Computational brain dynamics in prosopagnosia

Faghel-Soubeyrand, S, Richoz, A-R, Waeber, D., Woodhams, J., Gosselin, F. , Caldara, R., & Charest, I.

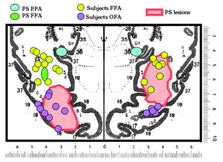
contact : simon.faghel-soubeyrand@umontreal.ca

SCAN ME

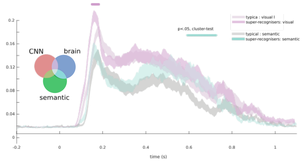
Background

Prosopagnosia

From a neuroanatomical & functional account to a **computational description of brain function**



Rossion et al. 2003



Faghel-Soubeyrand et al.,2022; biorXiv

Prosopagnosic patient PS

Right: Large right posterior inferior lesion (no 'OFA'); right middle temporal gyrus

Left: Medial part of ventral occipitotemporal cortex (no 'vLOC' or 'FFA')

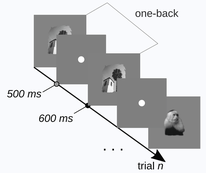
Method

Recording a large condition-rich high-density EEG data set

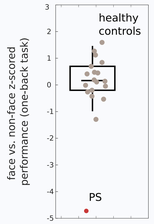
3.3k trials per individual (60k trials total) with faces, objects, scenes, animals, plants..

BioSemi 128 electrodes, band-passed .01-50hz

one-back task



face-specific behavioural impairment



- prosopagnosic patient PS (Fem, 69yo, right-handed)

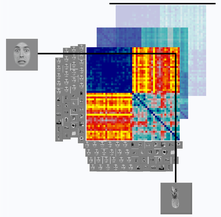
- aged-matched controls (N =4; 3 Fem, Mage=67.5, right-handed)
- neurotypical controls (N = 15; 9 Fem, Mage=22.9, right-handed)

aged-matched vs. typicals: $p > .40$

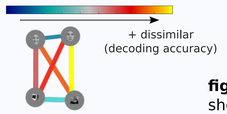
PS vs. controls: $t(17) = 7.15$, $p < .0001$

CFMT : PS vs. controls: $t(17) = -2.76$, $p = .01$

Applying RSA to EEG time courses to reveal brain dynamics



Representational Dissimilarity Matrices (RDMs) were derived using cross-validated decoding accuracies (5-fold, 5 reps) between topographies of all pairs of stimuli, for each 4 ms steps from onset



Brain representations reliable?

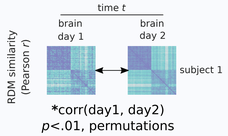


figure 1. Brain-lesioned patient PS showed reliable* brain RDMs across days from ~100-750 ms

Results

Impaired representational distance between face-identites?

face-identity neural distance (t-stats comparing cross-validated decoding accuracies)

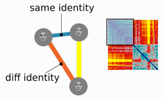
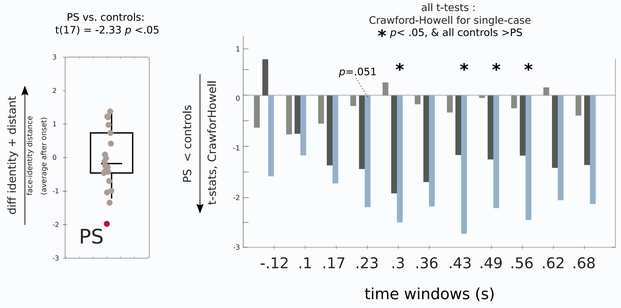
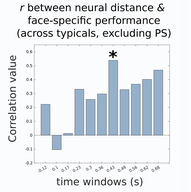
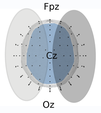


figure 2. Representational distance (AUC) betwen faces of different identities was significantly lower in PS vs controls, and correlated with individual performance. Significant windows (p<.05) also denote points where all controls exceeded PS's index.

