



# *Neural representations of restored acoustic rhythm in noise*

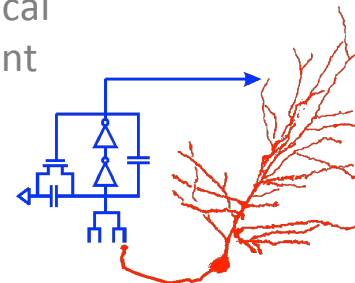
Francisco Cervantes Constantino<sup>1</sup> & Jonathan Z. Simon<sup>2,3,4</sup>

Acoustics '17 Boston

*Psychological and Physiological Acoustics: Physiology Meets Perception II* session

28 June 2017

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# *Introduction*

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*In dynamic soundscapes,  
extreme masking may incentive  
filling-in of sound signals lost*

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  - rule rather than exception
  - what adaptive mechanisms meet this demand?

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  - rule rather than exception
  - what adaptive mechanisms meet this demand?
- Key to facilitate communication:
- improve likelihood of invariant perceptual outcomes
  - despite simultaneous maskers

# *Research questions*

- During filling-in:
  - (1) How does adjustment to *dynamic percepts* correspond to adjustment in *dynamic neural representations*?
  - (2) What functional mechanisms underlie this correspondence?

*Part 1: Perceptual restoration of  
missing acoustic rhythm*

*Part 2: Reconstruction of missing  
speech sequences*



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- 5 Hz rhythm with noise maskers (1.2 s each)
  - 1 hour total

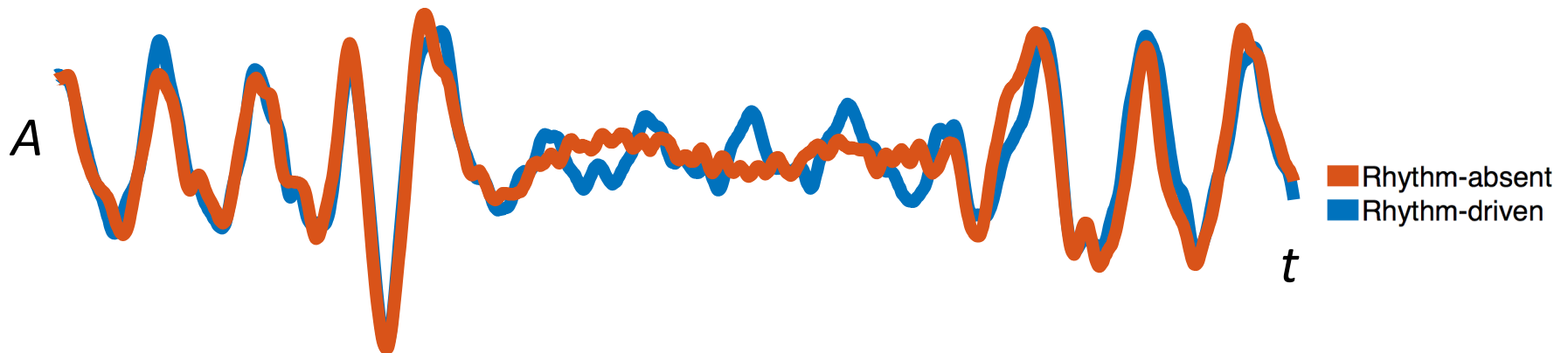


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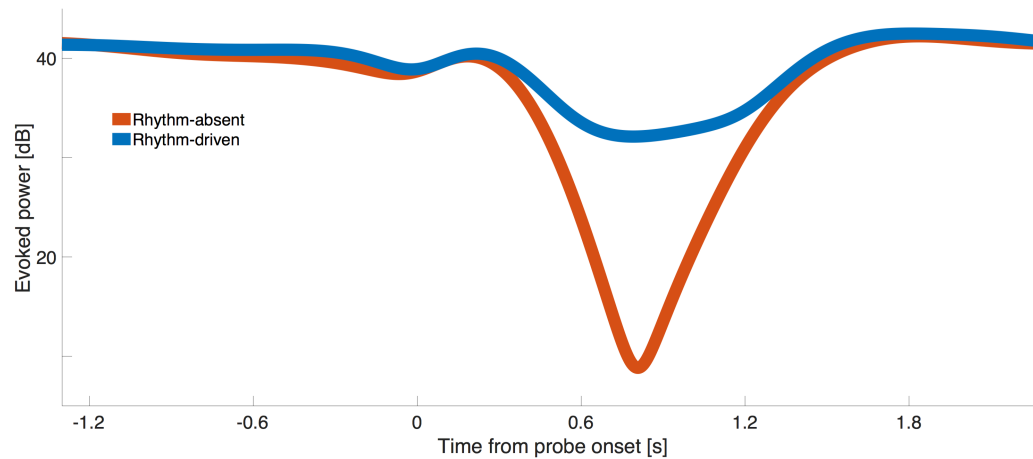


- Auditory cortex response by whole-head magnetoencephalography (MEG)



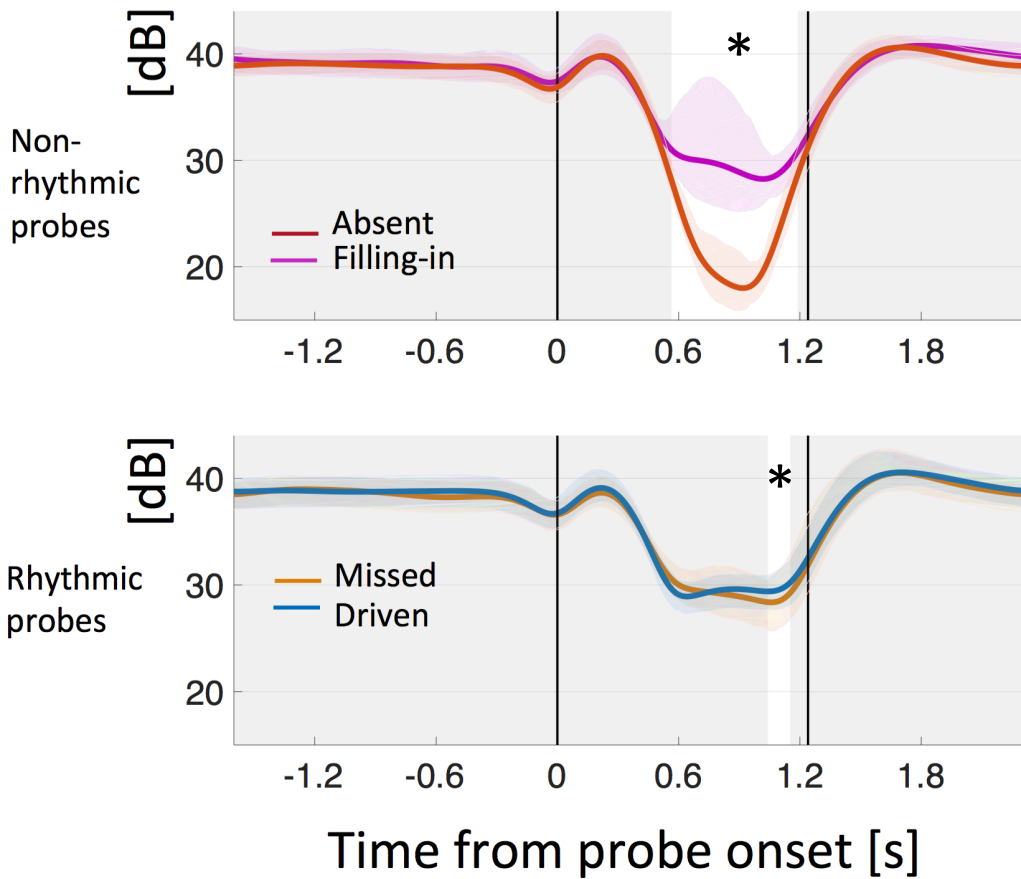
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- Neural representations defined by periodicity: spectral analysis viable



