Using observer similarity matrices to understand individual differences in gaze behaviour towards complex scenes

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Introduction

- People systematically differ in their gaze behaviour along several semantic object categories when viewing complex scenes (de Haas et al., 2019).
- Question: What proportion of individual gaze differences can be explained by semantic object features?
- We used a novel approach to analyse individual differences by computing 'dimension-agnostic' (dis-)similarities between observers.

Task

- 101 participants freely viewed 700 complex scenes, each for 3 seconds.
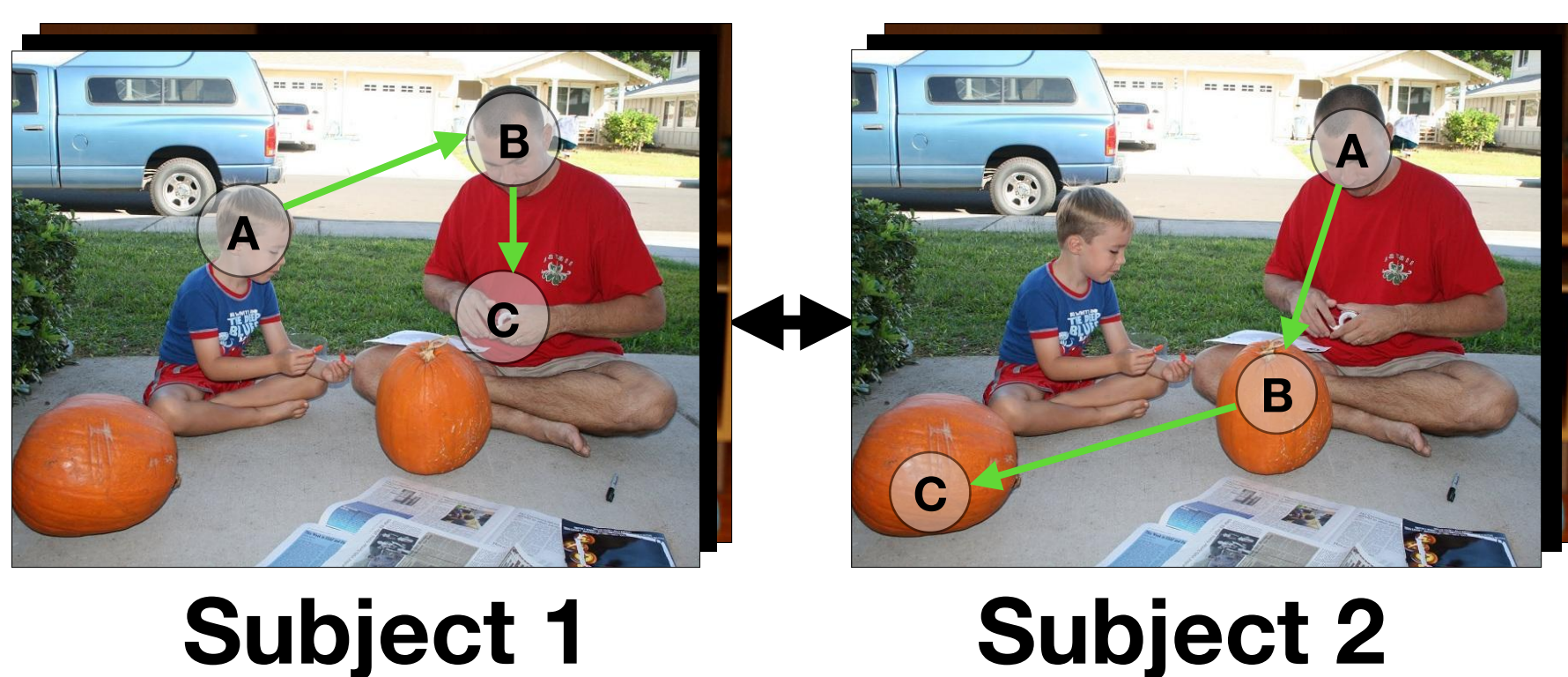- The scenes contained 5551 objects, belonging to several semantic categories.

