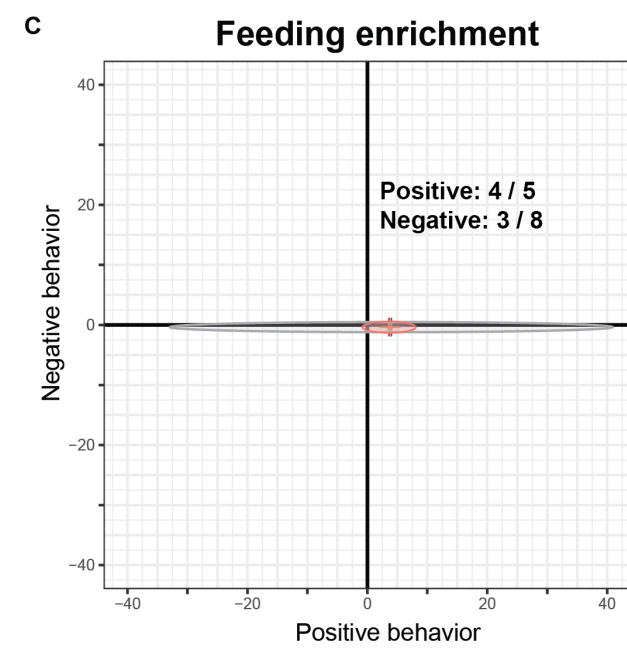
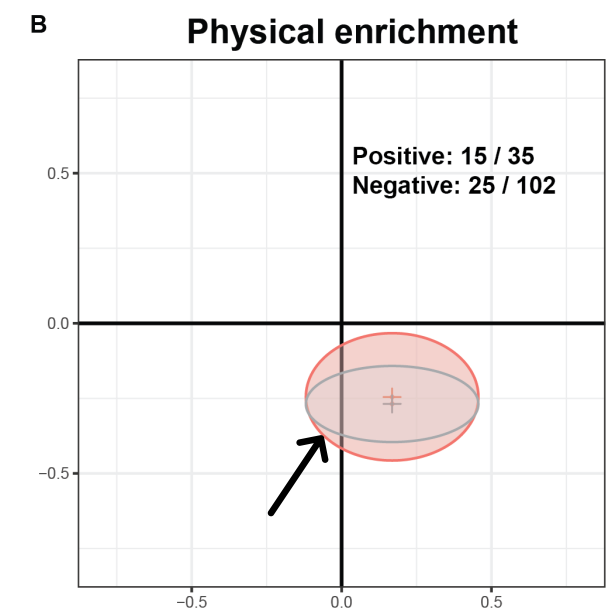
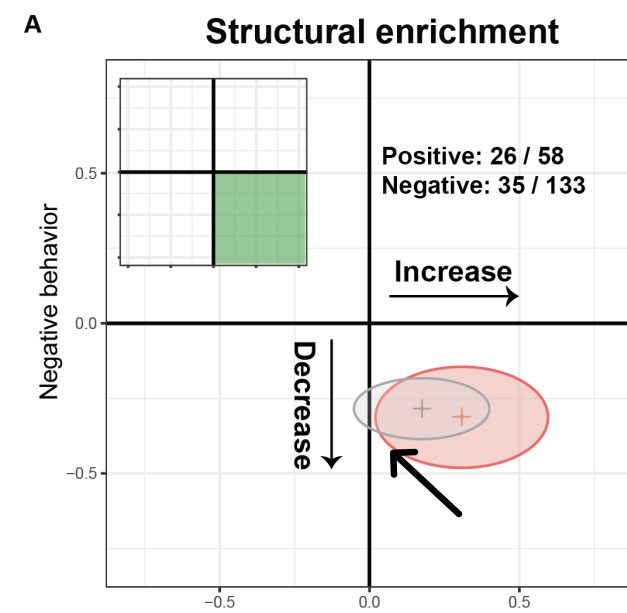
Physical enrichment subtypes