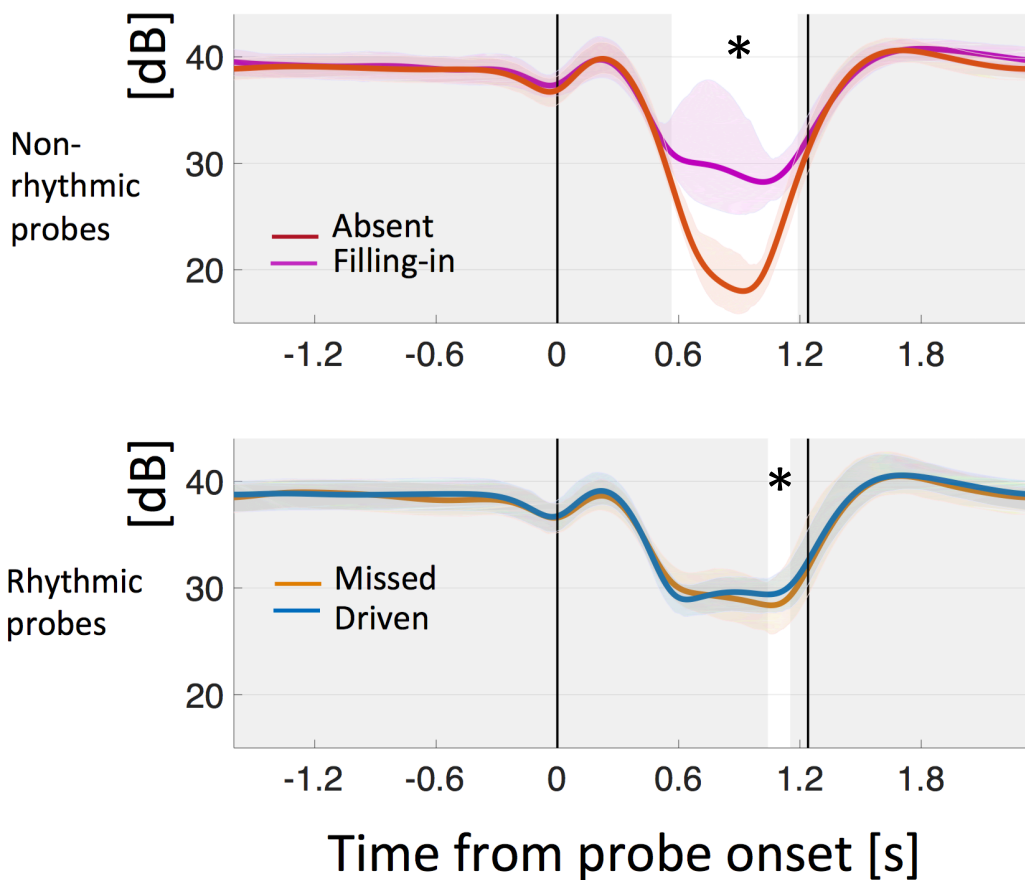
# Results

## 5 Hz evoked power



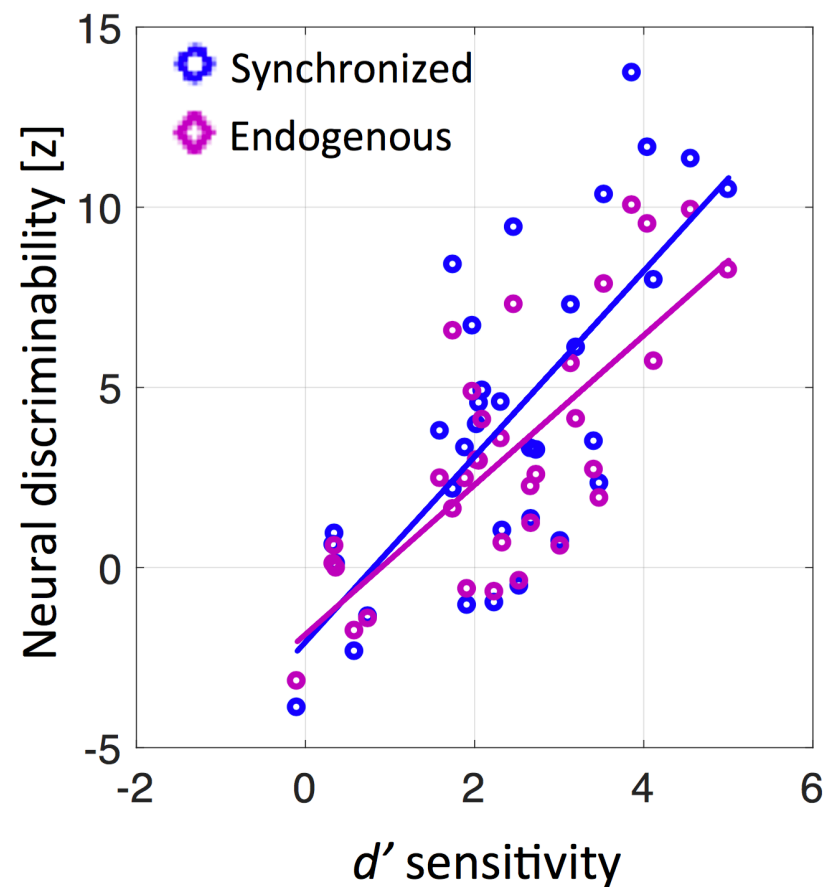
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\* $p < 0.01$

Neuro-psychometric comparison



## *Part 1 discussion*

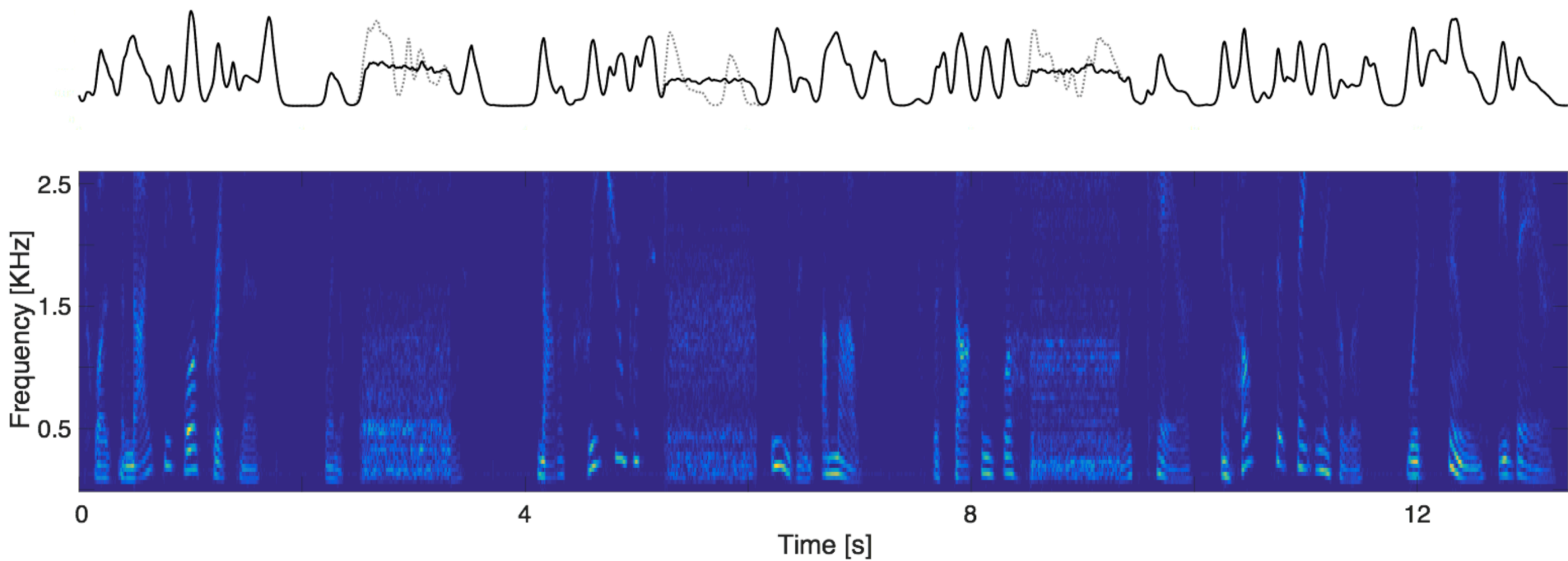
- 5 Hz power neurally restored in noise without 5 Hz rhythm stimulus
  - marker of restoration, from cortical activity
- Differential response related to percept & behavior
- Modulation rate probed relevant to human speech communication

