Commentary

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Evidence that correlations exist between sound and meaning

- **when sound and meaning are compatible:**
  - processing is faster than when they're incompatible (Howard)

- **when certain sound-meaning relations are present in words:**
  - people can predict the meanings of the words above chance (Laura, Lynne)
  - children and adults learn these words relatively quickly (Lynne, Mitsumi)
  - parents use these relations to teach children words (Mitsumi, Laura)
  - the words prime other words that share the same sound-meaning correspondence (Ben)
  - people and machines use these relations to draw inferences about other people's mental states (Sandy)

- **other relevant relations**
  - synesthesia (Daphne)
  - cross-modal mappings (Krish)
  - phonemic cues for grammatical class (Morten)

What mechanisms produce these effects?

- **simulation-based accounts of concepts and meaning**
  - a simple-minded insufficient account
    - direct feature overlap

- **possible mechanisms that link meaning to sound (etc.)**
  - direct neural connections between features
  - multi-sensory (supra-modal) areas
  - cross-modal learning
  - general magnitude

Simulation-based accounts of concepts and meaning

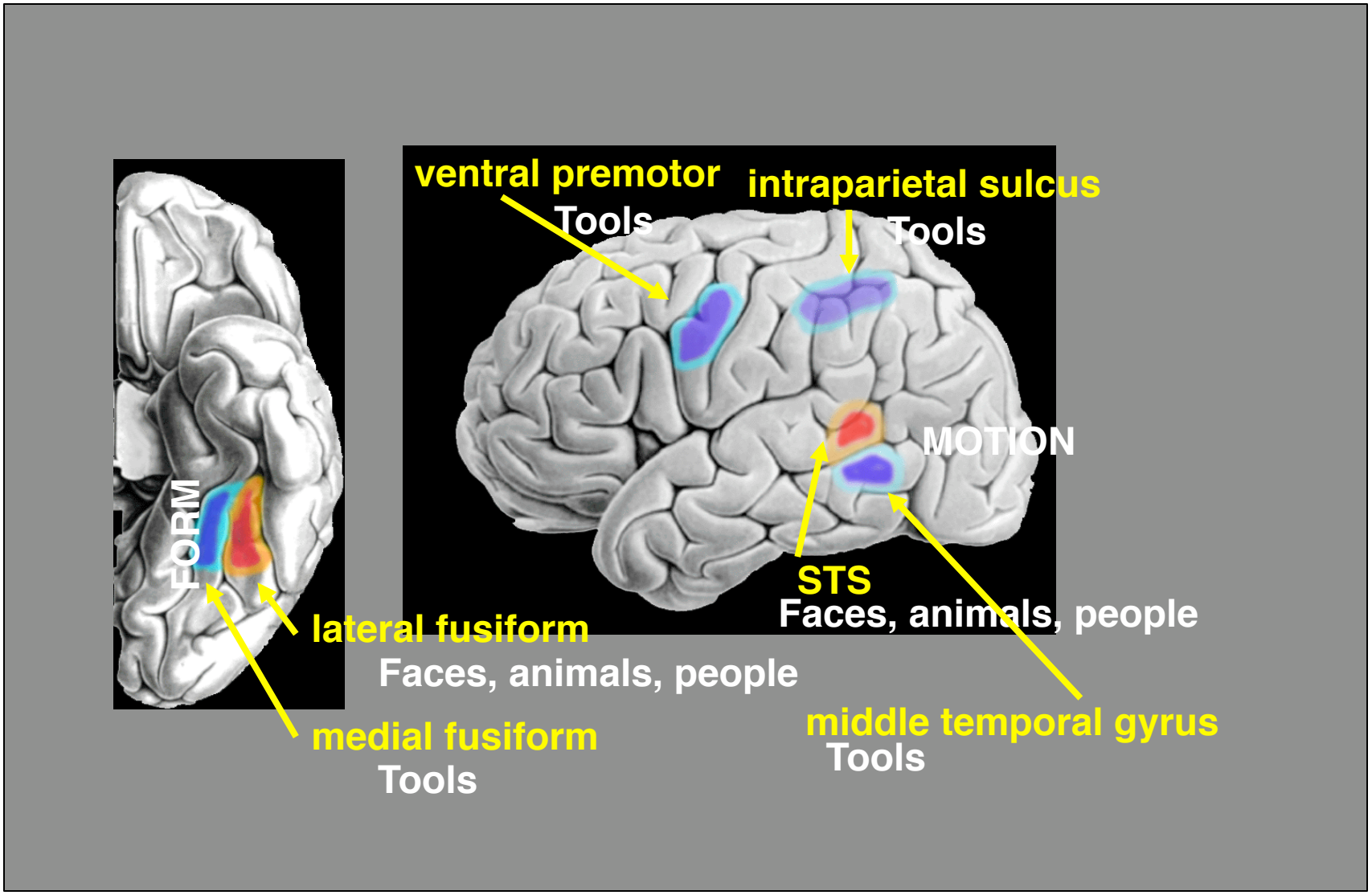
- **relevant modalities process the instances of concepts**
  - modalities in perception, action, introspection

