

A common language and tools for multidimensional analyses in ecology and palaeontology

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Acknowledgements



Andrew Beckerman

Pedro Cardoso

Carlos Carmona

Natalie Cooper

Stefano Mammola

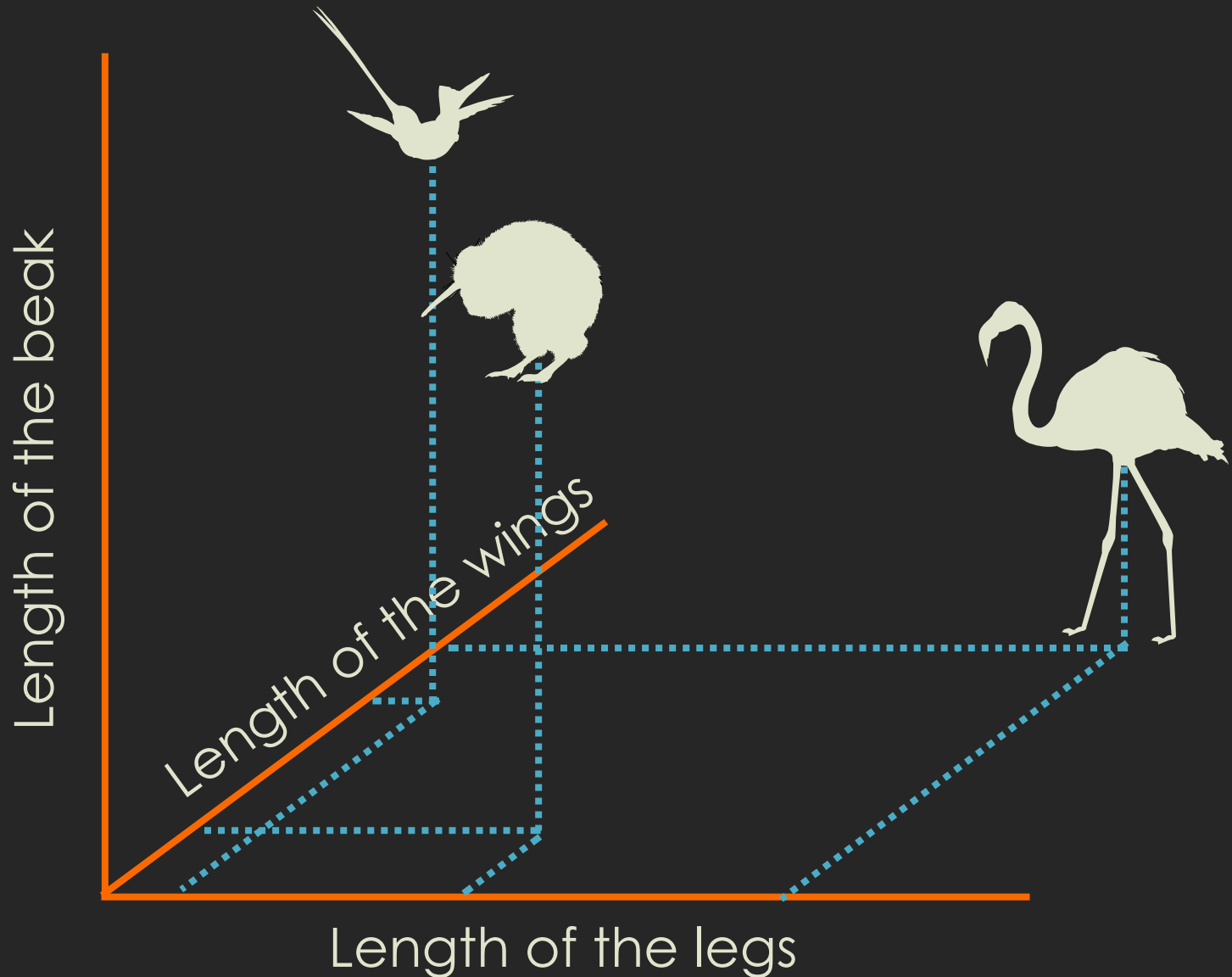
Ariel Marcy

Mark Puttick

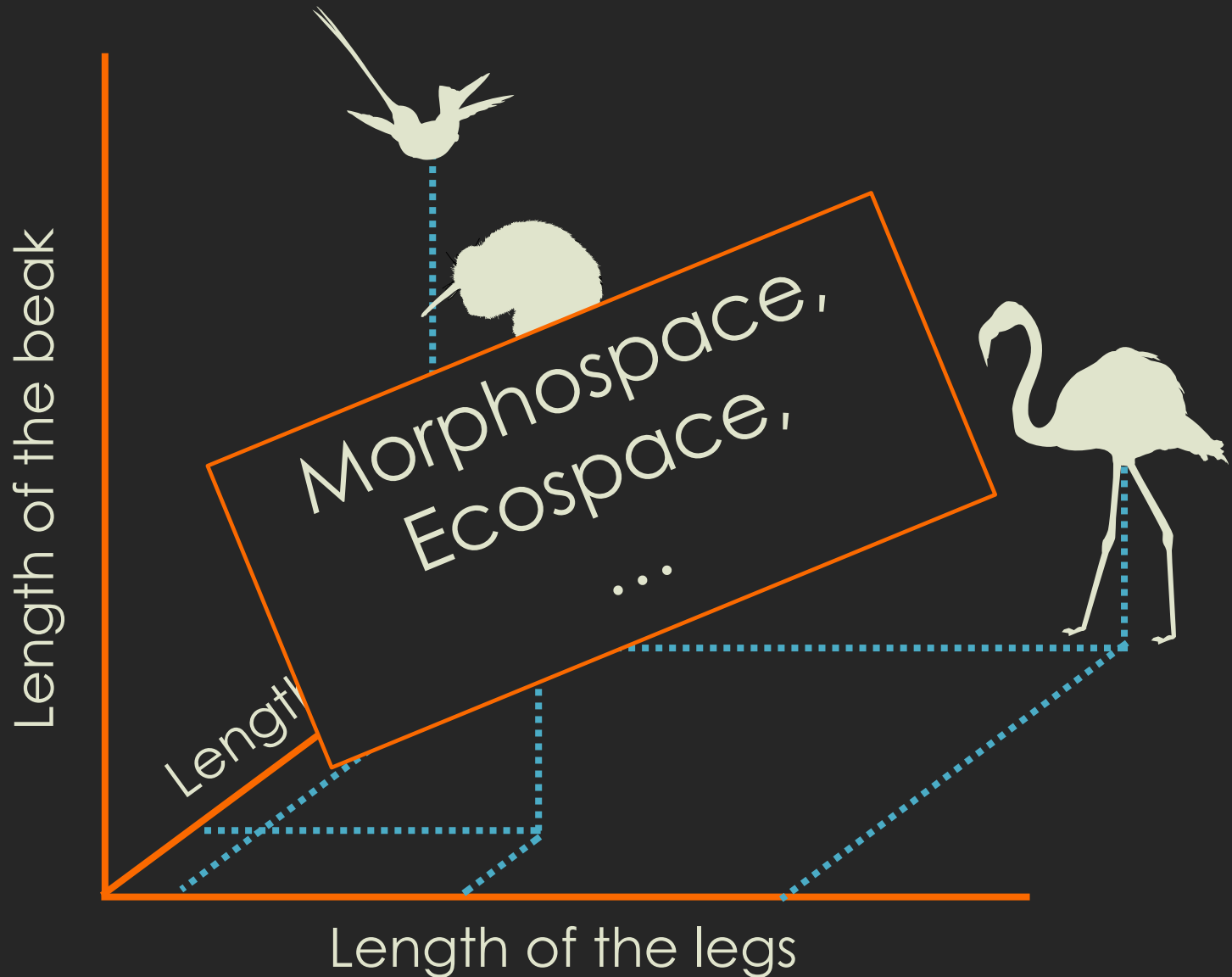
Gavin Thomas

Vera Weisbecker

Multidimensional spaces

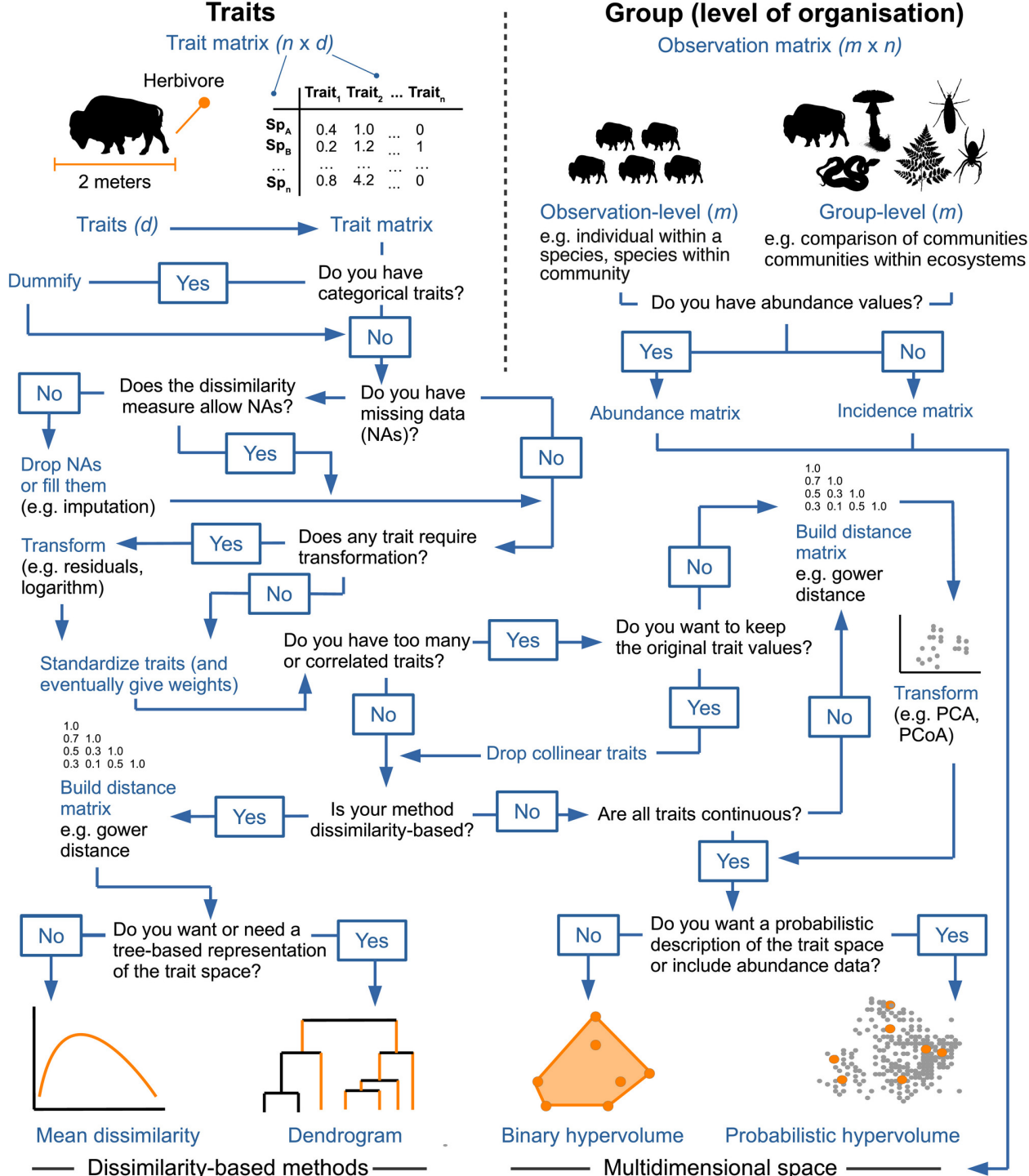


Multidimensional spaces

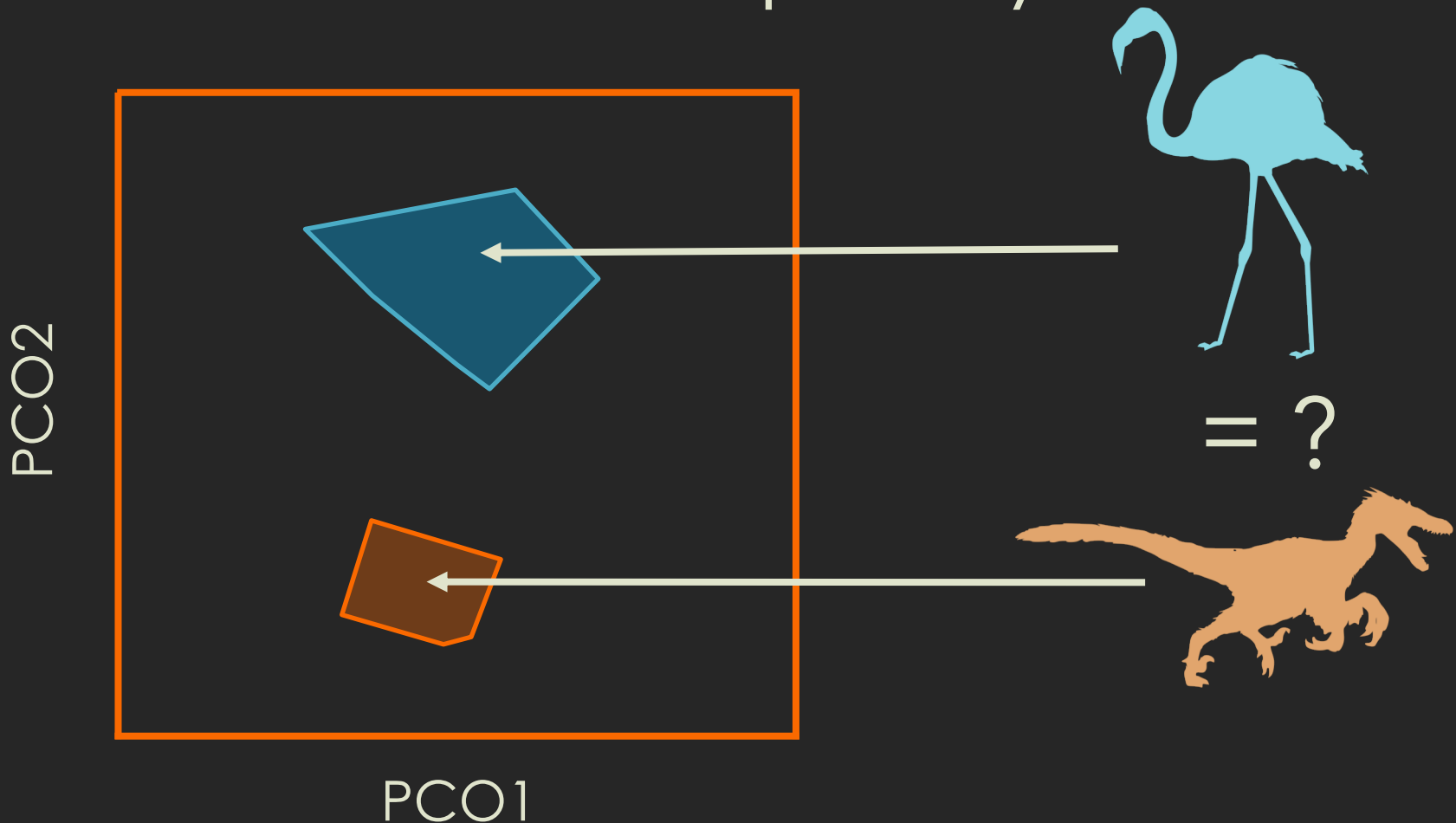


Input data & data preparation

Trait space delineation



Multidimensional analyses: Measuring aspects of space occupancy



Multidimensional analyses: Measuring aspects of space occupancy



Wang 2021

Pineda-Munoz
2021

Toussaint 2018

PROCEEDINGS B

royalsocietypublishing.org/journal/rspb

Research



Cite this article: Wang M, Lloyd GT, Zhang C, Zhou Z. 2021 The patterns and modes of the

The patterns and modes of the evolution of disparity in Mesozoic birds

Min Wang^{1,2}, Graeme T. Lloyd³, Chi Zhang^{1,2} and Zhonghe Zhou^{1,2}