*Part 1: Perceptual restoration of  
missing acoustic rhythm*

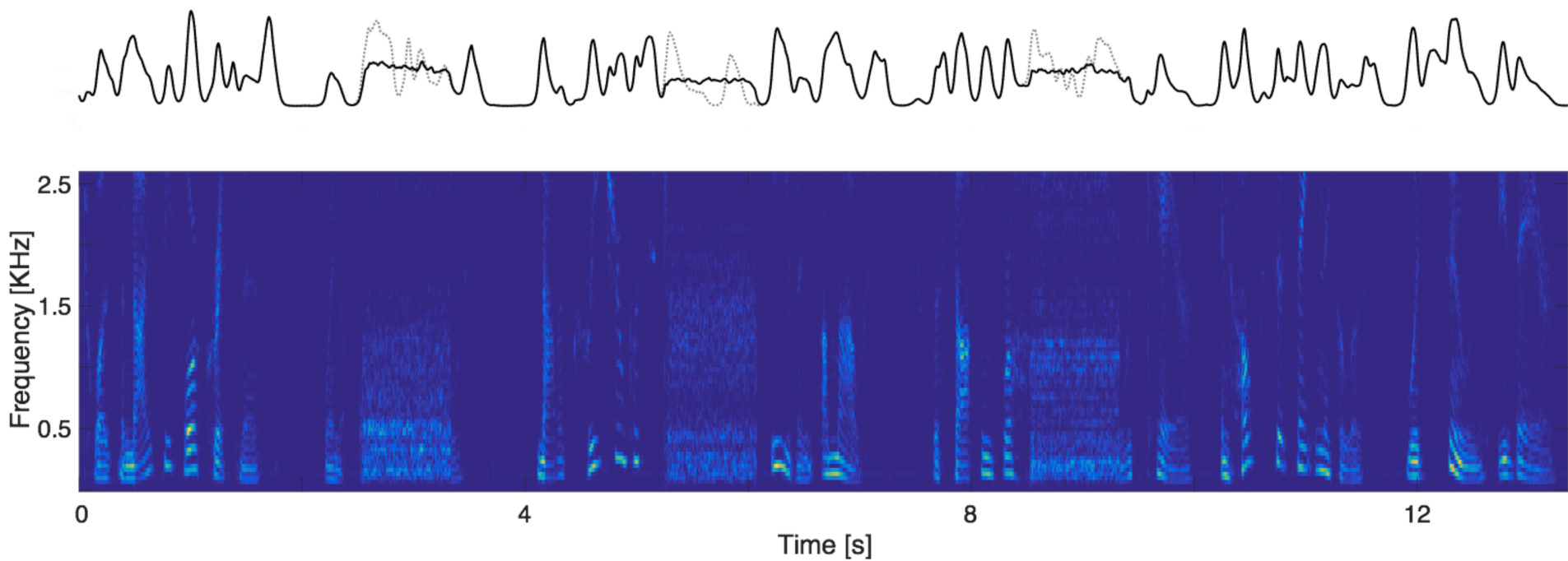
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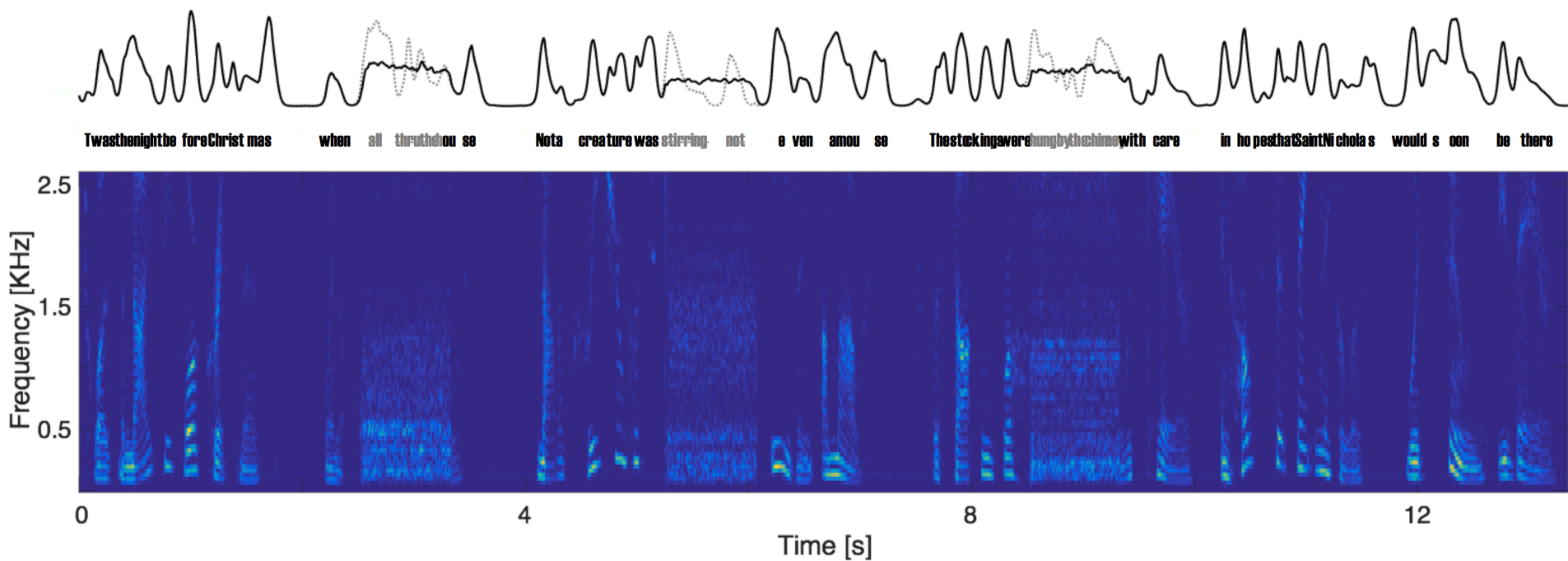
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The children were nestled all snug in their beds,  
while visions of sugar plums danced in their heads.  
And Mama in her 'kerchief, and I in my cap,  
had just settled our brains for a long winter's nap.

When out on the lawn there arose such a clatter,  
I sprang from my bed to see what was the matter.  
Away to the window I flew like a flash,  
tore open the shutter, and threw up the sash.

The moon on the breast of the new-fallen snow  
gave the lustre of midday to objects below,  
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With a little old driver, so lively and quick,  
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More rapid than eagles, his coursers they came,  
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"Now Dasher! Now Dancer! Now, Prancer and Vixen!  
On, Comet! On, Cupid! On, Donner and Blitzen!  
To the top of the porch! To the top of the wall!  
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As dry leaves that before the wild hurricane fly,  
when they meet with an obstacle, mount to the sky  
so up to the house-top the coursers they flew,  
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And then, in a twinkling, I heard on the roof  
the prancing and pawing of each little hoof.  
As I drew in my head and was turning around,  
down the chimney St. Nicholas came with a bound.

He was dressed all in fur, from his head to his foot,  
and his clothes were all tarnished with ashes and soot.  
A bundle of toys he had flung on his back,  
and he looked like a peddler just opening his pack.

His eyes--how they twinkled! His dimples, how merry!  
His cheeks were like roses, his nose like a cherry!  
His droll little mouth was drawn up like a bow,  
and the beard on his chin was as white as the snow.

The stump of a pipe he held tight in his teeth,  
and the smoke it encircled his head like a wreath.  
He had a broad face and a little round belly,  
that shook when he laughed, like a bowl full of jelly.

