Numb to the world: Desensitization to Emotional Stimuli over Time

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Existing Literature and COVID Context

- **COVID-Related:** Recent research has observed desensitization to fear-inducing COVID health news over time
  - Despite the steadily rising COVID-19 death toll, people's expression of anxiety decreased over time (11 months). Findings suggest individuals become desensitized to the increased COVID19 threat and their emotional responses are blunted overtime

- **fMRI studies:** Neural processing of emotional pictures in video game players vs controls investigating emotional desensitization over time (Szycik 2016)

- **PFC and amygdala habituation:** Repeated presentations of emotional facial expressions used to assess habituation in brain = decline of response to repeatedly presented stimuli (Hariri 2002)
  - PFC involved in maintaining directed attention to salient stimuli
  - Amygdala is "central fear processor" and initiates cascade of critical physiological and behavioral responses
  - Yet if repeated stimulus presentations occur, amygdala activity rapidly habituates and PFC is thought to be responsible

Research question(s)

Does emotional stimuli elicit less of a response overtime?

Hypothesis:

Emotional stimuli become less pyschologically arousing overtime.

We expect to see a linear decrease in brain activity regions associated with emotion and arousal.

How does functional connectivity in the vmPFC and the amygdala change over time?

Hypothesis:

The vmPFC will become more negatively correlated with emotional and movement regions, while the amygdala will become less connected with sensory regions.

Background

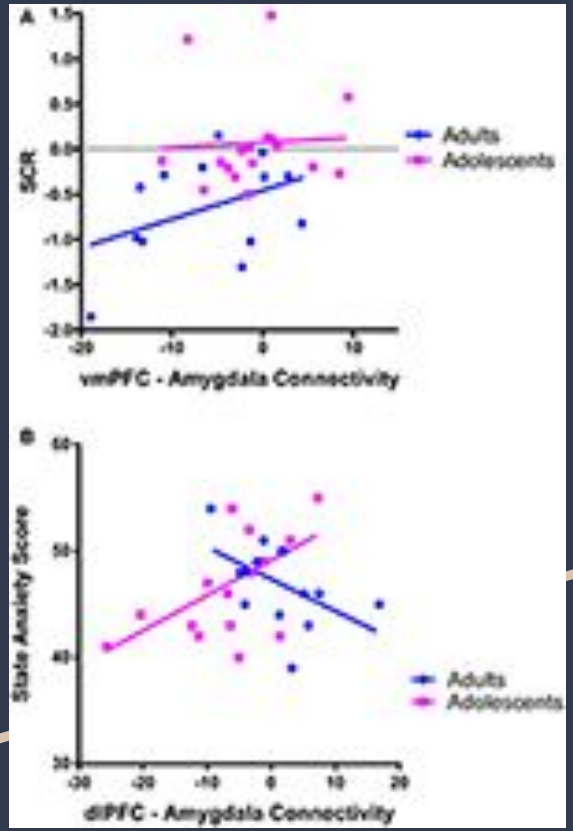
Physicians down-regulate their pain empathy response: An event-related brain potential study

Emotion regulation in physicians has very early effects, inhibiting the bottom-up processing of the perception of pain in others. physicians' down-regulation of the pain response dampens their negative arousal in response to the pain of others

Habituation of Rostral Anterior Cingulate Cortex (rACC) to Repeated Emotionally Salient Pictures

A significant decrement in blood level oxygen-dependent (BOLD) signal change was detected at the same focus within the rACC for both aversive (AV) – blank (BL) and aversive – neutral (NT) contrasts with repeated presentations

Background



Prefrontal-amygdala connectivity and state anxiety during fear extinction recall in adolescents

Psychophysiological interaction analyses revealed that during extinction recall there was significant negative connectivity between the vmPFC and amygdala in adults, but not adolescents. vmPFC-amygdala connectivity was positively correlated with SCR. Adolescents showed significant negative FC between the dlPFC and the left and right hippocampus, and the amygdala, which was positively correlated with state anxiety.

*SCR is a measure of the fear response

Analysis

Question

What happens to the brain regions associated with emotion regulation and how does the activity in those areas change over time?

