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Movie-induced emotion experiences modulate dynamically-occurring amygdala-CAPs

Background

- Emotion experience is a complex and dynamic process
- The neural processes underlying emotion experience are poorly understood (Saarimäki, 2021)
- Films evoke a reliable emotion response (Cowen & Keltner, 2017)
- Advances in fMRI analysis towards neural dynamics drive popularity of using film in affective neuroscience
- Much work in affective neuroscience is limited to studying few emotions at a time

Goals:

- Use films to investigate the neural basis underlying emotion experience for 13 emotion categories
- Identify regions with activation specfic for each emotion category
- Investigate Amygdala Co-Activation Patterns (CAP) from film fMRI
- Relate dynamic brain states to changes in emotion experience

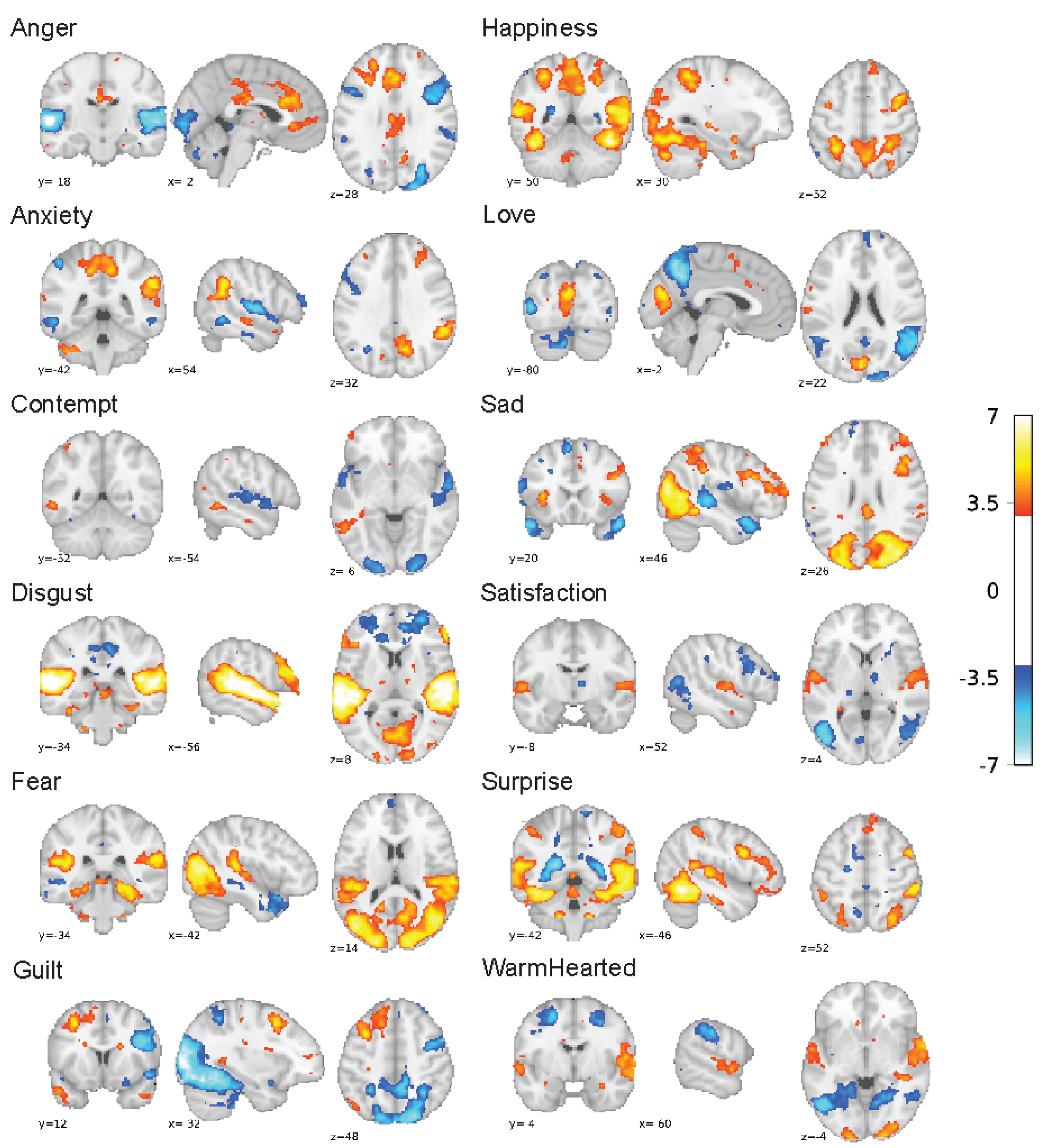

Figure 1. Brain activity maps representing significant clusters associated with discrete emotions. The maps show z-values beginning at the clusterthreshold of z = 3.1. All clusters reached a significance threshold of p < .05.

Method

Data:

- 30 healthy participants (18 female; aged 18 - 35)
- fMRI of participants watching 14 short films (avg. 11′26″)
- 3T Siemens Trio, TR = 1.3, voxels $2.5mm^3$
- Detailed emotion annotations from previous behavioural study for 13 emotion categories

Analysis:

- Standard fMRI preprocessing in fsl
- GLM of fMRI data with 13 regressors of interest using fsl
- Amygdala CAPs were calculated separately for each short film (Bolton et al., 2020)
- CAPs were matched using the Hungarian Algorithm
- GLMs of CAP time courses to predict emotion experience were performed separately for each emotion category

