Spatial and temporal characteristics of the neural representations of face familiarity

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BACKGROUND

- *endpoints* of familiarity with faces
  - behavioral studies
    - familiar face recognition (Johnston & Edmonds, 2009)
      - accurate and robust over various photometric changes
    - unfamiliar face recognition is not (Hancock, Bruce, & Burton, 2000)
  - fMRI and PET studies
    - famous, personally familiar (Gobbini & Haxby, 2007; Natu & O'Toole, 2011)
    - differential neural magnitude in multiple brain regions
    - complexity of familiarity
      - semantic and autobiographic information, emotion, episodic memories
      - **visual information - core component, drives familiarity**
        - visually familiar faces – (participants learn in a lab-setting)
        - activate early visual areas, high-level visual areas, precuneus, frontal areas (Dubois et al., 1999; Rosson et al., 2003, Gobbini & Haxby, 2006)
- *progression* of familiarity with faces
  - behavioral studies
    - improvement in matching and recognition abilities (Clutterbuck & Johnston, 2002, 2004, 2005, Rzark et al., 2006)
  - single fMRI study
    - neural magnitude changes (Kosaka et al., 2003)
      - fusiform, amygdala, posterior cingulate gyrus

QUESTION

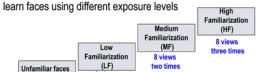
- how neural *patterns* elicited in response to faces varying in familiarity *differ* from each other?

APPROACH

- apply *pattern-based classification* analysis to discriminate
  - ***spatial patterns*** elicited in response to faces varying in ***levels of visual familiarity***
  - examine ***temporal*** characteristics of the spatial patterns
- examine differences in average response activation to faces varying in familiarity

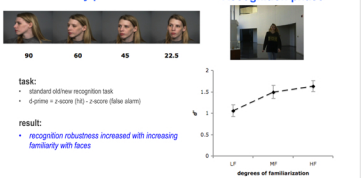
BEHAVIORAL FACE FAMILIARIZATION EXPERIMENT

- to test if participants can achieve different levels of robustness with faces
  - learn faces using different exposure levels



  - test for recognition using novel, naturalistic images of learned faces

Stimuli:



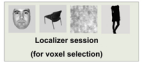
METHODS

second set of participants (N=9)

- learning phase (identical to the face-familiarization experiment)
  - outside the scanner
  - 20 min prior to the fMRI experiment

REGIONS OF INTEREST

Functional Localization:



VT mask

- ANOVA used to select voxels showing significant variation across faces, objects, and scrambled images ($p < 0.00001$)
- average number of voxels: 333

- FFA-OFA mask

- *faces > objects*
- average number of voxels: 24

Anatomical Localization (IBASPM)

- precuneus, frontal areas, hippocampal areas
- areas implicated in the acquisition of familiarity (e.g., Avidan & Behrmann, 2009)
- combine visual and parietal areas (inf+sup)

EXPERIMENTAL DESIGN

Scanner Details

- 3T Philips Scanner
- TR = 2000ms, TE = 30ms
- whole brain coverage (38 slices)
- voxel size: 3mm x 3mm x 4mm

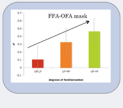
SPATIAL RESULTS

High-Level Visual Areas

	Faces-Scenes	HF-UF	UF-MF	HF-LF	HF-MF	UF-LF
FFA-OFA	√	√	√	x	x	x
VT	√	√	x	x	x	x

easy moderate difficult

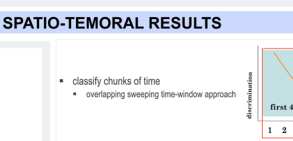
unfamiliar *vs.* familiar separable



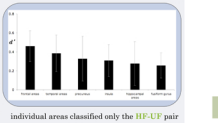
Visual + Parietal Areas

	Faces-Scenes	HF-UF	UF-MF	HF-LF	HF-MF	UF-LF
VT + Fusiform+ Parietal	√	√	√	√	x	x
VT + Fusiform+ Precuneus	√	√	√	√	x	x
Fusiform + Parietal	√	√	x	√	√	x
Fusiform + Precuneus	√	√	√	x	x	x
VT + Parietal	√	√	x	√	x	x
VT+ Precuneus	√	√	√	x	x	x

easy moderate difficult

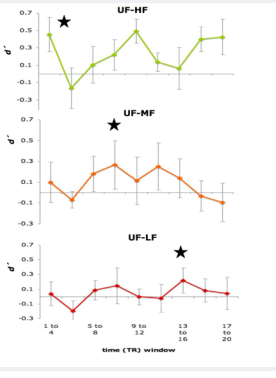


Anatomical Areas

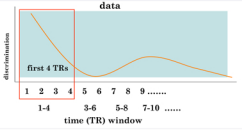


individual areas classified only the HF-UF pair

SPATIO-TEMORAL RESULTS



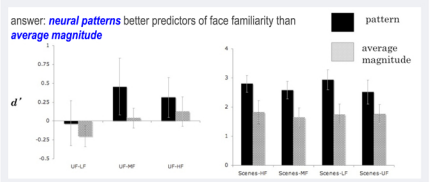
- classify chunks of time
  - overlapping sweeping time-window approach



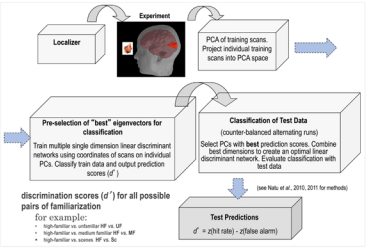
AVERAGE MAGNITUDE RESULTS

- how effective is average neural magnitude of the FFA-OFA for predicting face familiarity?
  - classification using average neural magnitude of the FFA-OFA

answer: ***neural patterns*** better predictors of face familiarity than ***average magnitude***



PATTERN-BASED CLASSIFICATION



Expected results (for high-level visual areas)

RESULTS SUMMARY

Spatial

- **high-level visual and parietal areas** (inf+sup and precuneus)
  - best graded classification results
- FFA-OFA
  - known *vs.* unknown faces
- graded discrimination - reflects behavioral generalization data
- **frontal areas, hippocampal areas, temporal areas**
  - known *vs.* unknown faces
- non-graded discrimination - signals familiarity
- *neural patterns* were better predictors of face familiarity than *average magnitude*

Spatiotemporal

- larger differences in familiarization levels of conditions, *earlier* classification success

UF-HF > UF-MF > UF-LF

easy -------> difficult

CONCLUSIONS

- gradual changes in neural representations of faces varying in visual familiarity
  - *spatial and temporal characteristics*
  - accord with behavioral recognition measures
- importance of parietal areas
  - stimuli independent familiarity trace
- importance of neural patterns
  - familiarity coded in the globally distributed patterns

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