Affective Neuroscience and Decision-making Lab

@ANDlab3

Every individual makes a difference:

A trinity derived from linking individual brain morphometry, connectivity and mentalising ability

Presenter: Zhaoning Li 李肇宁

PROLOGUE

(Adapted from 12371.cn)

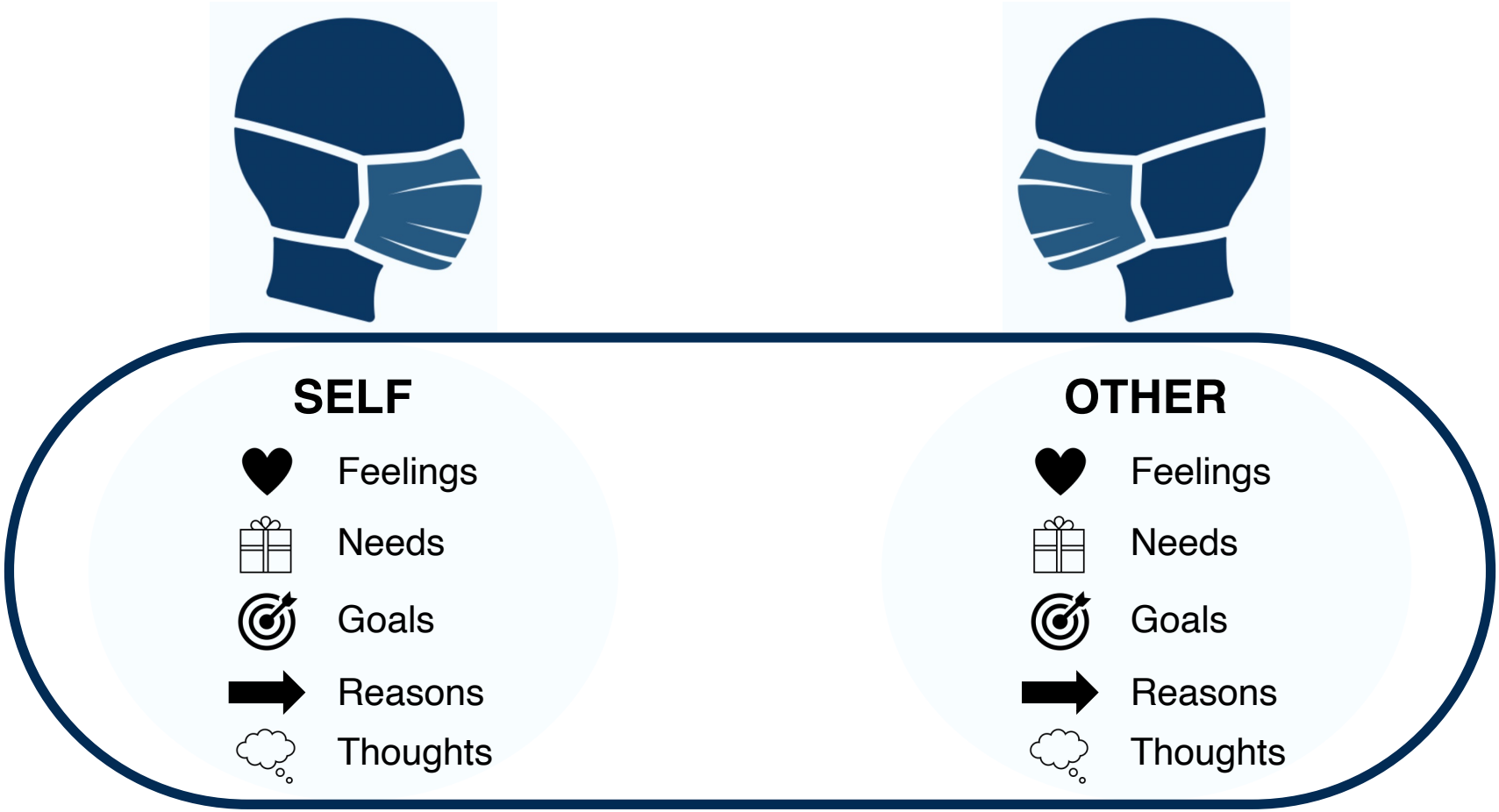
MAO TSE-TUNG – ON CONTRADICTION

'But this general character is contained in every individual character; without individual character there can be no general character. If all individual character were removed, what general character would remain?'

"矛盾的普遍性和矛盾的特殊性的关系，就是矛盾的**共性**和**个性**的关系。其**共性**是矛盾存在与一切过程中，并贯串于一切过程的始终，矛盾即是运动，即是事物，即是过程，也即是思想。否认事物的矛盾就是否认了一切。这是共通的道理，古今中外，概莫能外。所以它是**共性**，是绝对性。然而这种**共性**，即**包含于一切个性之中，无个性即无共性。假如除去一切个性，还有什么共性呢？**"

BACKGROUND

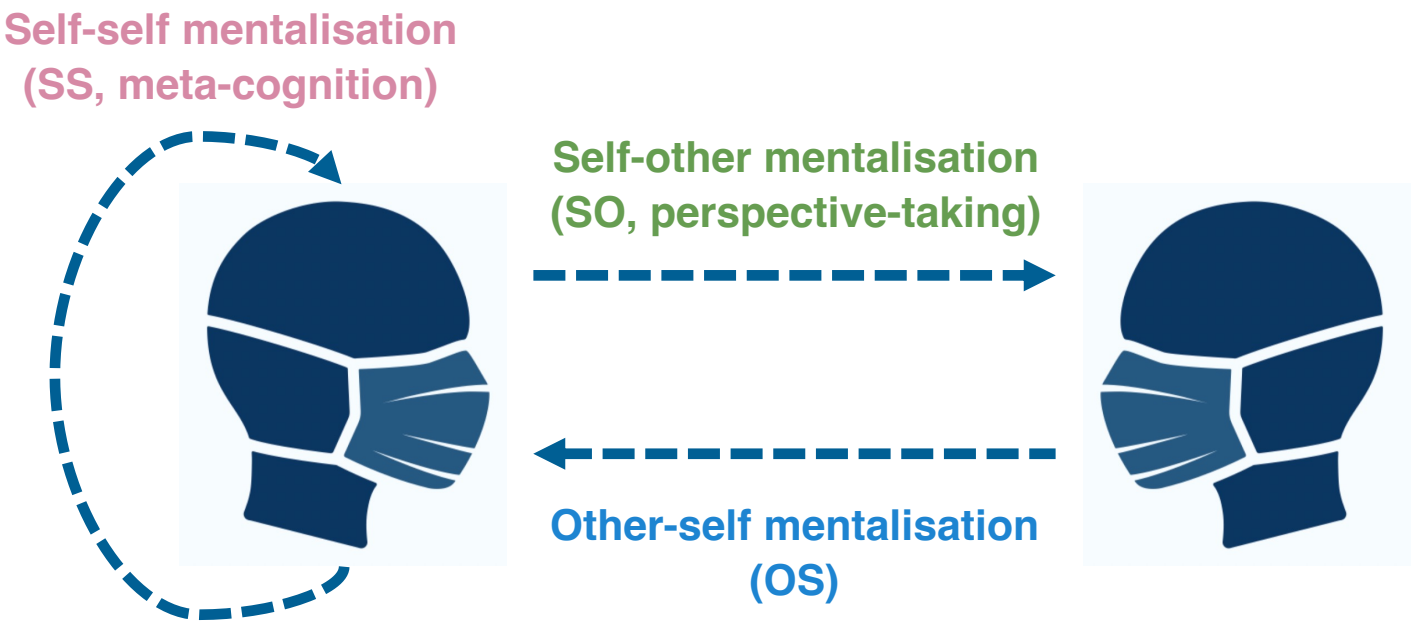
Mentalising ability is a pivotal and fundamental component of human social cognition.