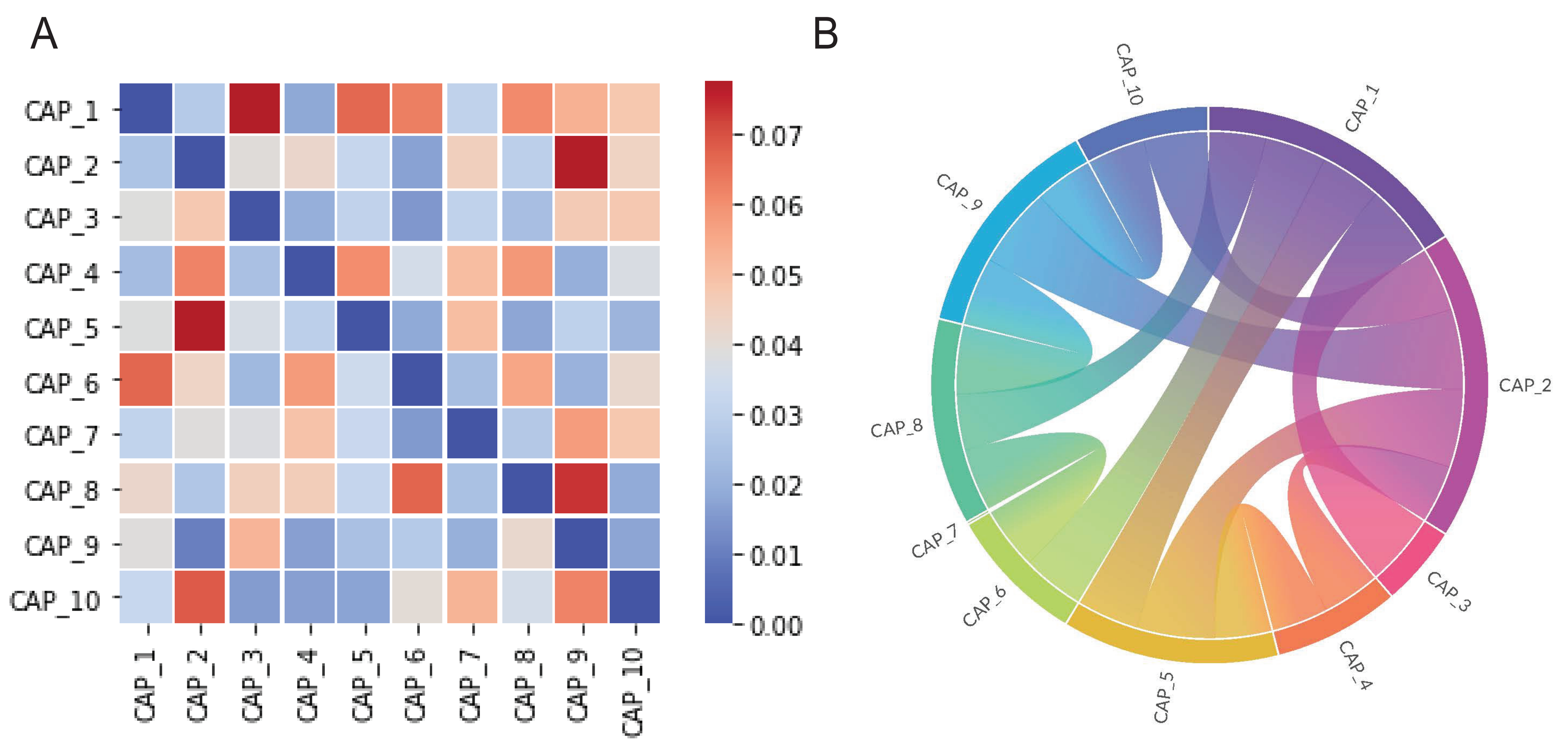

Figure 2. Transition probabilities between CAPs. (A) Directional transition probabilites between CAPs while not accounting for transitions of the baseline state. (B) Chord diagram of all transition probabilities greater 0.06 highlighting most frequent transitions.

Results

- GLM reveals distinct activation maps for each emotion except 'Shame', that overlapp with well-known functional networks (Figure 1)
- Amygdala CAPs were distributed relatively evenly; fractional occupancy ranging from 6.87% to 11.43%
- Rich transitions between states with CAP_1 and CAP_2 serving 'hub' function (Figure 2)
- CAPs show several functional networks to be coactivated with the amygdalae (Figure 3)
- All 13 emotion categories can be explained by a linear combination of between two and seven CAPs

