Happiness matters: distributed brain patterns underlie different positive emotions in OFC

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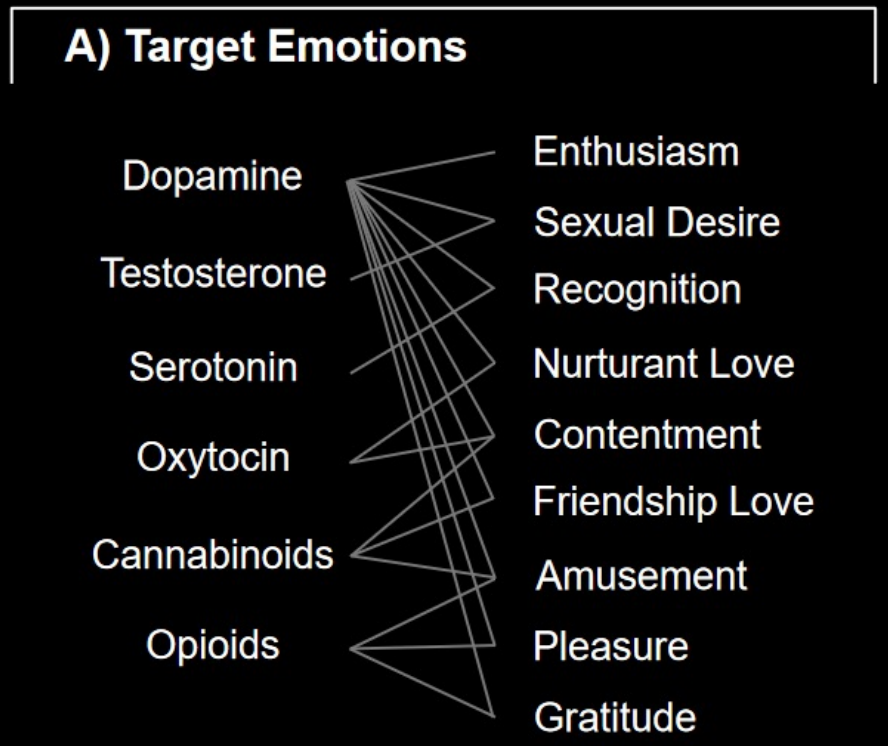
Introduction

Positive psychology is a promising branch in the field of psychology and the distinction of positive emotions receives increasing attention. Theoretical frameworks have proposed a “family tree” of 9 positive emotions that are assumed to have appeared during evolution in relation to 6 emerging neurotransmitters [1] (A). However, the neuroscientific basis of these emotions is poorly understood [2,3,4]. One of the reasons is that the discrimination of multiple positive emotions is challenging since they activate largely the same brain regions, requiring fine-grained multivariate pattern analyses.



Methods

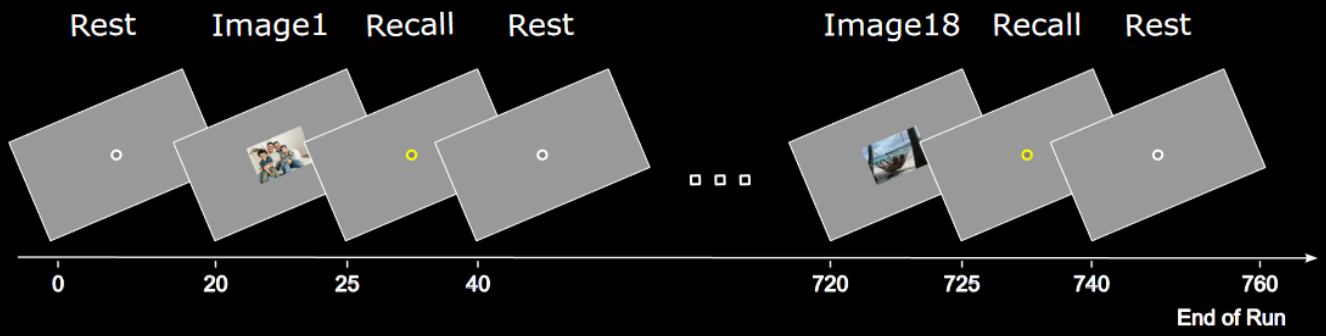
We investigated the neural correlates of these positive emotions in an fMRI experiment on 11 healthy volunteers using a 7T scanner (B). Emotions were induced via autobiographical memory recall cued by personal images (C). Participants used the “Matter”-App [5] to collect images associated with individual memories and rate to which degree each of 9 positive emotions was present. Post-scanning ratings were also collected and used to identify peak emotions for each personal memory (D). Before the first and after the final fMRI sessions, we administered the Subjective Wellbeing Questionnaire (SWQ) including questions about general life evaluation (e.g. “How satisfied are you with your standard of living?’), affect (e.g. “How often have you felt positive during the past four weeks?”), and flourishing (e.g. “Most days I get a sense of accomplishment from what I do.”). Pre-post effects were evaluated using paired two-tailed Wilcoxon test. Standard pre-processing of the fMRI data was performed using BrainVoyager, FSL and ANTs. An FFX model including predictors to encode peak events for each emotion was built to evaluate group level effects. Searchlight-based weighted Representational Similarity Analysis was employed to identify brain regions encoding information for each emotion specifically at individual level (E).