He was chubby and plump, a right jolly old elf,  
and I laughed when I saw him, in spite of myself.  
A wink of his eye and a twist of his head  
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He spoke not a word, but went straight to his work,  
and filled all the stockings, then turned with a jerk.  
And laying his finger aside of his nose,  
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He sprang to his sleigh, to his team gave a whistle,  
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But I heard him exclaim, 'ere he drove out of sight,  
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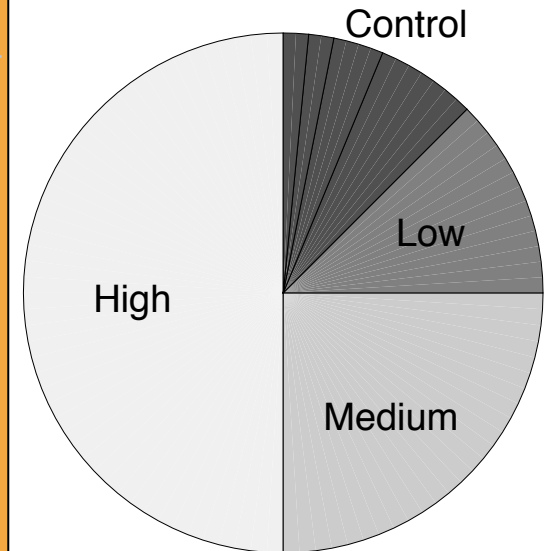
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Repetition rate



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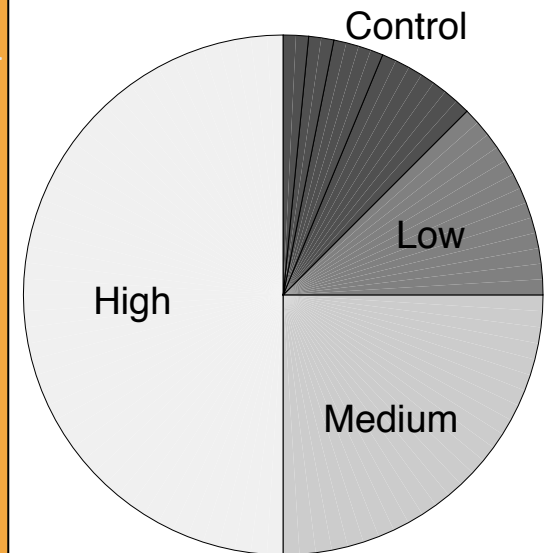
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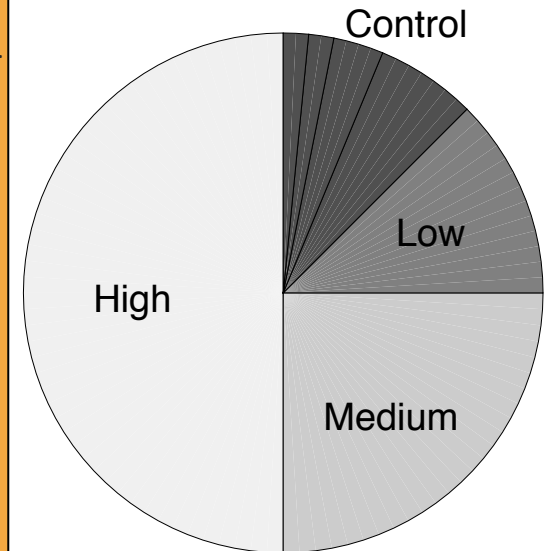
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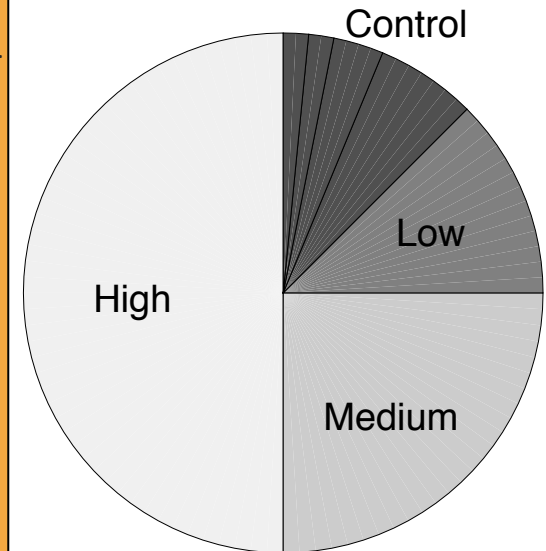
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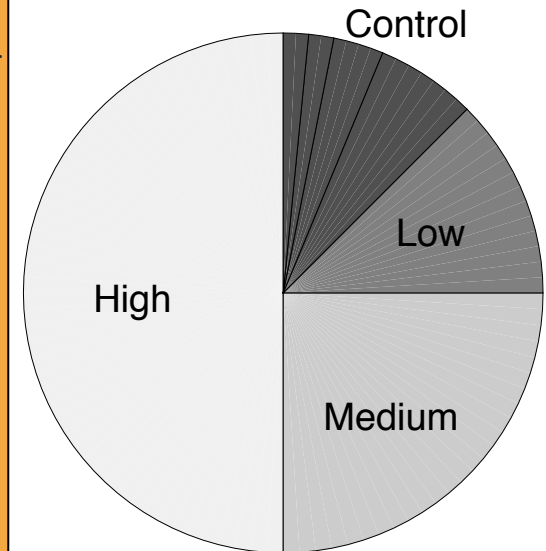
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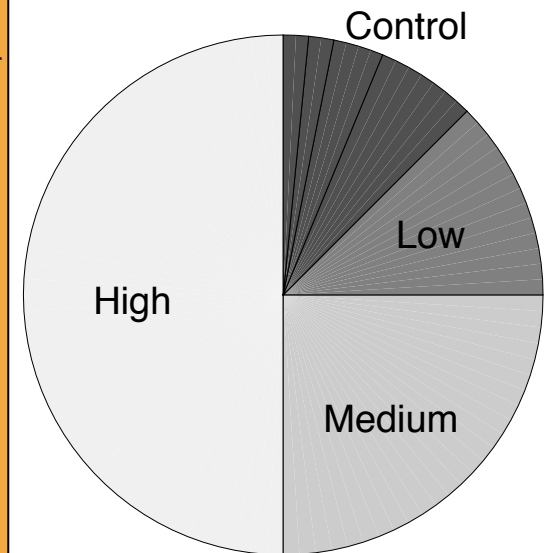
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gave the lustre of midday to objects below,  
when, what to my wondering eyes should appear,  
but a miniature sleigh and eight tiny reindeer.

With a little old driver, so lively and quick,  
I knew in a moment it must be St. Nick.  
More rapid than eagles, his coursers they came,  
and he whistled and shouted and called them by name.

"Now Dasher! Now Dancer! Now, Prancer and Vixen!  
On, Comet! On, Cupid! On, Donner and Blitzen!  
To the top of the porch! To the top of the wall!  
Now dash away! Dash away! Dash away all!"

As dry leaves that before the wild hurricane fly,  
when they meet with an obstacle, mount to the sky  
so up to the house-top the coursers they flew,  
with the sleigh full of toys, and St. Nicholas too.

And then, in a twinkling, I heard on the roof  
the prancing and pawing of each little hoof.  
As I drew in my head and was turning around,  
down the chimney St. Nicholas came with a bound.

He was dressed all in fur, from his head to his foot,  
and his clothes were all tarnished with ashes and soot.  
A bundle of toys he had flung on his back,  
and he looked like a peddler just opening his pack.

His eyes--how they twinkled! His dimples, how merry!  
His cheeks were like roses, his nose like a cherry!  
His droll little mouth was drawn up like a bow,  
and the beard on his chin was as white as the snow.

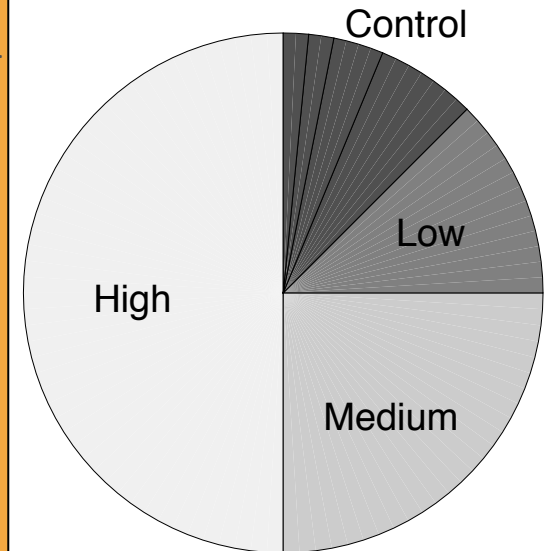
The stump of a pipe he held tight in his teeth,  
and the smoke it encircled his head like a wreath.  
He had a broad face and a little round belly,  
that shook when he laughed, like a bowl full of jelly.