(Adapted from BioRender.com)

BACKGROUND

However, considering the multifaceted nature of mentalising ability [1], little research has focused on characterising individual differences in different mentalising components [2].

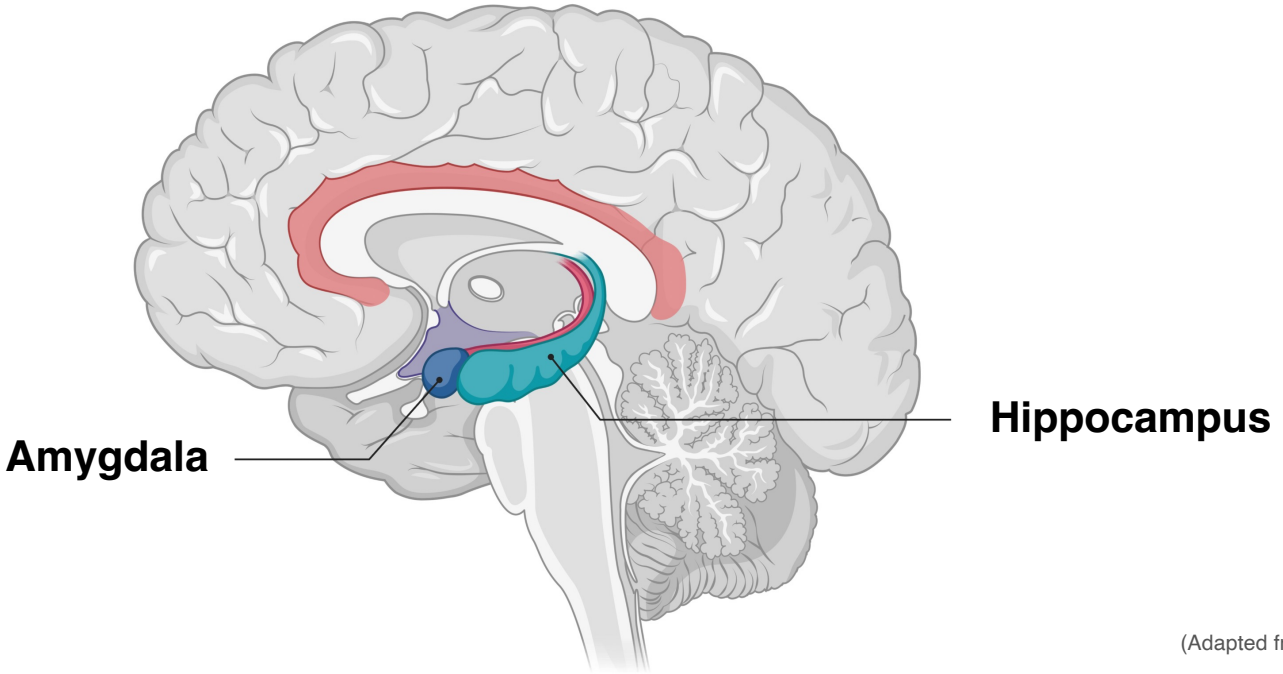


(Adapted from BioRender.com)

1. Wu, H., Liu, X., Hagan, C. C., & Mobbs, D. (2020b). Mentalising during social interaction: A four component model. *Cortex*, *126*, 242–252.
2. Wu, H., Fung, B. J., & Mobbs, D. (2022). Mentalising during social interaction: The development and validation of the interactive mentalising questionnaire. *Frontiers in Psychology*, *12*.

BACKGROUND

And even less research has been devoted to investigating how the variance in the structural and functional patterns of the amygdala and hippocampus, two vital subcortical regions of the 'social brain' [3, 4], are related to inter-individual variability in mentalising ability.



(Adapted from BioRender.com)

3. Bickart, K. C., Dickerson, B. C., & Barrett, L. F. (2014). The amygdala as a hub in brain networks that support social life. *Neuropsychologia*, *63*, 235–248.
4. Montagrin, A., Saiote, C., & Schiller, D. (2018). The social hippocampus. *Hippocampus*, *28*, 672–679.

RESEARCH QUESTION

Whether inter-individual variability in the structural or functional patterns of the above two brain regions is associated with that in different mentalising components?

