Neural Correlates of Over-Sensitivity to Negative Valence Expressions in Three-Year-Old Children

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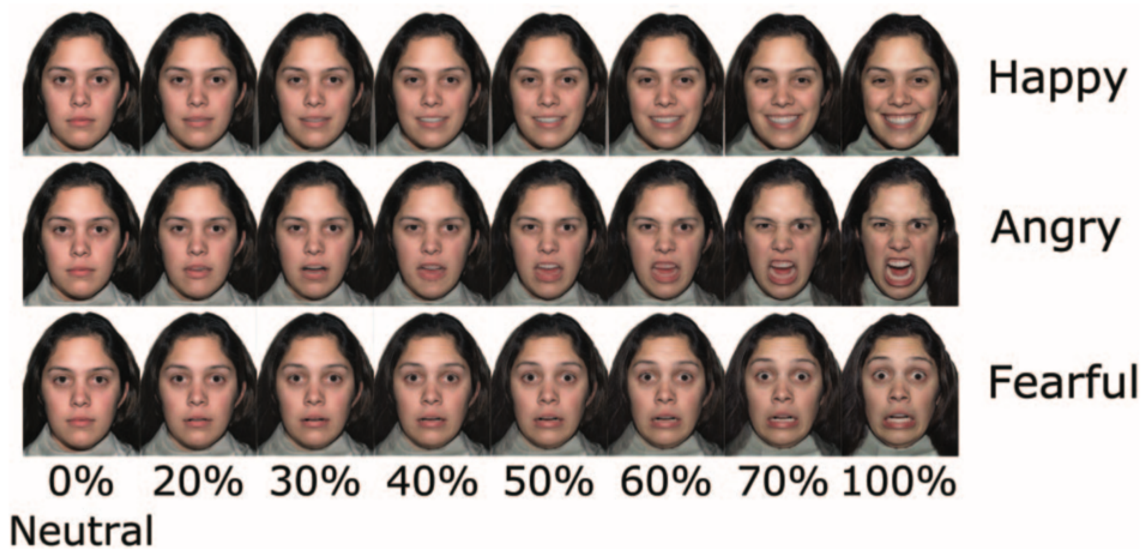
Abstract

Deficits in the ability to discern emotion from facial expressions such as individuals who are highly sensitive in response to negative expressions, have been suggested to indicate deficits in socio-emotional functioning and regulation of emotion. This thesis tested facial perception accuracy through a behavioral emotion sorting task to investigate the typical developmental trajectory of facial emotion perception in children at three years of age and five years of age. It also used functional near-infrared spectroscopy to measure neural activity in the prefrontal cortex in response to faces of positive and negative valence. This thesis found a linear relationship between the demonstrated sensitivity to negative valence expressions in the behavioral task and the deoxygenated hemoglobin response in the ventromedial prefrontal cortex, such that greater sensitivity to negative faces in the behavioral task was correlated with a greater condition difference in deoxygenated hemoglobin response. Our research suggests that the medial prefrontal cortex responds differentially to the valence of facial emotion and may play a role in accurately perceiving facial emotion during development.

Emotion Sorting Task

In order to assess facial perception accuracy at both three years old and five years old, we created laminated cards of a subset of the MacBrain Stimulus set which each had an image of a woman displaying a happy, angry, or fearful expression at an intensity between 0% and 100%. Children were asked to sort each card by the emotion ascribed by the image.

In order to evaluate facial emotional recognition sensitivity at the individual level, two scores were created: 1) the number of happy or neutral cards that were sorted as fear or angry, and 2) the number of low intensity (40% and below) fear and angry cards that were sorted as fear or angry. These combined scores were used to quantify a child's sensitivity to negative valence expressions.

