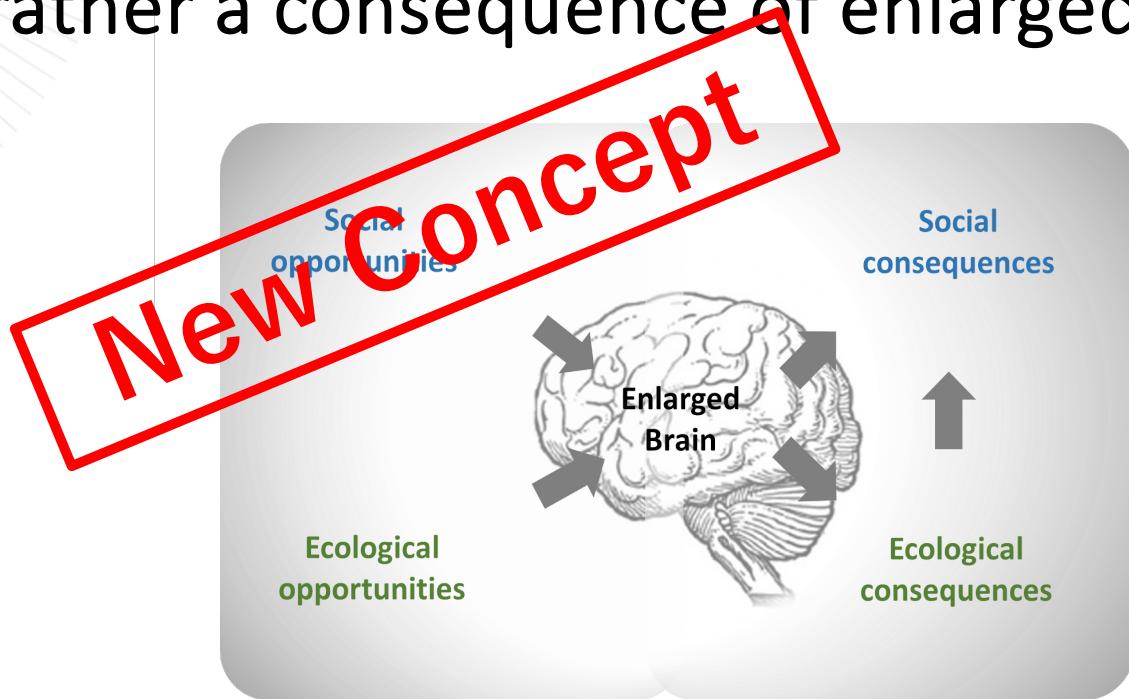
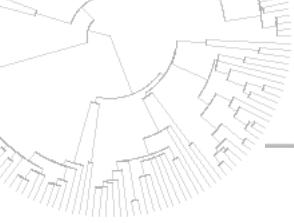


Primate social complexity is not the driver but
rather a consequence of enlarged brains

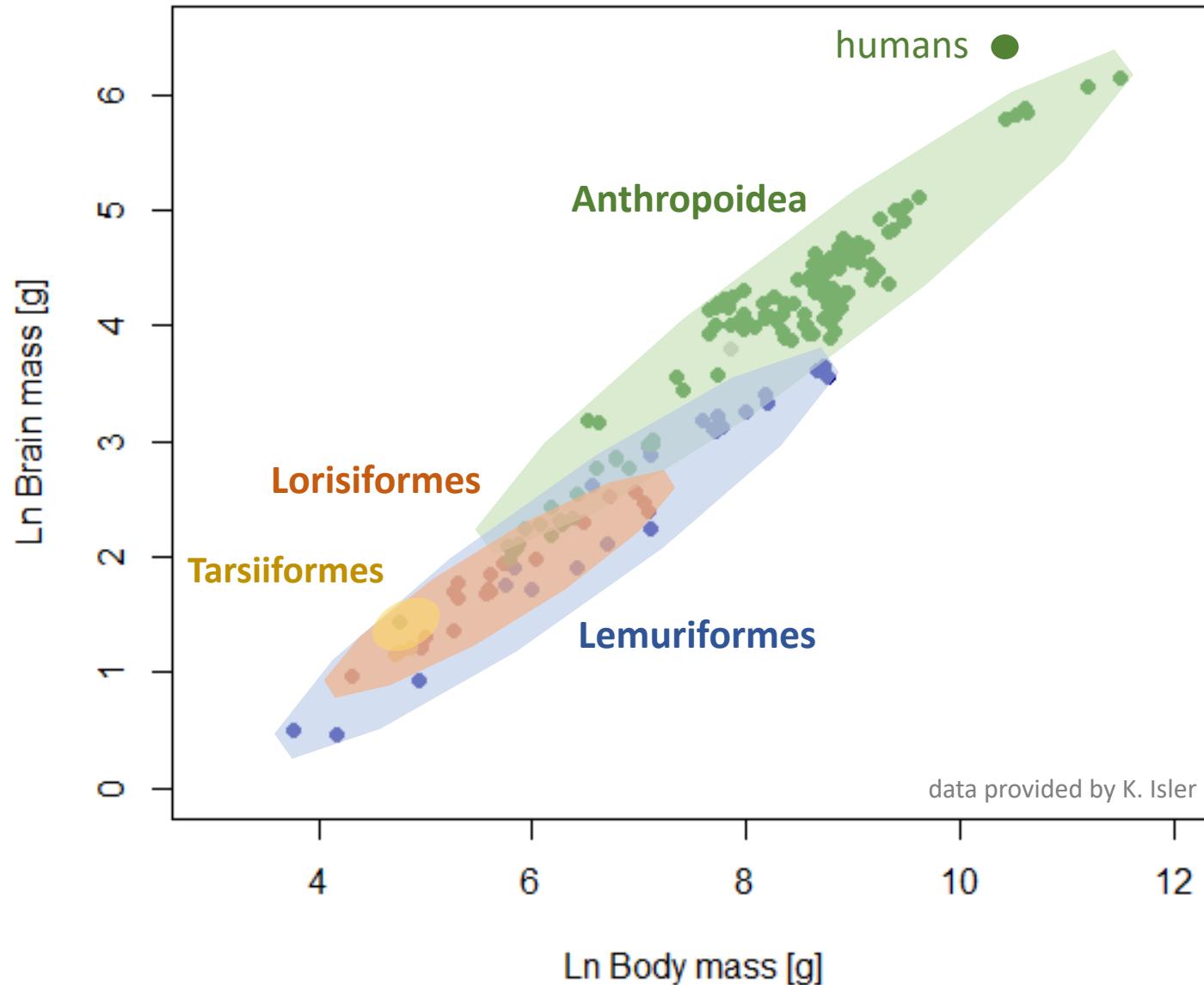


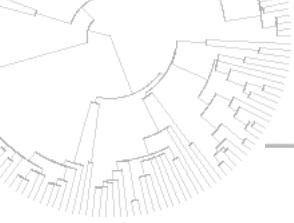
Sereina M. Graber, Caroline Schuppli, Sandra A. Heldstab, Karin Isler and Carel van Schaik