700 images ⏱ 3s

Measures and Results
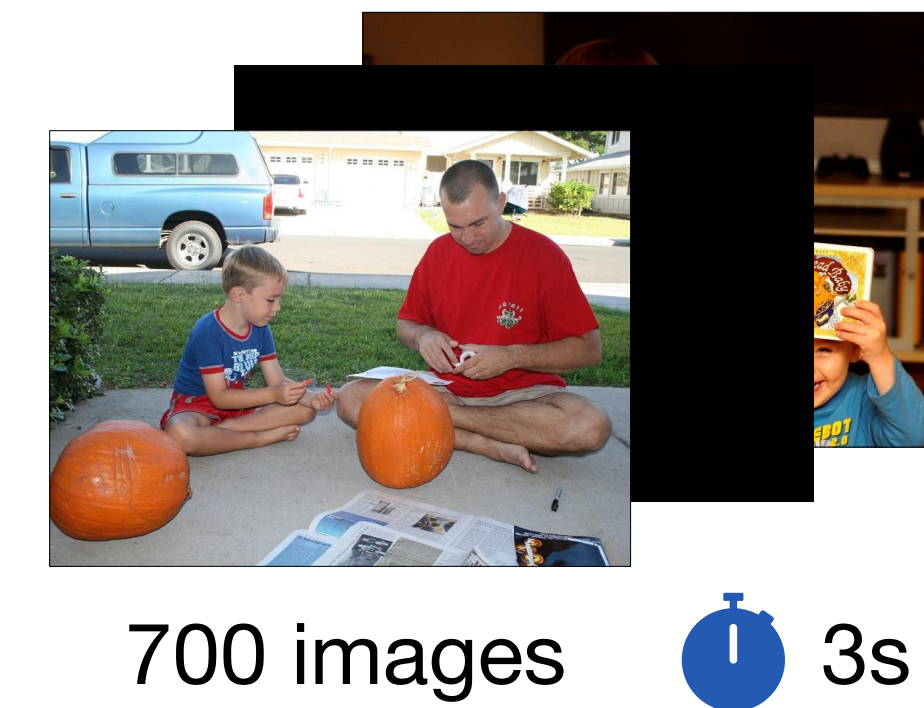
Observer similarity matrices (101 x 101 observers)

Dependent measures:

