

9.35 Illusion Lab #1

Auditory scene analysis

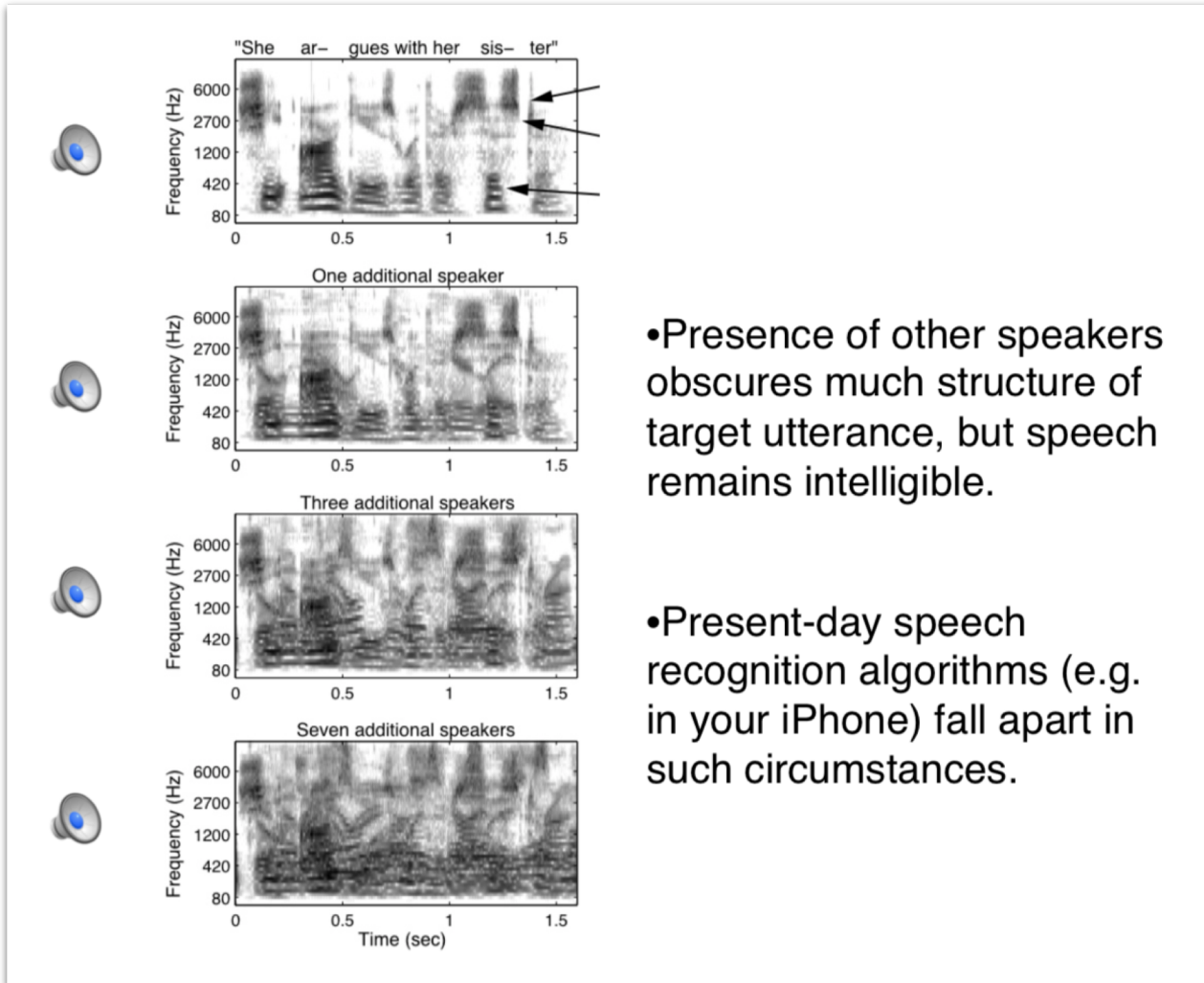
Recitation, March 6 2020

Maddie Cusimano (mcusi@mit.edu)

