The map in the brain: Distributed cortical representations of large-scale space

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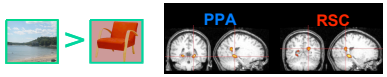
INTRODUCTION

A neural code for space?

The Parahippocampal Place Area (PPA) and Retrosplenial Cortex (RSC) respond more strongly to scenes than to other visual stimuli.

The RSC plays an important role in encoding spatial and place information, whereas PPA extracts immediate perceptual information from a scene (Epstein & Higgins, Cereb Cortex, 2007; Epstein, Parker & Feiler, J Neuroscience, In Press)

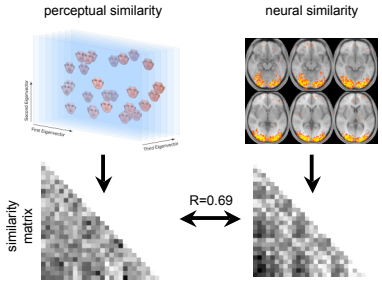
What is the form of spatial representation in the RSC?



Neural similarity

Categorization of distributed fMRI patterns:
- object category in temporal cortex (Haxby et al.,Science, 2001)
- orientation in V1 (Kamitani & Tong, Nature Neurosci, 2005)

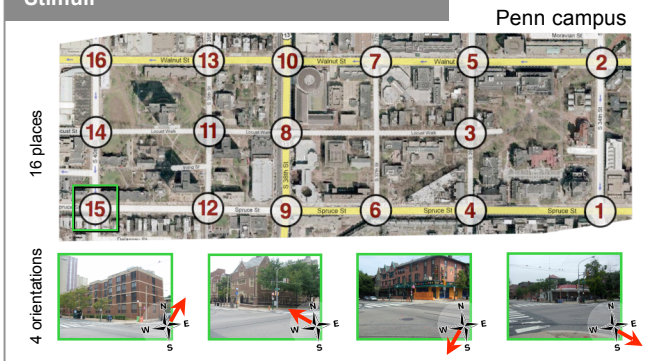
The similariy of patterns of neural activity can reflect the perceptual similarity of stimuli, e.g. a set of faces (Aguirre et al, VSS 2007)



Is there a map-like neural code for place such that geographic proximity is represented by neural similarity on a focal or distributed level?

METHODS

Stimuli



Behavioral Training and Testing

Subjects with > 2 years familiarity with campus

Location and Orientation familiarity task: Subjects viewed the 64 campus images and reported orientation, and location by match to map. >90% performance on both tests for inclusion

Subjective distance task: Ss indicated time to travel between each pairwise set of locations

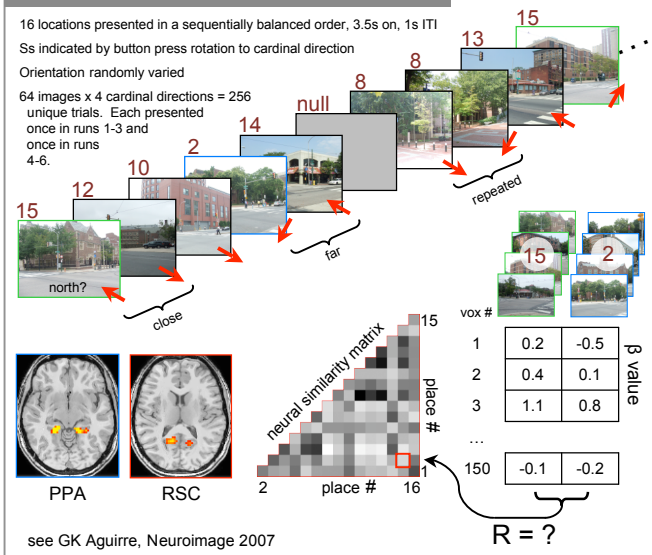
Continuous Carry-over fMRI Experiment

16 locations presented in a sequentially balanced order, 3.5s on, 1s ITI

Ss indicated by button press rotation to cardinal direction

Orientation randomly varied

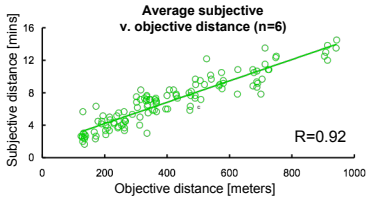
64 images x 4 cardinal directions = 256 unique trials. Each presented once in runs 1-3 and once in runs 4-6.



see GK Aguirre, Neuroimage 2007

RESULTS

Behavioral Effects



Accuracy in behavioral tests

Subject	Location	Orientation
s1	0.93	0.95
s2	0.92	0.78
s3	0.88	0.98
s4	0.97	0.98
s5	0.87	0.98
s6	1.00	0.98

Accuracy during fMRI

Subject	Orientation
s1	0.95
s2	0.93
s3	0.95
s4	0.96
s5	0.91
s6	0.94

Pattern Analysis

Distributed pattern reliability

Does the neural similarity matrix for place from the first half of the experiment correlate with the pattern from the second half?

RSC distributed pattern

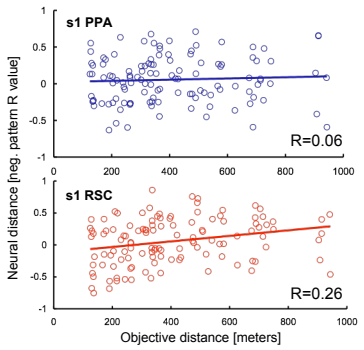
Subject	R value
s1	0.38
s2	0.33
s3	0.04
s4	0.10
s5	-0.05
s6	0.15

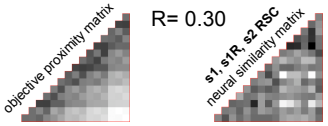
Neural distance v. Objective distance

Does the neural similarity matrix from the PPA or RSC correlate with the objective (map-wise) proximity between places?

Neural v. Objective distance

Subject	PPA	RSC
s1	0.06	0.26
s2	0.09	0.15
s3	-0.01	-0.08
s4	-0.05	-0.02
s5	0.02	0.00
s6	-0.02	0.06





Replication of s1 results 4 months later

Pattern reliability (1st half v. 2nd half)	Place similarity (objective v. neural)
R = 0.42	PPA R = 0.03
	RSC R = 0.16

Conclusions

In some subjects the similarity of distributed neural activity evoked by viewing a place reflects the geographic proximity of those places.

This was observed in the RSC, but not the PPA, supporting our hypotheses regarding the functions of these regions.

Despite good subject performance within the scanner, substantial variation between subjects was seen in the reliability of the distributed neural pattern.