- **the profile of modalities relevant for a concept varies** **(Cree & McRae, 2006)**
  - birds, tools, food, musical instruments, etc.

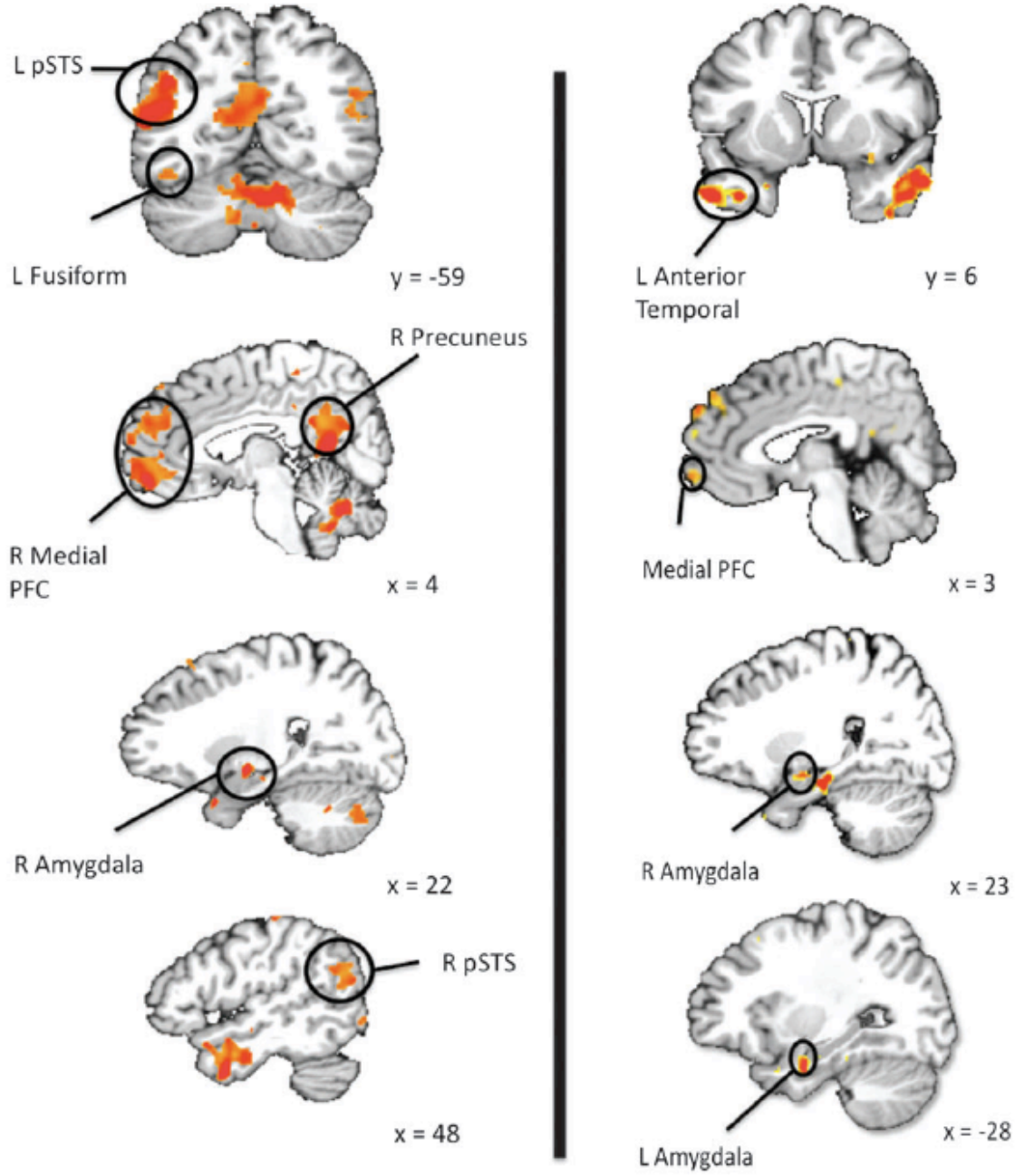
- **concepts become captured in the circuits that process a concept's instances**
  - feature areas integrated by association areas
  - a concept is a distributed multimodal circuit that captures the information processed for its instances