Department of Anthropology, University of Zurich



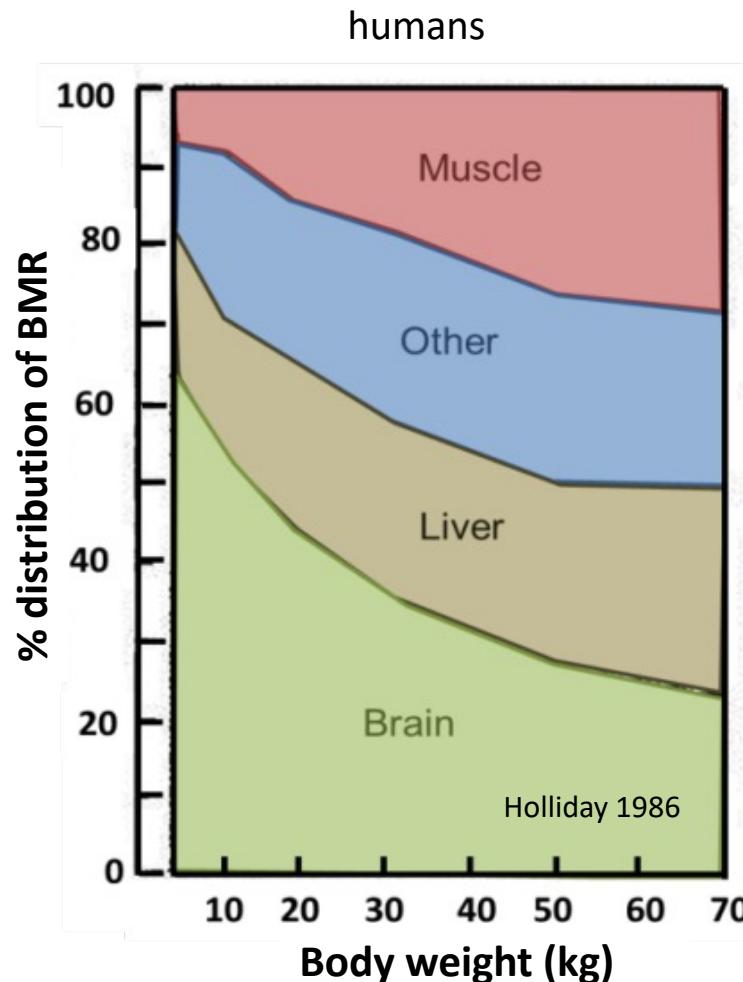
Variation in Brain Size - Primates



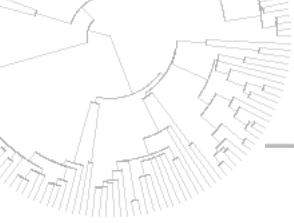


Explaining Variation in Brain Size

Cost perspective - Brains are energetically very expensive

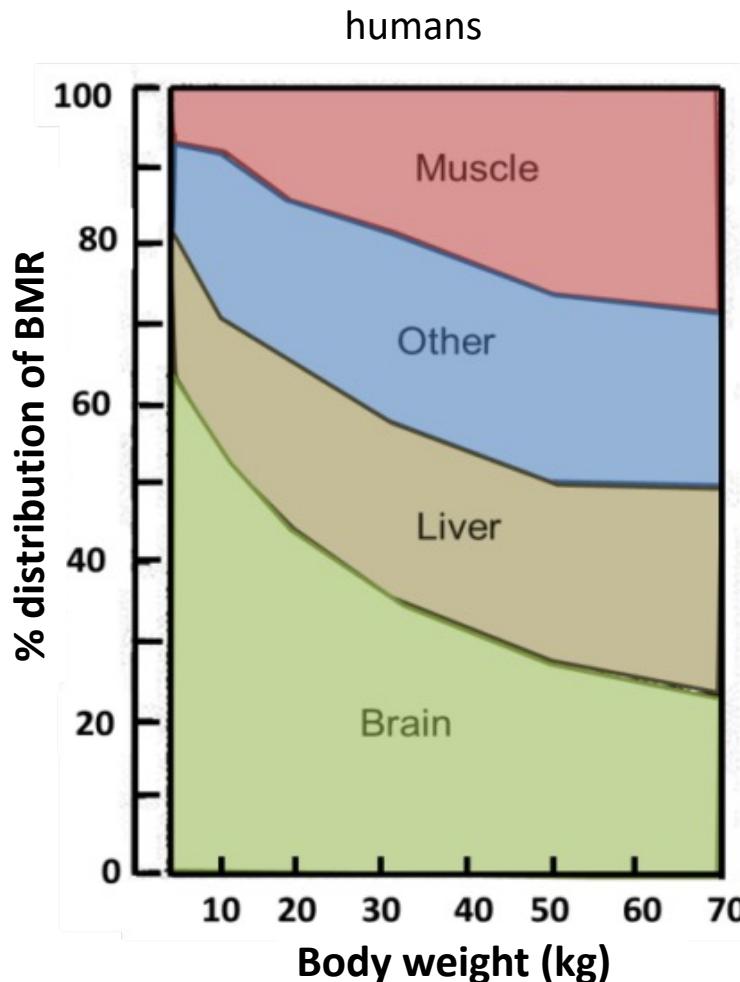


- Primates: 13 -20% of BMR^{1,3,4}
- Large brains come with the costs of energetic allocation to other functions (e.g. locomotion, production)⁵



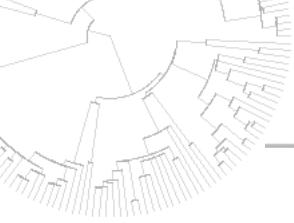
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**Brains are
expensive**



Explaining Variation in Brain Size

Benefit perspective – Sociality and Ecology



Explaining Variation in Brain Size

Shortcomings of previous studies

- Major divergences in brain size not explained
- Tested only one or the other domain
- Simple ad-hoc measurements
- Evidence for general behavioral flexibility
Selective benefits vs. cognitive consequences!