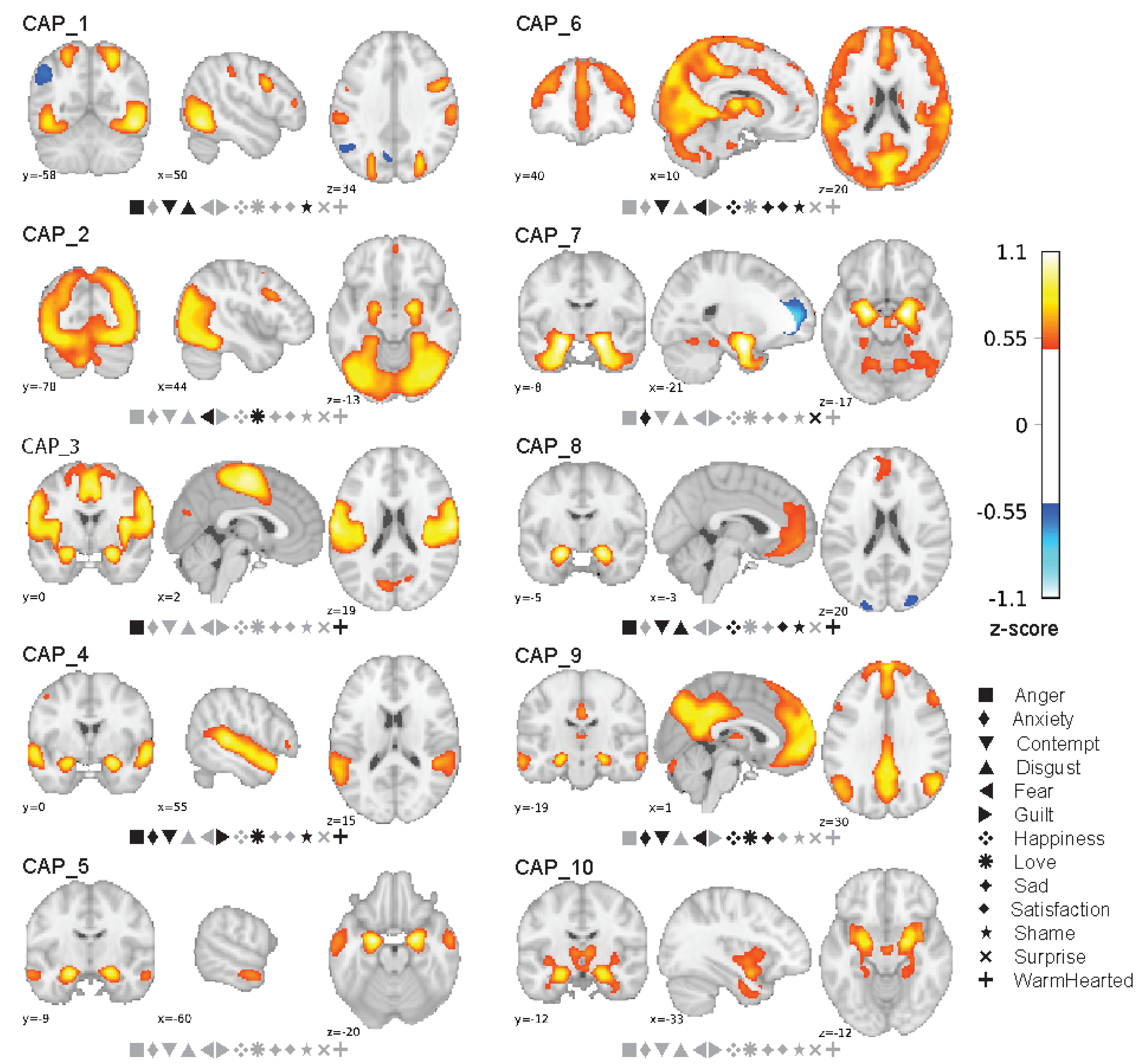

Figure 3. Amygdala CAPs and their relationship with emotion time courses. Black symbols represent a significant relationship between the CAPs time courses and the respective emotion while grey symbols represent that there was no relationship.

Conclusion

- Short films evoke a wide range of emotions, each with distinct neural activation patterns
- Despite a lack of experimental control both the static and the dynamic analysis revealed robust links between neural activation and emotion experience
- Amygdala CAPs probe large-scale functional networks comparable to brain states reported in a recent resting-state study using the same technique (Rey et al., 2021).
- CAPs analysis revealed strong relationship between time courses of data-driven brain states and behavioural regressors.
- Future analysis should focus on overlapping brain states to probe an underlying integration process of multiple brain states (e.g. using iCAPs)
- Dynamic states provide additional insight to static GLM
- This is an important contribution to a growing body of research into the neural underpinnings of diverse emotion experiences (Horikawa et al., 2020)