Task

All participants (n=7) viewed were shown a set of visual stimuli related to events happened in the years 2020-2021. There were 153 images and 1 video, which were shown across 4 runs. The first three 8-minute runs being the 153 images displayed in random order, and the last run being the video.

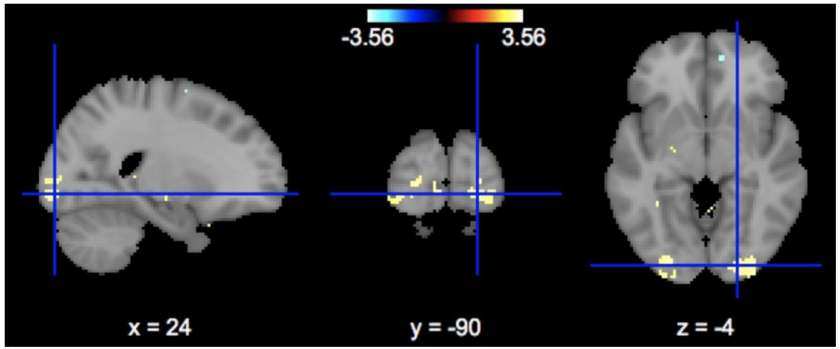
Methods

1. Create time regressor using image timestamps
2. Concatenate runs into single run
3. Run group level model to find monotonic changes in brain activation
4. Calculate changes in seed-based functional connectivity for regions of interest across time.
5. Calculate correlation of vmPFC and amygdala connectivity to other brain regions
6. Threshold and plot (uncorrected, 0.01)

Results: What brain regions monotonically increase/decrease in activation over time?

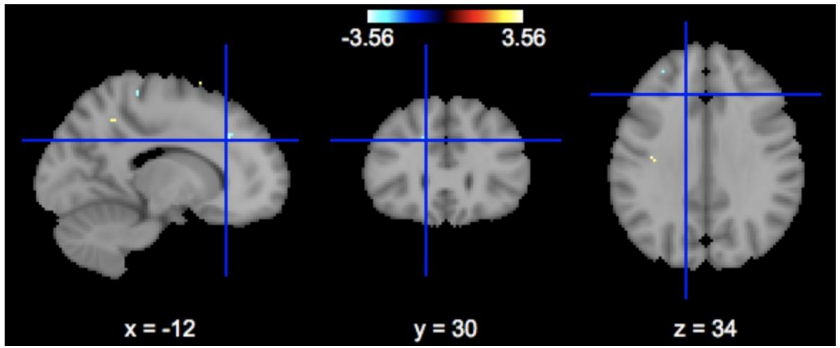
Increase:

- Left-Right inferior occipital lobe/fusiform gyrus (Face Recognition)
- Amygdala (emotion), hippocampus (spatial memory),
- Insula (interoceptive awareness)
- Precuneus & dmPFC (DMN)



Decrease:

- Anterior Cingulate & vmPFC - regions associated with cognitive control and morality.
- Temporal sulcus - theory of mind, memory
- Premotor cortex & caudate nucleus - inhibitory control of motion



Results: How does the functional connectivity of the amygdala change over time ?

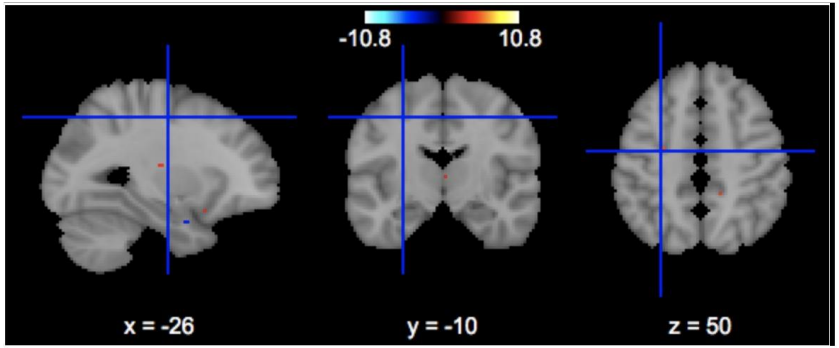
Increase:

- FEF/Premotor Cortex - Control/Planning of (eye) movement; also contain mirror neurons
- Superior Temporal Gyrus - Processing of Speech/Language
- Putamen - Preparation/Execution of Movement; also involved in a “hate” circuit

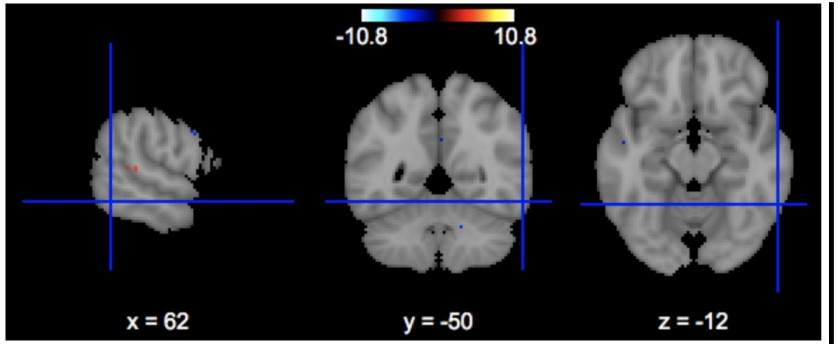
Decrease:

- Parahippocampal gyrus - Memory encoding, retrieval
- Planum Temporale - Auditory processing?
- Inferior Parietal Lobe - Processing emotions in facial stimuli

Premotor Cortex



IPL



Results: How does the functional connectivity of the vmPFC change over time ?

Increase:

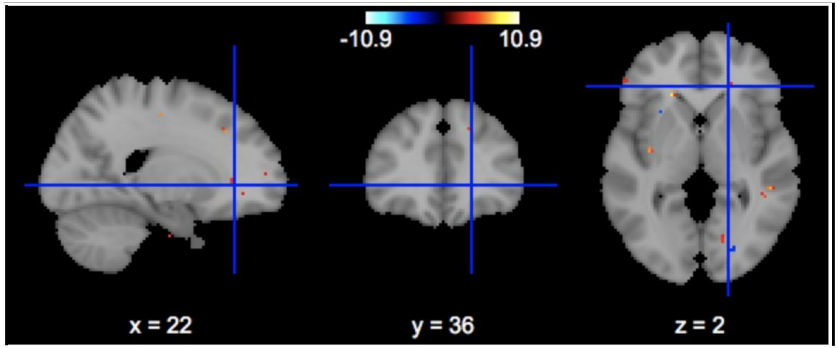
- Striatum/Caudate - Inhibitory Control of Movement
- Premotor Cortex - Control/Planning of (eye) movement, recognizing the actions of others
- Insula: Interoceptive awareness

Decrease:

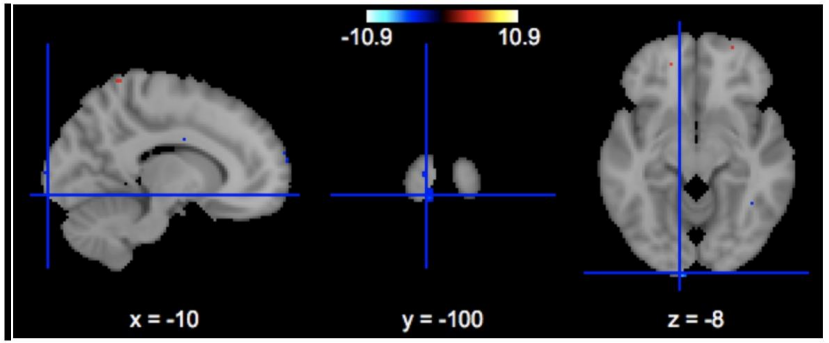
- Nucleus Accumbens & Amygdala:: Aversion, fear, motivation
- Putamen - Preparation/Execution of Movement; also involved in a “hate” circuit
- Medial Temporal Gyrus & Fusiform Gyrus/Occipital Lobe - Face/Emotion Recognition

* DMN is inconsistent - increased in dmPFC & hippocampus, decreased in precuneus & MTG

Dorsal Striatum



Nucleus Accumbens



Results: How does the functional connectivity of the amygdala and the vmPFC correlate with the activation of other brain regions?

