# Distinct Speech Production and Speech Perception Regions in the Human Cerebellum: A Neuroimaging Meta-Analysis

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## Introduction

Prior neuroimaging meta-analyses based on small samples report a functional topology of nonmotor activation in the cerebellum, but fail to illuminate the roles of the cerebellum in nonmotor functions.

The cerebellum plays a known role in speech motor control, but its role in speech perception and language comprehension is unknown.

We conducted a large scale, but behaviourally specific, meta-analysis to test the prediction that the cerebellum contains distinct and overlapping circuits for speech perception and production.

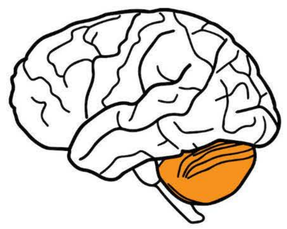
Coactivation meta-analyses and text mining were used to reveal associated cortical networks and task-related correlates (respectively) of speech-related cerebellar activity.

## Methods

**14,371** → **8,206** → **2,168** → **72** passive perception studies (n=1321) / **175** production studies (n=3787)

Neurosynth.org

**Cerebellum Mask**



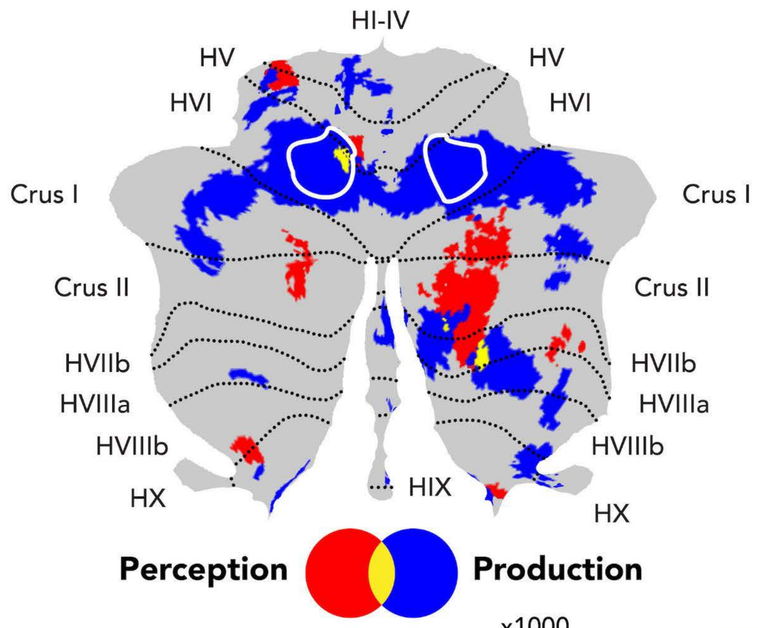
**Keyword Filter**

*acoustic, audiovisual, audition, articulate, hear, listen, music, naming, phonetic, phonological, speak, speech, speech perception, speech production, talk, tones, orofacial, pitch, vocal, voice*

**Hand Filter**

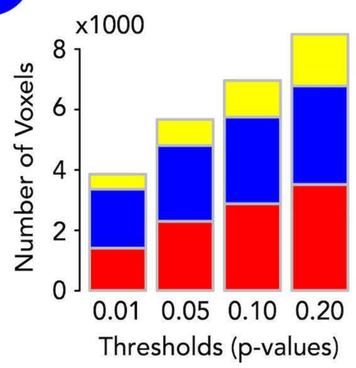
## Perception and Production

We conducted KDA meta-analysis in Neurosynth to compare cerebellar acitivity between: passive perception and production.

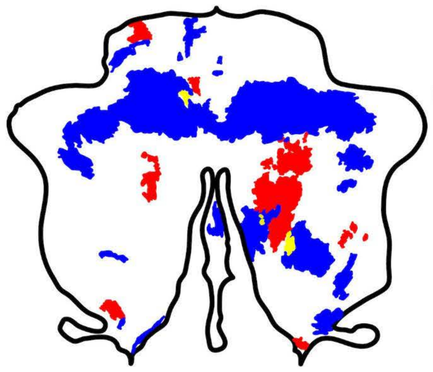



We observed distinct patterns of activity in the cerebellum related to passive perception and production regardless of the threshold used to correct for multiple comparisons.

Overlap was primarily in (dorsal and ventral) regions previously identified in moving the mouth and tongue.