Bolton, T. A., Tuleasca, C., Wotruba, D., Rey, G., Dhanis, H., Gauthier, B., Delavari, F., Morgenroth, E., Gaviria, J., & Blondiaux, E. (2020). TbCAPs: A toolbox for co-activation pattern analysis. NeuroImage, 211, 116621.
Cowen, A. S., & Keltner, D. (2017). Self-report captures 27 distinct categories of emotion bridged by continuous gradients. Proceedings of the National Academy of Sciences of the United States of America, 114(38), E7900–E7909. https://doi.org/10.1073/pnas.1702247114
Horikawa, T., Cowen, A. S., Keltner, D., & Kamitani, Y. (2020). The Neural Representation of Visually Evoked Emotion Is High-Dimensional, Categorical, and Distributed across Transmodal Brain Regions. IScience, 23(5), 101060. https://doi.org/10.1016/j.isci.2020.101060
Rey, G., Bolton, T. A. W., Gaviria, J., Piguet, C., Preti, M. G., Favre, S., Aubry, J.-M., Van De Ville, D., & Vuilleumier, P. (2021). Dynamics of amygdala connectivity in bipolar disorders: A longitudinal study across mood states. Neuropsychopharmacology, 46(9), 1693–1701. https://doi.org/10.1038/s41386-021-01038-x
Saarimäki, H. (2021). Naturalistic Stimuli in Affective Neuroimaging: A Review. Frontiers in Human Neuroscience, 15, 318. https://doi.org/10.3389/fnhum.2021.675068