Motor Processing During Gesture Perception Across Development: An fMRI Study

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Visual perception is affected, both behaviorally and neurally, by our history of action with objects (e.g., James, 2010; Longcamp et al., 2003). In the present study, we explore whether *perception* of manual gestures might similarly be influenced by a history of gesture *production*.

Behavioral research has shown that children do not produce gesture to the same extent as adults (Colletta et al., 2010). Thus, if gesture perception is affected by gesture production, one would expect to see differences in neural processing during perception across development. We investigate whether these differences exist in two regions: the posterior middle temporal gyrus (pMTG) (part of gesture perception and motor representation networks; e.g., Beauchamp & Martin, 2007; Dick et al., 2011; Kircher et al., 2009; Martin & Chao, 2001) and the premotor cortex (reactivated after active production; James, 2010; Longcamp et al., 2003).

Methods

Participants

- 5-6 yr olds (n = 13, *M* = 5.47)
- 7.5-8.5 yr olds (n = 13, *M* = 7.70)
- 10-11 yr olds (n = 13, *M* = 10.50)
- Adults (n = 13, *M* = 24.77)

Experimental Session

(1) fMRI simulator exposure (children only)

(2) Scan (functional & anatomical)

(3) Behavioral session

Stimuli & Functional Run Design

Sentence alone (S) | Gesture + Sentence (GS) | Gesture alone

- 2.5 sec videos, 12 per block
- Gesture type: Iconic

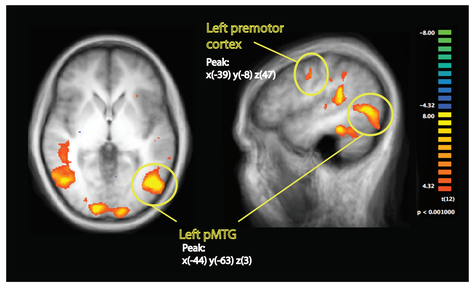
Example Sentences

The teacher ***spoke*** to her.
The bubble gum ***popped*** onto her face.
The string was ***wrapped*** around her finger.

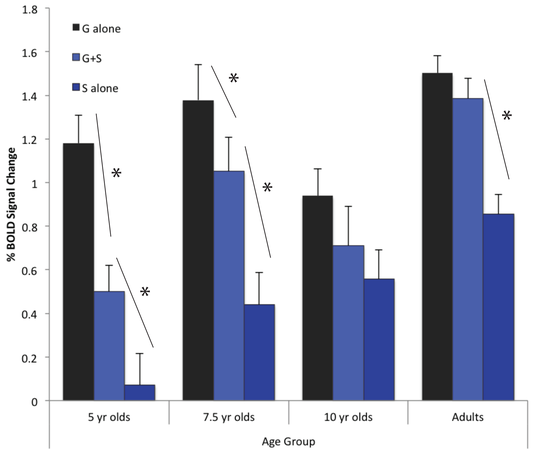
Results

Region of interest (ROI) analyses were conducted for the left pMTG and left premotor regions:

Gesture > Rest (Adult Group)



ROI Analysis: pMTG



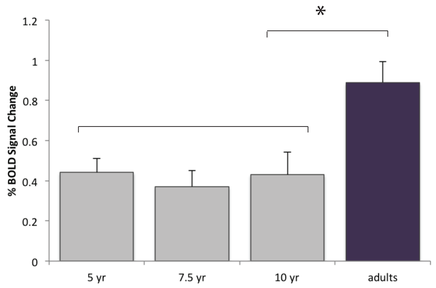
In the pMTG, the 5 yr old and 7.5 yr old groups show significant differences between all conditions: G > GS > S

The 10 yr old group follows the same basic pattern, but no significant differences between conditions, due to variance

The adults show a slightly different pattern of activation: G = GS > S

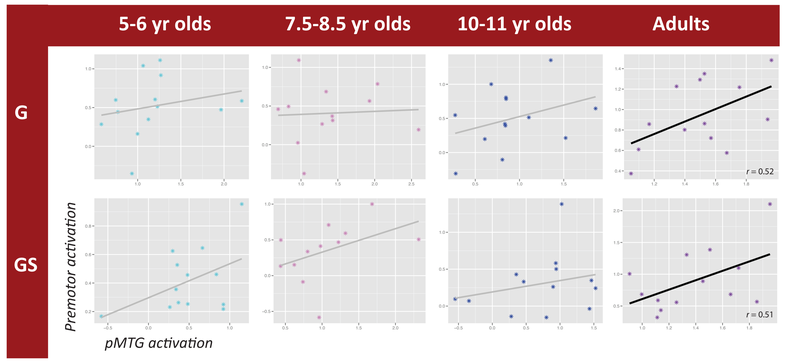
ROI Analysis: premotor cortex

In the premotor cortex, adults show greater activation across all conditions, when compared to children



Previous literature suggests that the pMTG and premotor regions may be functionally connected during processing of motoric information (Bestmann et al., 2005). To determine if this connectivity changes by condition or across development, correlational analyses were conducted.

Correlational Analysis: pMTG x premotor cortex



Significant positive correlations were found for premotor and pMTG activation during G and GS conditions for adults, but not for children

Summary

pMTG patterns of activation change across development

The pMTG responds to information related to the motion components of stimuli, which help construct part of semantic knowledge (e.g., Beauchamp & Martin, 2007; Martin & Chao, 2001).

Gestures may also provide information that is stored as part of conceptual or semantic representations - perhaps adding to the representation of speech content, or as a way to access knowledge about a concept represented by the motion.

Our results may suggest that in adults, the GS combination elicits as strong of a representation as the numerous representations that would be elicited by G alone (equivalent activation).

In contrast, children may not yet have the ability to integrate GS content to the same degree, or children may not have had enough experience using gestures to represent concepts to store these as meaningful representations.

Premotor cortex is recruited significantly more by adults than children when combinations of gesture and speech are being processed

This finding can be explain in relation to the common coding hypothesis (Prinz, 1997). If there is a common representation in the brain for perceived stimuli and planned actions that is reliant on experience, adults *should* show greater premotor activation than children, given the differences in gesture production across development.

Activation of pMTG and premotor regions is correlated for adults during gesture processing, but not for children

We suggest producing gesture gives rise to stronger representation of gesture, so when gesture is later perceived,

1) reactivation of motor plans helps reactivate semantic representations in the pMTG *OR*
2) perceiving gesture drives both areas independently

It is experience with gesture production that could lead to both premotor cortex activation, and reactivation of action knowledge in the pMTG. It is lack of experience gesturing, that may partially underlie the differences in premotor and pMTG activation in children, as well as the lack of functional connectivity.

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