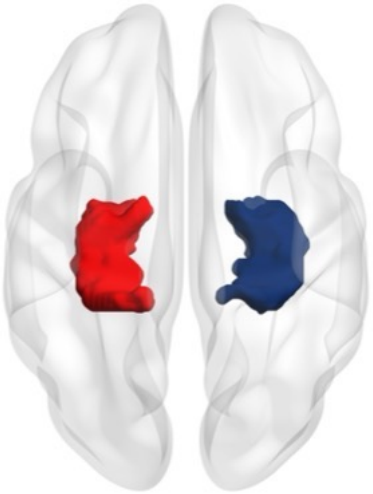
METHODS

MMS: Surface-based multivariate morphometry statistics

(a)

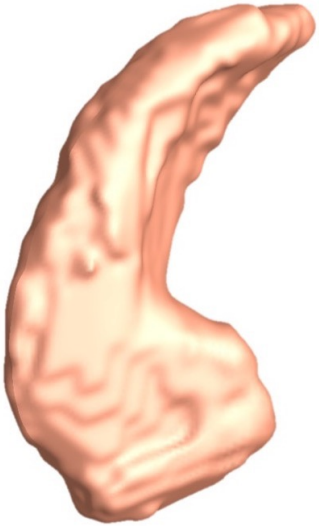
T1-weighted MRI scans

(b)



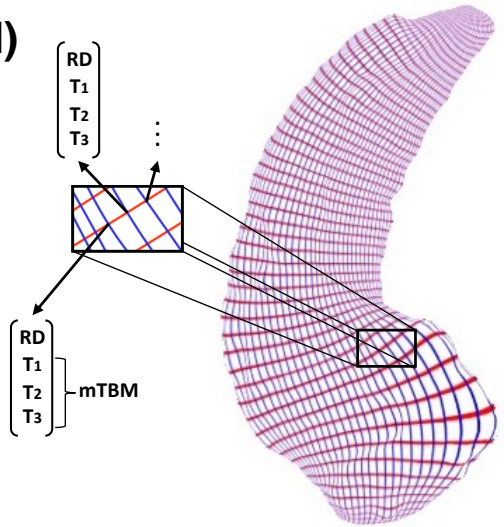
Hippocampal segmentation

(c)



Smoothed surface

(d)

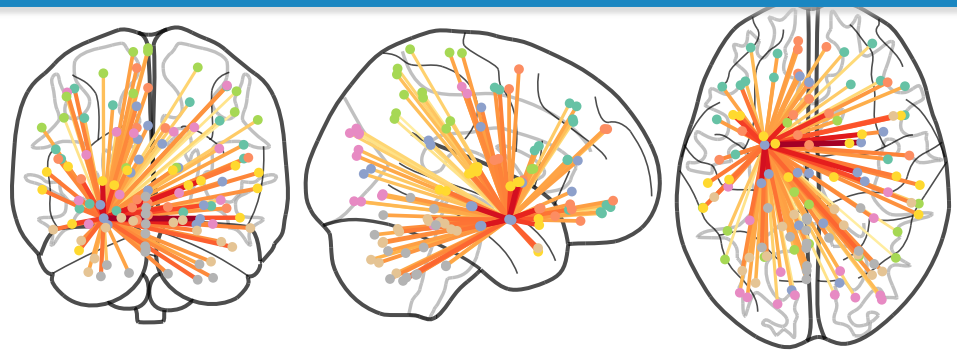


Multivariate morphometry statistics

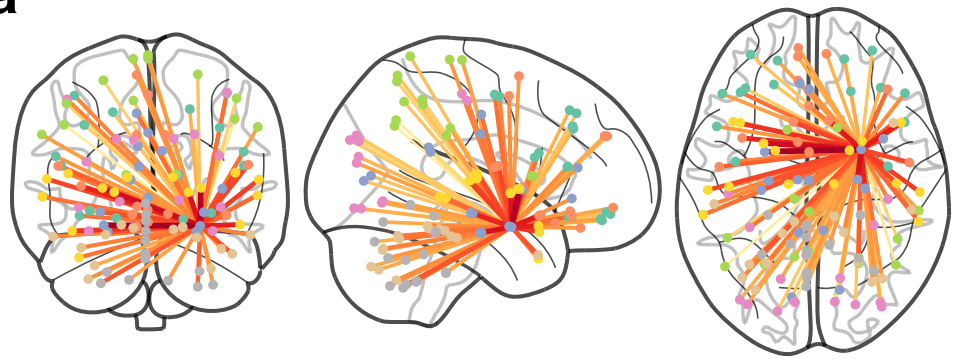
METHODS

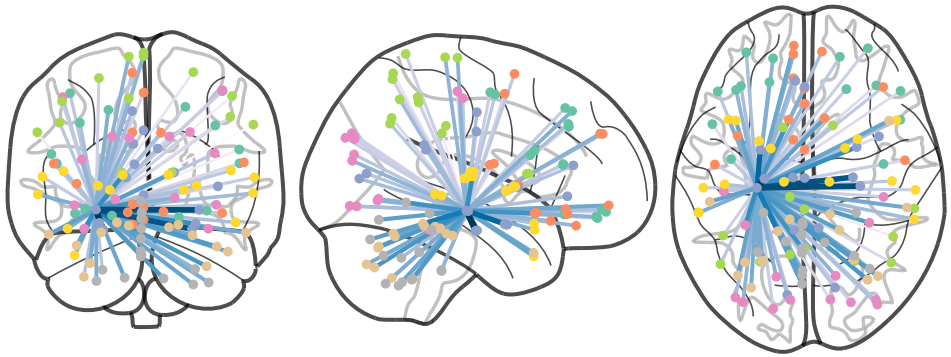
Rs-FC: Resting-state functional connectivity