C) Experimental Design

Acquisition Protocol

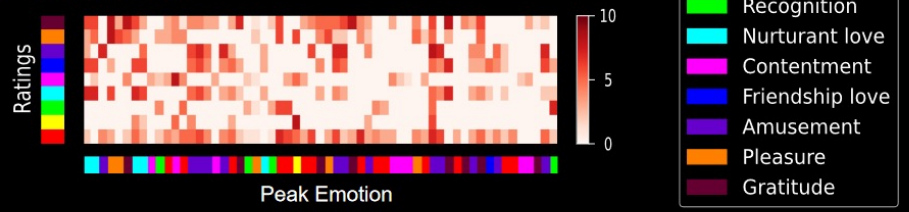
MP2RAGE: Whole brain
0.7 mm iso voxels

4 funtional runs:
Whole brain 1.8 mm
iso voxels, 1s TR

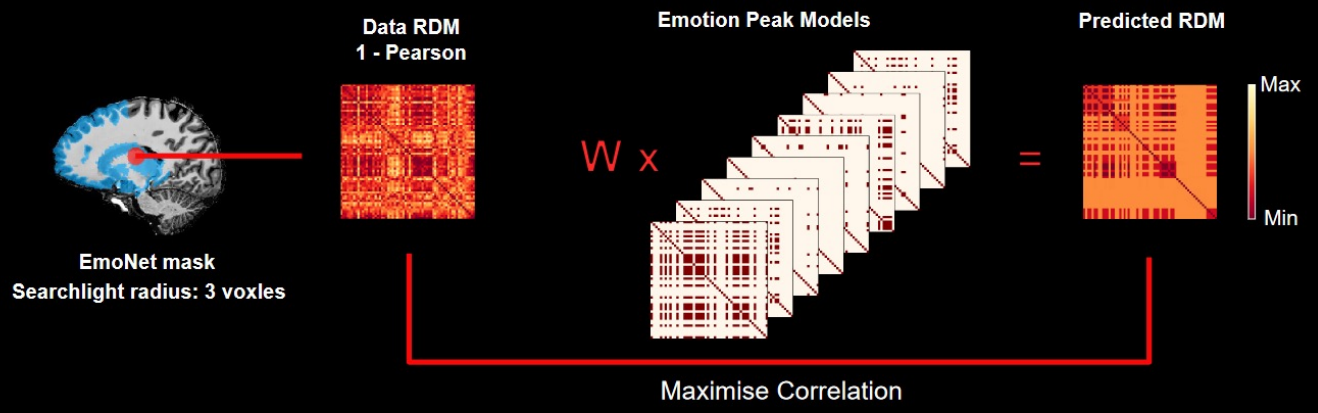


D) Post-scanning Rating Analysis

Ratings of a representative subject for all (72) memories employed in the fMRI experiment. The emotion(s) with the maximum score was(were) identified.



E) Searchligh-based wRSA



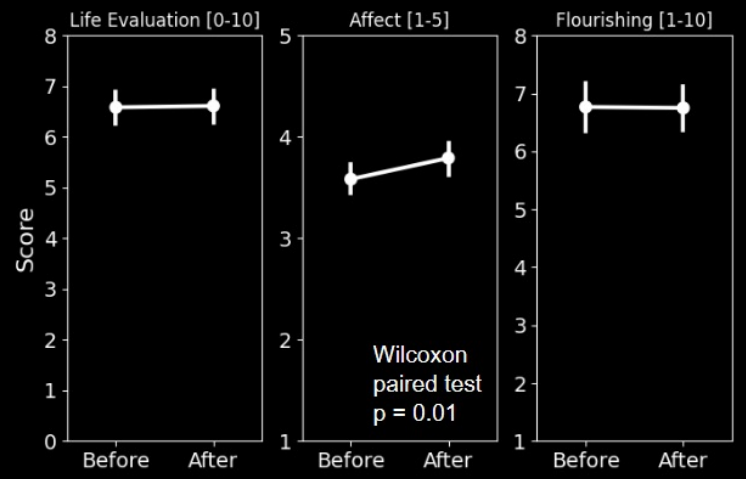
Results

The SWQ pre-post assessment revealed a significant increase of the affect score between the first and second administration (p = 0.01) (**F**).