He was chubby and plump, a right jolly old elf,  
and I laughed when I saw him, in spite of myself.  
A wink of his eye and a twist of his head  
soon gave me to know I had nothing to dread.

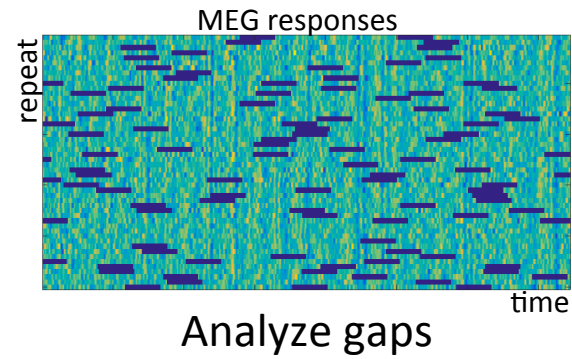
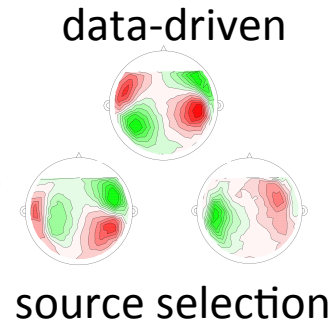
He spoke not a word, but went straight to his work,  
and filled all the stockings, then turned with a jerk.  
And laying his finger aside of his nose,  
and giving a nod, up the chimney he rose.

He sprang to his sleigh, to his team gave a whistle,  
And away they all flew like the down of a thistle.  
But I heard him exclaim, 'ere he drove out of sight,  
"Happy Christmas to all, and to all a good night!"

Repetition rate

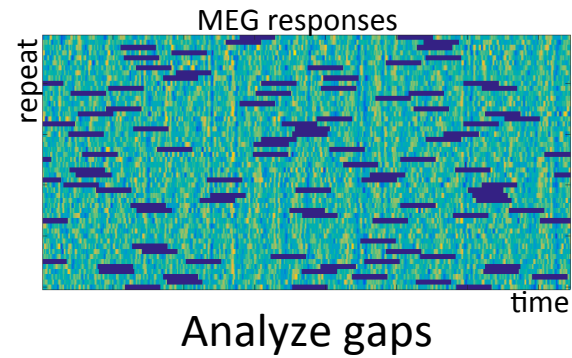
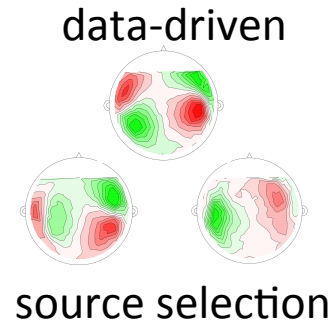


MEG responses,  
speech delivered



*Subject R2349*

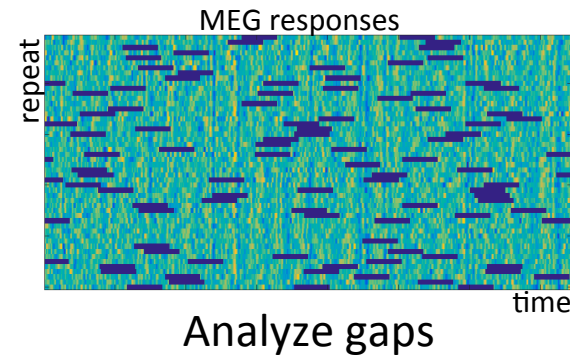
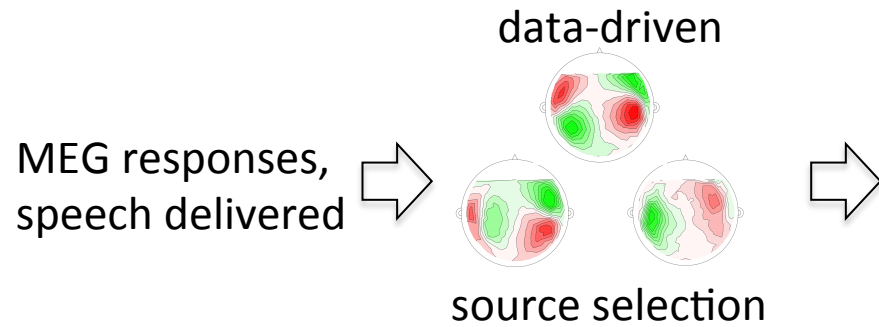
MEG responses,  
speech delivered



*Subject R2349*

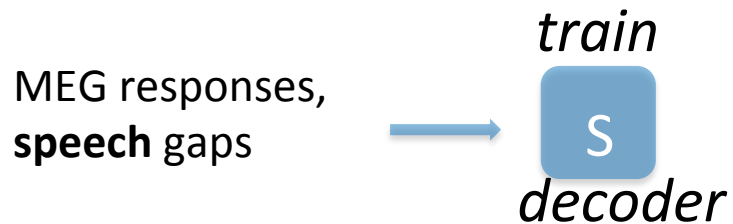
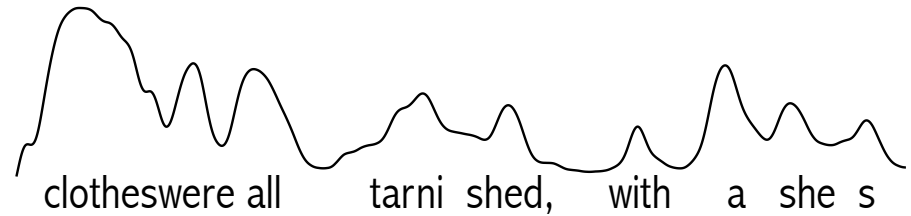
Speech  
envelope