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Mammal species occupy different climates following the expansion of human impacts

Silvia Pineda-Munoz, Yue Wang, S. Kathleen Lyons, Anikó B. Tóth, and Jenny L. M. ...
[+ See all authors and affiliations](#)

PNAS January 12, 2021 118 (2) e1922859118; <https://doi.org/10.1073/pnas.1922859118>

ECOLOGY LETTERS

Letter | Full Access

Non-native species led to marked shifts in functional diversity of the world freshwater fish faunas

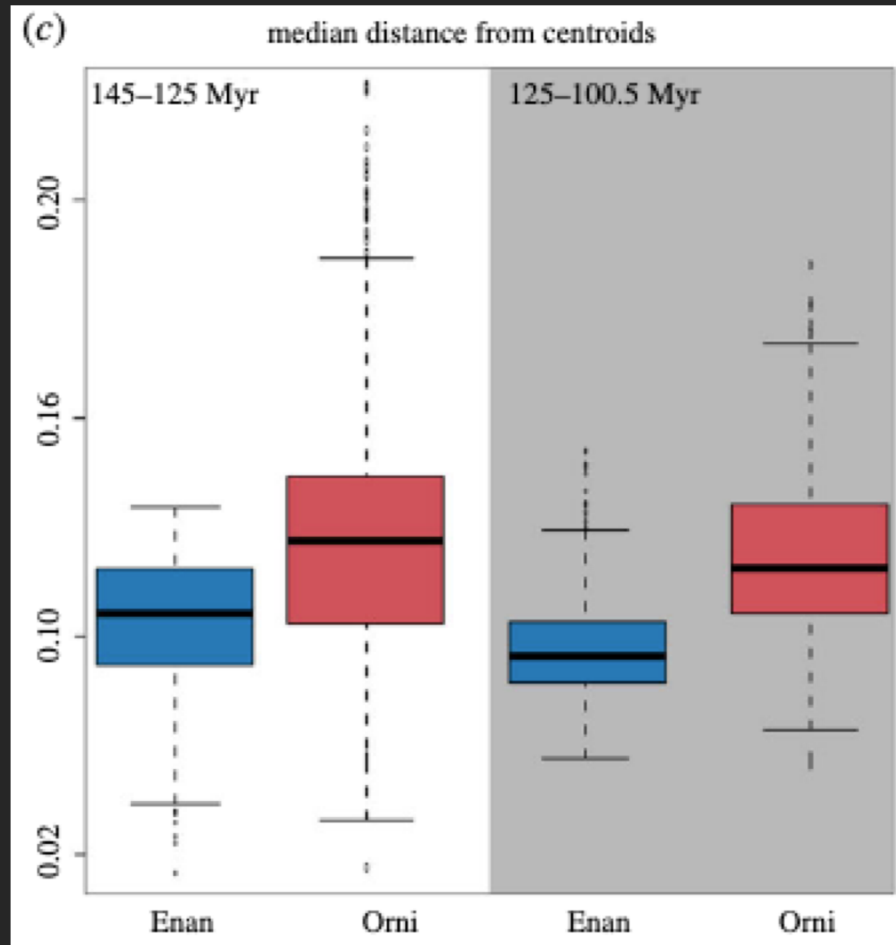
Aurèle Toussaint , Nicolas Charpin, Olivier Beauchard, Gaël Grenouillet, Thierry Oberdorff, Pablo A. Tedesco, Sébastien Brosse, Sébastien Villéger

First published: 25 September 2018; doi: <https://doi.org/10.1111/ele.12111>; | Citation: 26

Wang 2021

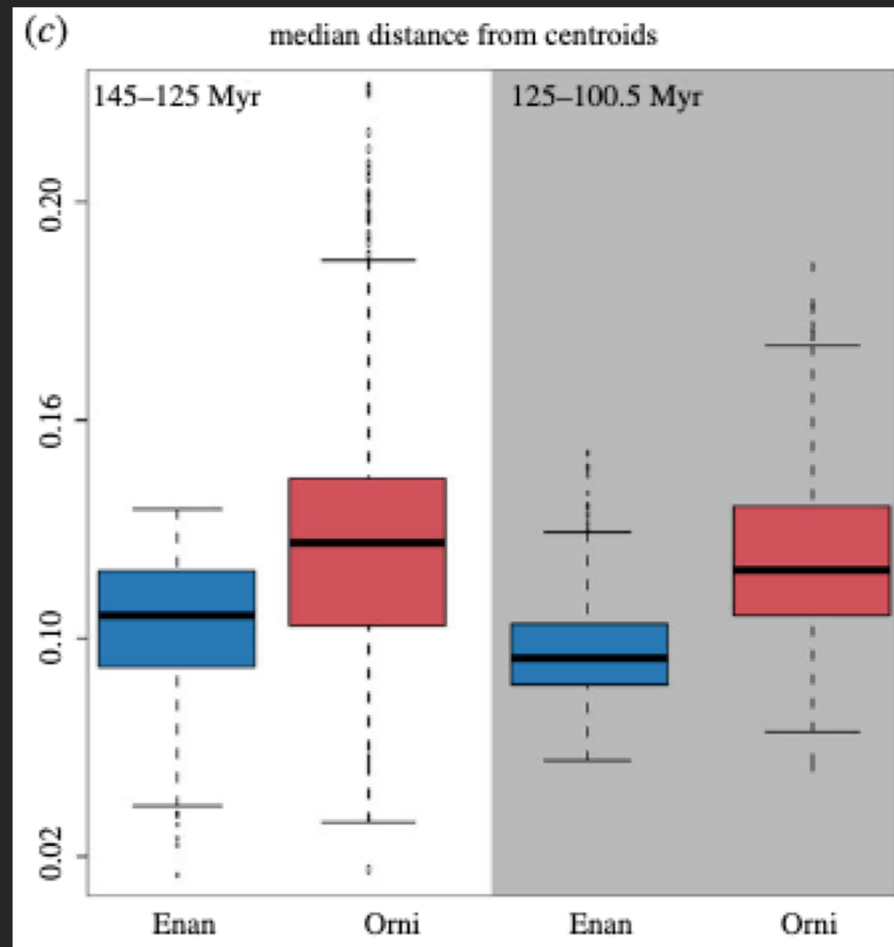
Paleontology,
morphology,
birds/dinosaurs

Wang et al. 2021 Proc. B. – Fig. 3c



Wang 2021

Wang et al. 2021 Proc. B. – Fig. 3c



Wang 2021

Disparity: How diverse are the morphologies, between groups and through time?

What are we measuring in the multidimensional space?