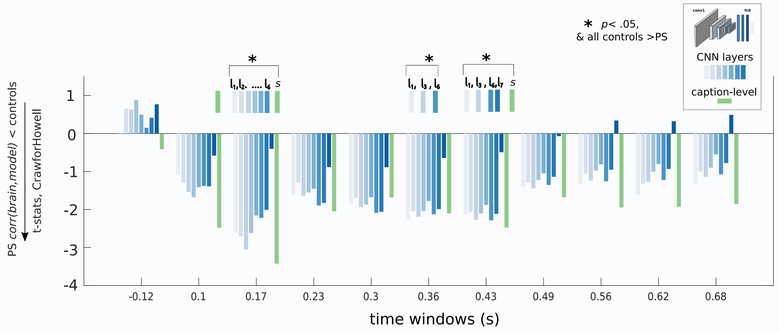






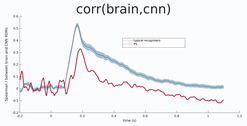
What are the neurocomputational aspects affected in prosopagnosia?

figure 3. comparison of PS's brain RDMs with RDMs derived from visual and caption-level models shows reduced similarity compared to controls. To compute these values, time course of brain correspondance with CNN (example shown below) was averaged every 65 steps, and compared between PS and controls.

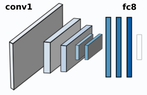


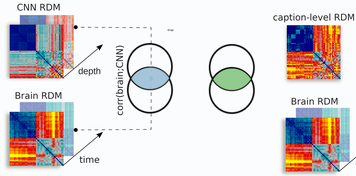
Brain similarity with..

example time course corr(brain,cnn)

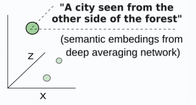


visual Conv Neural Net (CNN, AlexNet)





caption-level description



Highlights

Reliable brain representations of acquired prosopagnosia with RSA applied to EEG

Impaired neural distance between face-identity representations [230-560 ms after onset]

Reduced similarity with visual [~160ms &~350-450 ms after onset] & caption-level computations [~110-180 ms & 450 ms after onset]

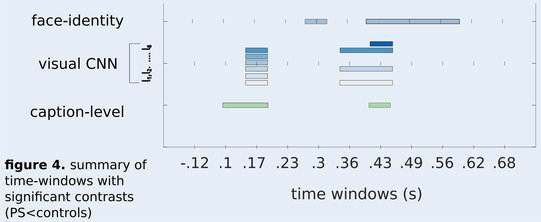


figure 4. summary of time-windows with significant contrasts (PS<controls)

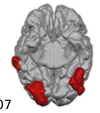
Discussion

Prospagnosia affects a cascade of different neural computations, from visual & face-identity to even higher-level semantic processing

Visual and semantic brain computations seem to be involved from prosopagnosia to "super-recognition" (see Faghel-Soubeyrand et al. 2022; biorXiv)

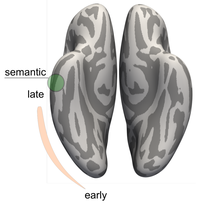
Differences in time courses with *super-recognisers* likely emerge from extensive lesions of PS at the beginning of the face processing stream (right OFA, e.g. Pitcher et al., 2007).

RSA proves to be a powerful tool to define neural computations of individuals with substantial structural alterations



PS

Sorger, Goebel, Schiltz & Rossion, 2007



References

- Sorger, B., Goebel, R., Schiltz, C., & Rossion, B. (2007). Understanding the functional neuroanatomy of acquired prosopagnosia. NeuroImage, 35(2), 836–852. https://doi.org/10.1016/j.neuroimage.2006.09.051
- Faghel-Soubeyrand, S., Ramon, M., Bamps, E., Zoia, M., Woodhams, J., Richoz, A.-R., Caldara, R., Gosselin, F., & Charest, I. (2022). The neural code behind real-world recognition abilities. In bioRxiv (p. 2022.03.19.484245). https://doi.org/10.1101/2022.03.19.484245
- Grill-Spector, K., Kourtzi, Z., & Kanwisher, N. (2001). The lateral occipital complex and its role in object recognition. Vision Research, 41(10-11), 1409–1422. https://doi.org/10.1016/s0042-6989(01)00073-6
- Pitcher, D., Walsh, V., Yovel, G., & Duchaine, B. (2007). TMS evidence for the involvement of the right occipital face area in early face processing. Current Biology: CB, 17(18), 1568–1573. https://doi.org/10.1016/j.cub.2007.07.063
- Rossion, B., Caldara, R., Seghier, M., Schuller, A., Lazeyras, F., & Mayer, E. (2003). A network of occipito-temporal face-sensitive areas besides the right middle fusiform gyrus is necessary for normal face processing. Brain: A Journal of Neurology, 126(11), 2381–2395. https://doi.org/10.1093/brain/awg241