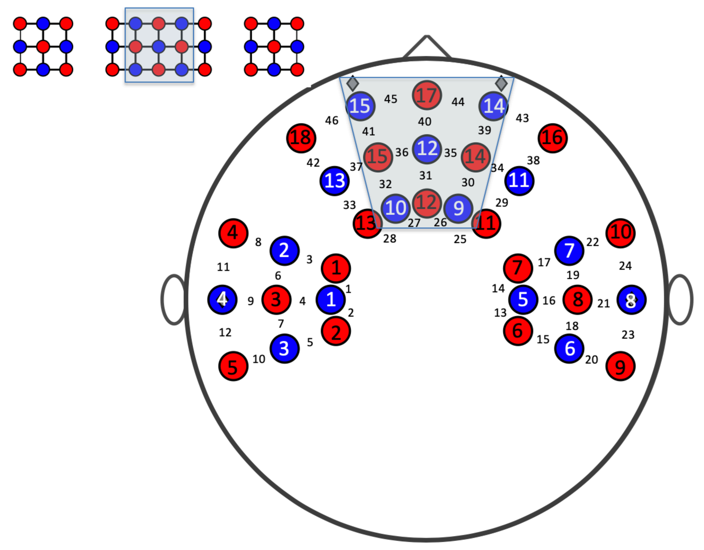


Specific Aims

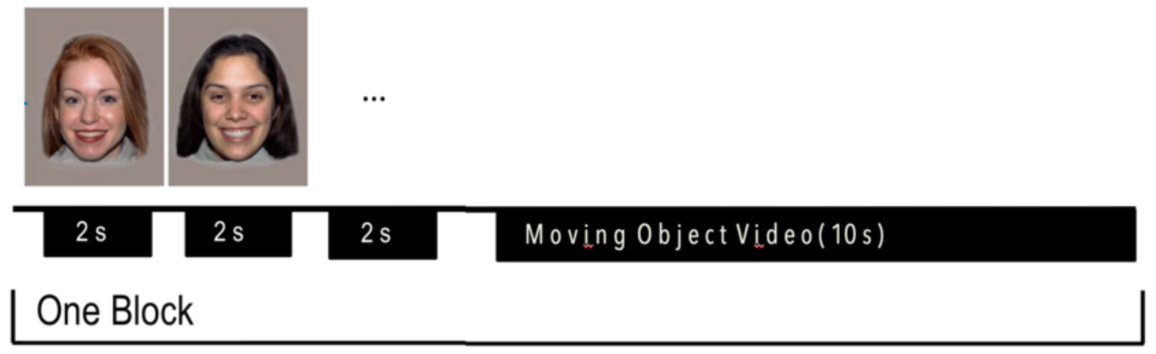
1. To characterize development changes in overall performance on the emotional sorting task between three-year-olds and five-year-olds
2. To explore development change and stable individual difference in sensitivity to negative facial emotions between three and five years old
3. To examine the relationship between hemodynamic responses and sensitivity to negative faces demonstrated through the emotional sorting task in three-year-old children

Functional Near-Infrared Spectroscopy

fNIRS is a non-invasive neuroimaging technique that measures the hemodynamic changes in oxyhemoglobin (oxy-Hb) and deoxyhemoglobin (deoxy-Hb) concentrations in response to a discrete stimulus as an indirect measure of local neural activity.



The fNIRS probeset designed for this study includes 18 emitters (shown in red), 15 detectors (shown in blue), and 46 channels arranged along the frontal and temporal regions of the child's head. The light blue box illustrates the 12 mPFC channels included in fNIRS processing to investigate patterns of neural activity in response to facial emotion.