Left amygdala

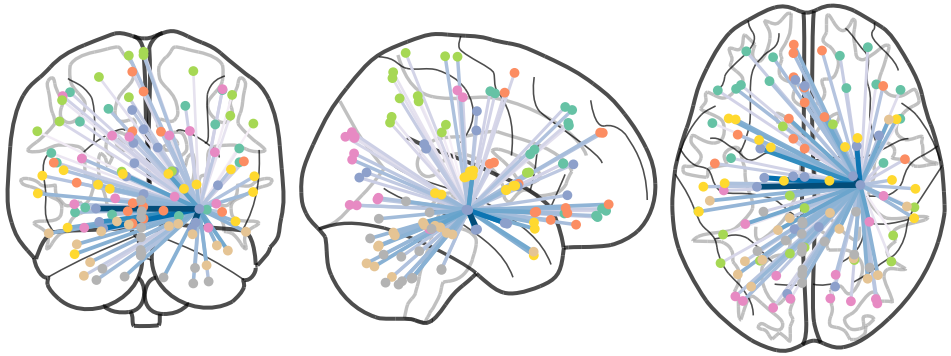


Right amygdala

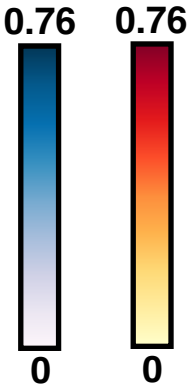




Left hippocampus

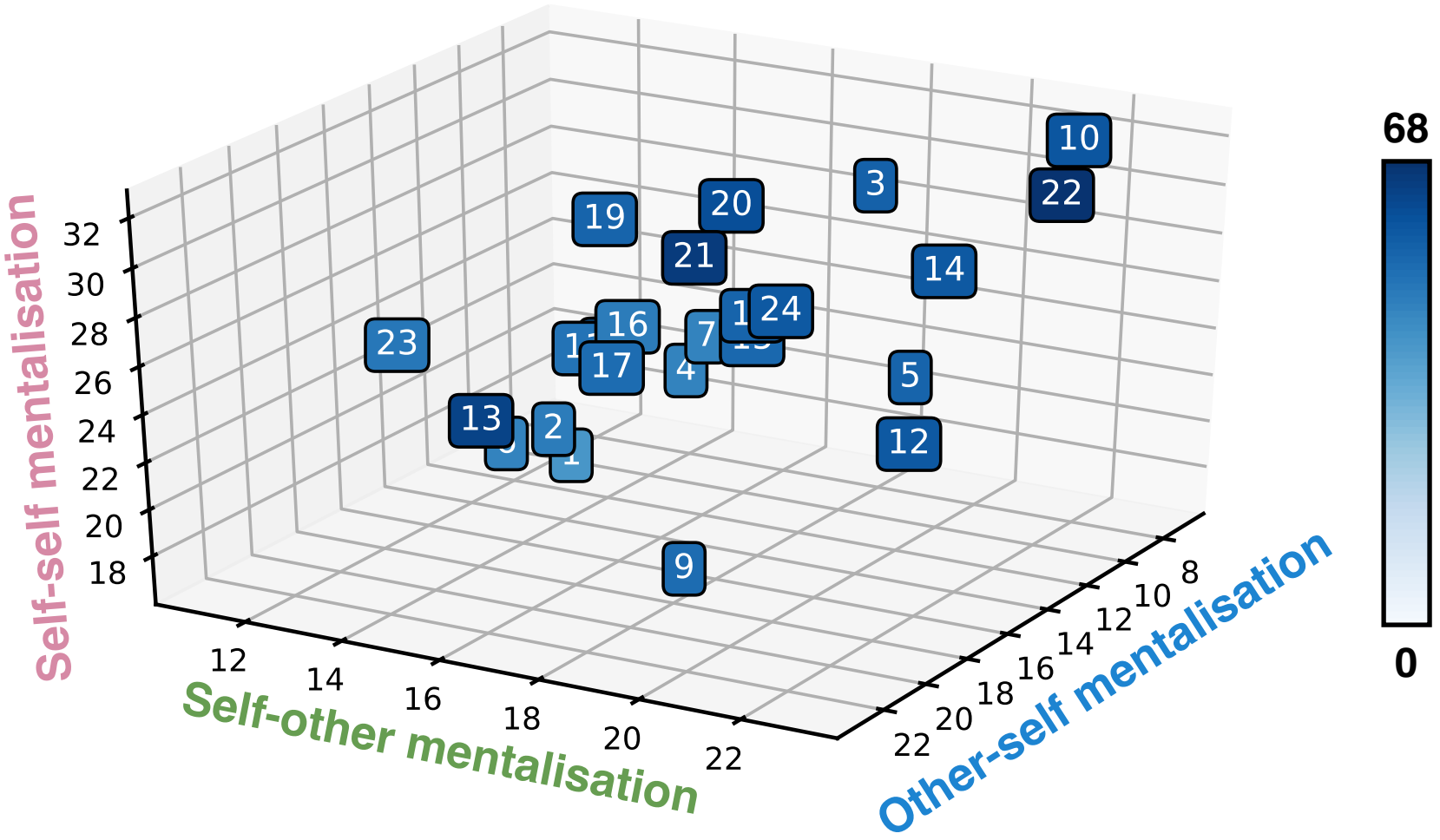


Right hippocampus



METHODS

IMQ: Interactive mentalisation questionnaire [2]



2. Wu, H., Fung, B. J., & Mobbs, D. (2022). Mentalising during social interaction: The development and validation of the interactive mentalising questionnaire. *Frontiers in Psychology*, *12*.

METHODS

IMQ: Interactive mentalisation questionnaire [2]

Different versions of IMQ are available at https://github.com/andlab-um/IMQ

IMQ (interactive mentalization questionnaire)