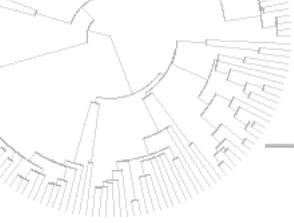
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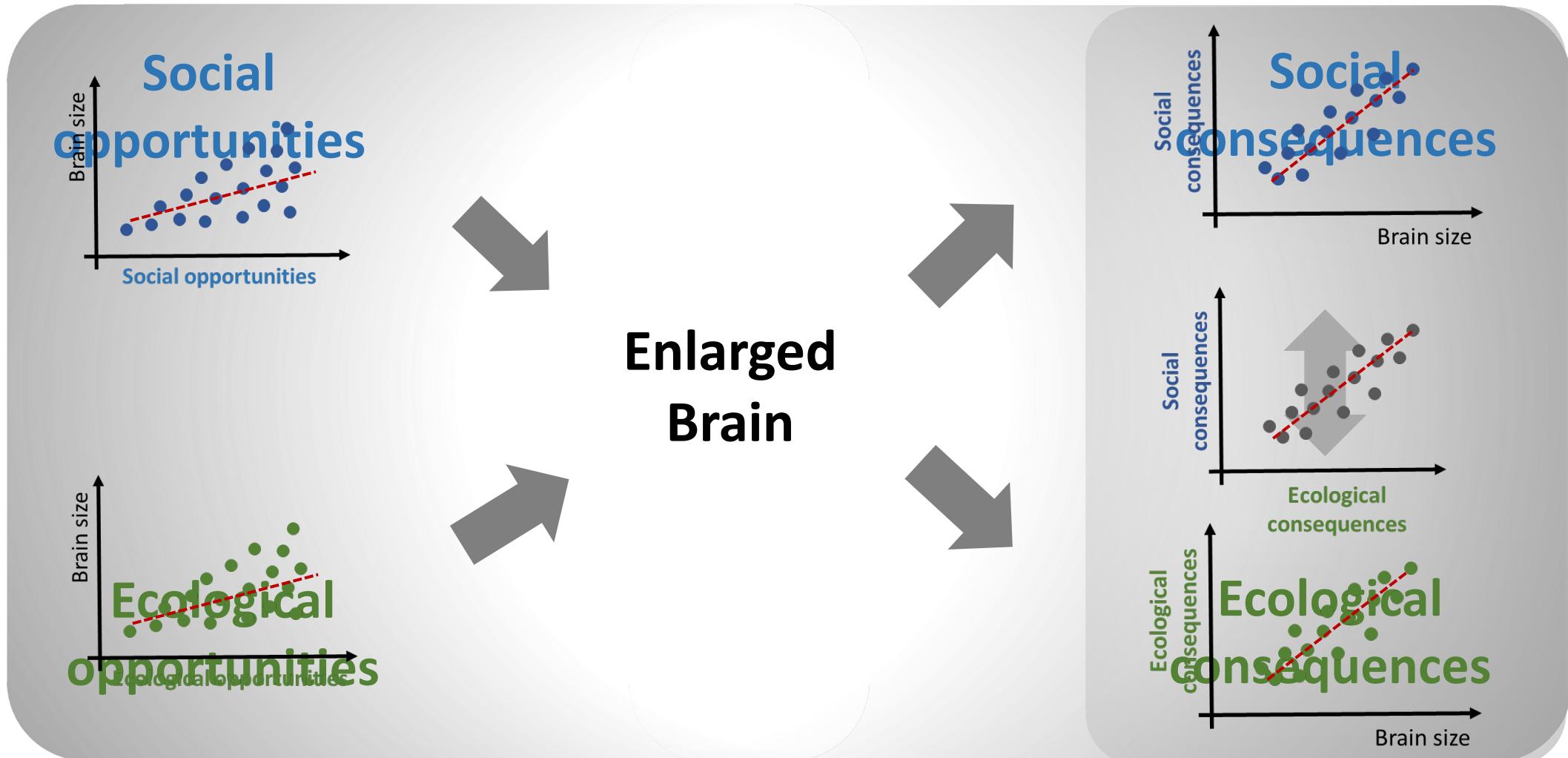
New approach

- Include a broad range of social and ecological variables
- Systematic distinction between possible selective pressures and cognitive consequences of enlarged brains