1. Object dwell time

Dwell time per object

Subject 1	200	120	0	0	1090	700
Subject 2	0	200	900	0	1500	690

Subject 101

... 5500 ⟶

Via pairwise Euclidean distance

$R^2 = 80\%$

Odd images ↔ Even Images

2. Scanpath similarity (ScanMatch; Cristino et al., 2010)

Subject 1   Subject 2

... 101 ⟶

Via substitution matrix

$R^2 = 95\%$
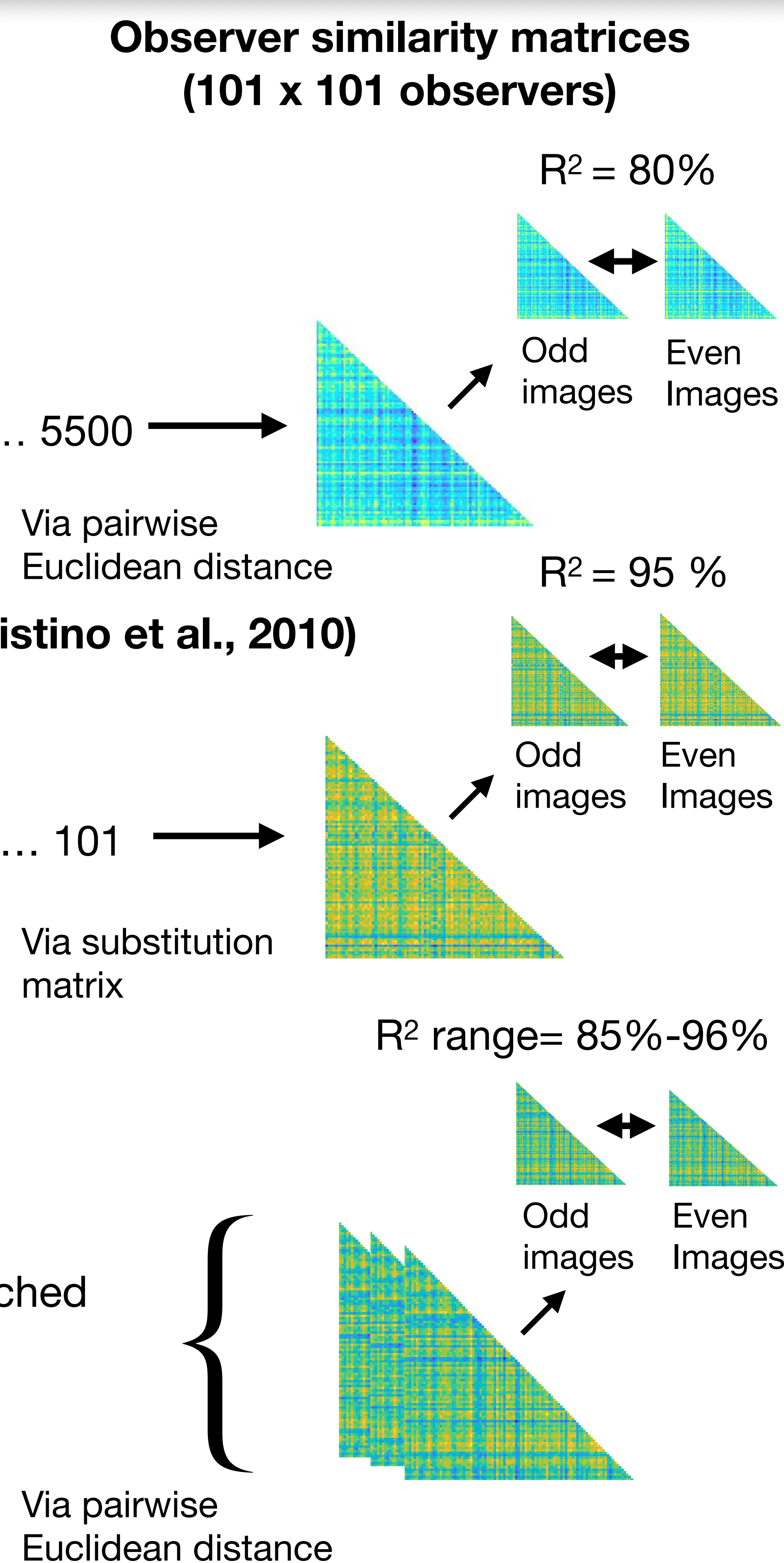
Odd images ↔ Even Images

Independent measures :

1. % Dwell time towards:

- Text, Faces, Taste, Motion and Touched

2. Visual exploration

- Number of objects fixated

R^2 range = 85%-96%

Odd images ↔ Even Images

Via pairwise Euclidean distance

We applied two cross-validated ridge regression models

Object dwell time

1. $Y_{Object\ dwell\ time} = \beta_0 + \beta_{Text} + \beta_{Face} + \beta_{Taste} + \beta_{Motion} + \beta_{Touched} + \beta_{Visual\ exploration}$

Beta — Text *** , Face *** , Taste *** , Motion *** , Touched *** , Vis.expl. n.s.

Model performance (cross validated): $R^2 = 27\%$
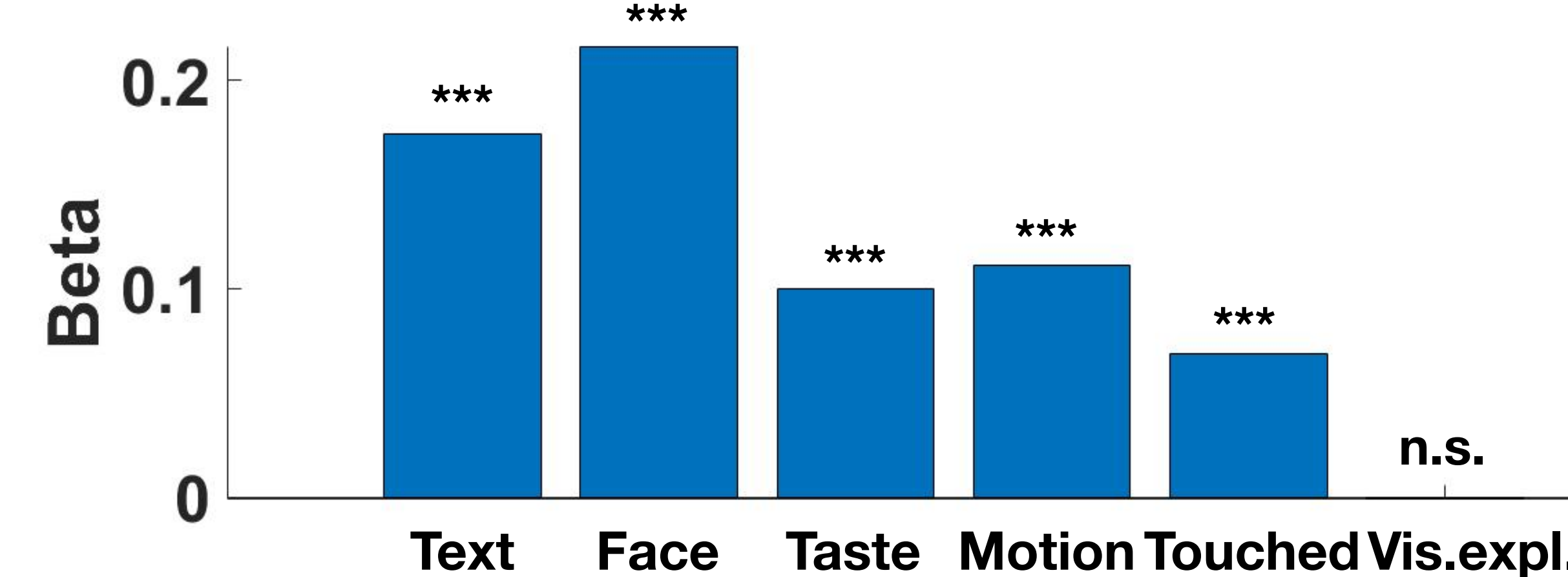
p<.001***, p<.01**, p<.05*