repo size 432 kB

DOI 10.3389/fpsyg.2021.791835

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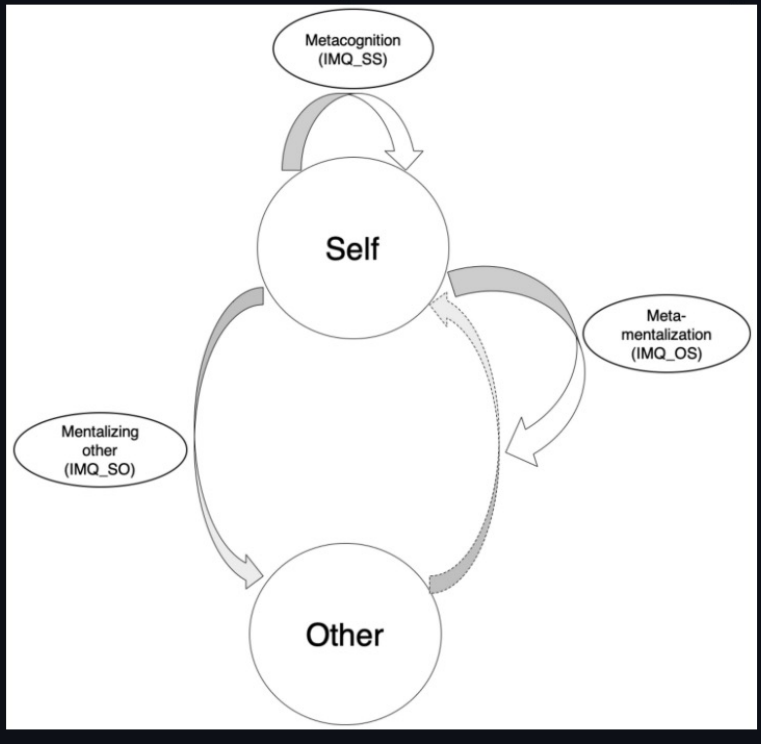
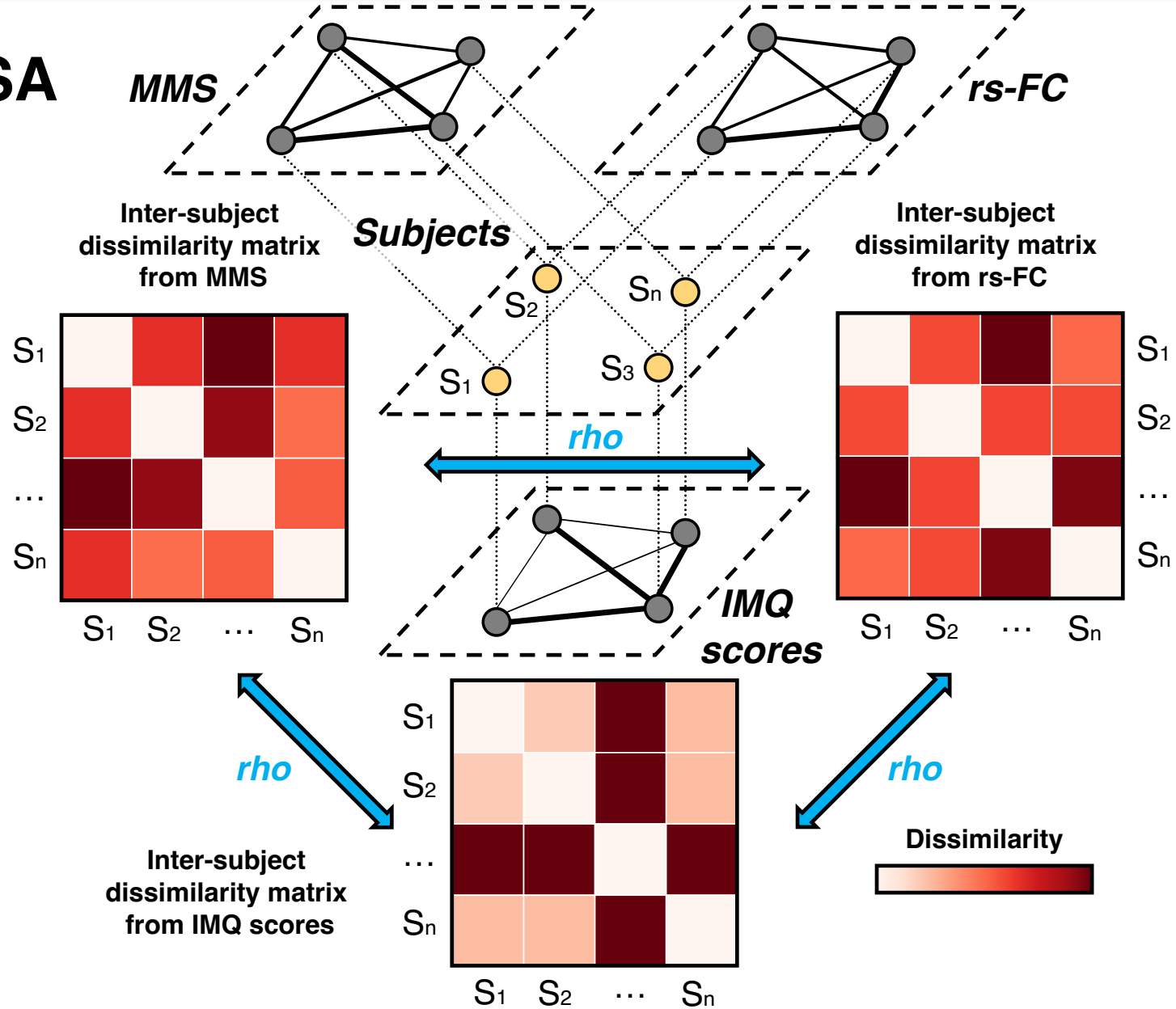
For different versions of IMQ:
Wu, H., Fung, B. J., & Mobbs, D. (2022). Mentalizing during social interaction: the development and validation of the interactive mentalizing questionnaire. *Frontiers in psychology*, *12*.
DOI: 10.3389/fpsyg.2021.791835.



2. Wu, H., Fung, B. J., & Mobbs, D. (2022). Mentalising during social interaction: The development and validation of the interactive mentalising questionnaire. *Frontiers in Psychology*, *12*.