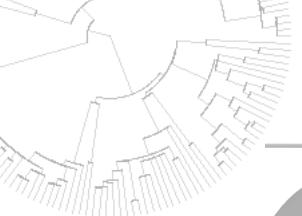
Explaining Variation in Brain Size

Concept of opportunities and consequences

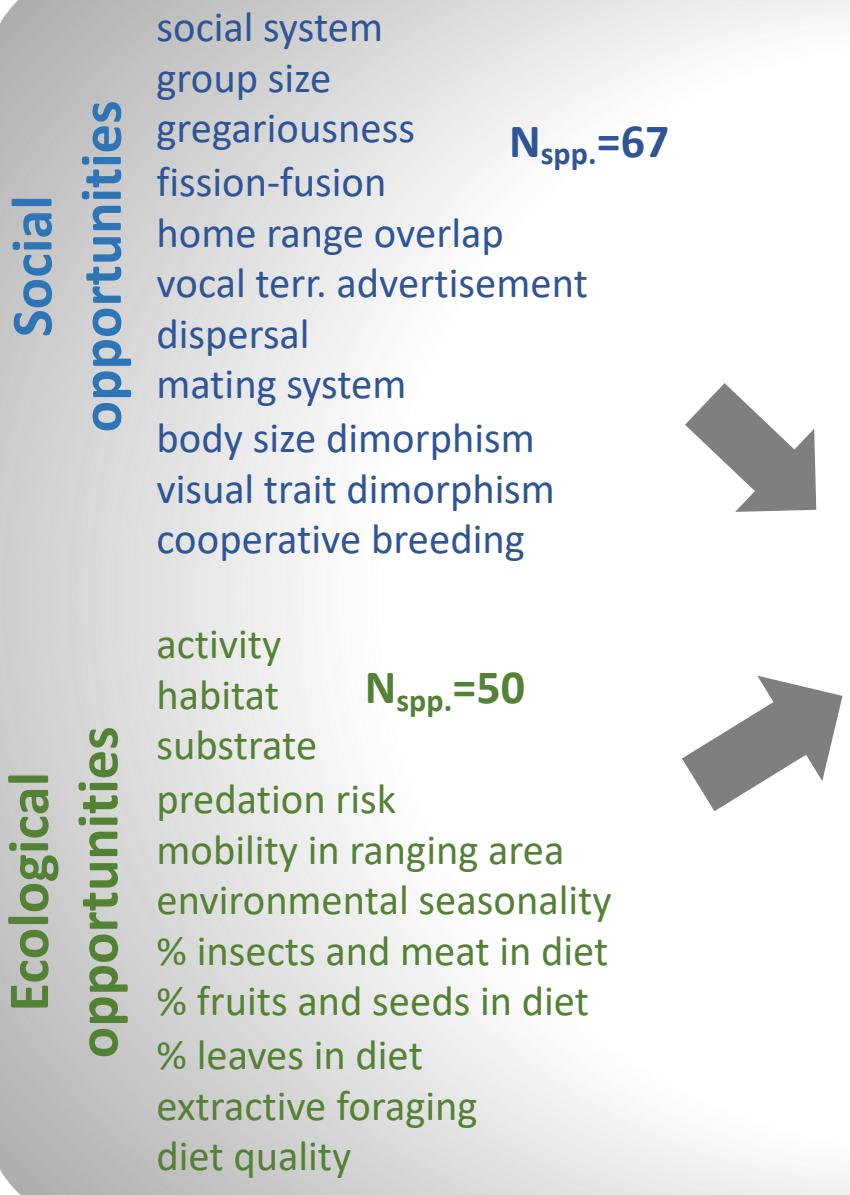


Facilitation of enlarged brains

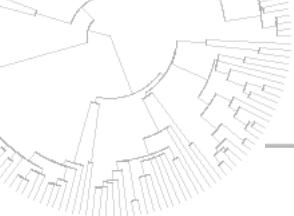
General behavioral flexibility



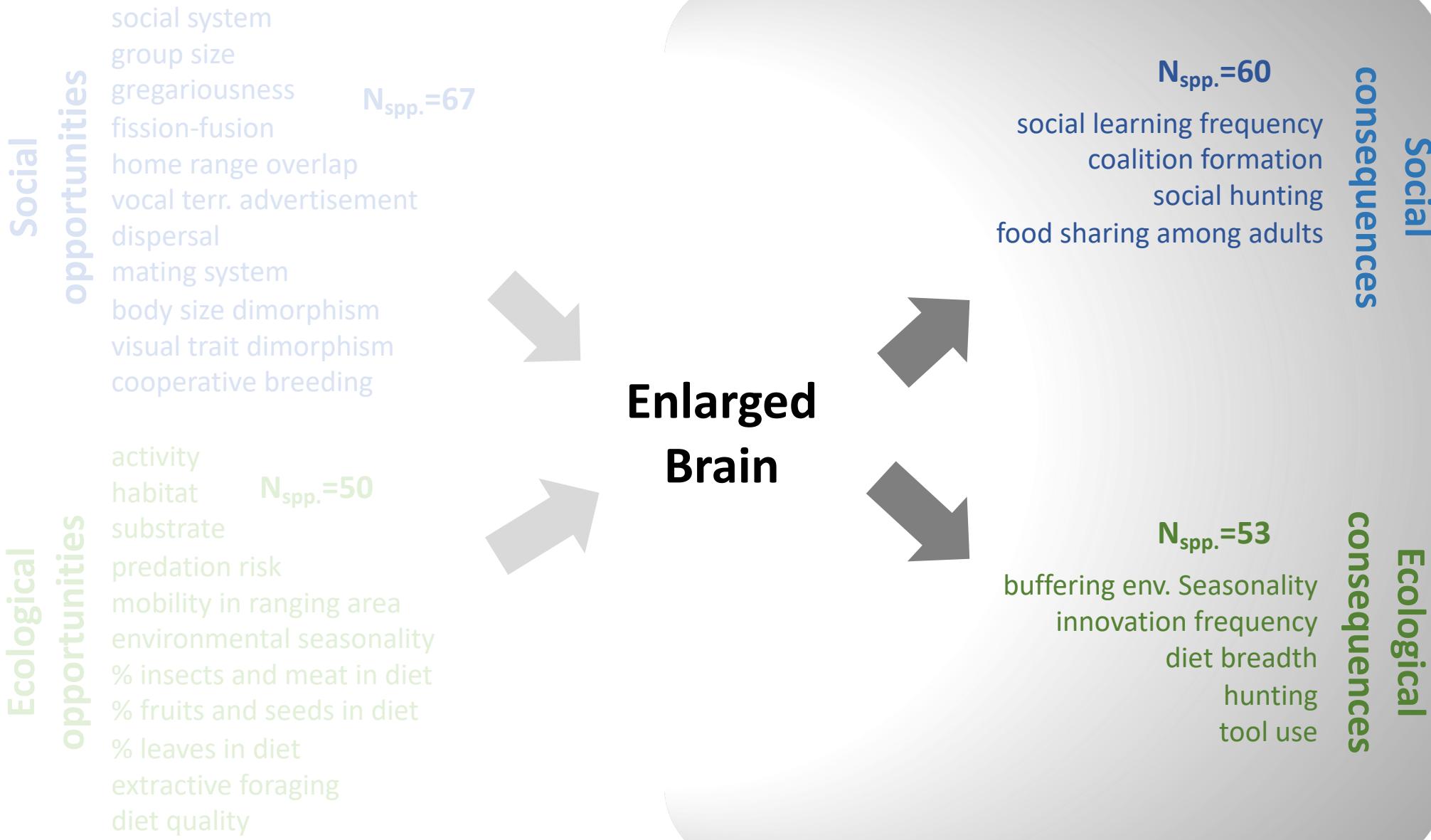