Wang 2021

Diversity of
Morphologies

Pineda-Munoz
2021

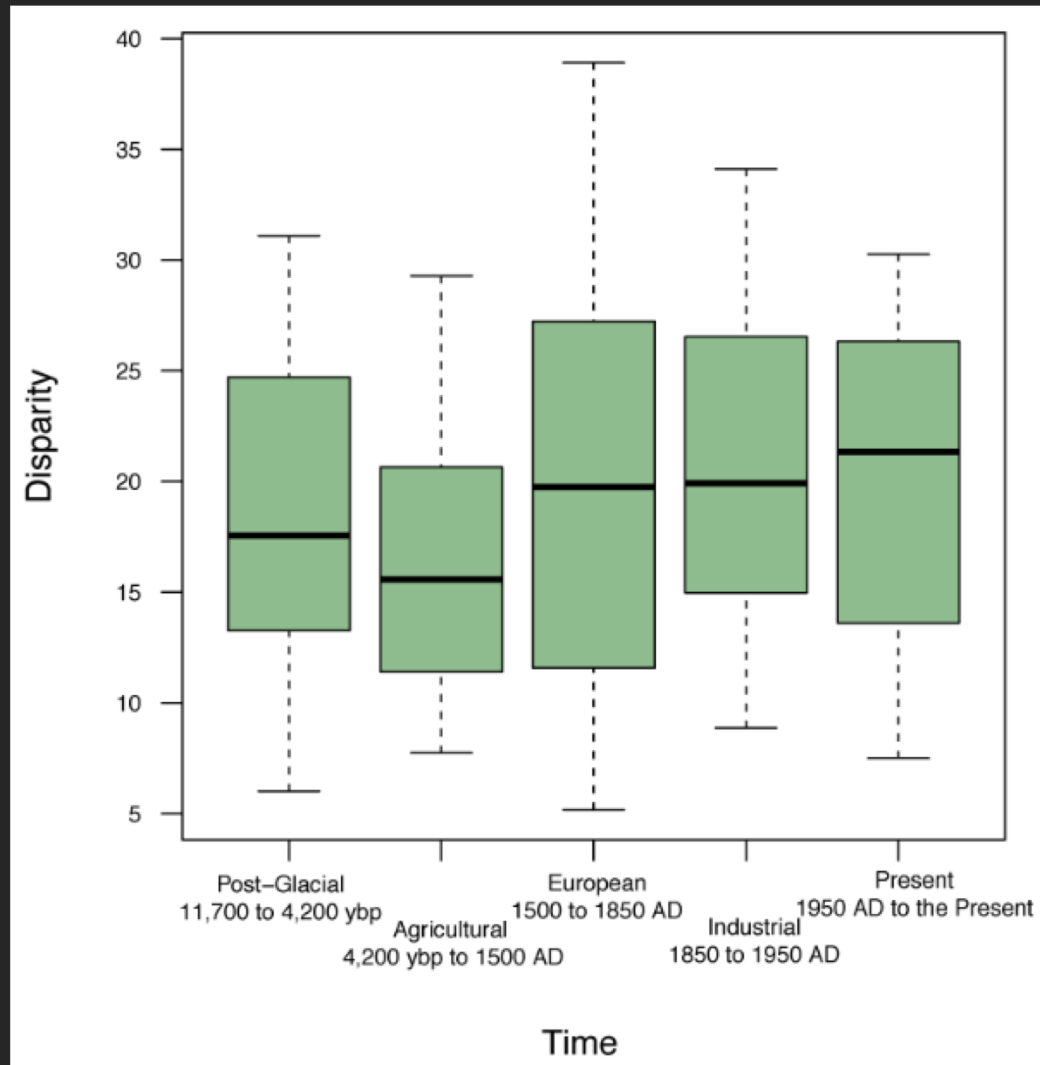
Toussaint 2018

**Pineda-Munoz
2021**

Paleoecology,
climatic niches,
mammals,

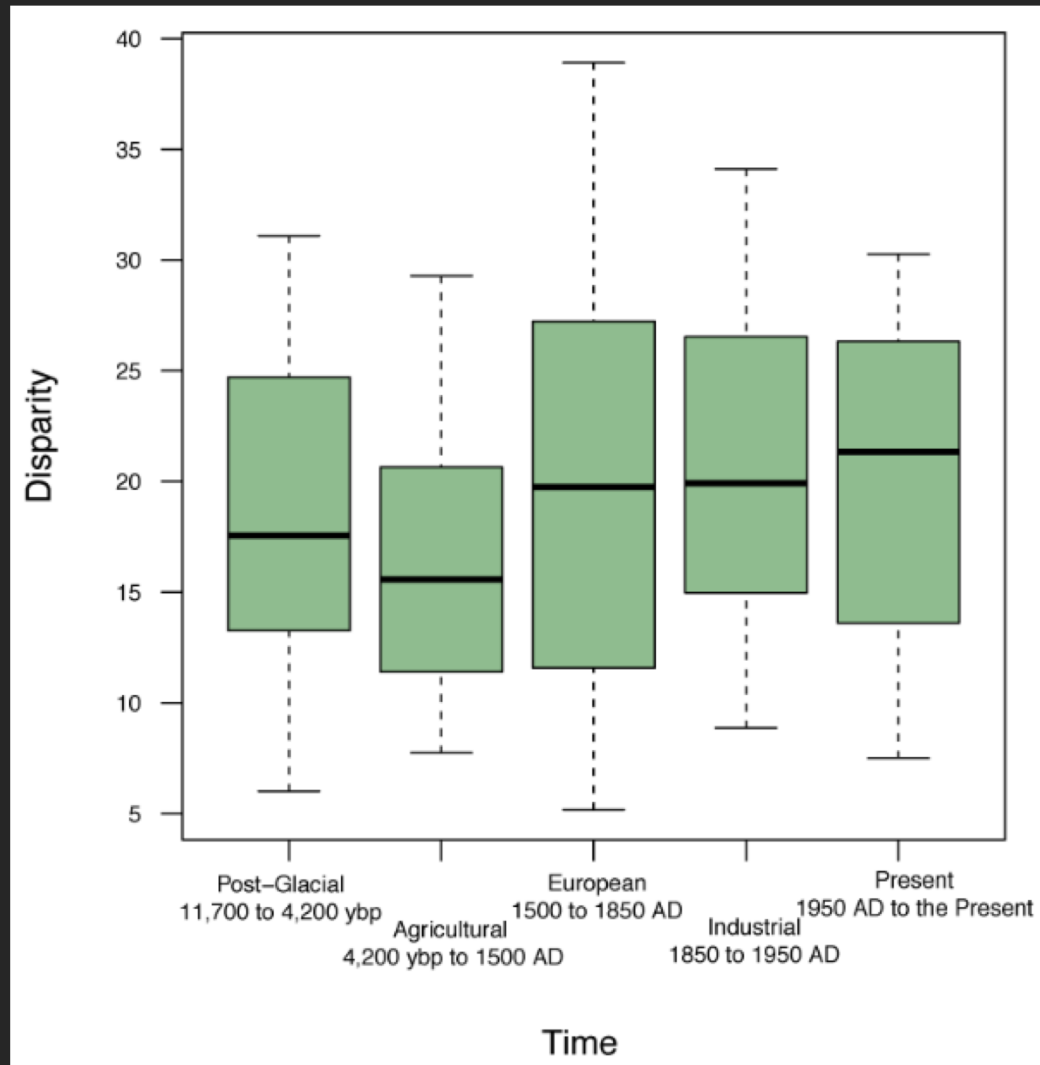
Pineda-Munoz et al. 2021 PNAS – Fig. S2

**Pineda-Munoz
2021**



Pineda-Munoz et al. 2021 PNAS – Fig. S2

**Pineda-Munoz
2021**



Disparity: how dispersed is the data within different time bins?

What are we measuring in the multidimensional space?

Wang 2021

Diversity of
Morphologies

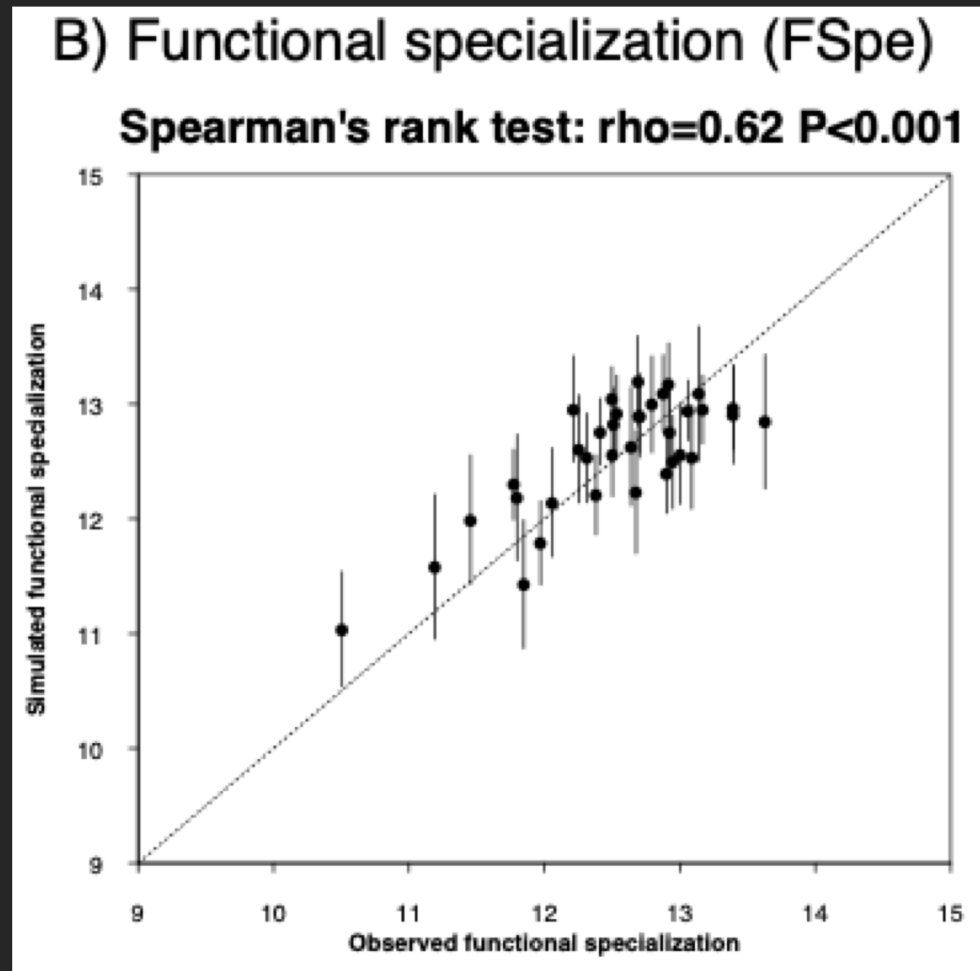
Pineda-Munoz
2021

Data dispersion

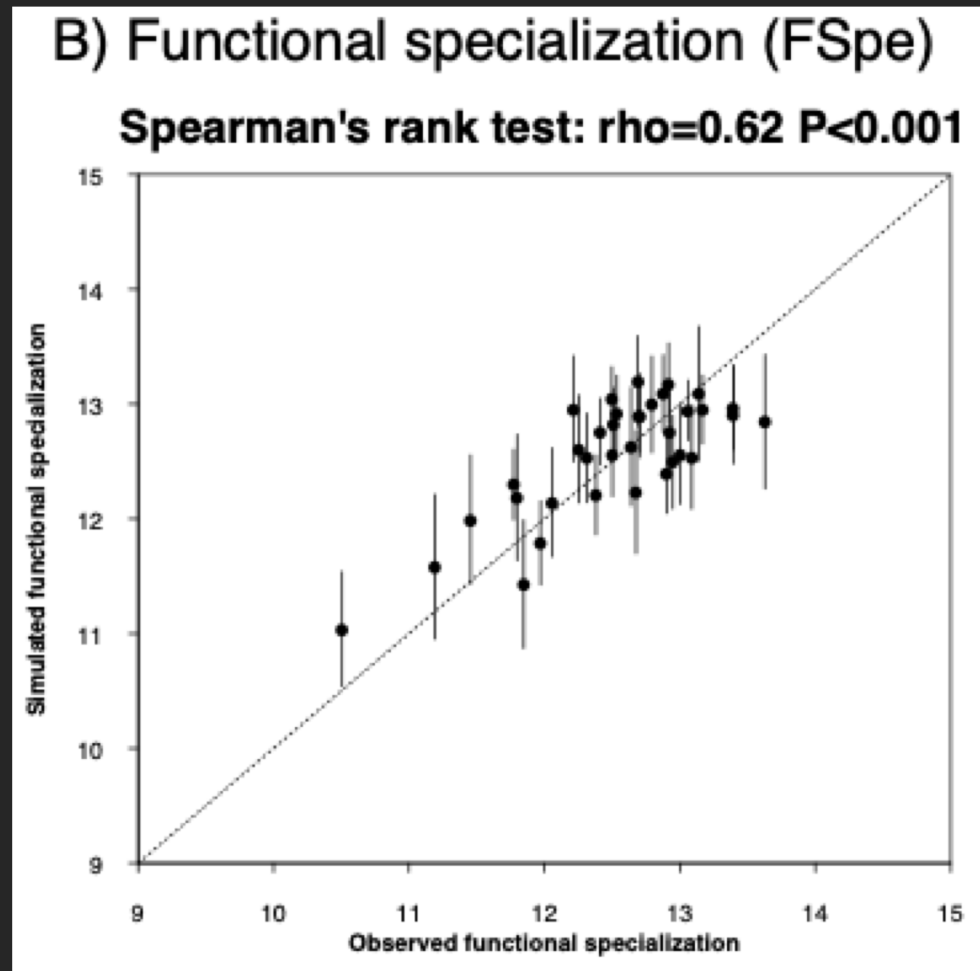
Toussaint 2018

Toussaint 2018

Ecology,
invasive species,
fishes



Toussaint 2018



Toussaint 2018

Functional specialization: What is the intraspecific variation of extreme trait values?