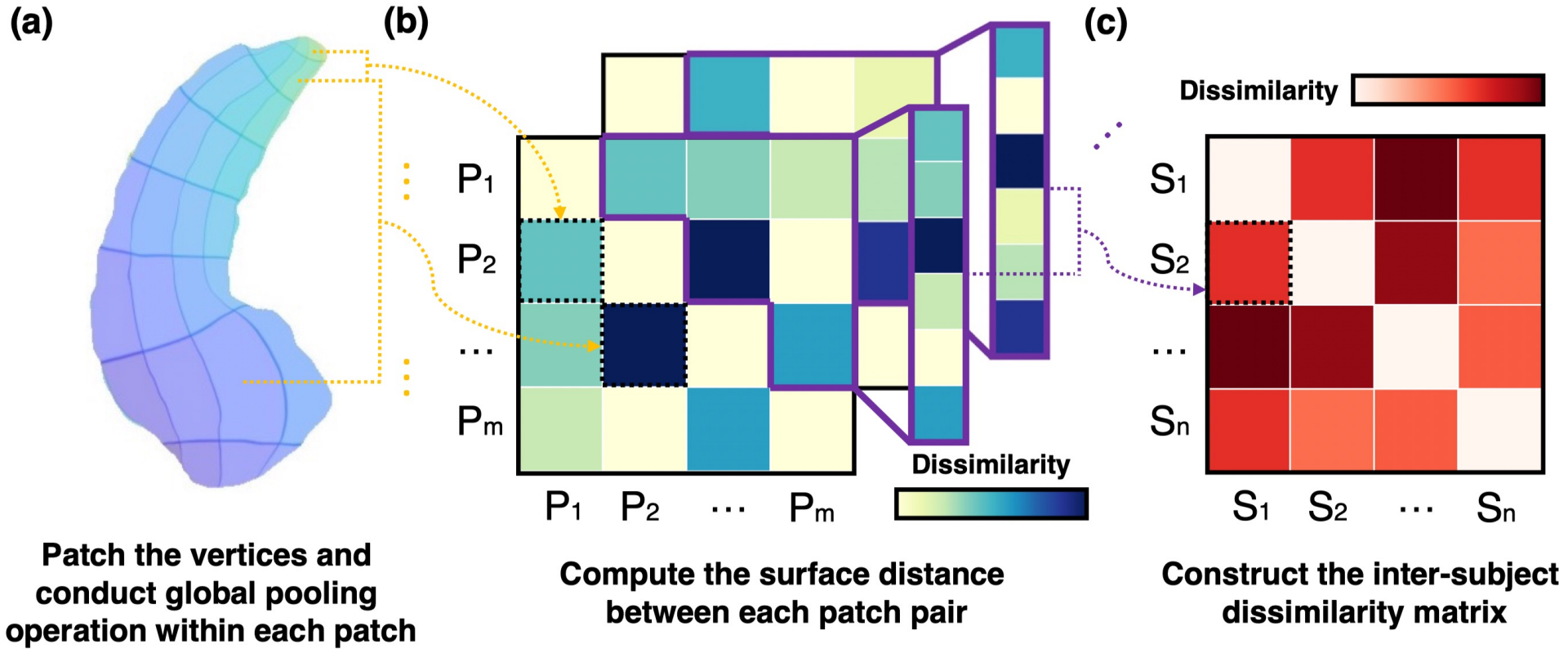
METHODS

IS-RSA



METHODS

CPP-SD: Computing patching and pooling operations-based surface distance



HYPOTHESIS 1

We predicted that

1) **the levels of mentalising ability would correlate positively with the dissimilarity in amygdala and hippocampal morphometry and connectivity;**
2) **dissimilarity in functional and structural patterns would positively covary with each other.**

HYPOTHESIS 1

Three distinct modalities will share one essence, i.e., there is a structure that existed in idiosyncratic patterns of brain morphometry, connectivity and mentalising ability, and we termed it as 'trinity'.

(Adapted from Wikipedia)

HYPOTHESIS 2

There will be a region-related specificity in associations among different mentalising components and amygdala or hippocampal MMS and rs-FC.

Self-self mentalisation (SS, meta-cognition)

Allen et al., *Neuroimage*, 2017
Alkan et al., *Schizophr. Bull.*, 2020

Ye et al., *Brain Struct. Funct.*, 2019
Zou & Kwok, *J. Cogn. Neurosci.*, 2022

(Adapted from PriMed)

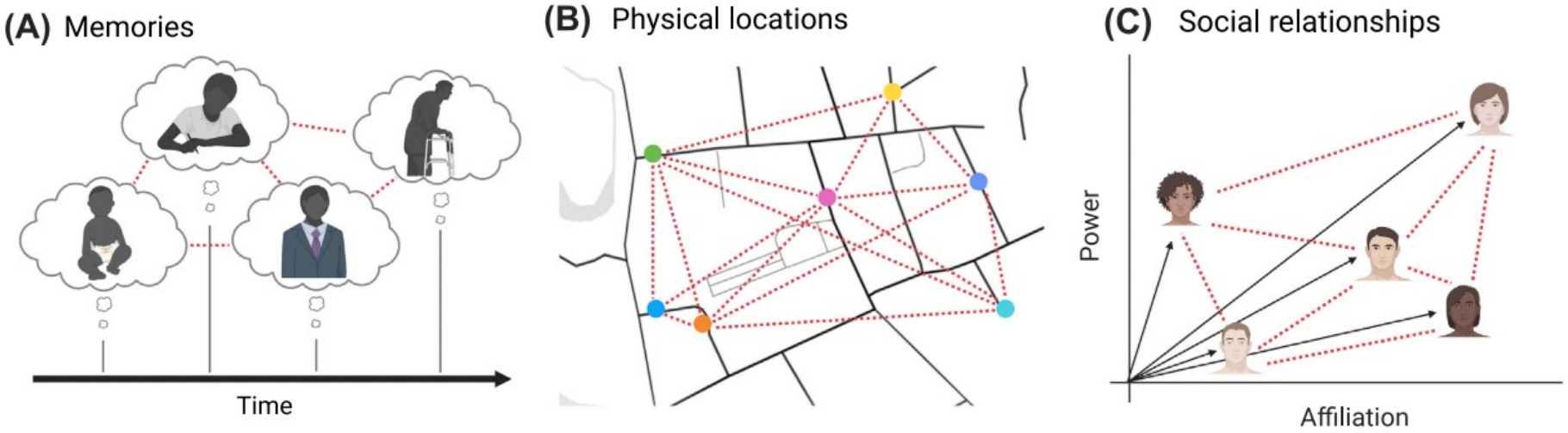
HYPOTHESIS 2

There will be a region-related specificity in associations among different mentalising components and amygdala or hippocampal MMS and rs-FC.

Self-other mentalisation (SO, perspective-taking)

Relational integration theory

O'Keefe & Nadel, *The hippocampus as a cognitive map*, 1978
Rubin et al., *Front. Hum. Neurosci.*, 2014



(Adapted from Banker et al., *Trends Neurosci.*, 2021)

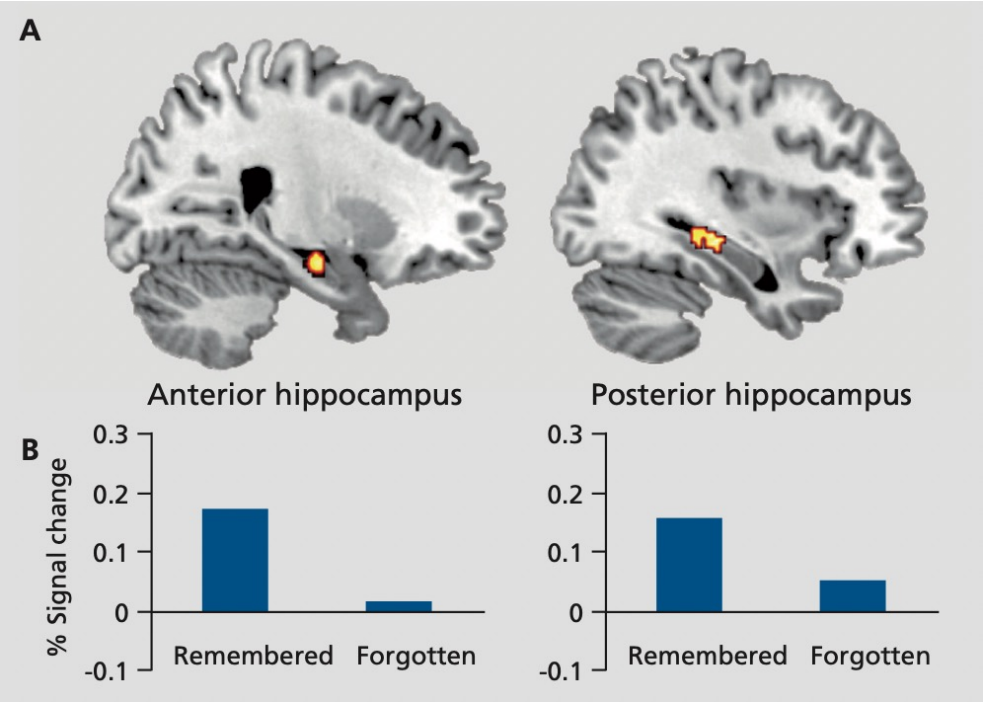
HYPOTHESIS 2

There will be a region-related specificity in associations among different mentalising components and amygdala or hippocampal MMS and rs-FC.