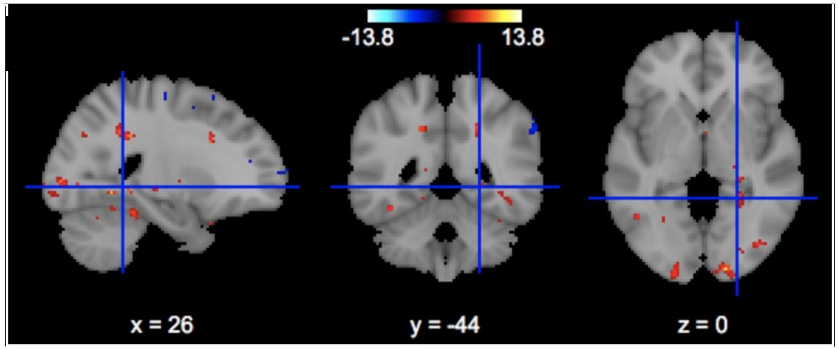
Increase:

- Ventral Stream (V1/Fusiform/Parahippocampal Cortex/Inferior Temporal Lobe) - identifying the “what,” visual memory
- Intraparietal & Motor Cortices - Eye/Motion control, spatial location.

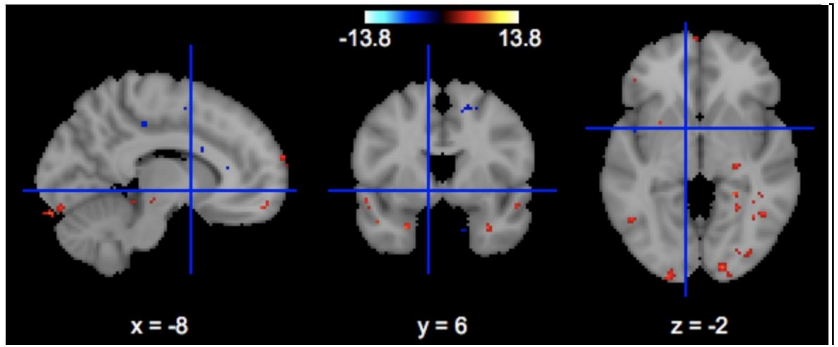
Decrease:

- Anterior Cingulate & Ventral Striatum - Reward, morality
- Supplementary & Premotor Areas - Diverse control of movement
- Right Inferior Parietal Lobe - No go tasks

Parahippocampal Cortex



Ventral Striatum



Limitations / Alternative Explanations

Limitations

- Small sample size
- Different number of runs for each participant
- Participants become tired, bored, or distracted as the run progresses
- Effect could be due to participants adjusting to the unfamiliar environment (of MRI machine)
- COVID stimuli particularly subject to “desensitization” / people are likely to “block it out”
- Range of background and context to understand the images and elicit emotional response (although the fact that images were random largely controls for this)
- Lack of specificity for brain regions

Conclusion

- The degree of activation of certain brain regions in response to the experimental paradigm change over time
- In general, regions associated with emotion and the DMN become more active, while regions exhibiting executive control over emotions and movement became less active
    - Possibly difficult to maintain executive control over long period?
- Our two regions of interest - the amygdala and the vmPFC appear to be consistently negatively correlated (vmPFC is low when amygdala high)
    - Aligns with previous literature on the regulatory role of the vmPFC on the amygdala
- However, there appears to be a complicated relationship between time and regions involved in movement and visual processing, with related areas showing different trends
- The amygdala and the vmPFC show similar functional connectivity to visual processing regions and motor control

Future Directions

- Probe for difference in **type of arousal** by looking at **categories**
- Test **auditory stimuli** to see if the emotional desensitization is apparent in other senses and not purely visual
- Investigate correlations with **participant reports** by including survey data
- Isolate the effect of **COVID-related stimuli** - try experiment with non COVID stimuli
- Examine the effect of numbness to the negative consequences of taking risk on an individual's risk-appetite

References

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