What are we measuring in the multidimensional space?

Wang 2021

Diversity of
Morphologies

Pineda-Munoz
2021

Data dispersion

Toussaint 2018

Functional
specialization

What are we measuring in the multidimensional space?

Wang 2021

Diversity of
Morphologies

$$\frac{\sum_i^n \sqrt{d_i - \frac{\sum d}{n}}}{n}$$

Pineda-Munoz
2021

Data dispersion

Toussaint 2018

Functional
specialization

What are we measuring in the multidimensional space?

Wang 2021

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Pineda-Munoz
2021

Data dispersion

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Toussaint 2018

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Pineda-Munoz
2021

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Toussaint 2018

Functional
specialization

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What are we measuring in the multidimensional space?

Wang 2021

Diversity of
Morphologies

$$\frac{\sum_i^n \sqrt{d_i - \frac{\sum d}{n}}}{n}$$

Pineda-Munoz
2021

Data die

Mean distances
from centroid

$$\frac{\sum d}{n}$$

n

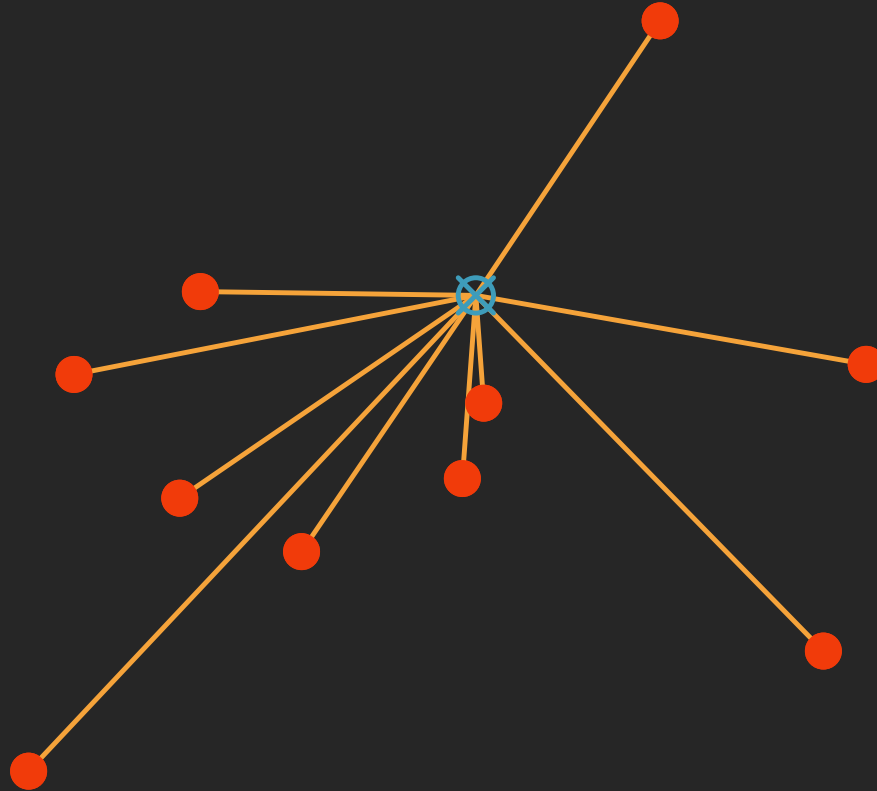
Toussaint 2018

Fun
specialization

$$\frac{\sum_i^n \sqrt{d_i - \frac{\sum d}{n}}}{n}$$

What are we measuring in the multidimensional space?

$$\frac{\sum_i^n \sqrt{d_i - \frac{\sum d}{n}}}{n}$$



Distances from centroid

Different data and different questions used

Different data and different
questions used
= different biological processes

Different data and different
questions used
= different biological processes

BUT also:

Different data and different
questions used
= different biological processes

BUT also:

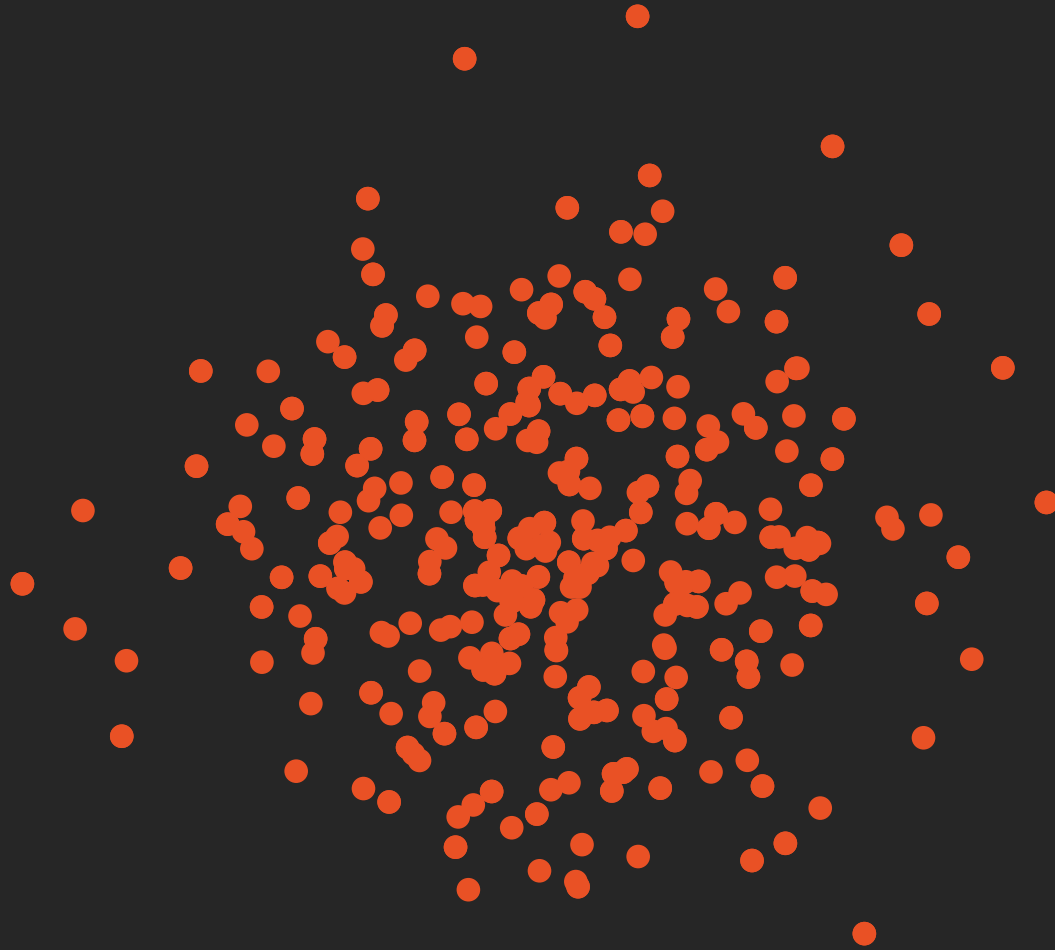
Measuring things in a similar
way in similar objects

Different data and different
questions used
= different biological processes

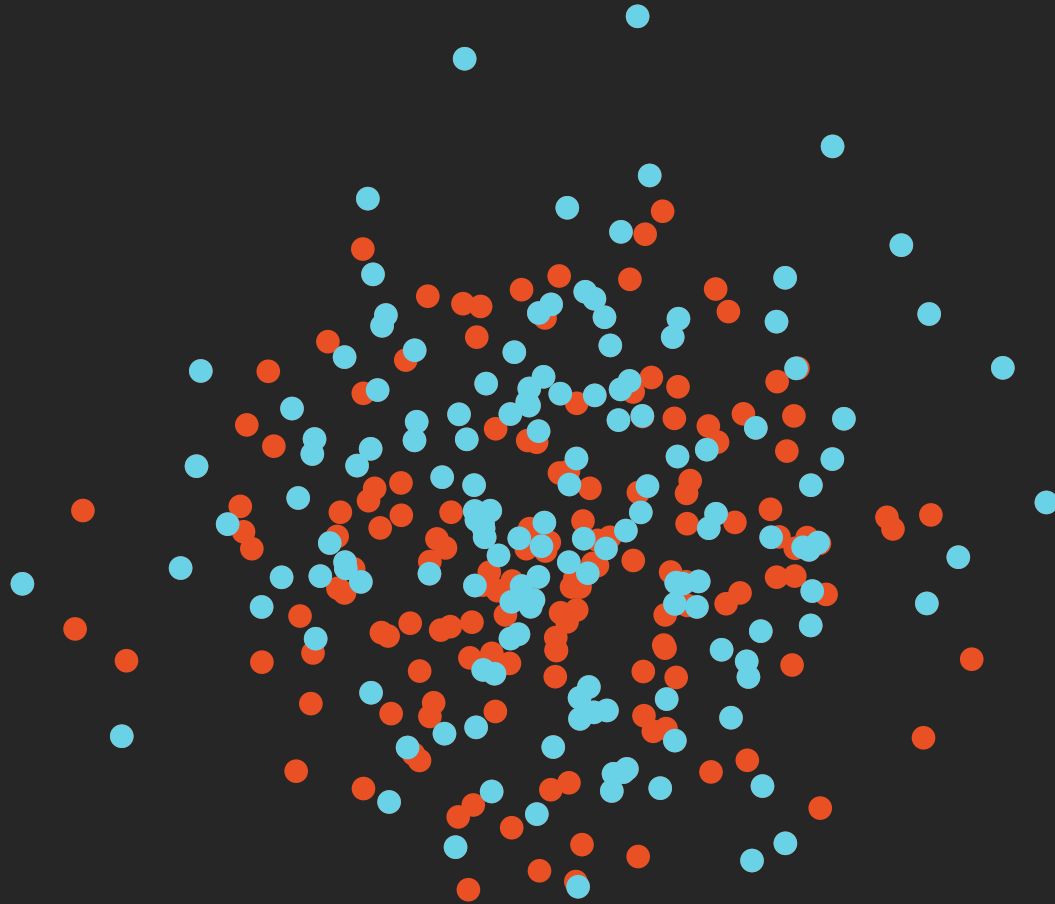
BUT also:

Measuring things in a similar
way in similar objects
= similar mathematical patterns

How does the metric works in multidimensional space?