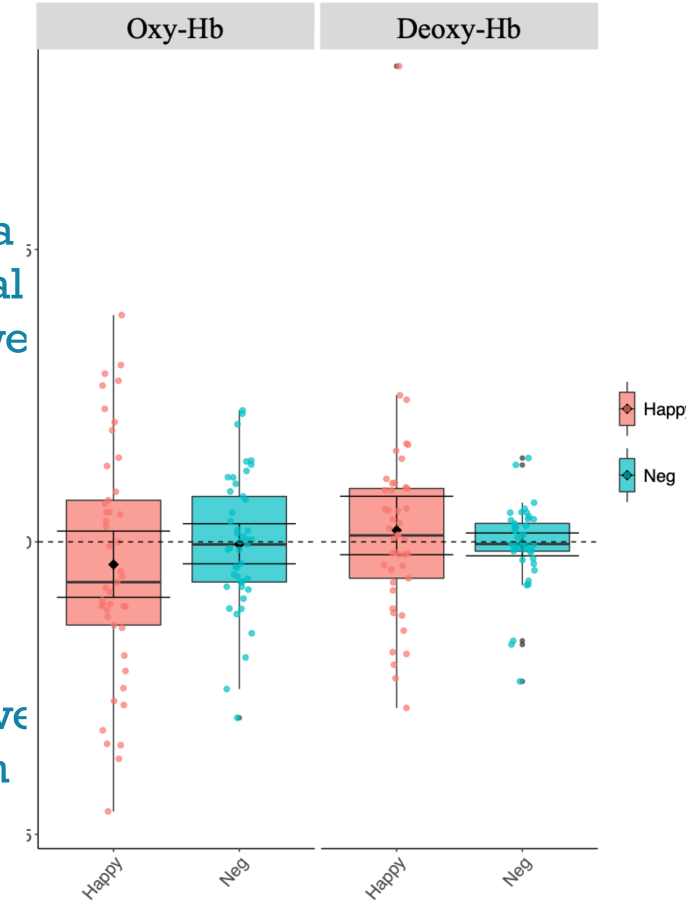


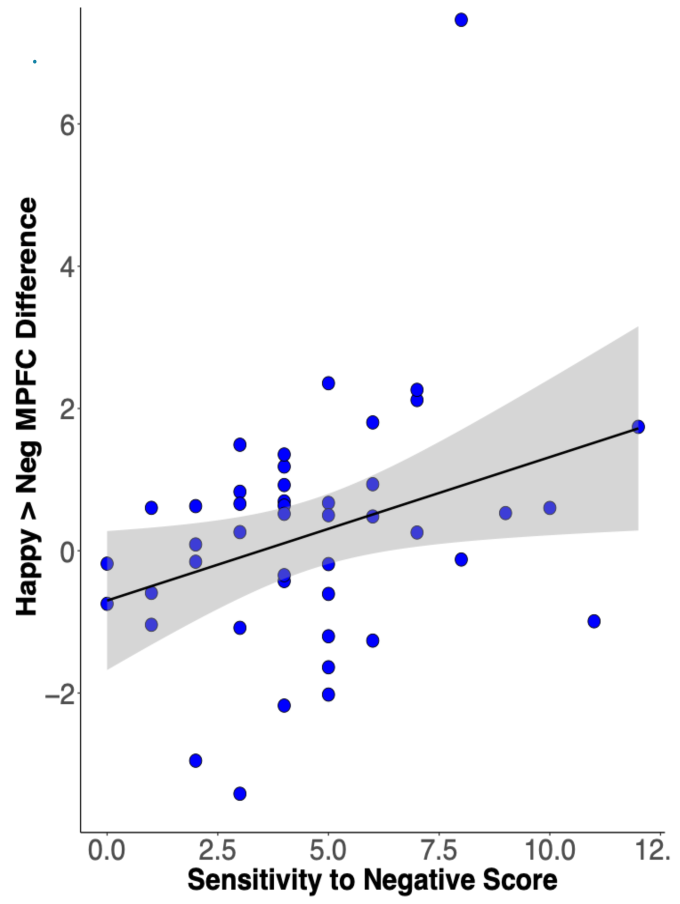
Neuroimaging was conducted while children were presented with a block design task consisting of 60 total trials of either dynamic positive or negative valence faces.