Self-other mentalisation (SO, perspective-taking)

Constructive memory theory

Schacter, *Am. Psychol.*, 2012



Hippocampal responses to encoding simulations of future events

(Adapted from Schacter, *Am. Psychol.*, 2012)

HYPOTHESIS 2

There will be a region-related specificity in associations among different mentalising components and amygdala or hippocampal MMS and rs-FC.

Other-self mentalisation (OS, the ability to see 'ourselves from the outside')

Wu et al., *Front. Psychol.*, 2022

Koscik & Tranel, *Neuropsychologia*, 2011
Haas et al., *Neuroimage*, 2015
Santos et al., *PLoS ONE*, 2016
Eskander et al., *Neural Correlates and Mechanisms of Trust*, 2020

(Adapted from Earth.com)

HYPOTHESIS 3

Subject pairs with similar hippocampal MMS will have even greater SS and SO similarity if they are also similar in hippocampal rs-FC.

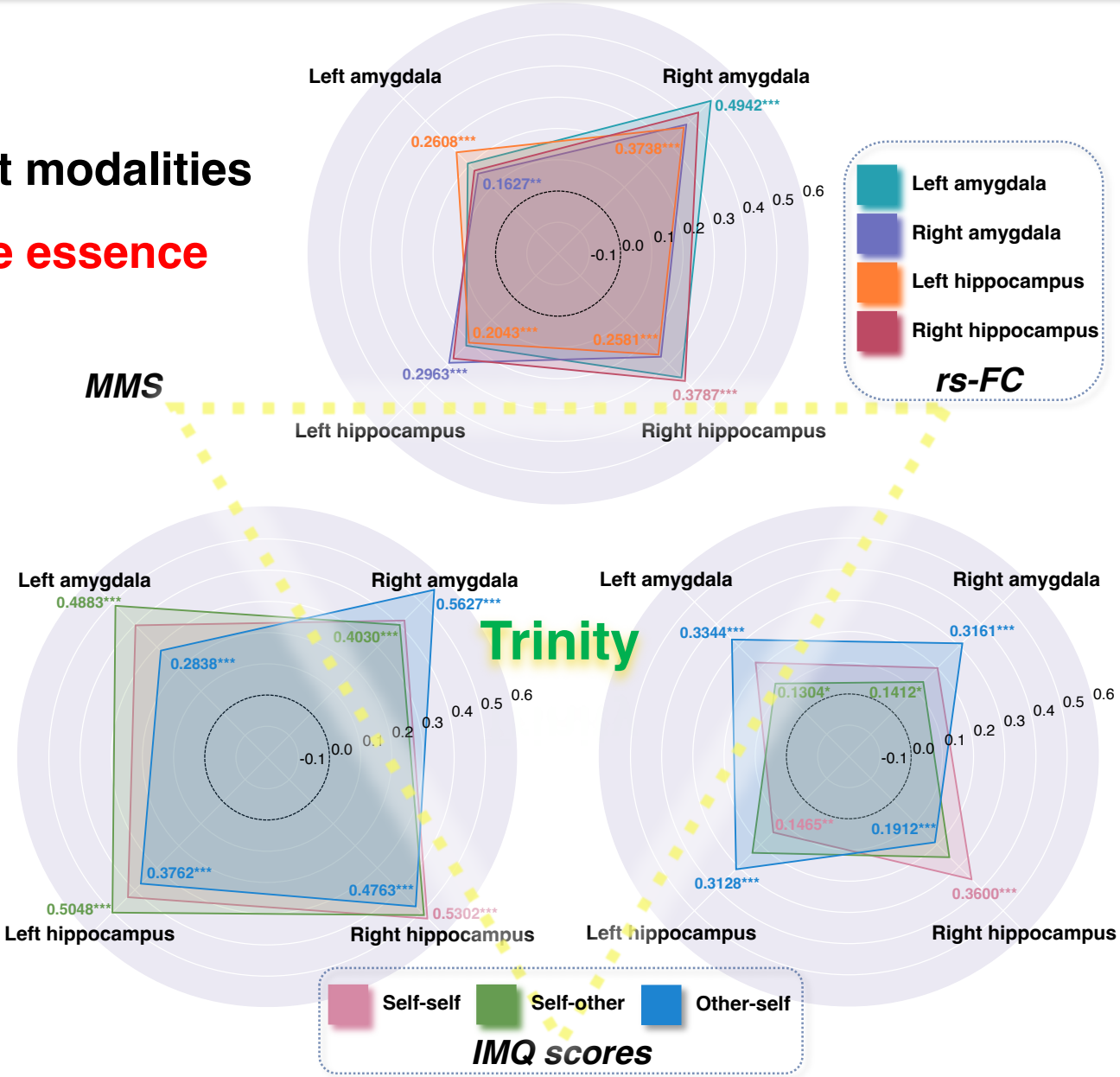
In a similar vein, subject pairs with similar amygdala MMS will have even greater OS similarity if they are also similar in amygdala rs-FC.

(Adapted from thoughtco.com)

RESULTS

Three distinct modalities

shared one essence



RESULTS

A region-related mentalising specificity emerged from the trinity

Comb.	*rho*	Mean (*95% CI*)	p_{FDR}
SS			
LA	0.3981	0.3677 (0.3569-0.3785)	<.001***
RA	0.4228	0.3947 (0.3861-0.4034)	<.001***
LH	0.4347	0.4127 (0.4055-0.4199)	<.001***
RH	0.5302	0.5168 (0.5051-0.5284)	<.001***
SO			
LA	0.4883	0.4607 (0.4478-0.4736)	<.001***
RA	0.4030	0.3821 (0.3751-0.3891)	<.001***
LH	0.5048	0.4678 (0.4601-0.4755)	<.001***
RH	0.5156	0.4766 (0.4657-0.4875)	<.001***
OS			
LA	0.2838	0.2890 (0.2801-0.2980)	<.001***
RA	0.5627	0.5153 (0.5051-0.5255)	<.001***
LH	0.3762	0.3548 (0.3453-0.3643)	<.001***
RH	0.4763	0.4433 (0.4321-0.4544)	<.001***

(a) Results of similarities between IMQ scores and MMS.