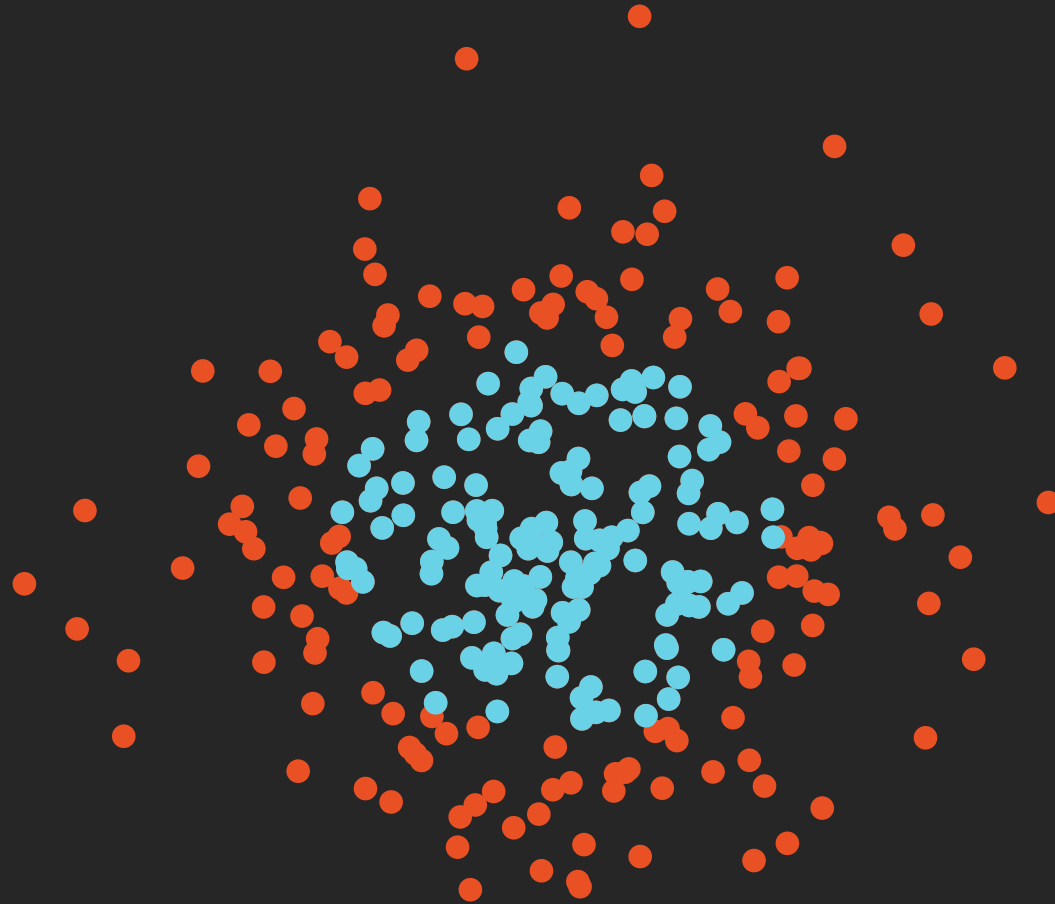


How does the metric works in multidimensional space?



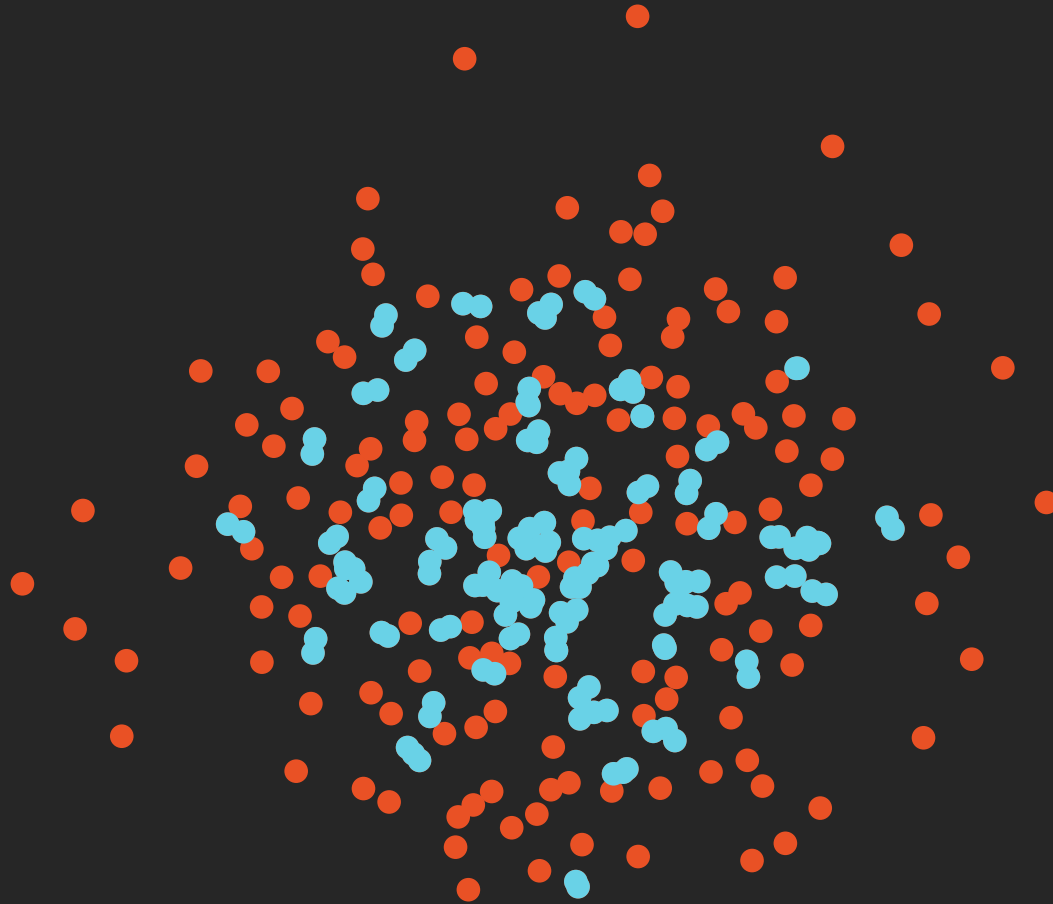
Random change (null)

How does the metric works in multidimensional space?



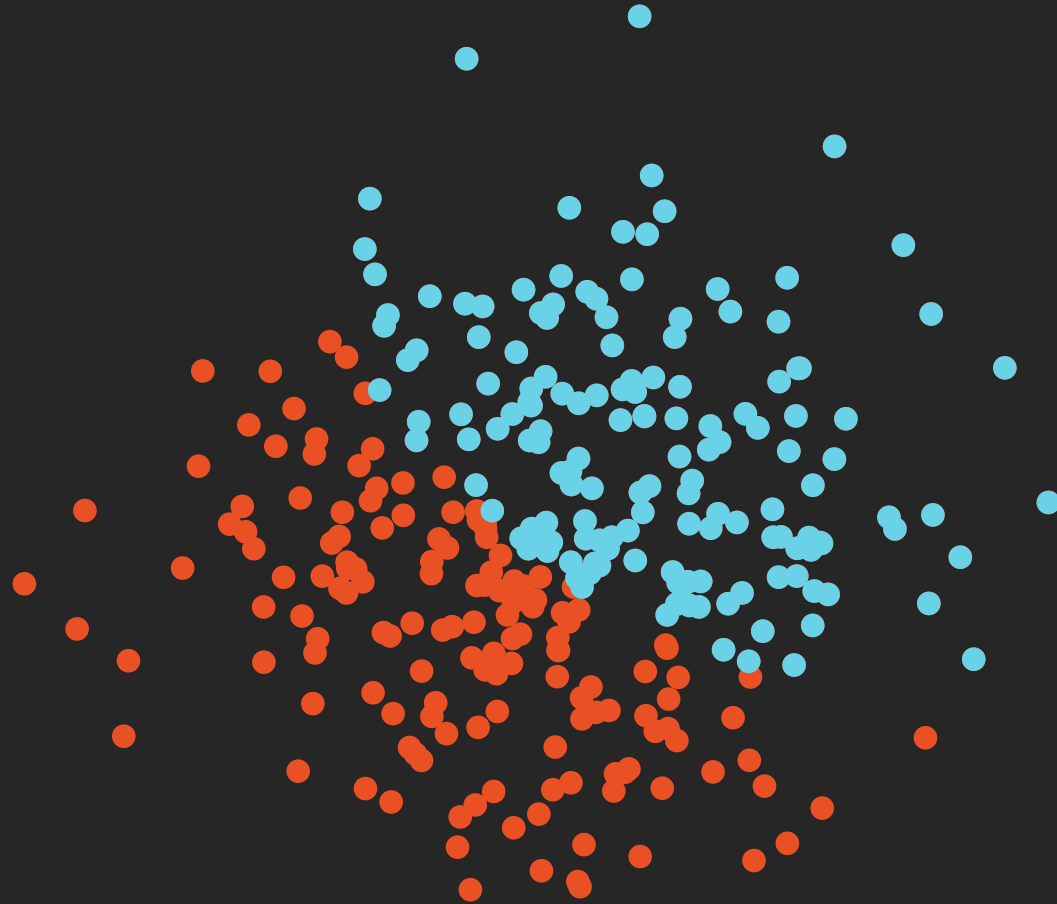
Volume change

How does the metric works in multidimensional space?

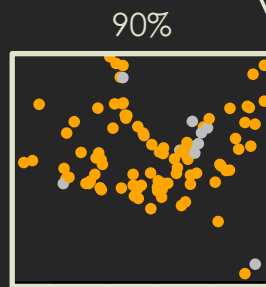
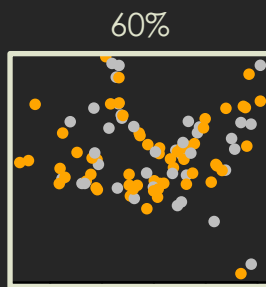
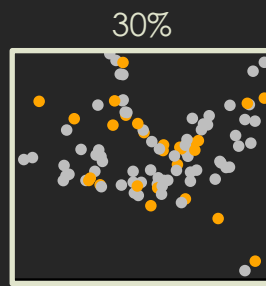
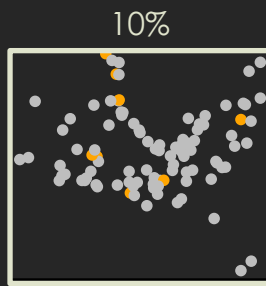


Density change

How does the metric works in multidimensional space?