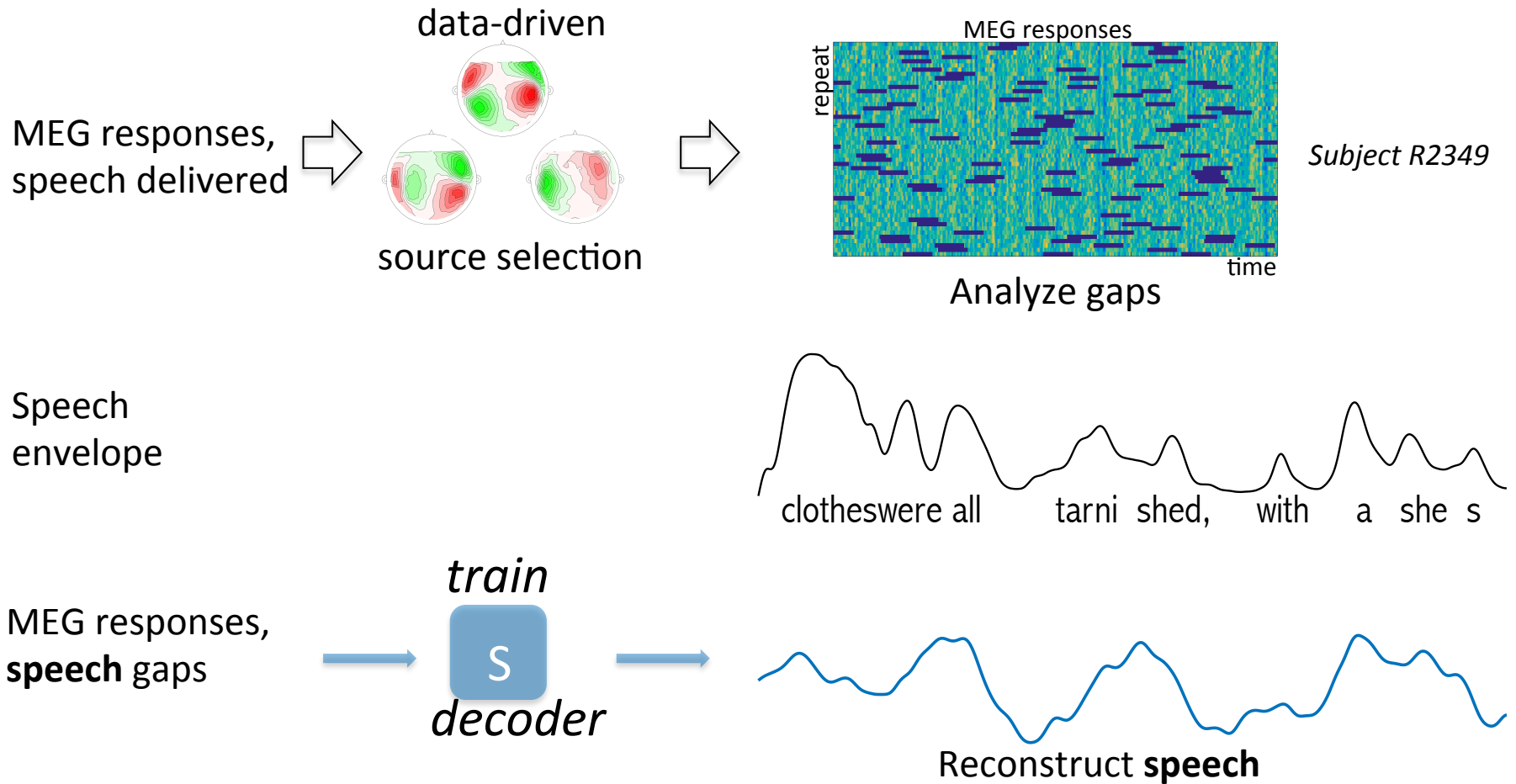


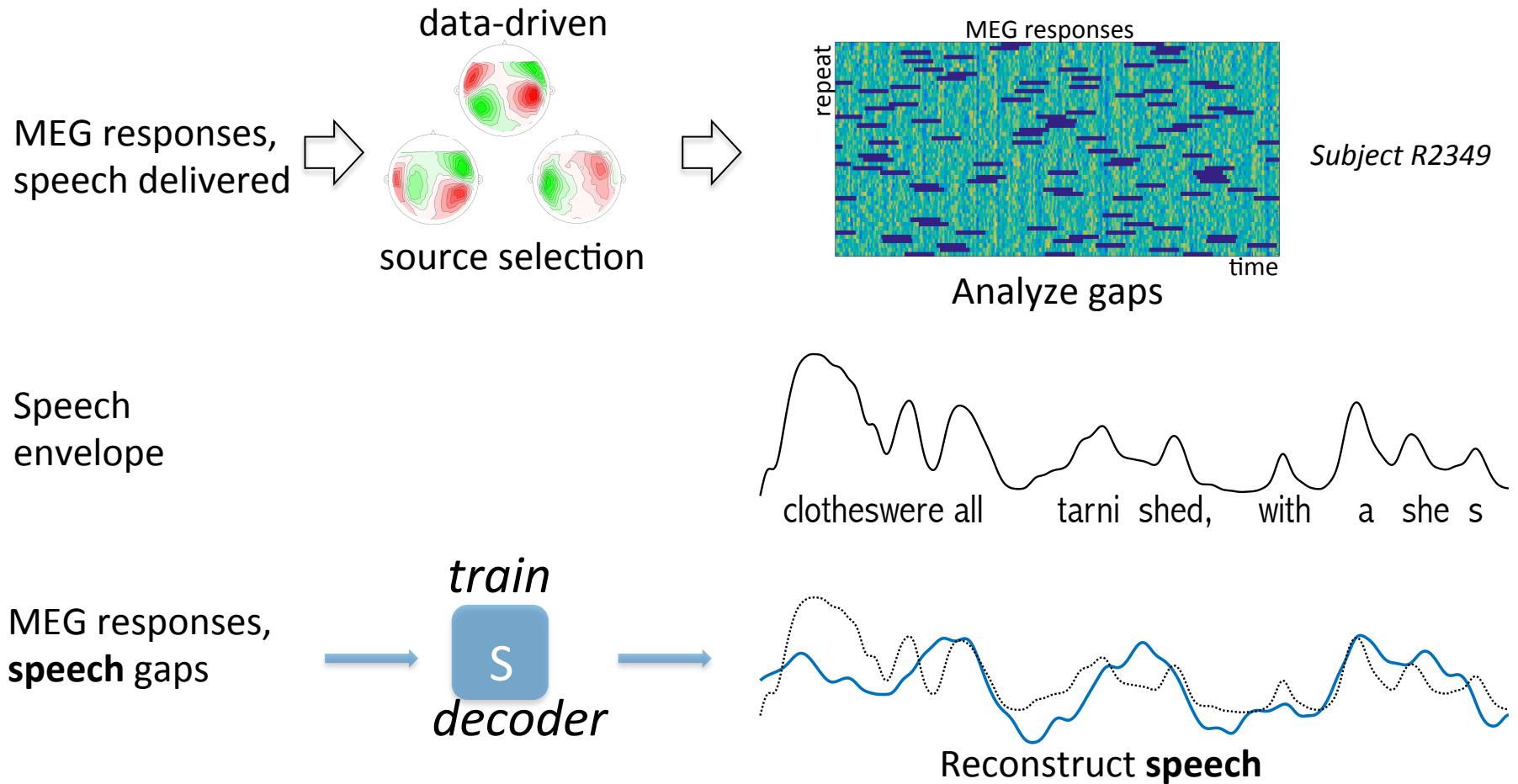


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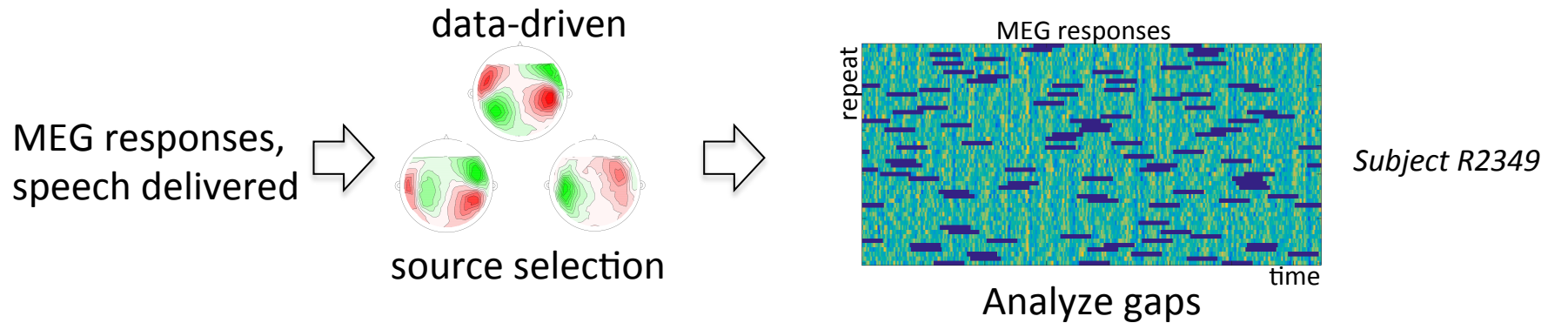
Speech  
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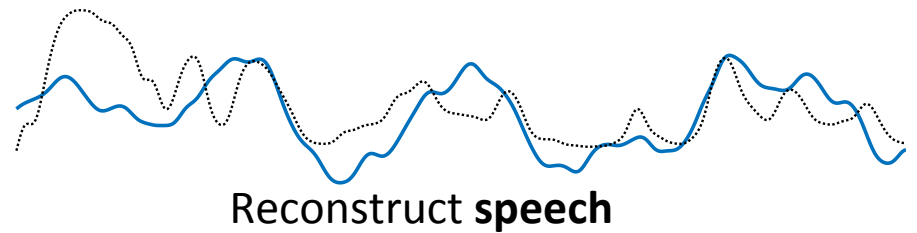
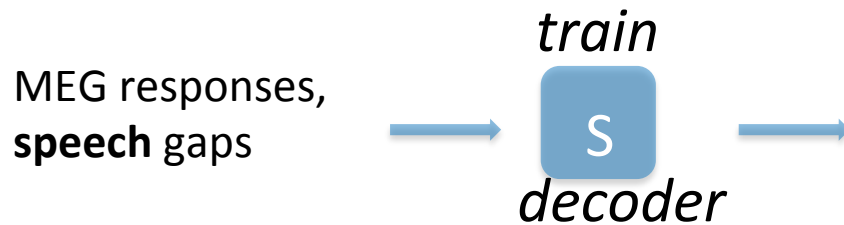
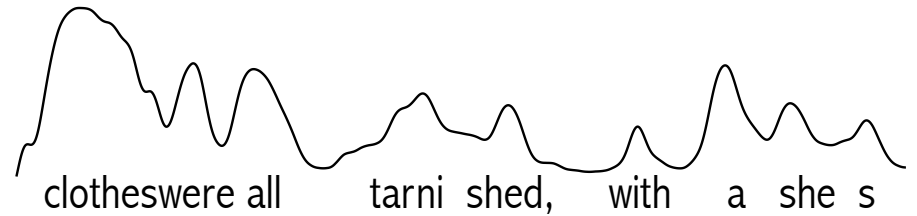