Opportunity and Consequence Variables

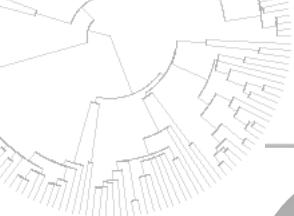


**Enlarged
Brain**

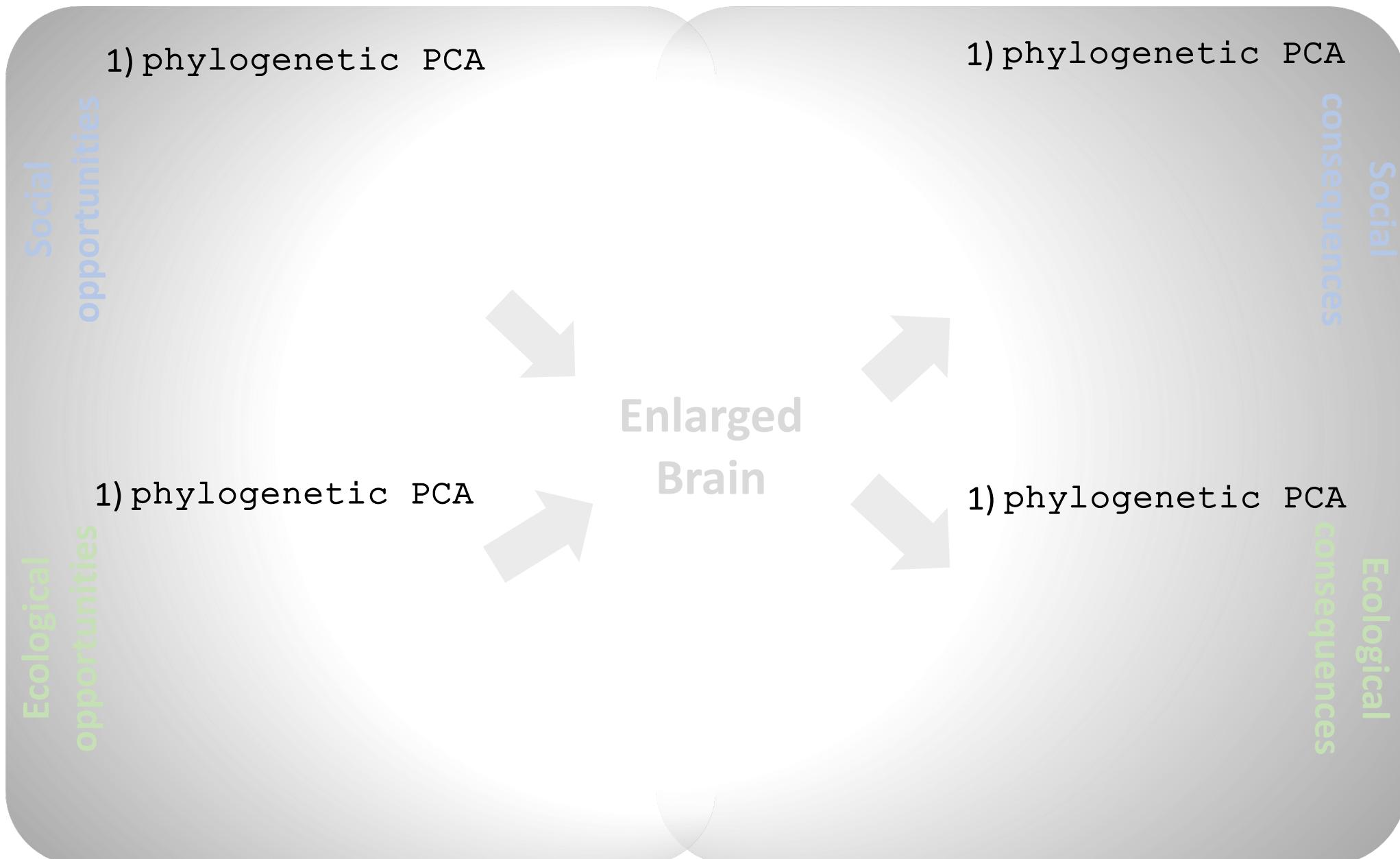


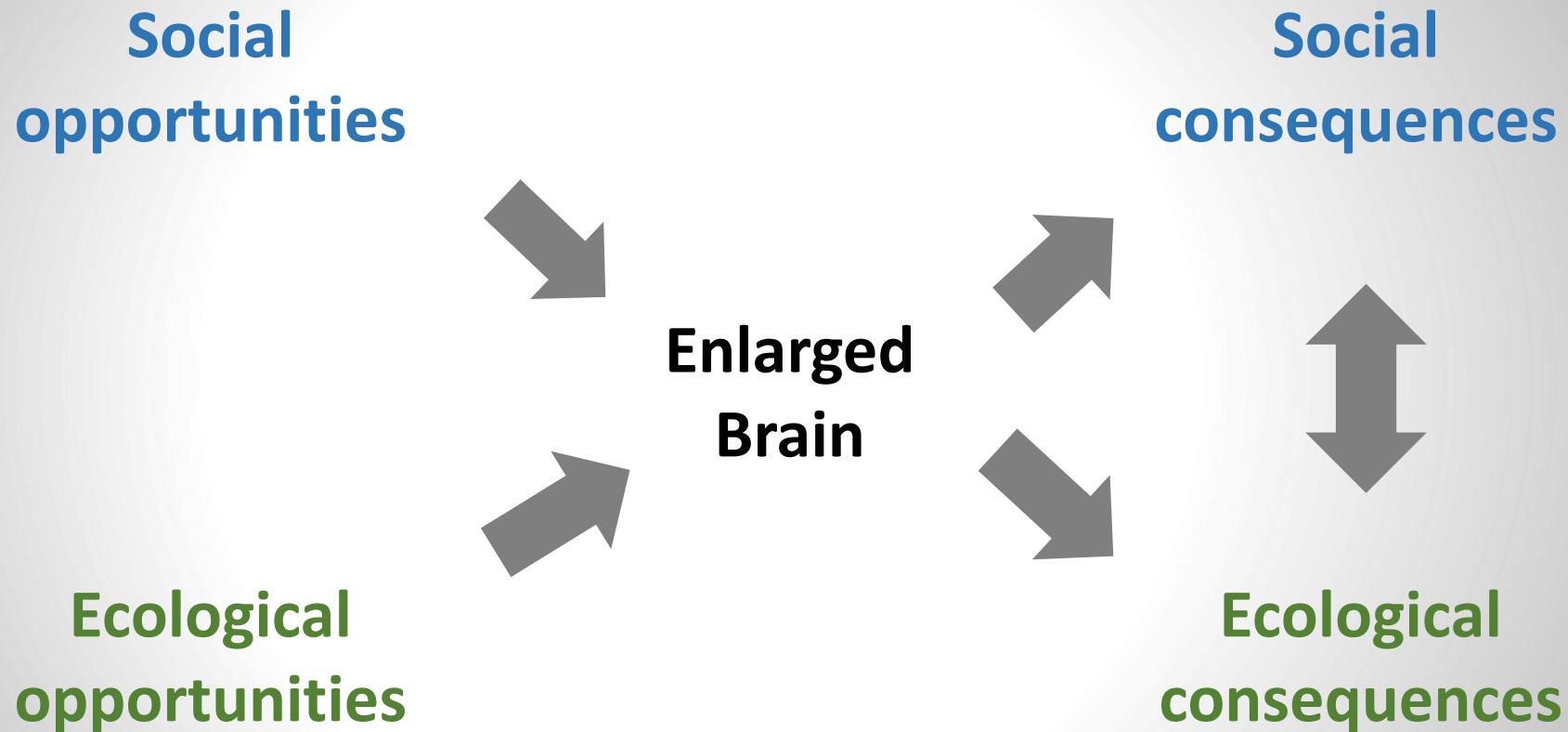
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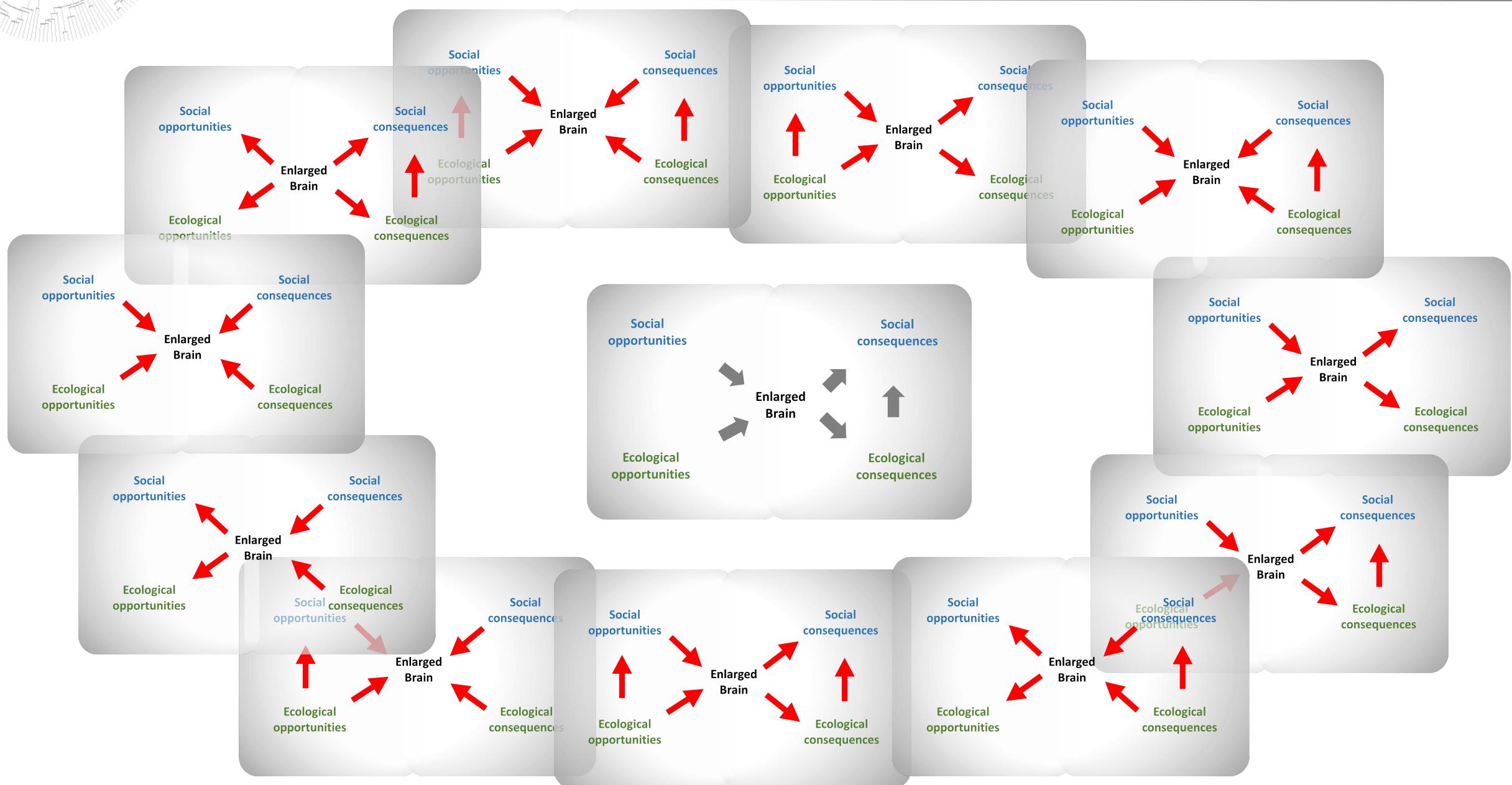
Phylogenetic Analyses – 1. phylogenetic PCA