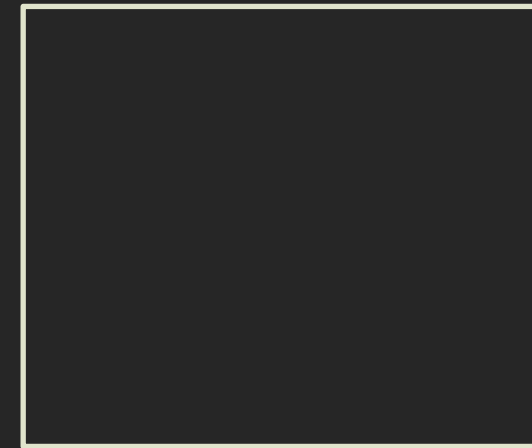


Position change



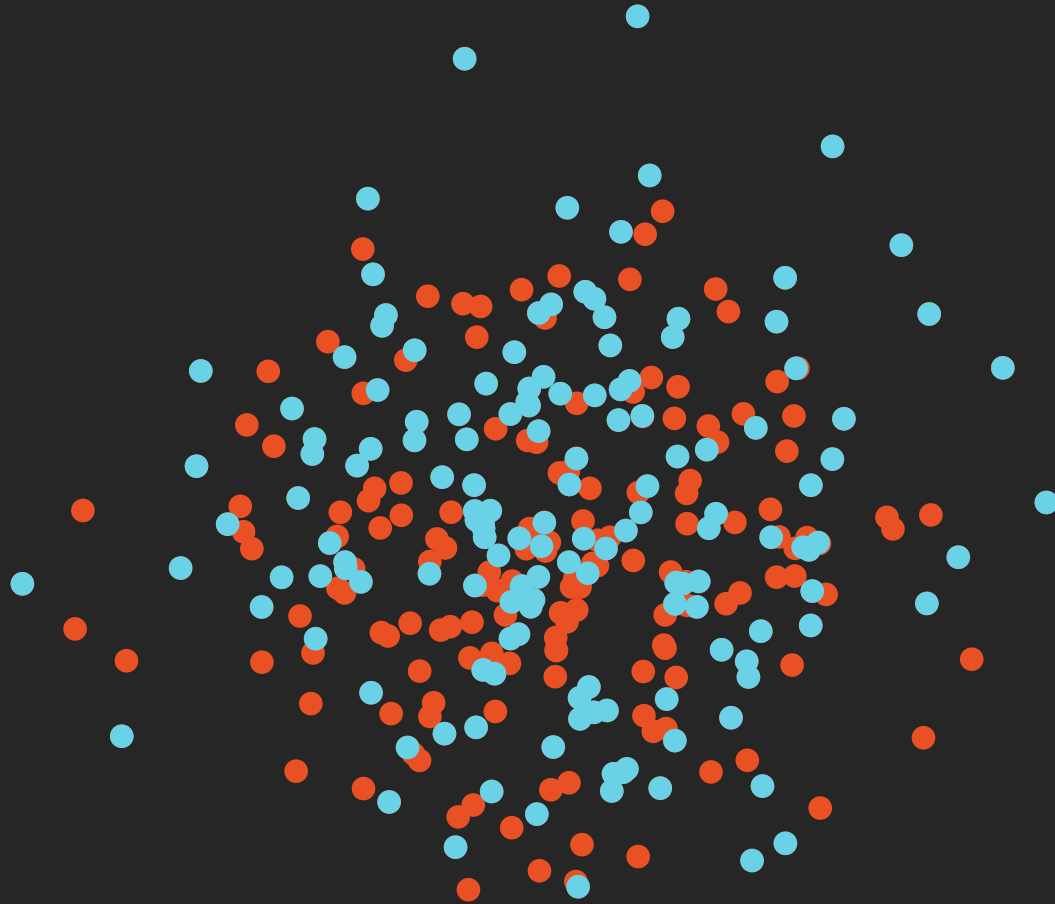
Sum of
variances

Random

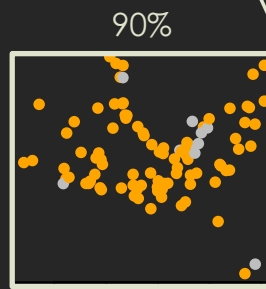
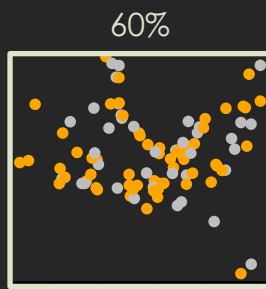
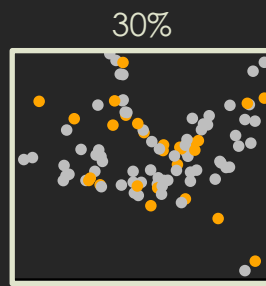
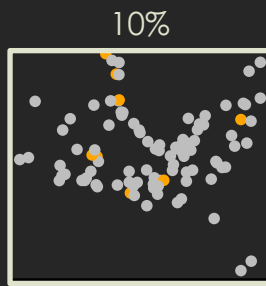


% data available

How does the metric works in multidimensional space?



Random change (null)

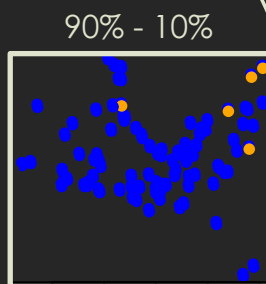
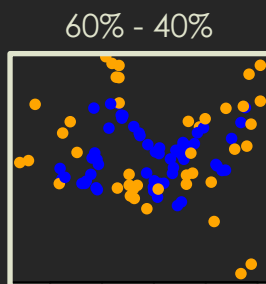
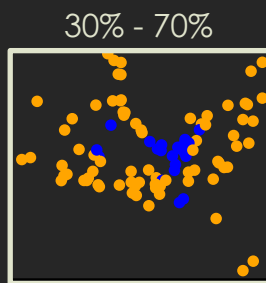
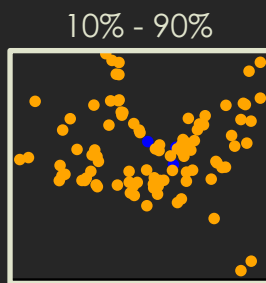
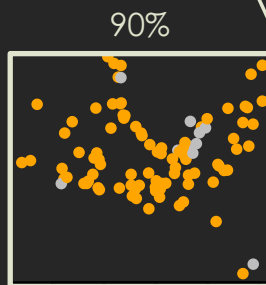
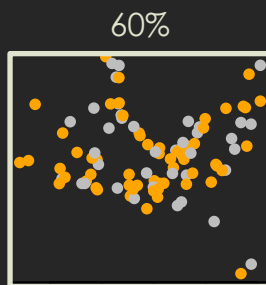
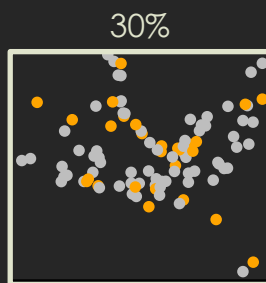
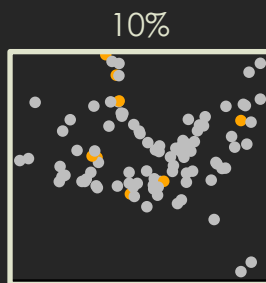


Sum of
variances

Random



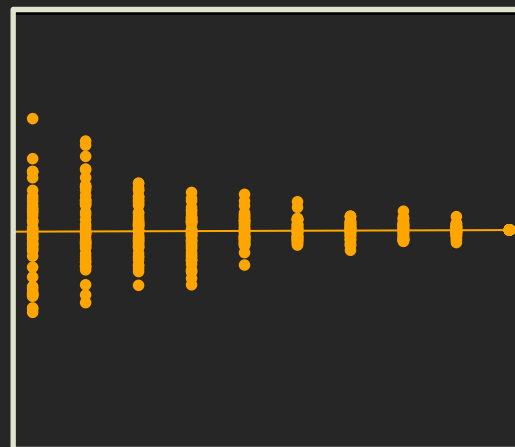
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Sum of
variances

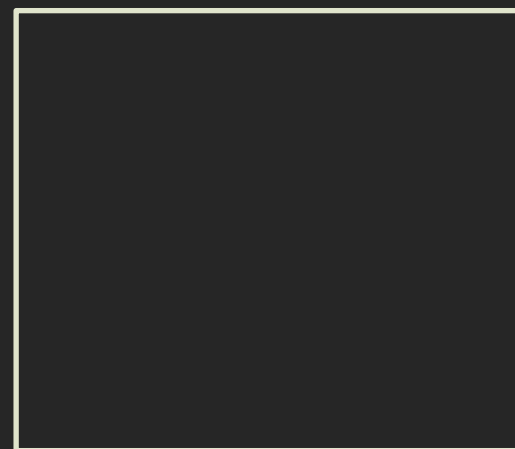
Sum of
variances

Random



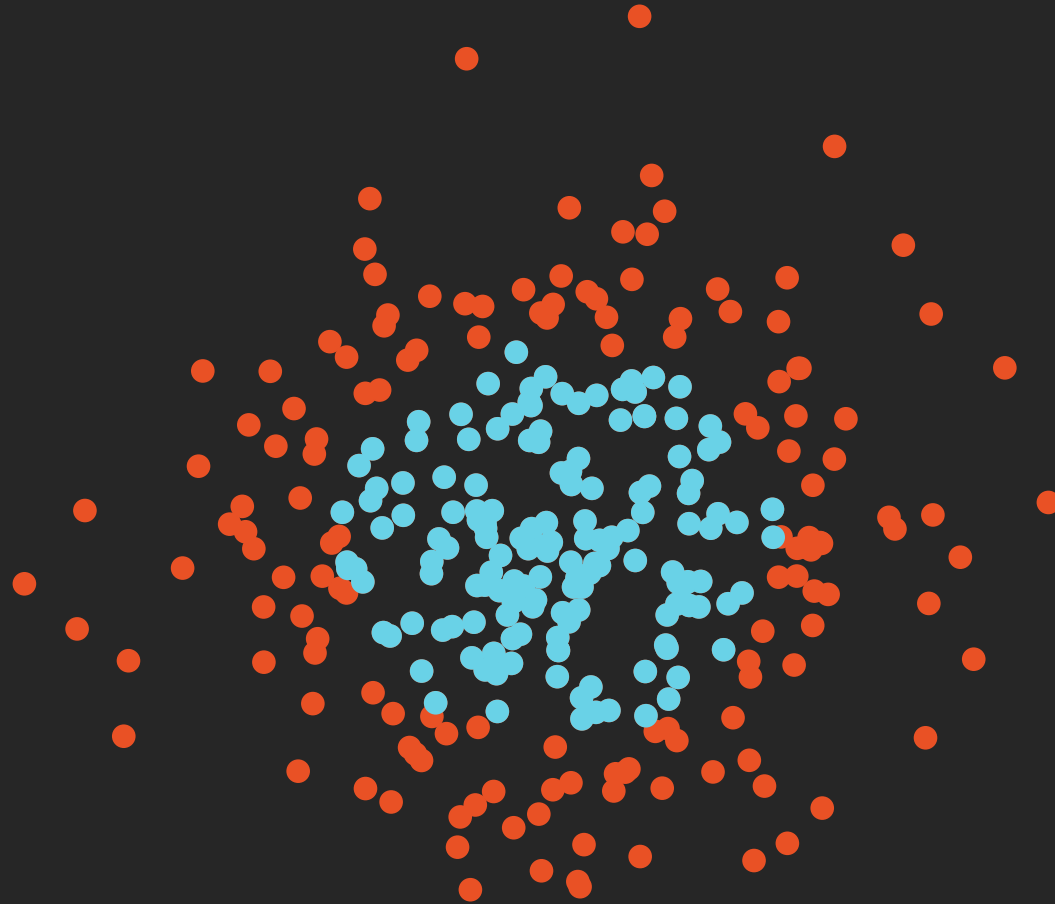
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Size

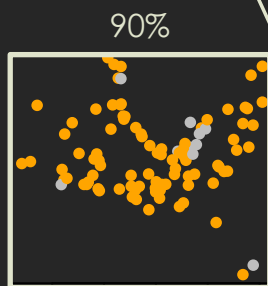
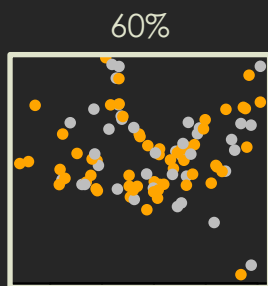
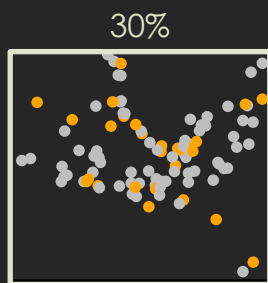
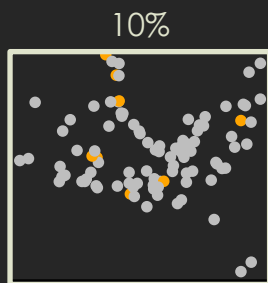


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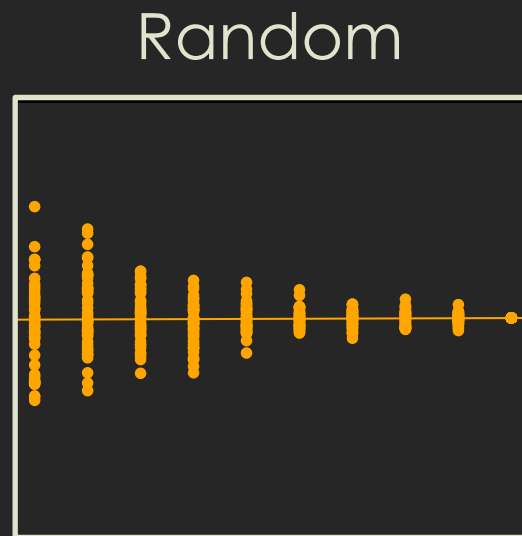
How does the metric works in multidimensional space?