Recitation outline

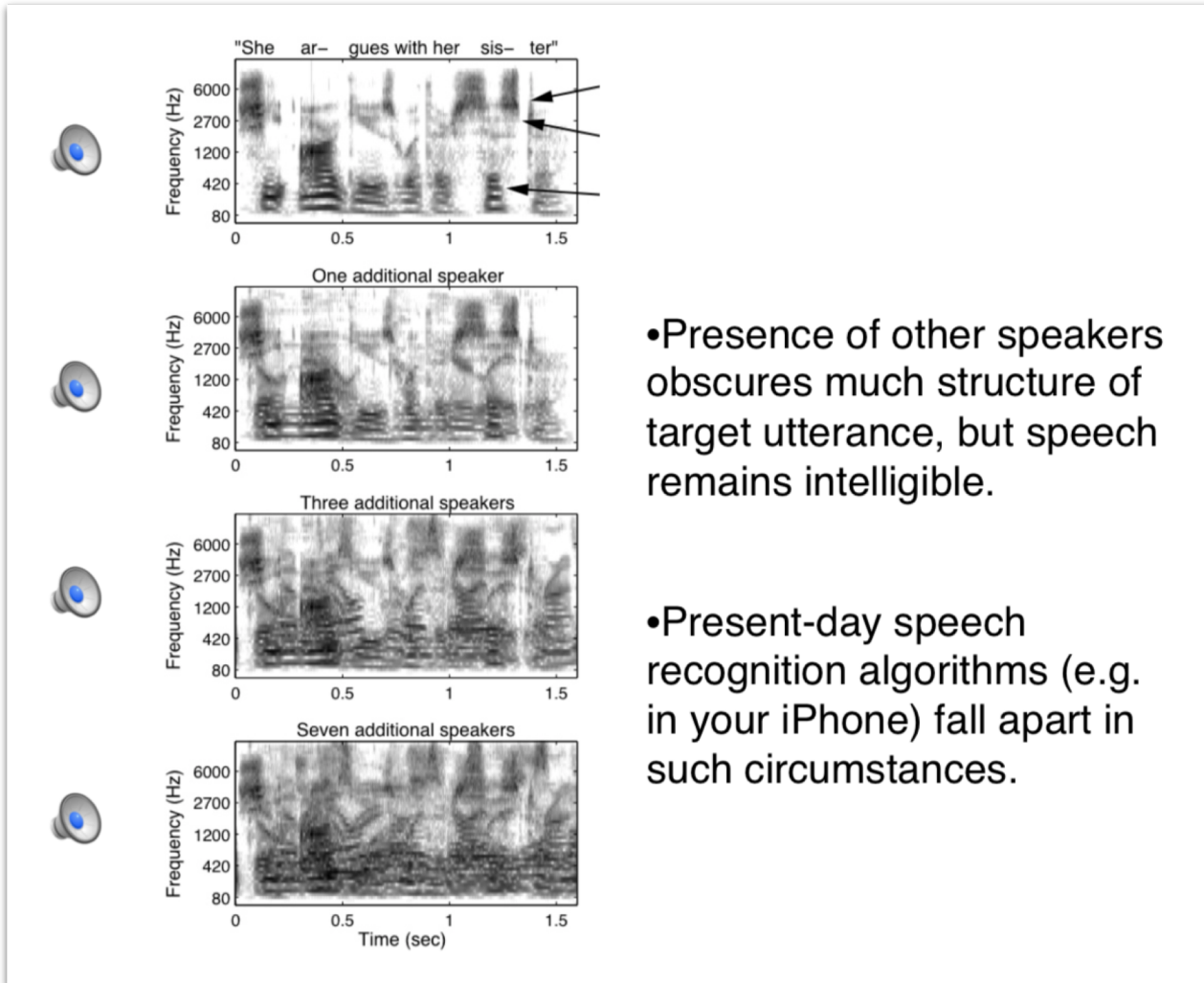
- 20 min:
 - Overview of problem set
 - Run-through of concepts and illusions
- 20 min: code example
- 20 min: tips for brainstorming