Results

Hemodynamic Responses in the mPFC

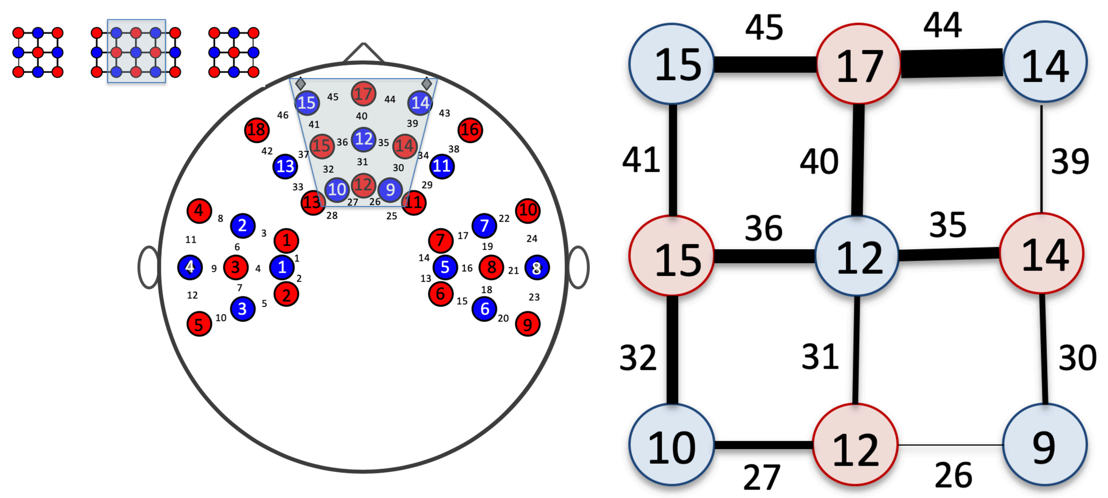
On average, there was no significant difference in the medial prefrontal cortex response as a function of emotional valence. However, we see a significant correlation emerge when we compare the difference in deoxy-Hb response to valence with the sensitivity to negative score in the emotion sorting task (p=0.03154).





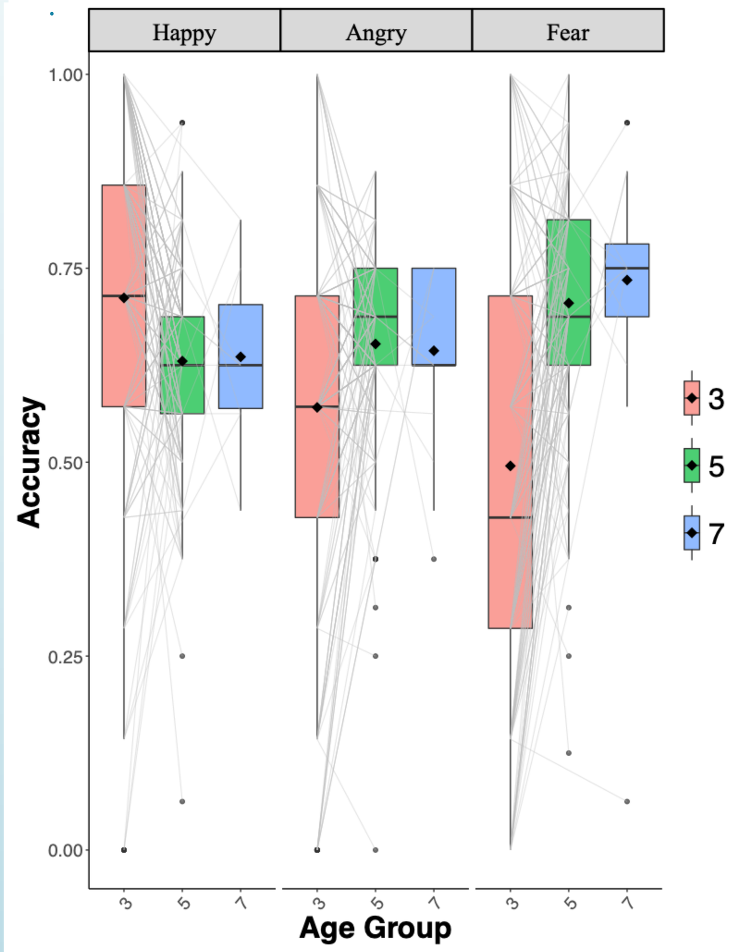
Children who demonstrated higher sensitivity scores show a greater difference between their deoxy response to happy versus negative valence faces.