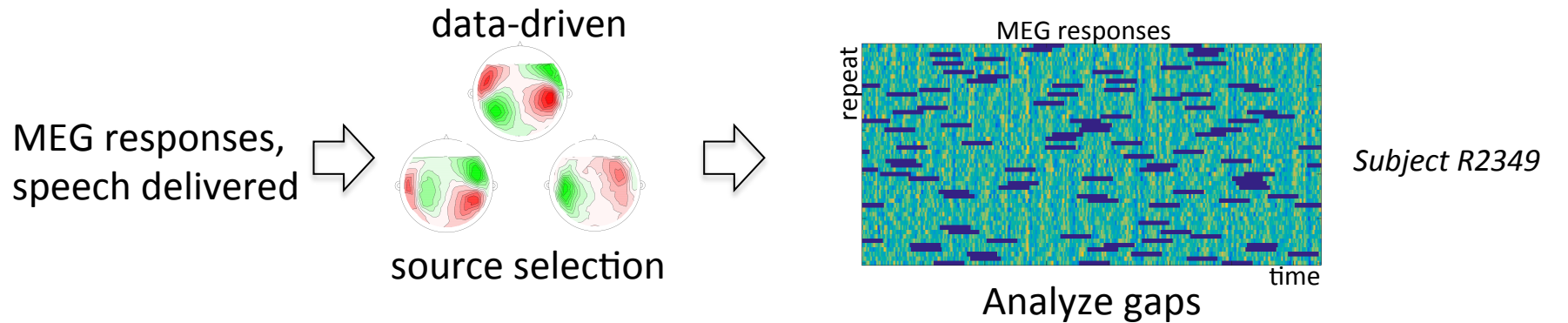




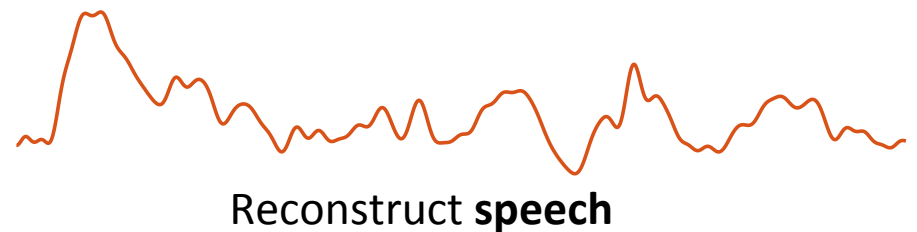
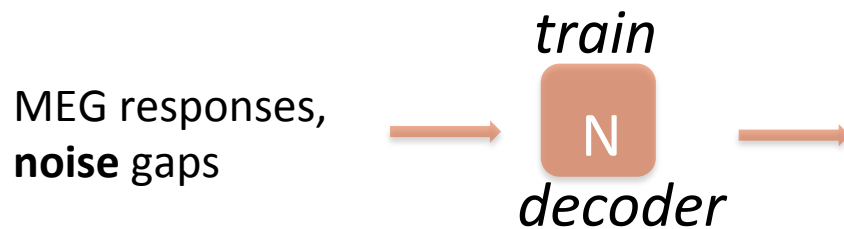
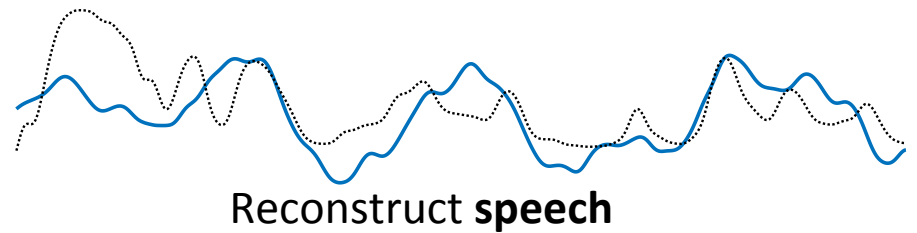
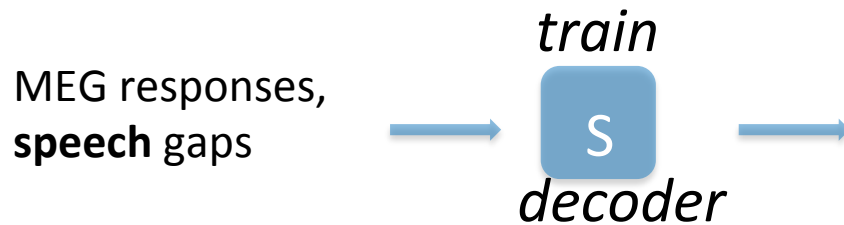
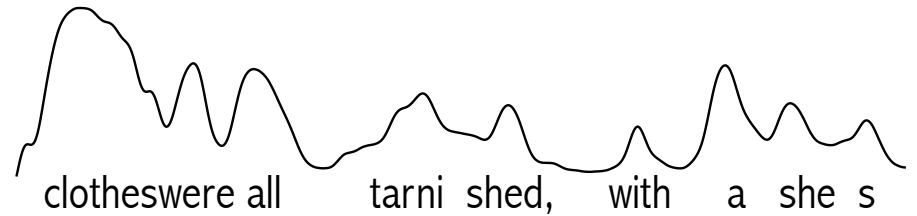