Phylogenetic Analyses – 2. Phylogenetic Path Analysis

Gonzalez-Voyer and von Hardenberg 2014





Phylogenetic PCA

| Social opportunities | PC1 | PC2 |
|---------------------------|--------------|--------------|
| multi-male-female group | -0.05 | 0.66 |
| home range overlap | -0.31 | 0.09 |
| vocal terr. advertisement | 0.60 | -0.46 |
| group size | -0.51 | 0.42 |
| gregariousness | 0.26 | 0.65 |
| fission-fusion | -0.57 | -0.12 |
| dispersal | 0.08 | -0.42 |
| polygynandry | -0.25 | 0.60 |
| body size dimorphism | -0.77 | -0.25 |
| visual trait dimorphism | -0.66 | -0.59 |
| cooperative breeding | 0.41 | -0.17 |
| Proportion explained | 0.22 | 0.20 |



Enlarged
Brain



Phylogenetic PCA

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| dispersal | 0.08 | -0.42 |
| polygynyandry | -0.25 | 0.60 |
| Proportion explained | 0.77 | 0.25 |

| Ecological opportunities | PC1 | PC2 |
|----------------------------|--------------|--------------|
| diurnality | -0.38 | -0.34 |
| wooded habitat | 0.02 | -0.65 |
| arboreality | 0.03 | -0.50 |
| Predation risk | 0.39 | 0.30 |
| mobility in raining area | 0.33 | 0.46 |
| environmental seasonality | 0.25 | 0.50 |
| % insects and meat in diet | 0.52 | -0.47 |
| % fruits and seeds in diet | 0.70 | 0.05 |
| % leaves in diet | -0.92 | 0.06 |
| extractive foraging | 0.15 | 0.47 |
| diet quality | 0.90 | -0.33 |
| Proportion explained | 0.26 | 0.18 |

