Aging and Emotion: The Mediating Role of Amygdala Connectivity

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Abstract

The amygdala is an essential brain region for emotional processes, and it is notably affected by aging. In this study, we focused on the effect of aging on resting amygdala functional connectivity (AMYG-FC), which represents the coordinated activity between the amygdala and other brain regions during rest. Next, we examined the relationship between age-related changes in AMYG-FC and emotion, as measured by facial electromyography (EMG) corrugator reactivity to negative emotional stimuli. Utilizing resting-state functional Magnetic Resonance Imaging (fMRI) data from 111 participants of the Midlife in the U.S. (MIDUS) study's 3rd follow-up, we tested AMYG-FC across 328 brain regions of interest (ROIs), with sex, education level, and head motion as covariates. Our findings revealed an age-related decline in AMYG-FC to 29 different ROIs and an increase to 3 ROIs (FDR corrected, $p < .05$). A positive correlation was found between the age-related average decrease in AMYG-FC from the 29 regions and the corrugator reactivity to negative stimuli. Mediation analysis suggested an indirect pathway – the age-related reduction in AMYG-FC contributes to a stronger corrugator reactivity to negative stimuli. This decrease in AMYG-FC might reflect both neurological changes due to aging and a diminished ability to regulate negative emotional reactivity. Future research is vital to unravel the long-term progression of AMYG-FC and to understand its influence on emotional processes, reactivity and regulation in aging individuals.

Background

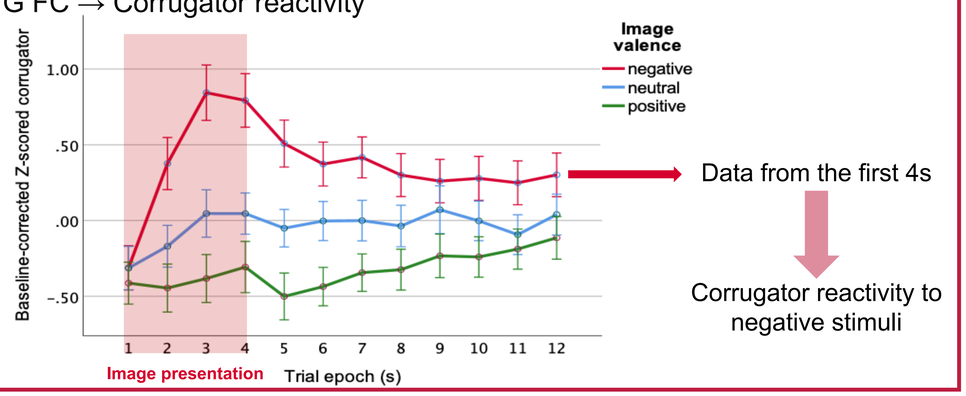
- The amygdala is crucial for emotional processes (Banks et al., 2007).
- Aging impacts structural (Fjell et al., 2009) and resting functional properties of the amygdala (Sakaki et al., 2016).
- Activity of the corrugator supercilia muscle is a valuable measure for investigating emotional responses to negative stimuli.
  - Corrugator muscle's activity linearly corresponds to the emotional valence of stimuli (Larsen et al., 2003).
  - Differences in corrugator muscle activity related to emotional regulation demonstrate moderately high retest reliability, $r_s > .71$ (Lee et al. 2009).
- The Midlife in the U.S. (MIDUS) study collected resting fMRI data and facial EMG across a broader and older age spectrum than is customarily studied.

Implication

- Aging indirectly impacts emotional reactivity through a decline in AMYG-FC, suggesting a crucial mediating role of brain networks in negative emotion in aging.
- The study reveals potential neural mechanisms that link corrugator reactivity to negative stimuli and AMYG-FC.
- The research establishes a foundation for studying the long-term effects of changes in AMYG-FC on emotional processes, including emotional reactivity and regulation.

Method

- Midlife in the United States (MIDUS) study's 3rd follow-up (2017-2022; *N* = 111; Age: 45-95; Mean = 65.58, SD = 9.09).
- Emotional image viewing task (30 negative, 30 neutral, and 30 positive IAPS images were presented for 4 s); Resting fMRI data (8 mins; 240 TRs)
- Preprocessing: Remove the first 4 time points; Slice timing; Volume registration and motion correction; Bias field correction; Realign (coregistration, and normalization); Regress out nuisance (white matter, CSF, head motion and derivatives); Temporal bandpass filter (0.01–0.1 Hz); Censor time points; Smoothing. Brain parcellation.
- Data analysis:
  - Regression analysis: Age ~ AMYG FC with ROI X + Sex + Race + Education + Head motion
  - Regression analysis: Corrugator reactivity ~ Average AMYG-FC + Sex + Race + Education + Head motion
  - Mediation analysis: Age → Average AMYG FC → Corrugator reactivity



Results

- Age demonstrated negative associations with AMYG-FC across 29 ROIs, and positive associations with AMYG-FC in 3 ROIs (FDR corrected, $p < .05$; Fig 1).
- The ROIs with AMYG-FC that negatively associated with age included: superior temporal gyrus, postcentral gyrus, inferior parietal lobule, superior parietal lobule, precentral gyrus, middle temporal gyrus, paracentral lobule, precuneus, and inferior temporal gyrus.

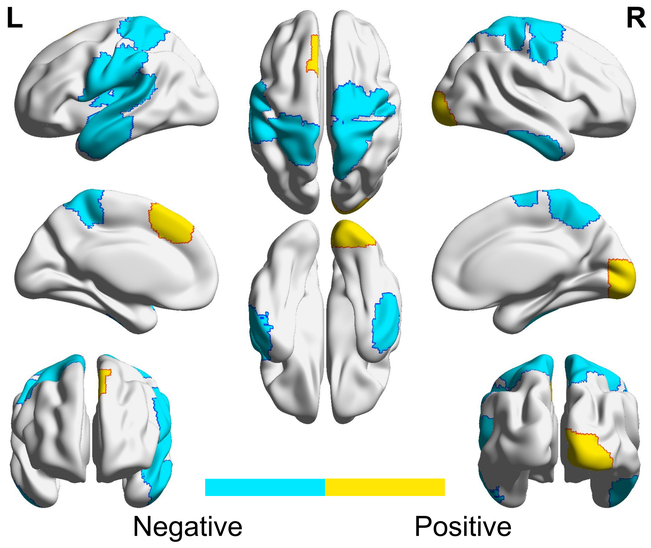
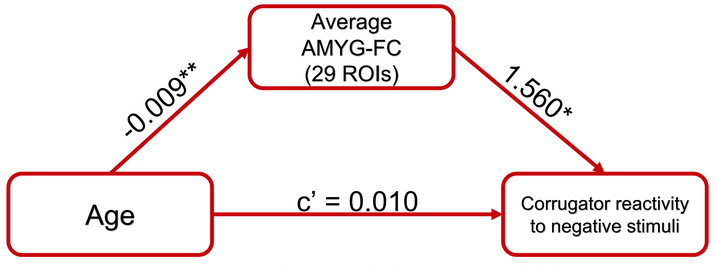


Fig. 1 The association between age and AMYG-FC

- The ROIs with AMYG-FC that positively associated with age included: superior frontal gyrus and medioventral and lateral occipital cortex.
- The average AMYG-FC from the 29 ROIs negatively associated with age mediated the relationship between age and corrugator reactivity to negative stimuli (Fig. 2).



Indirect effect = -0.014*, $p = .002$

Fig. 2 Mediation role of AMYG-FC

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