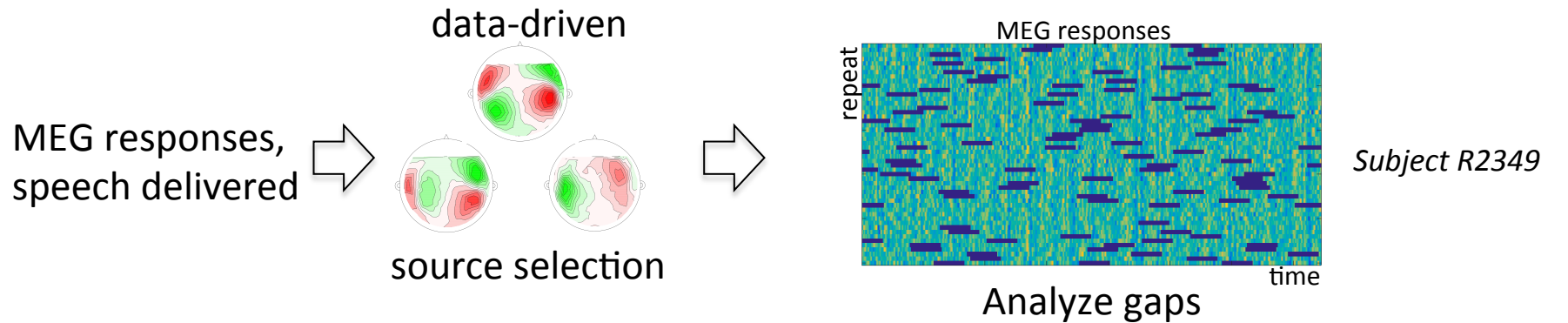
Speech  
envelope



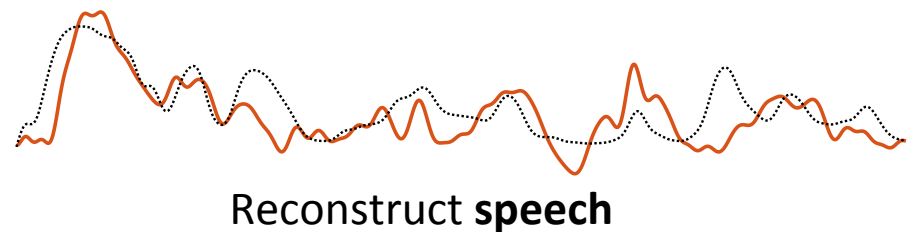
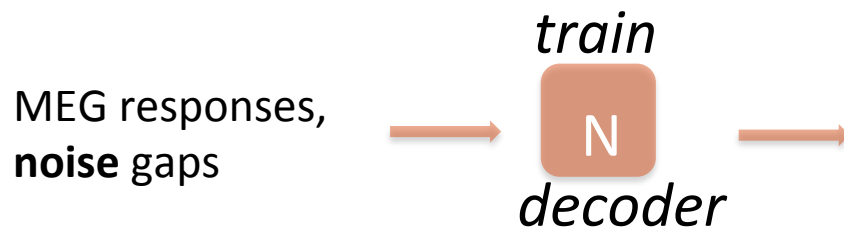
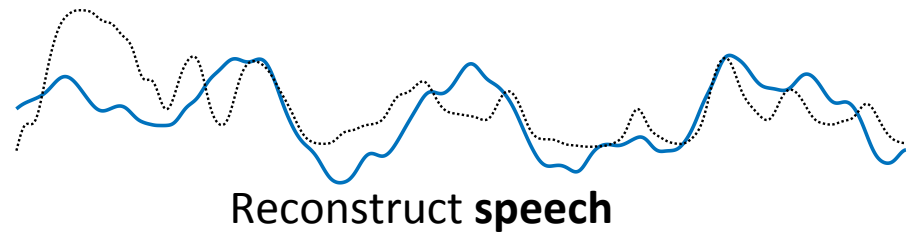
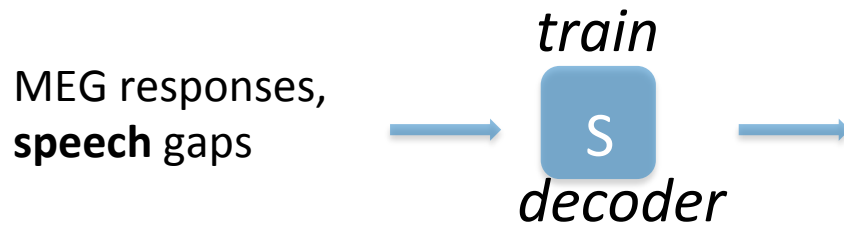


Speech  
envelope



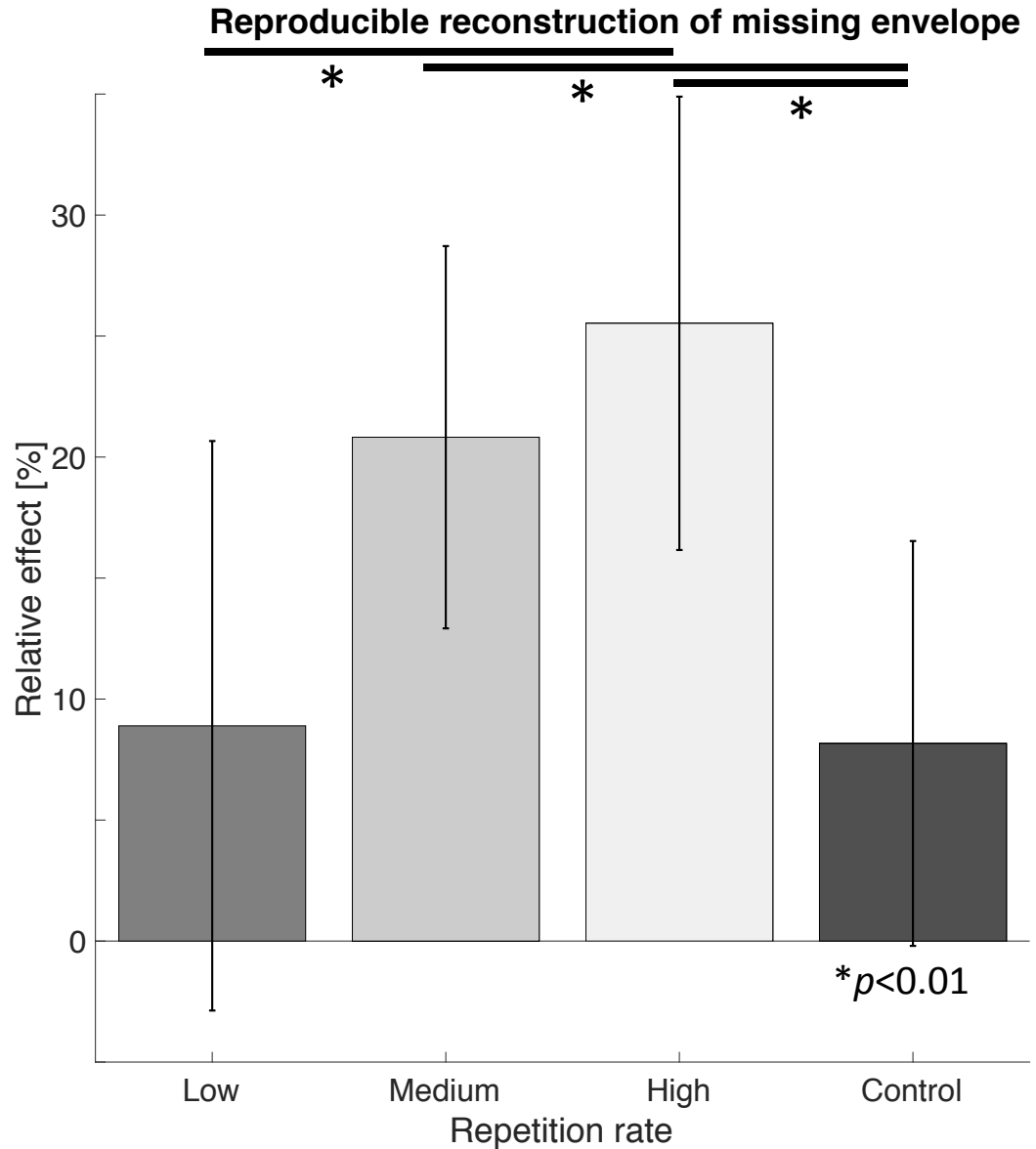
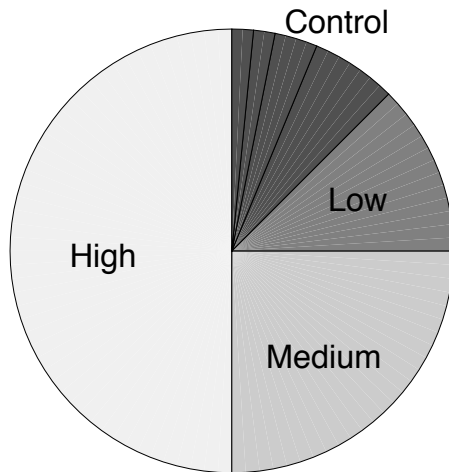


Speech  
envelope



# Results

## Repetition rate



## *Part 2 discussion*

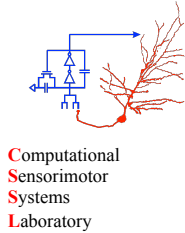
- Auditory cortex activity partially reconstructs missing speech envelope
  - over ecologically-relevant timescales
  - disappears with little or no prior experience

# *Conclusions*

- Temporal coding sustained during acoustic signal gaps consistent with perceptual restoration
- Sustained filling-in over steady or syllabic rhythm modulation components
- Adaptive modifications include
  - patterned cortical dynamics during restoration
  - decoding of missed speech tokens

# Acknowledgments

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# Operating definitions (for volitional tasks)

- “To Recall”: the description is either a real memory or an object seen previously
- “To Recreate”: an imagined scene/object previously created **is to be** reconstructed
- “To Imagine”: a new fictitious scene/object **is to be** imagined for the first time