Scanpath similarity

2. $Y_{Scanpath\ similarity} = \beta_0 + \beta_{Text} + \beta_{Face} + \beta_{Taste} + \beta_{Motion} + \beta_{Touched} + \beta_{Visual\ exploration}$

Text *** , Face *** , Taste * , Motion ** , Touched ** , Vis.expl. ***
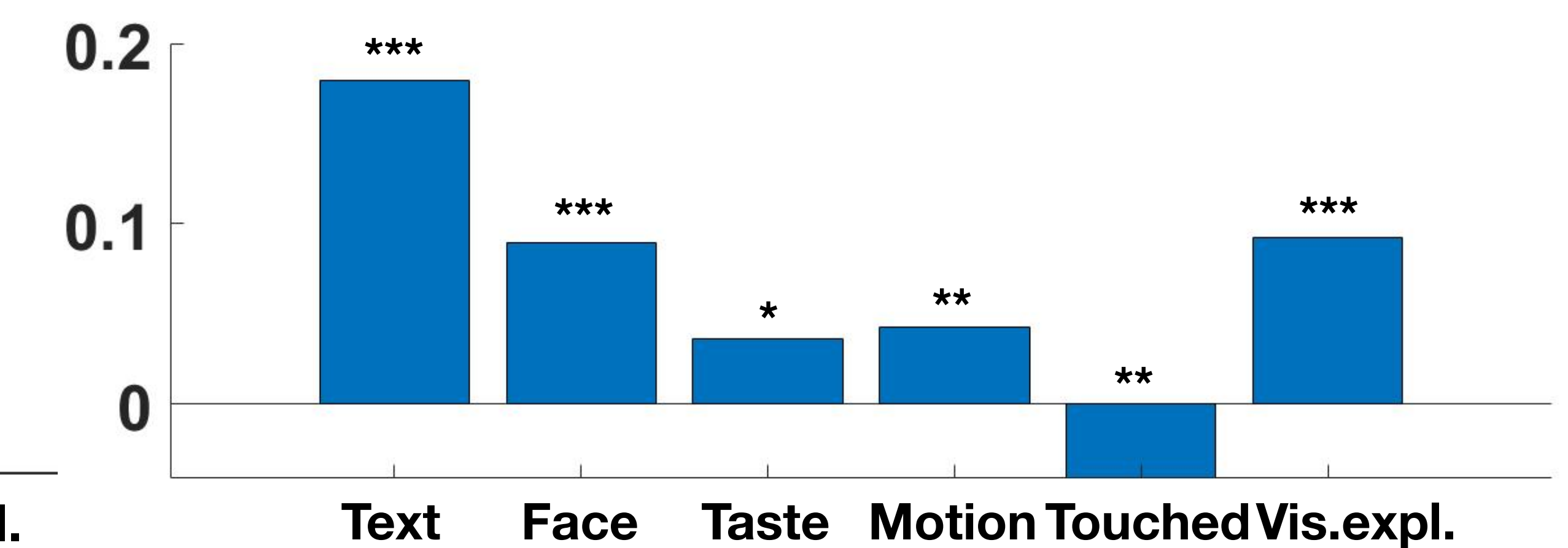
Model performance (cross validated): $R^2 = 9\%$

Conclusion

- Observer similarity matrices allow an upper bound estimate of explainable variance and an evaluation of proposed dimensions.
- Individual gaze tendencies along several semantic categories and visual exploration account for a substantial amount of individual differences in object fixations and spatio-temporal aspects of gaze behaviour.
- At the same time most of the explainable variance could not be explained by the current models.
- Future work should aim to identify missing dimensions of individual gaze. We will use OSMs to explore these, e.g. by comparing the gaze patterns of observers with high predicted similarity who empirically show strong divergence.