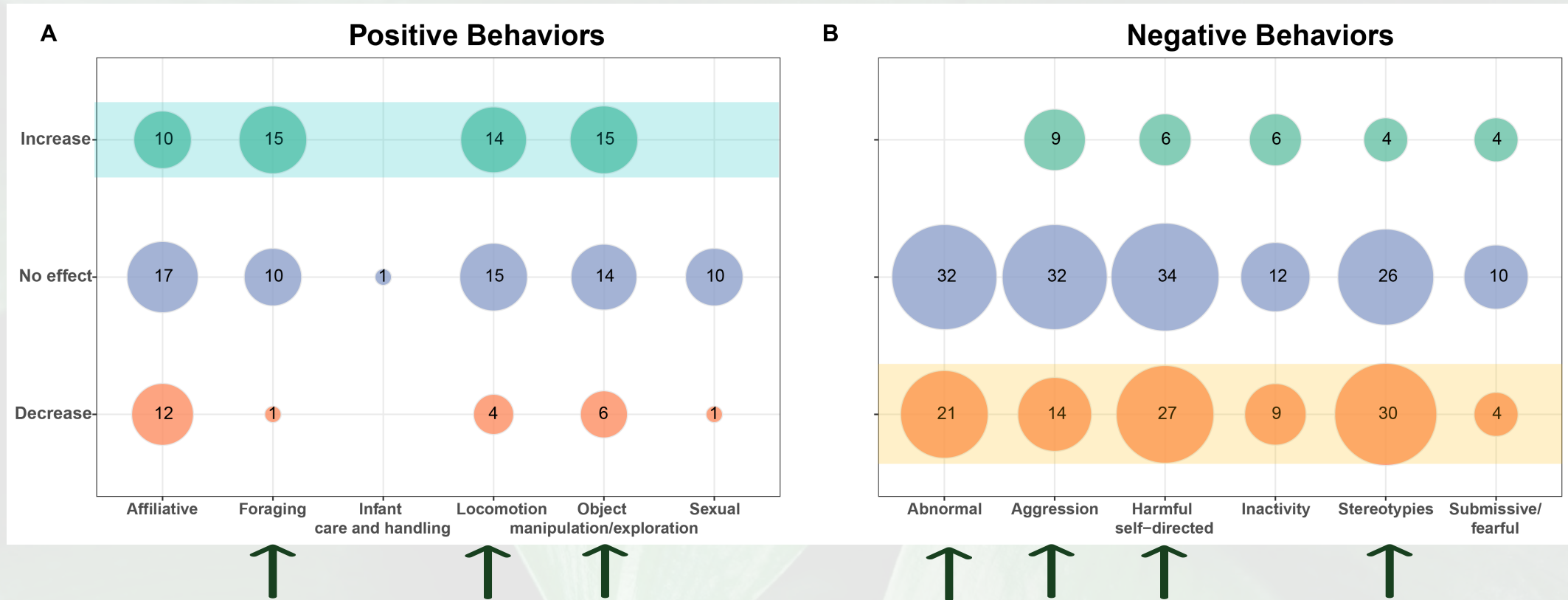


Even a small positive change can translate into significant improvements in lifetime well-being

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Structural enrichment has a net **beneficial effect** on welfare as measured through behavior, particularly in **reducing abnormal behaviors and aggression**.

Mixed enrichments that incorporate varied physical enrichment and feeding strategies proved **most effective** in mitigating these issues.

Our findings underscore the importance of **moving beyond simplistic approaches** to enrichment, instead **embracing varied strategies** that consider the complex behavioral needs of these intelligent animals.



We can
do better!

Amazing TEAM!



Otto Kalliokoski

Associate Professor

LASW group – University
of Copenhagen



Christopher Musembi

Neurophysiologist

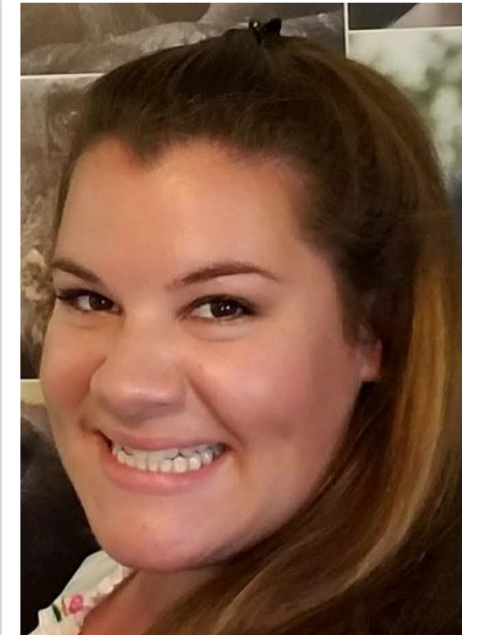
University of Nairobi



Dana Pfefferle

Welfare and Cognition
Group

German Primate Center



Sarah Neal

Research Faculty and
Resource Coordinator

University of Texas

Tak and let's connect!



Linked-in profile



Preprint in BioRxiv

Studies of interest		Exclusion reason
a.	Papers reporting an original study in	Wrong publication type
b.	Macaques of the species of interest	Wrong population
c.	Kept in captivity , that	
d.	Used a structural enrichment* intervention, and	Wrong intervention
e.	Assessed its effect on one or more behaviors fitting to the categories of interest , and had a	Not appropriate outcome
f.	Reference group or time that serves as a control for the intervention (“control vs exposed” or within-subject design)	Wrong study design
Behavioral categories of interest		
Positive welfare-related behaviors		Negative welfare-related behaviors
Behaviors whose increased frequency or duration is generally considered indicative of positive welfare states.		Behaviors whose increased frequency or duration is generally considered indicative of negative welfare states.
Foraging		Inactivity
Affiliative behaviors		Aggression
Locomotion		Submissive/fearful behaviors
Object manipulation and exploration		Stereotypies
Infant care and handling		Harmful self-directed behaviors
Sexual behaviors		Other abnormal behaviors^ (e.g. urine drinking, coprophagy)
*Structural enrichment: any structural item and/or space added to the home cage that increases its complexity and/or its usable space. ^This category also included a combination of harmful self-directed behaviors and stereotypies, which were reported together and thus could not be fit into either category alone.		