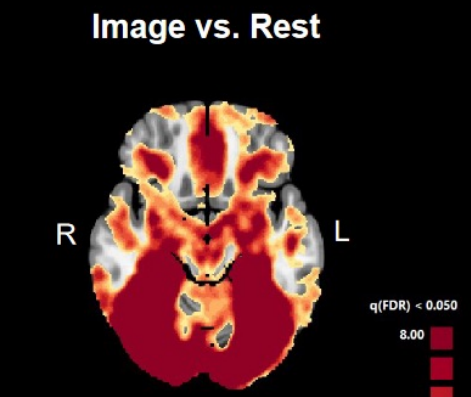
Univariate group-analysis showed activations in regions well know for the process of emotions and memory recall during the Recall task block (**G**).

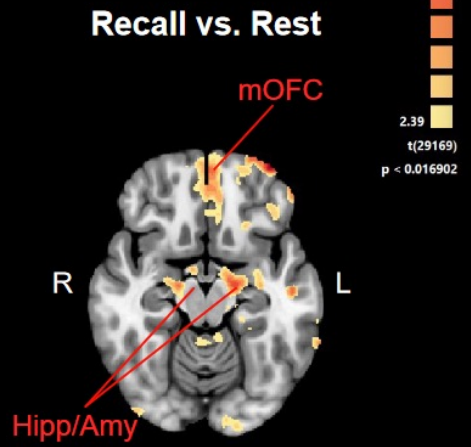
Individual subject wRSA enabled the identification of regions carrying discriminative information for specific positive emotions. Most frequently across subjects, a combination of different emotion models explained the fMRI response patterns (**H**).