Enlarged
Brain





Phylogenetic PCA

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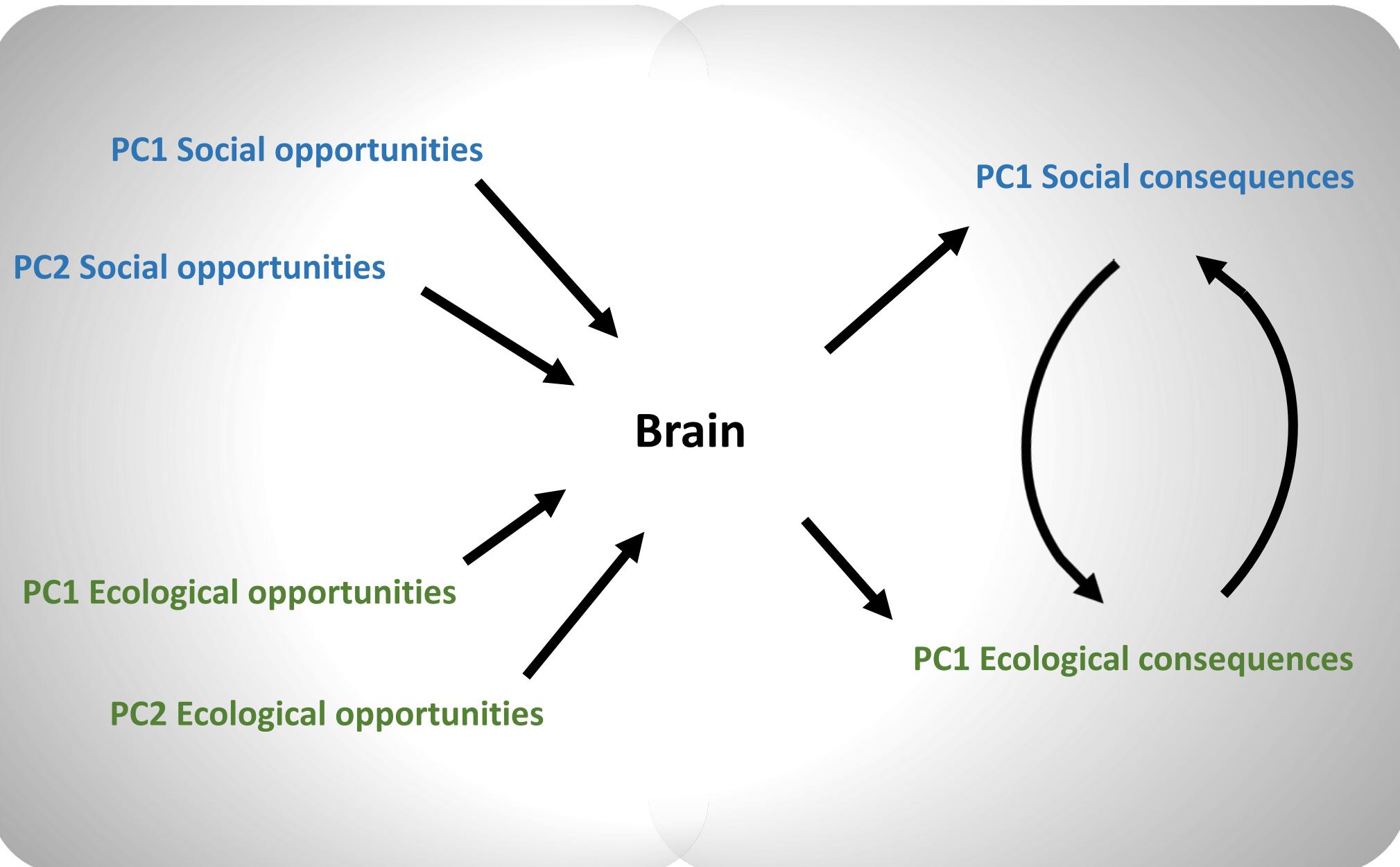
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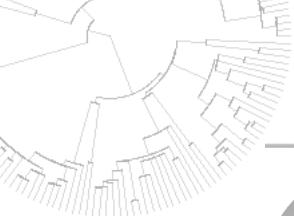


| Social consequences | PC1 |
|---------------------------|-------------|
| Social learning frequency | 0.78 |
| Coalition formation | 0.73 |
| Social hunting | 0.86 |
| Food sharing among adults | 0.63 |
| Proportion explained | 0.57 |

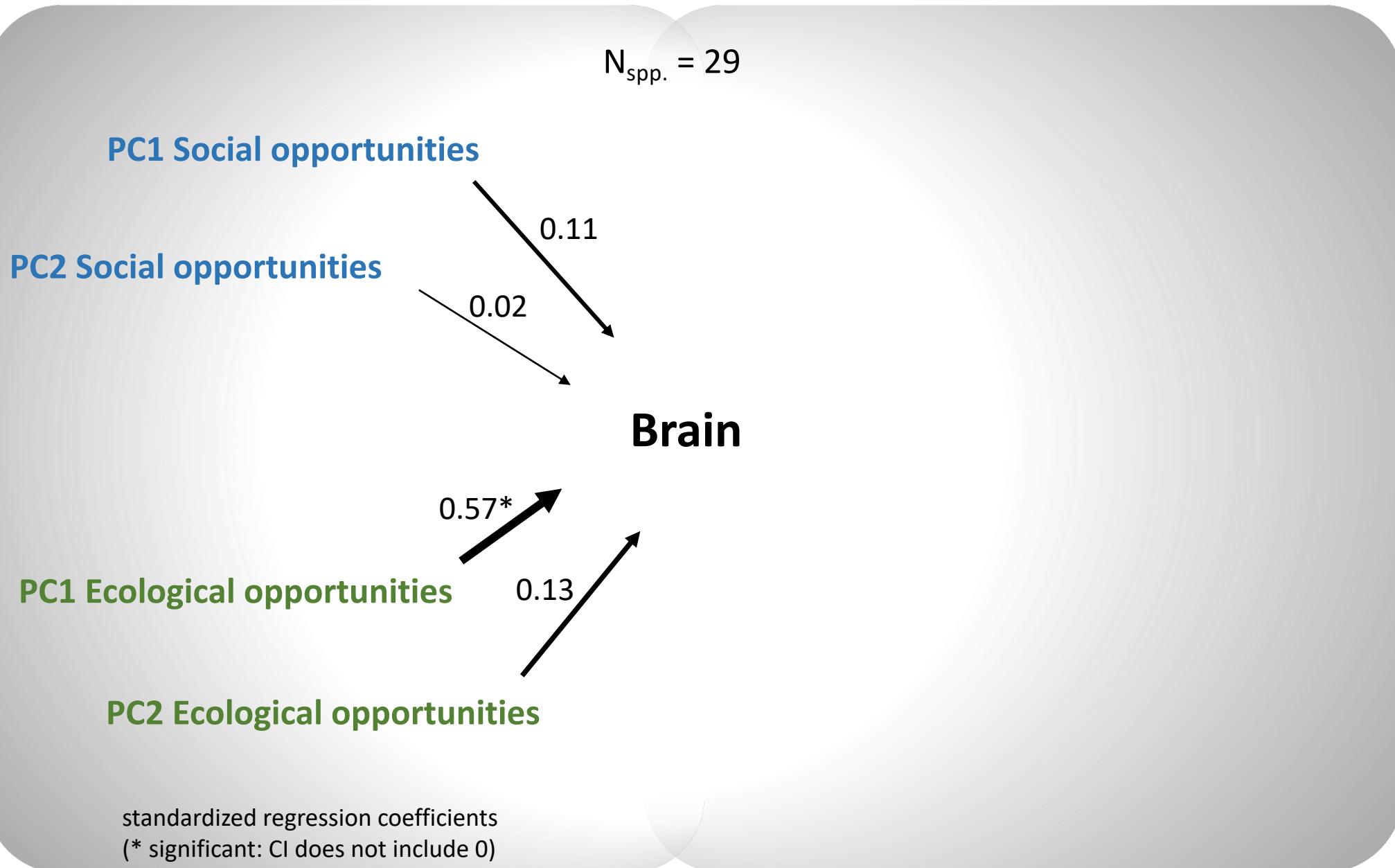
| Ecological consequences | PC1 |
|----------------------------|-------------|
| Buffering env. seasonality | 0.11 |
| Diet breadth | 0.47 |
| Hunting | 0.77 |
| Tool use | 0.82 |
| Innovation frequency | 0.79 |
| Proportion explained | 0.42 |