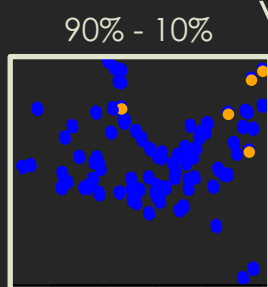
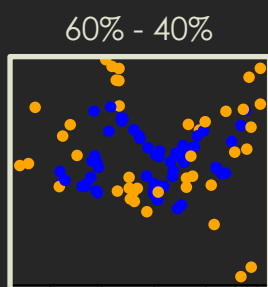
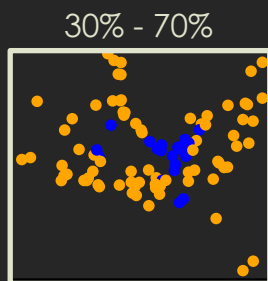
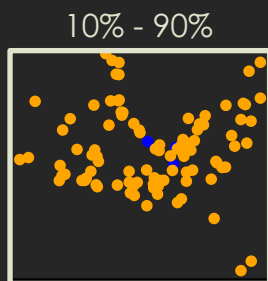
Volume change



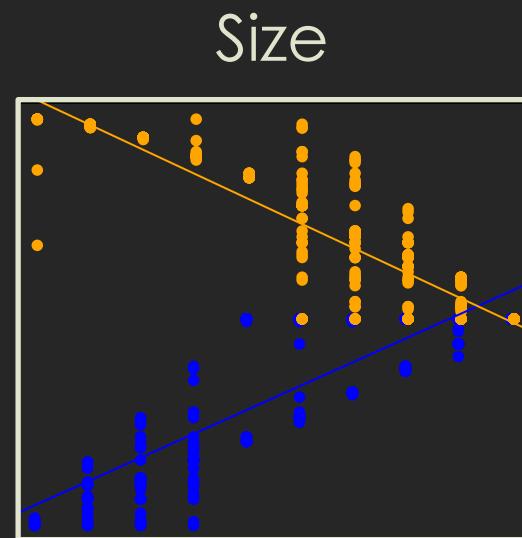
Sum of
variances



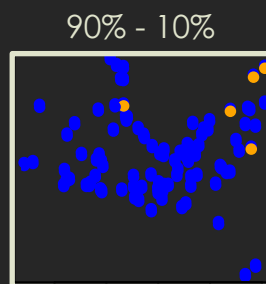
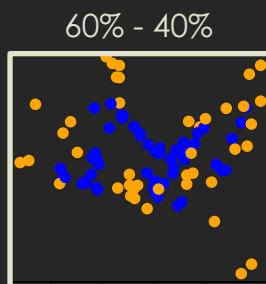
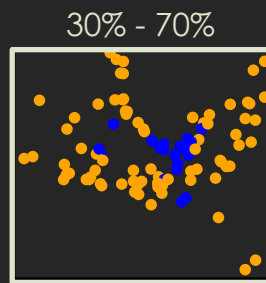
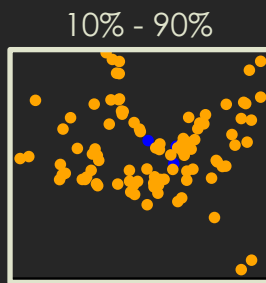
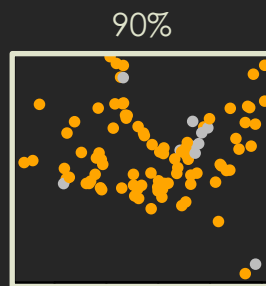
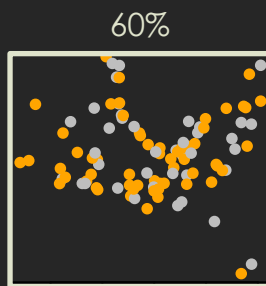
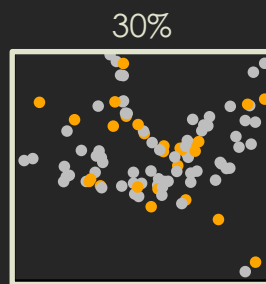
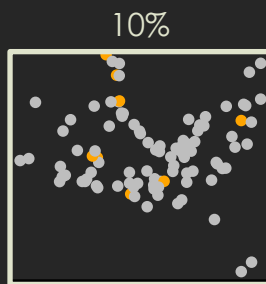
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Sum of
variances



% data available

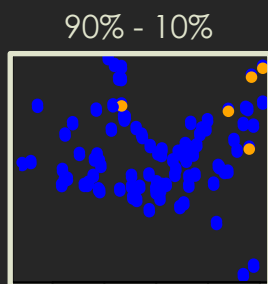
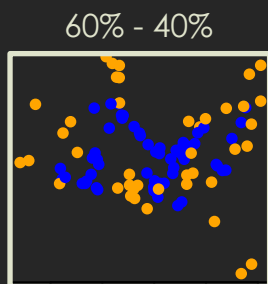
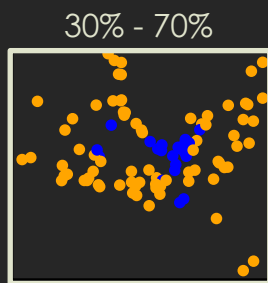
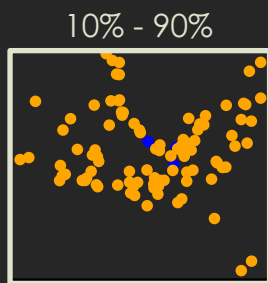
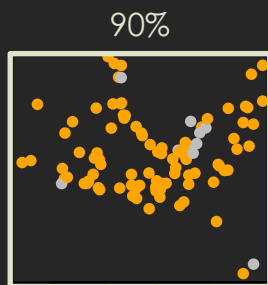
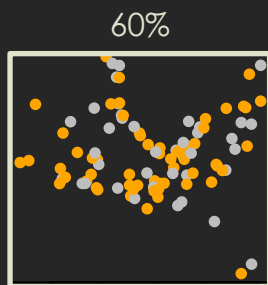
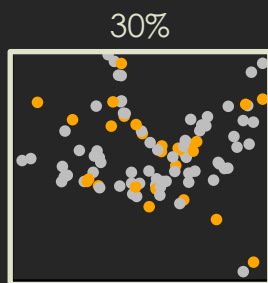
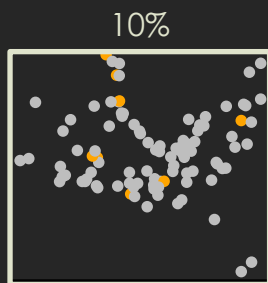


Sum of
ranges



Sum of
ranges





Sum of
ranges

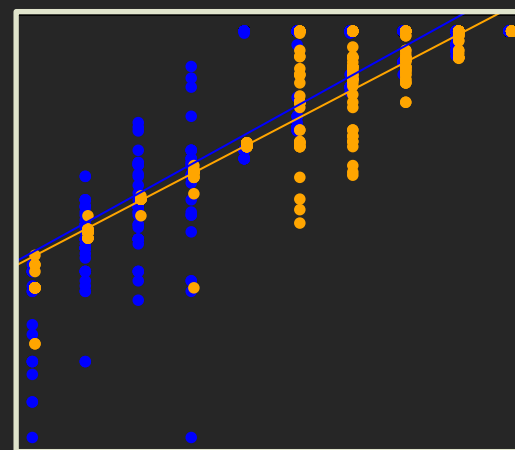
Random



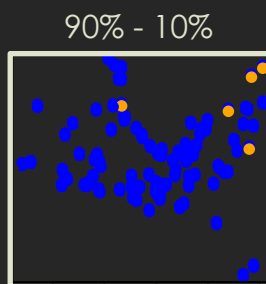
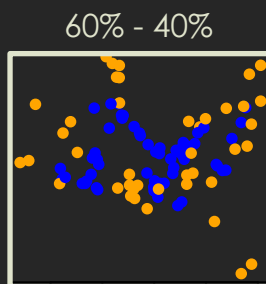
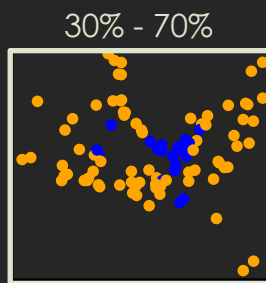
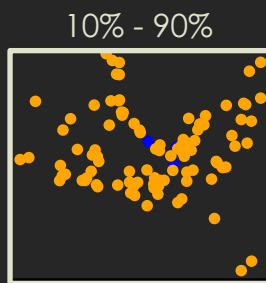
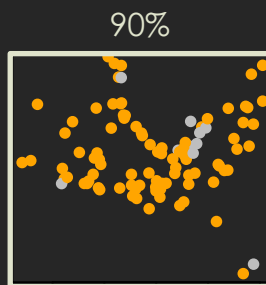
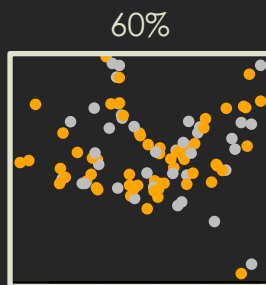
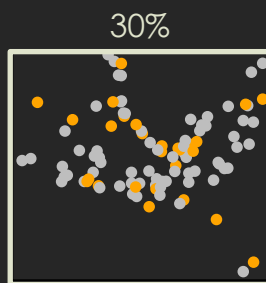
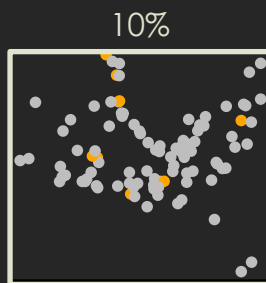
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Size

Sum of
ranges

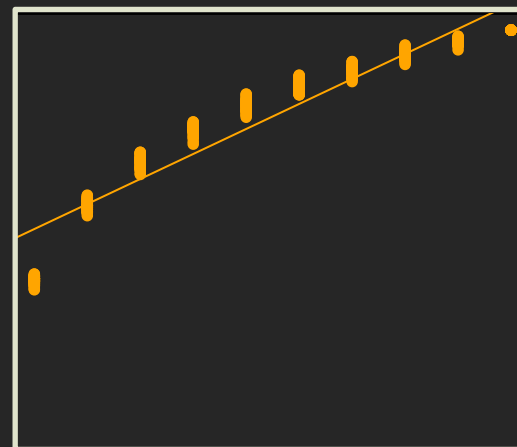


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Sum of
ranges

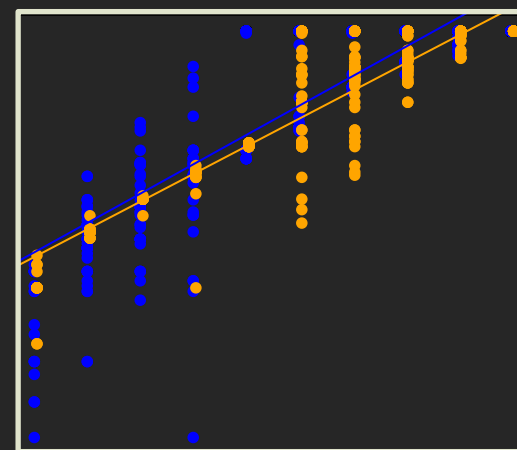
Random



% data available

Sum of
ranges

Size



% data available



moms: measuring
occupancy in
multidimensional space

moms: Measuring Occupancy in Multidimensional Spaces

Guillermo T. Puttick M, Marcy A, and Weisbecker V (2019). Moms: an exploratory tool for multidimensional space analyses. Some journal. doi: [some DOI](#) .

[USER MANUAL](#)

Multidimensional space parameters

Select the type of space to use:

Input

Select a multidimensional matrix in csv format.

Browse...

trait_space_full.csv

Upload complete

Upload your own multidimensional matrix! The matrix must be in .csv format, with numeric values no NAs.