- **these circuits later produce simulations of instances**
  - sampling of circuit information that is:
    - dynamic, context-sensitive, frequency-based
  - conceptualization uses the same circuits as perception, action, and introspection

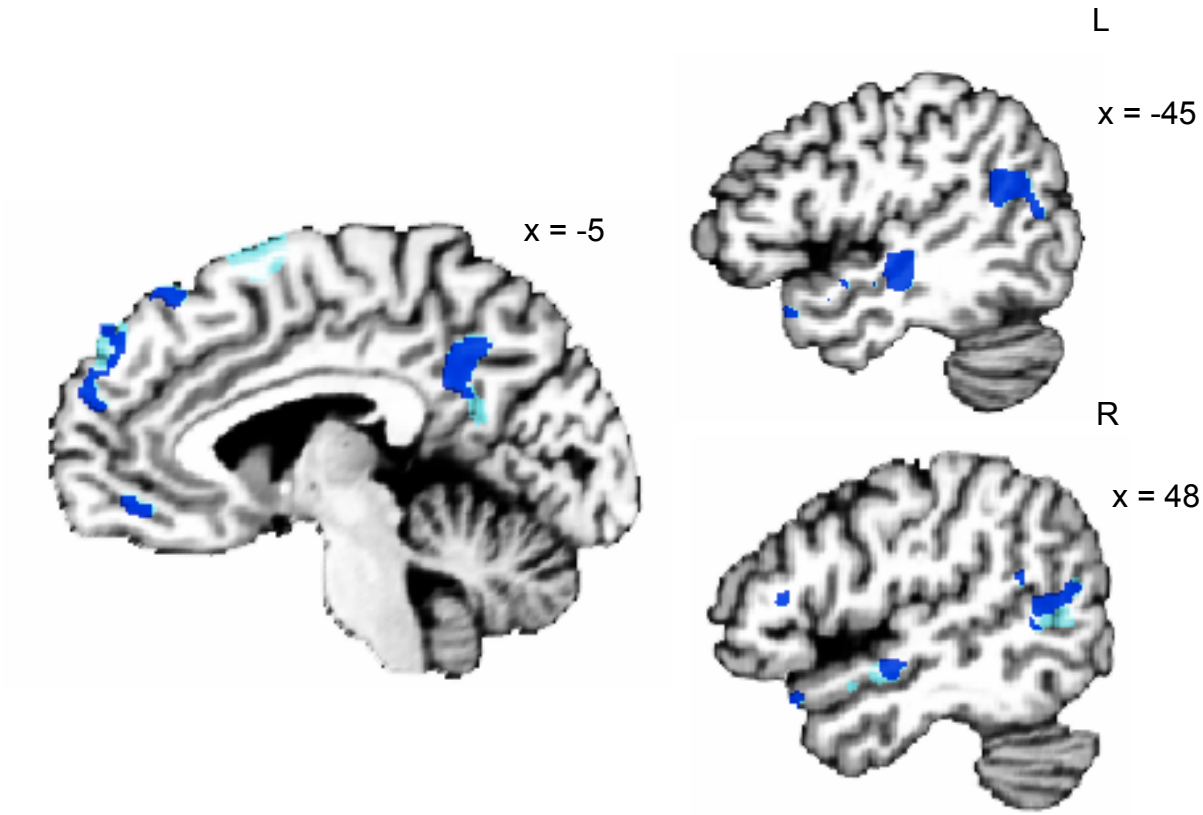
Martin's (2001, 2007) circuits for object concepts