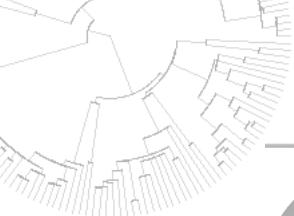
Path Analysis: confirmation of concept of opportunities and consequences



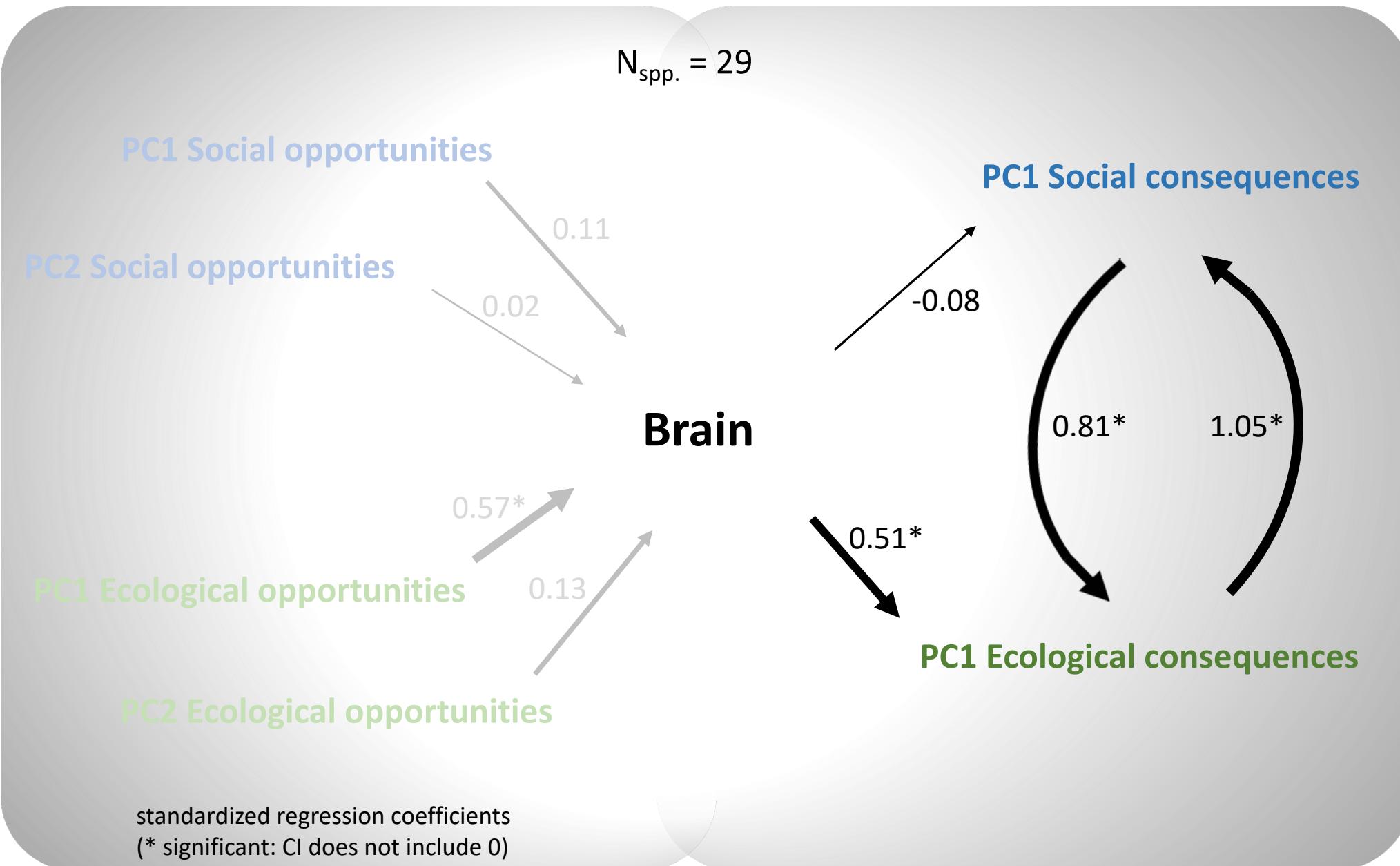


Path Analysis: Ecological rather social opportunities lead to enlarged brains

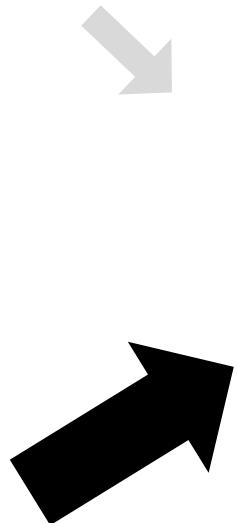




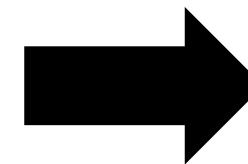
Path Analysis: Enlarged brain allows for complex social and ecological cognitive abilities



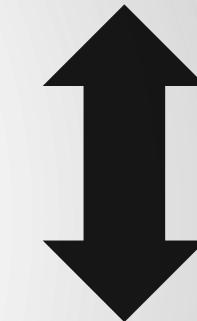
Social
opportunities



Enlarged
Brain



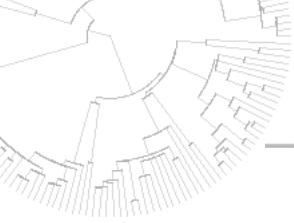
Social
consequences



Ecological
consequences

Ecological
opportunities

Ecological preconditions allow for the evolution of complex cognition



Thank you...

- Janneke van Woerden
- Erik Willems
- Swiss National Science Foundation (No. 31003A-144210)
- A. H. Schultz-Stiftung



**Universität
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