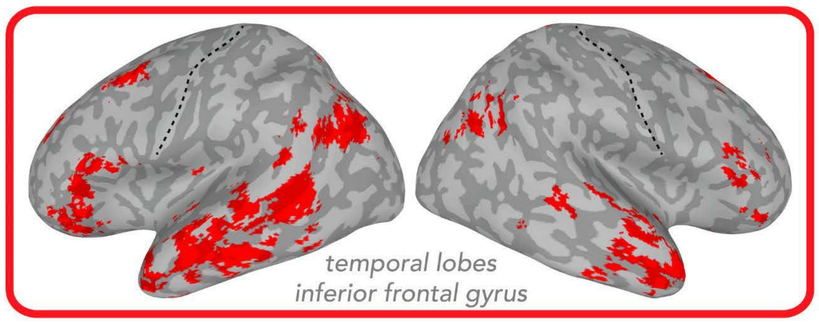



## Cortical Coactivation

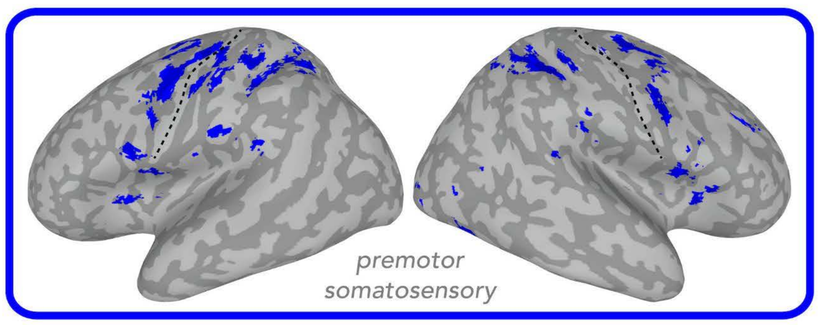


We created three masks that covered the production (blue), perception (red), and sensorimotor (overlapping, yellow) regions found in the cerebellum. Drawing on all 14k studies in the Neurosynth database, we found cortical regions that reliably co-activated with activity in each of our cerebellar regions of interest.

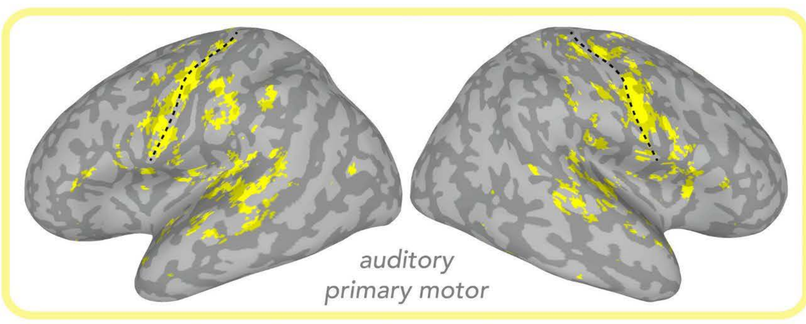
**Perception Network**




**Production Network**




**Sensorimotor Network**

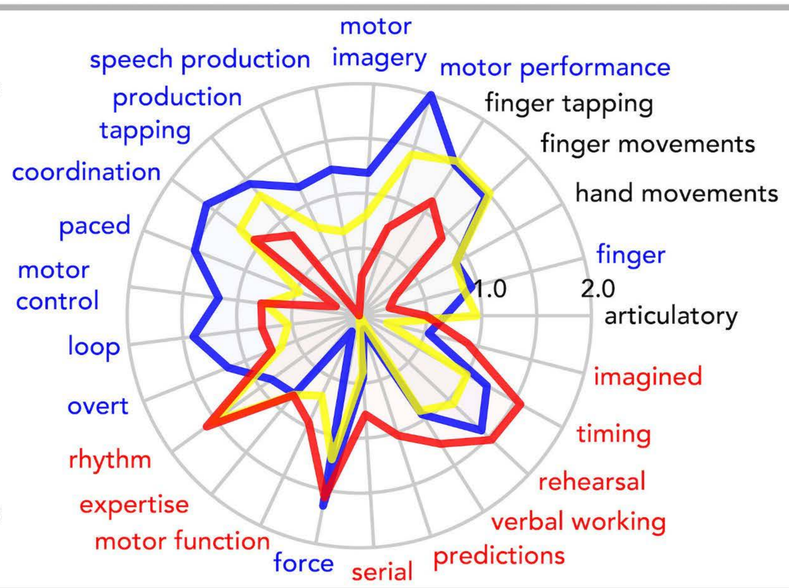



## Functional Profiles

We determined which psychological terms used in the abstract and titles of all 14k papers in the Neurosynth database best predicted activity in each of our three cerebellum regions of interest (ROIs).

A naive bayes classifer was used on sets of studies that showed activity in our ROIs and sets of studies that did not. By the end of training, the classifier could predict (with .64 accuracy) whether a study that frequently used a given term (e.g., *coordination*) would show activity in our cerebellar ROIs (see Yarkoni et al. 2016).

In the polar plot on the right, Log Odd Ratios (LORs) greater than zero suggest that a psychological topic predicts activity in cerebellar ROIs. For example, *motor performance* predicts activity in cerebellar regions associated with speech production. LORs reflect the log of the ratio between the probability that studies with ROI activity contain a topic versus the probability that studies lacking ROI activity contain a topic.




## Discussion

Speech perception zones are distinct from speech production zones in the cerebellum, with overlapping "sensorimotor" regions in tongue areas (dorsal) and motor production areas (ventral).

Each zone has distinct cortical connectivity, which indicates that they may perform different computations. Text mining suggests that behaviours involving prediction exclusively activate cerebellar regions associated with passive speech perception.

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