Simmons et al.'s (2010) person processing circuit



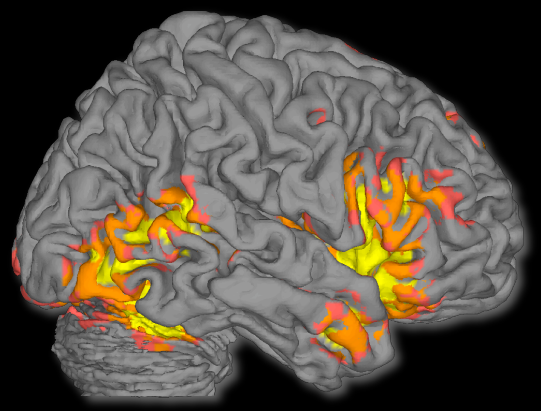
Wilson-Mendenhall et al.'s (2010) circuit for CONVINCE



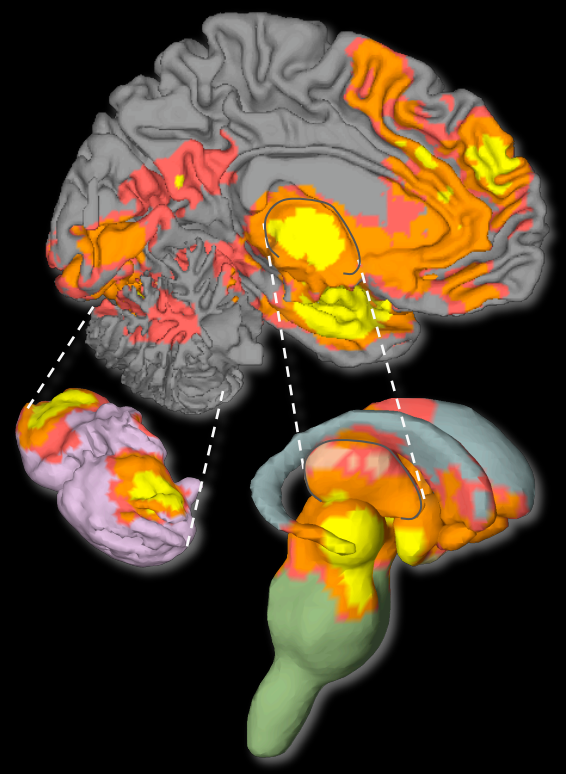
Feldman Barrett et al.'s (2007) circuit for EMOTIONS

Neural Reference Space for Emotion

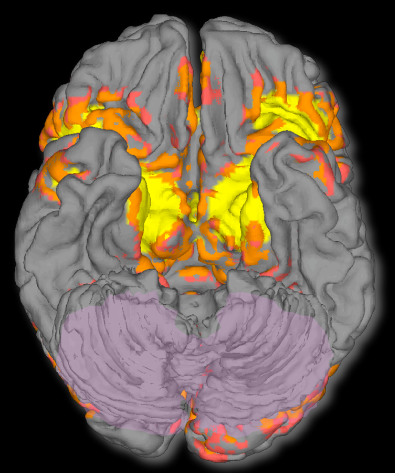
LATERAL



MEDIAL



VENTRAL



Linking sound and meaning
Simple-minded account

- **a speaker's conceptualization implemented as a simulation**

  WALK (me, lecture hall, quickly)

  - activates relevant modality-specific areas for self, body, walking, lecture hall, path in space, etc.
  - motor areas associated with speed become active

- **the speaker produces an utterance spoken at a fast rate**

  "I'm going to walk to the lecture hall quickly."