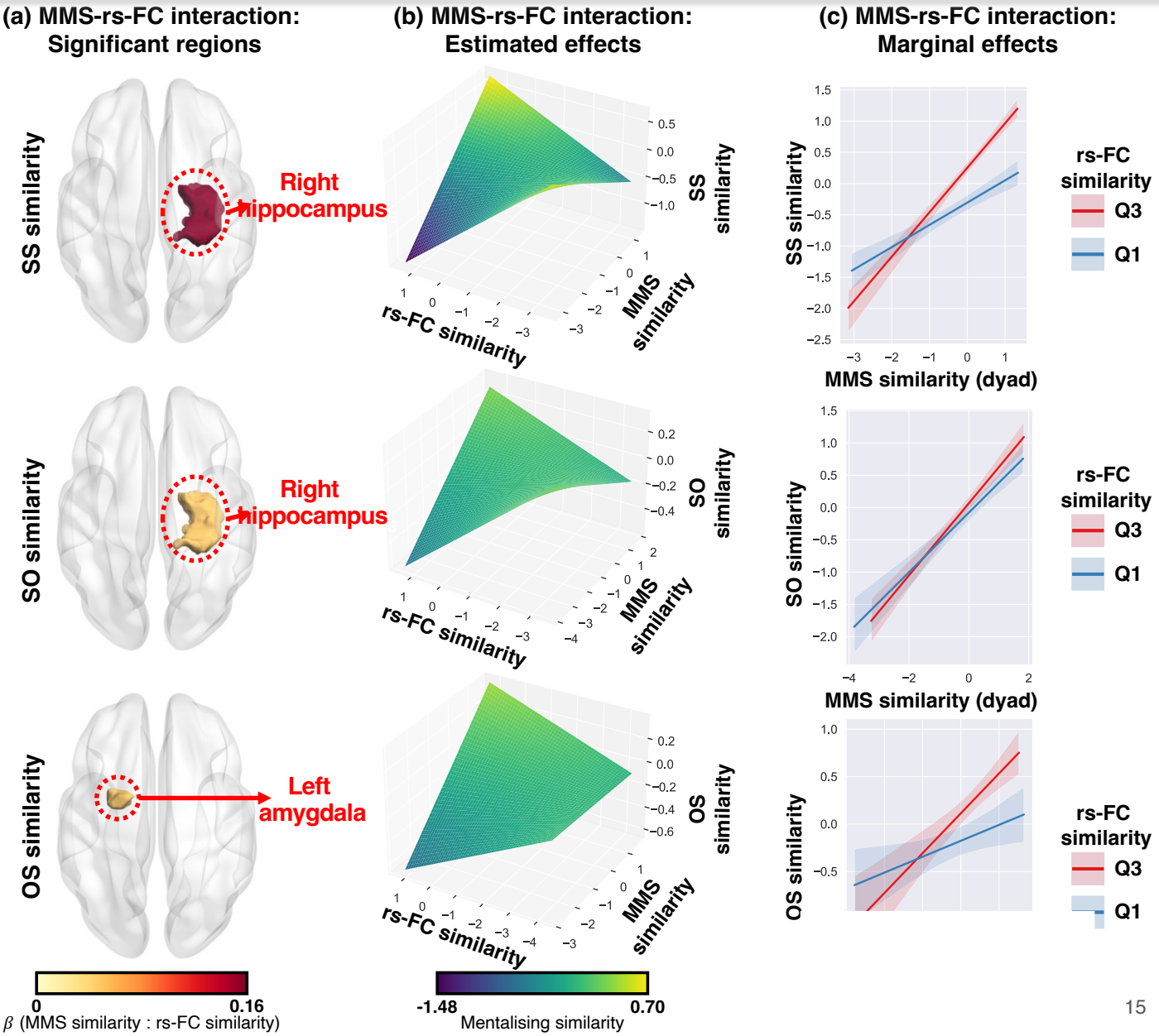
Comb.	*rho*	Mean (*95% CI*)	p_{FDR}
SS			
LA	0.2272	0.2094 (0.1995-0.2194)	<.001***
RA	0.2025	0.1747 (0.1668-0.1826)	<.001***
LH	0.1465	0.1256 (0.1162-0.1350)	.007**
RH	0.3600	0.3434 (0.3348-0.3520)	<.001***
SO			
LA	0.1304	0.1239 (0.1169-0.1310)	.016*
RA	0.1412	0.1359 (0.1266-0.1452)	.010*
LH	0.2383	0.2254 (0.2147-0.2360)	<.001***
RH	0.2580	0.2427 (0.2347-0.2508)	<.001***
OS			
LA	0.3344	0.3164 (0.3078-0.3250)	<.001***
RA	0.3161	0.2890 (0.2788-0.2993)	<.001***
LH	0.3128	0.2861 (0.2742-0.2980)	<.001***
RH	0.1912	0.1682 (0.1538-0.1825)	<.001***

(b) Results of similarities between IMQ scores and rs-FC.

'LA' for left amygdala; 'RA' for right amygdala; 'LH' for left hippocampus; 'RH' for right hippocampus

RESULTS

Rs-FC gates the MMS predicted similarity in mentalising ability



DISCUSSION

- The current work defines an **integrative trinity framework** that provides a testable basis for understanding individual differences in brain morphometry, connectivity and mentalising ability.
- Trinity's finding not only advances our understanding of the neural basis of mentalising but also may further help shed light on the implementational or the physical realisation of **artificial mentalising ability** and thus pave the way for **artificial social intelligence**.
- Our study reveals the existence of a **region-related specificity**: the variation of SS and SO are more related to individual differences in hippocampal MMS and rs-FC, whereas the variation of OS shows a closer link with individual differences in amygdala MMS and rs-FC. Our finding is among the first to present additional evidence on the inter-individual level supporting the different but same pivotal role of the amygdala and hippocampus in rich and complex social life.
- Our data suggest that rs-FC gates the MMS predicted similarity in mentalising ability, revealing the **intertwining role** brain morphometry and connectivity play in social cognition.

ACKNOWLEDGEMENT & CONTACT

Qunxi Dong

Bin Hu

Haiyan Wu

Presenter: Zhaoning Li 李肇宁

yc17319@umac.mo @lizhn7

@lizhn7@sciences.social

github.com/das-boot

Preprint: https://doi.org/10.1101/2022.04.11.487870

The data and code used are available at https://github.com/andlab-um/trinity

HBM Paper