F) SWQ Results



G) Univariate Results





MNI z = -16

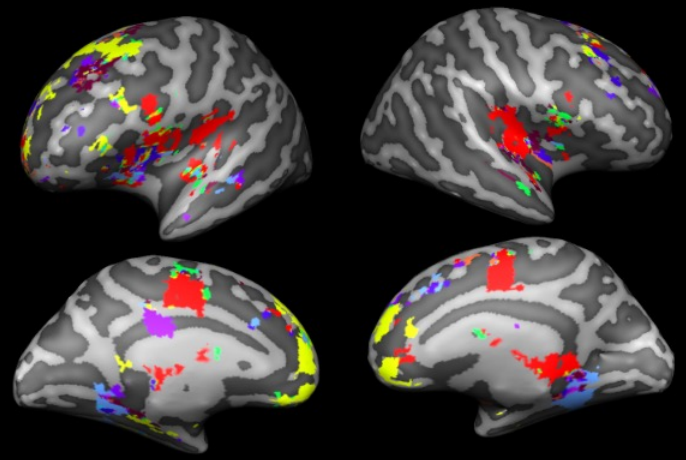
H) wRSA Results

Weights winner map

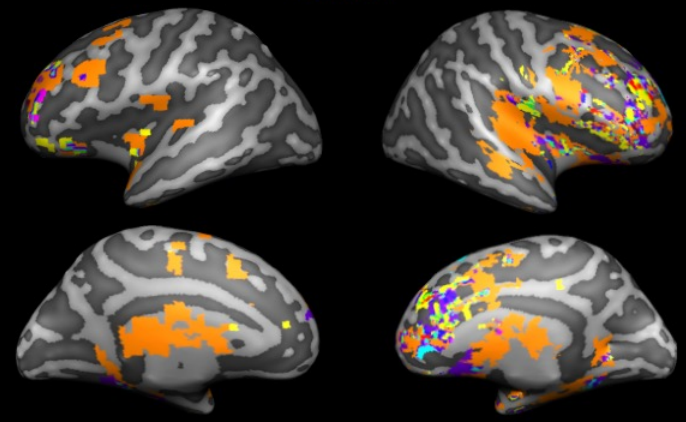
Left-hemisphere

sub-01

Right-hemisphere



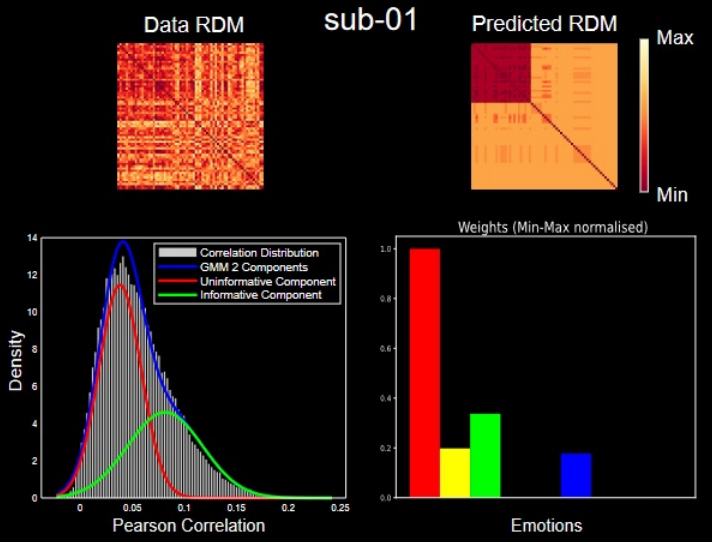
sub-07



Weights winner map within best fitting regions obtained via GMM modelling of the wRSA model correlation distribution [6]. MNI inflated white matter surface (nr_iterations: 800).

Best Searchlight Data

sub-01



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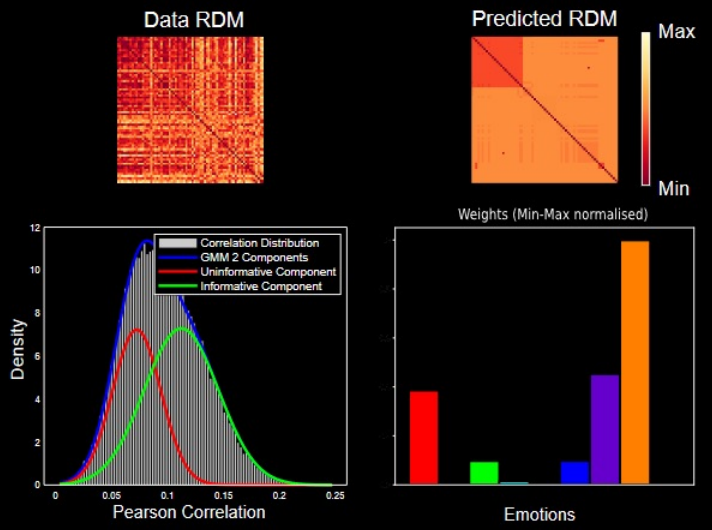

Conclusions

Our 7 Tesla fMRI study demonstrated the potential to discriminate different positive emotions in individual participants. We are currently analysing the similarity of emotion-specific patterns across individuals. The individual emotion-specific patterns of activity could provide the possibility to monitor emotional mental states to prevent mood disorders in healthy individuals and to quantify progress of pharmacological and non-pharmacological (e.g. behavioral and neurofeedback) treatment in patients. Our insights may offer a promising path towards a biomarker of subjective wellbeing.

References: [1] Shiota, M. N., Campos, B., Oveis, C., Hertenstein, M. J., Simon-Thomas, E., & Keltner, D. (2017). Beyond happiness: Building a science of discrete positive emotions. American Psychologist, 72(7), 617. [2] Turnbull, O. H., & Salas, C. E. (2021). The Neuropsychology of Emotion and Emotion Regulation: The Role of Laterality and Hierarchy. Brain Sciences, 11(8), 1075. MDPI AG. Retrieved from http://dx.doi.org/10.3390/brainsci11081075. [3] Ralph Adolphs (2017). How should neuroscience study emotions? by distinguishing emotion states, concepts, and experiences, Social Cognitive and Affective Neuroscience, Volume 12, Issue 1, Pages 24–31. [4] Celeghin, A., Diano, M., Bagnis, A., Viola, M., (2017) Basic Emotions in Human Neuroscience: Neuroimaging and Beyond. Front. Psychol. [5] Matter Neuroscience (2023) Matter - Science and Happiness (Version 1.0) [Mobile app] Apple TestFlight. [6] Urbschat, A., Uppenkamp, S,, Jörn, A. (2021). Searchlight Classification Informative Region Mixture Model (SCIM): Identification of Cortical Regions Showing Discriminable BOLD Patterns in Event-Related Auditory fMRI Data. Frontiers Neuroscience, Volume 14.

OHBM 2024 JUNE 23~27, SEOUL, KOREA

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