Space modification

Limit

Proportion to remove:

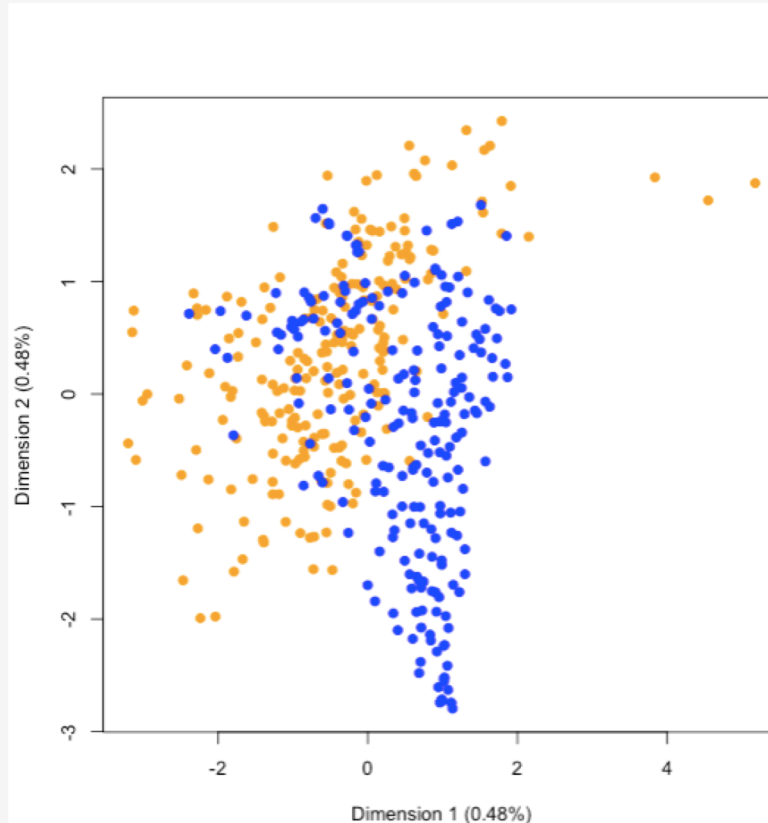
0.1

0.5

0.9

0.1 0.18 0.26 0.34 0.42 0.5 0.58 0.66 0.74 0.82 0.9

☐ Inverse removal



Multidimensional space occupancy (disparity):

n	Sum of variances	change
443	264.30	
221	259.90	-1.66 %

Space occupancy metric (disparity)

Metric type

Volume

Volume metric

Sum of variances

☐ Show metric code

You can find more informations about the metric types in the [disPrity manual](#) .

Display

Horizontal axis

1

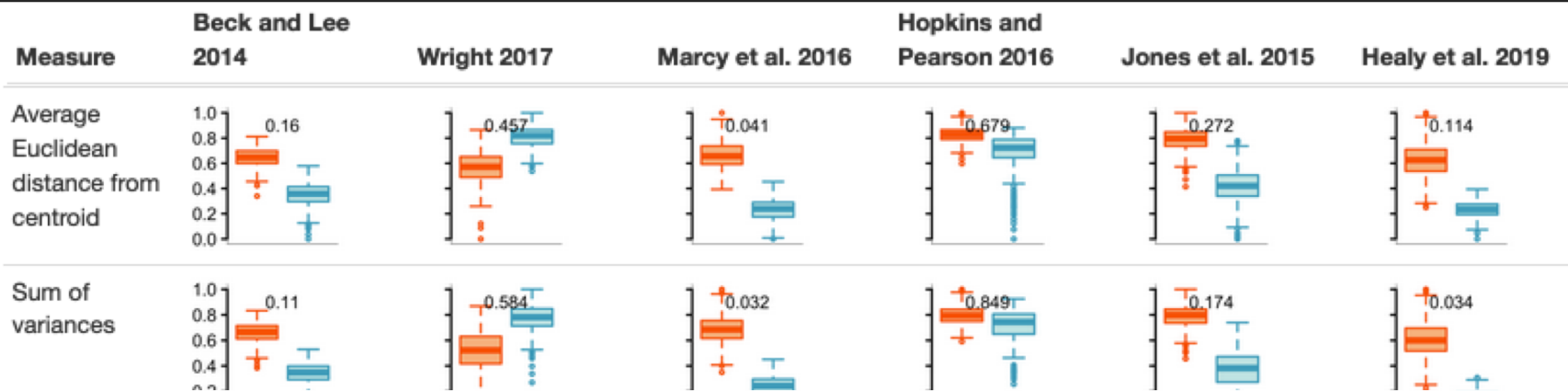
Vertical axis

2

Colours

Contrast

☐ Axis with the same scale



DOI: 10.1002/ece3.6452

ORIGINAL RESEARCH

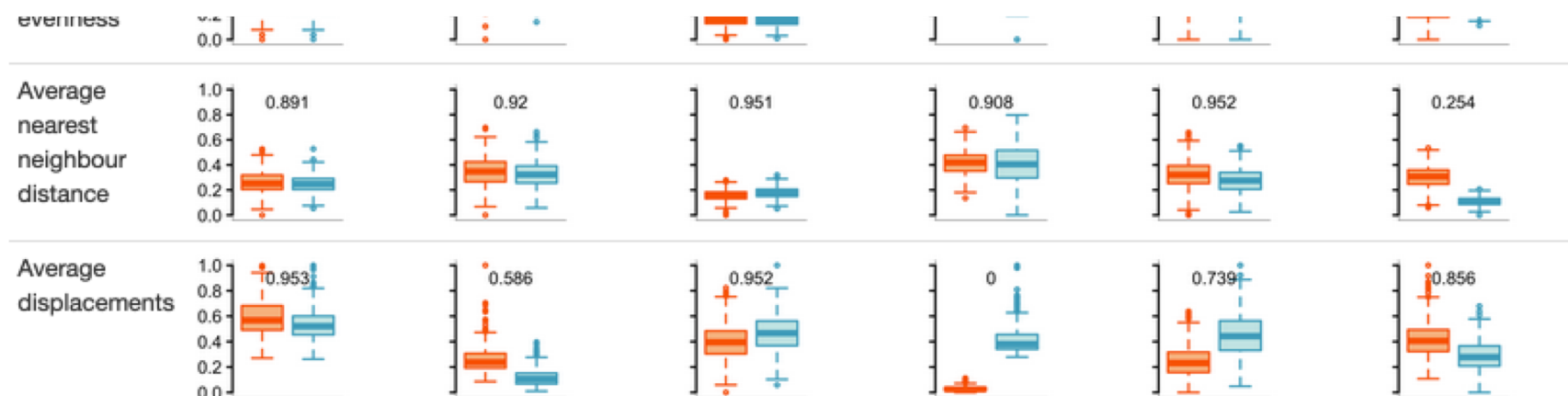
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Shifting spaces: Which disparity or dissimilarity measurement best summarize occupancy in multidimensional spaces? 📊 🏠 📌

Thomas Guillaume^{1,2} | Mark N. Puttick³ | Ariel E. Marcy¹ | Vera Weisbecker^{1,4}



Shifting spaces: Which disparity or dissimilarity measurement best summarize occupancy in multidimensional spaces?

Thomas Guillaume^{1,2}  | Mark N. Puttick³  | Ariel E. Marcy¹  | Vera Weisbecker^{1,4} 

Measuring things in a similar
way in similar objects
= similar mathematical patterns

Different data and different
questions used
= different biological processes

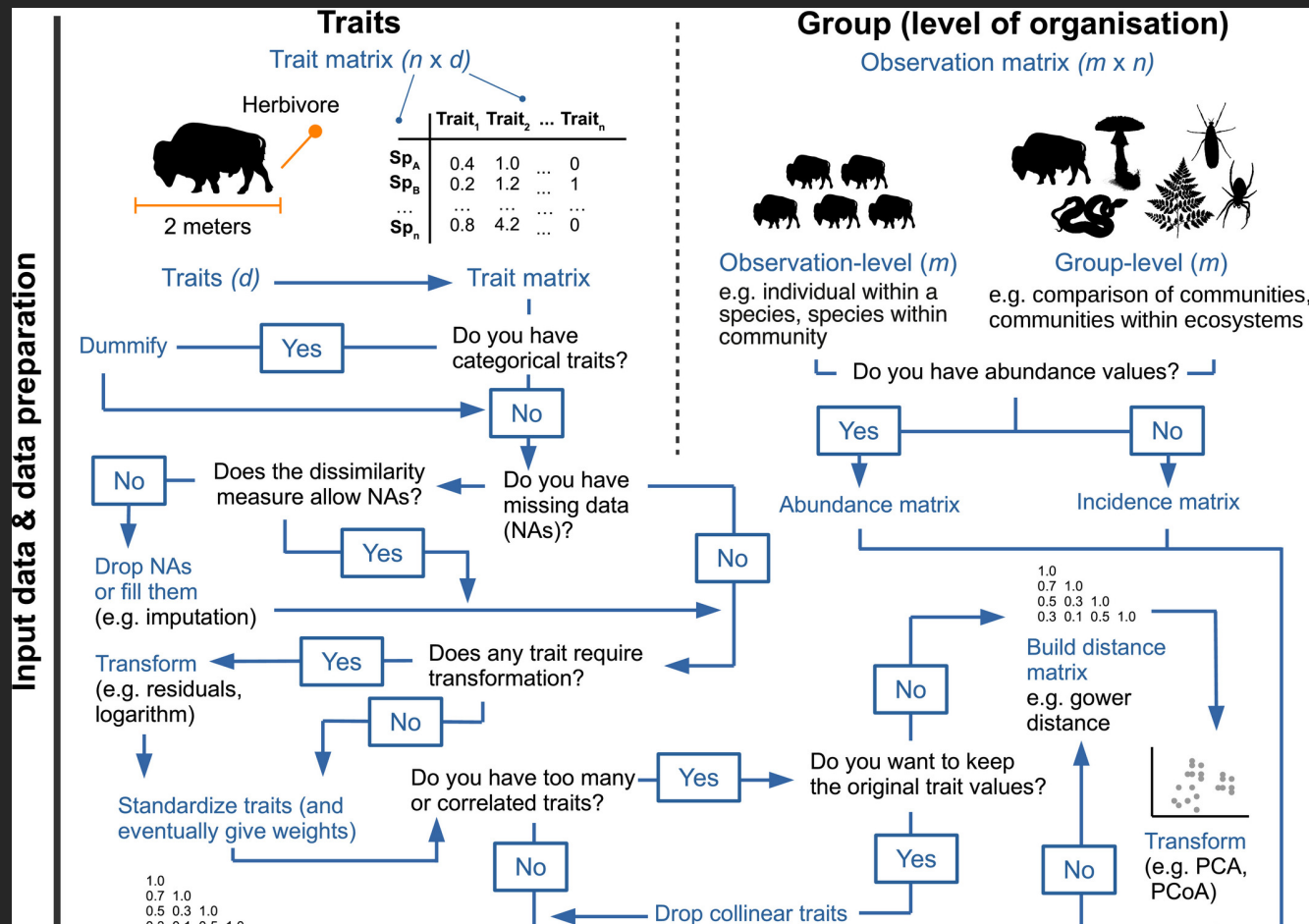
BUT also:

Measuring things in a similar
way in similar objects
= similar mathematical patterns

But maybe we need a
process based approach?

Concepts and applications in functional diversity

Stefano Mammola^{1,2}  | Carlos P. Carmona³  | Thomas Guillaume⁴  | Pedro Cardoso¹ 



Different data and different
question
= different processes



Coming soon!

but also:

Measuring things in a similar
way in similar objects
= similar mathematical patterns



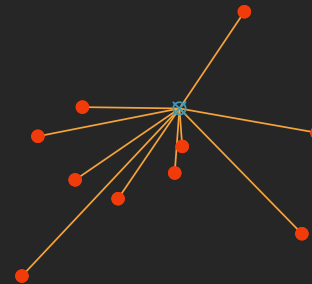
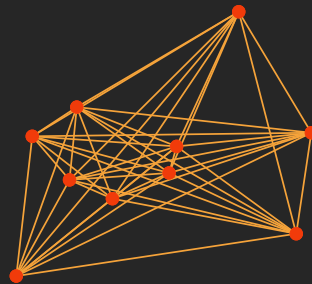
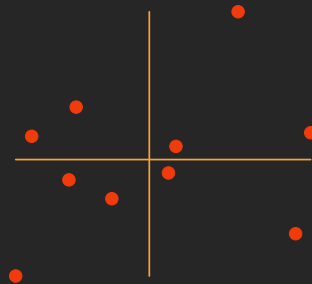
Thanks!



github.com/TGuillerme/dispRity

github.com/TGuillerme/moms

github.com/cardosopmb/BAT



Guillerme 2018 – *Methods in Ecology and Evolution*
Guillerme et al. 2020 – *Ecology and evolution*
Mammola et al. 2021 – *Functional ecology*