  - the speed of action in the simulation of walking affects the speed of speaking
  - assume that a common population of neurons underlies the speed of:
    - simulated walking
    - speaking

Linking sound and meaning
Simple-minded account

- **a listener's processing of the utterance**

  "I'm going to walk to the lecture hall quickly."

  - the spoken utterance activates motor areas via mirroring
  - activates neurons associated with fast speed

- **the listener represents the utterance's meaning as a simulation**

  WALK (speaker, lecture hall, quickly)

  - activates relevant modality-specific areas for self, body, walking, lecture hall, path in space, etc.
  - neurons associated with fast speed are already active, thereby facilitating constructing the appropriate simulation

Linking problems

- **does a common population of neurons really represent speed?**
  - for the spoken rate of the utterance
  - for the speed of walking in the simulation

- **identifying the ends of two dimensions involves different features**
  - fast speaking
  - fast walking

- **dimension-specific reference points must be involved**
  - fast speaking relative to average speaking rate
  - fast walking relative to average walking rate

- **how are these different dimensional categorizations computed and linked?**

More distant mappings

Conceptualization : Speech

vertical position : speaking pitch

object speed : speaking speed and pitch

urgency : speaking speed

affective valence : speaking pitch and speed

size : loudness

Conceptualization : Non-Speech

object speed : music speed

subjective states : honest signs

Synesthesia

sound : shape

shape : color

Cross-modal mappings

vision : touch

Possible linking mechanisms

- **direct neural connections between features**
  - initial brain organization (Daphne)
  - activating one feature activates the other via a direct connection

- **multi-sensory (supra-modal) areas**
  - perhaps another form of initial brain organization (Krish)
  - activating one feature activates the other via the shared area

- **cross-modal learning**
  - correlations across modalities in experience
  - large things tend to be loud, slow, and to produce low pitches
  - small things tend to be soft, fast, and to produce high pitches
  - activating one feature in a pattern activates others in it, via pattern completion

"It's all general magnitude"

Stella muttering to herself all day yesterday

- **extensive evidence for cross-modal mapping**
  - Dahaene's SNARC effect
    - mapping number to handedness
  - Stella's recent developmental work
    - size maps to number, duration

- **suggests the presence of a general magnitude scale** **(Walsh, 2003)**
  - maps dimensions into one another
  - automatically, rapidly, ubiquitously
  - implemented by the IPS?

- **potential implication**
  - as entities and events are processed, salient values on dimensions are mapped onto the general magnitude scale
  - values on the general magnitude scale are mapped back into other dimensions that become relevant
  - thus, speed of simulated walking can be mapped onto speed of speaking

Simultaneous linking mechanisms

- **in many cases, simultaneous mechanisms may operate together**
  - structure in initial brain organization
  - empirical cross-modal patterns
  - general magnitude
  - others???

- **learning and expertise**
  - how much learning is necessary to establish a mapping?
  - how does practice at a mapping affect subsequent performance?

Phonaesthemes

- **for non-arbitrary relations, this account may work**
  - e.g., roundedness ➔ round

- **for arbitrary relations, another account may be necessary**
    - e.g., gl-
    - language-specific cues for nouns vs. verbs (different across languages)
  - perhaps network discrimination learning dynamics are sufficient
    - i.e., linking mechanisms aren't necessary

The relevance problem

- **a given sound cue could potentially prime multiple dimensions**
  - speaking pitch ➔ height, valence, rate, etc.

- **contextual constraint**
  - fly ball: speaking pitch ➔ height
  - emotional event: speaking pitch ➔ valence
  - walking somewhere: speaking pitch ➔ rate