The most common channels demonstrating the greatest functional response to valenced expressions were channel 44 and 45, which sit above the brow bones in our probeset design. The location of these channels (relative to an MRI atlas) suggests that the highest functional response to facial expression valence is in the ventromedial prefrontal cortex.



Developmental Change in Emotional Accuracy

This figure highlights how accuracy changes by age for each emotion. Grey lines represent each individual's performance over time.

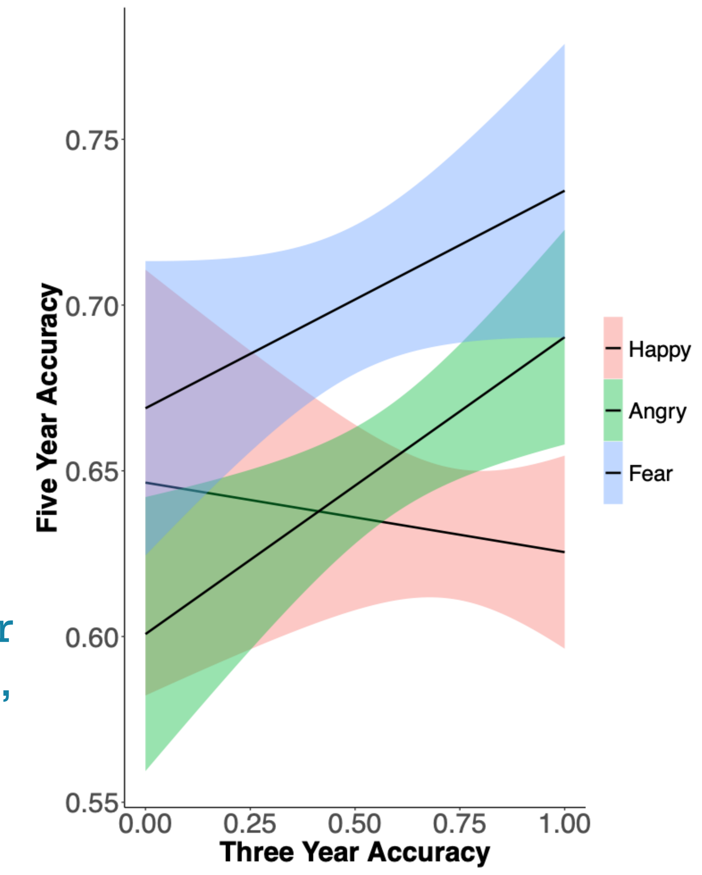


From 3 years of age to 5 years of age, children became more accurate in sorting angry (t(179)= -3.8863, p= 0.0001432, paired t-test) and fearful expressions (t(179)= -8.6027, p= 3.858e-15), and less accurate in sorting happy expressions (t(179)= 5.2763, p= 3.779e-07)

Stable Individual Differences

This visualization of individual differences in accuracy performance demonstrates how performance at three-years-old relates to performance at five-years-old by emotion.

Accuracy in sorting angry faces at age three predicted accuracy in sorting angry faces at age five (b= 0.0963890, t= 2.833, p= 0.00516) and there were no stable individual differences in sorting happy (b= 0.089039, t= -0.831, p= 0.407) or fearful (b= 0.0532617, t= 1.410, p= 0.160) expressions.



Acknowledgements

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