Auditory scene analysis



- Analogous to solving $x + y = 10$
- Auditory system needs to make a guess based on assumptions about the world & how it generates patterns in sound

Auditory scene analysis



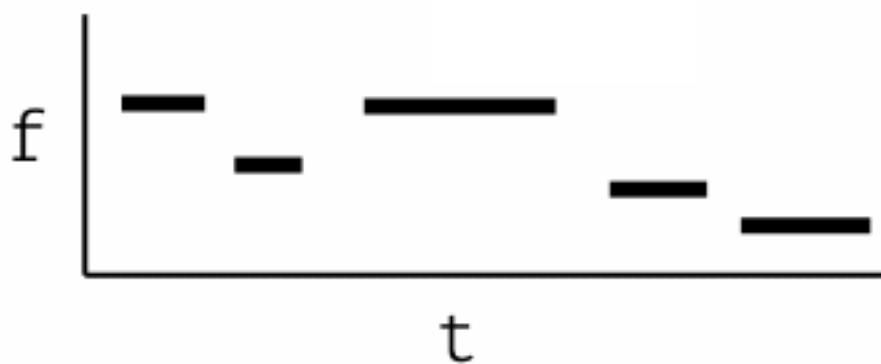
- Analogous to solving $x + y = 10$
- Auditory system needs to make a guess based on assumptions about the world & how it generates patterns in sound
- **Research Q:** What are those assumptions?

Illusion categories

1. Sequential grouping
2. Simultaneous grouping
3. Perceptual filling-in

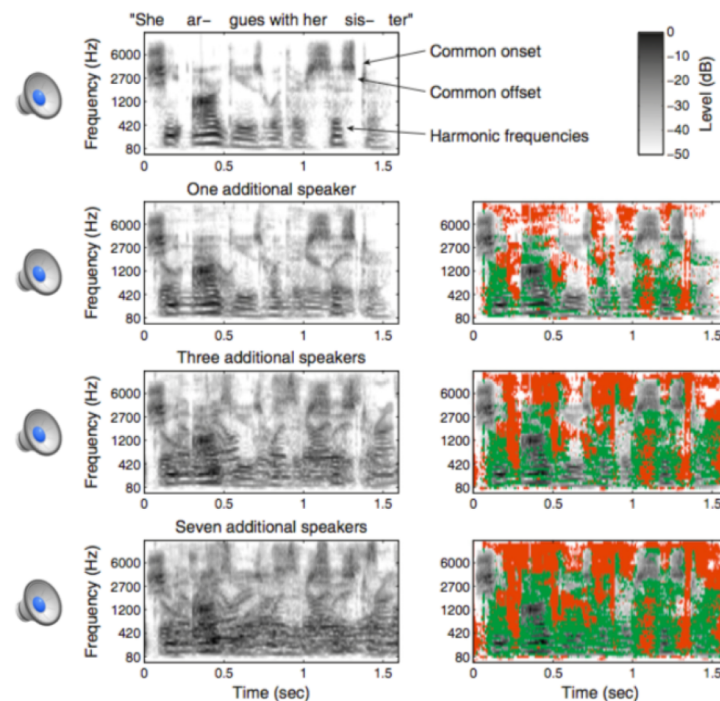
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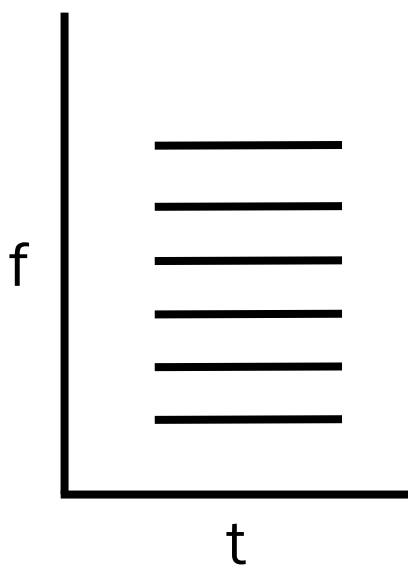
One intuitive view of inferring a target source from a mixture:

1) Determine grouping of observed sound elements.

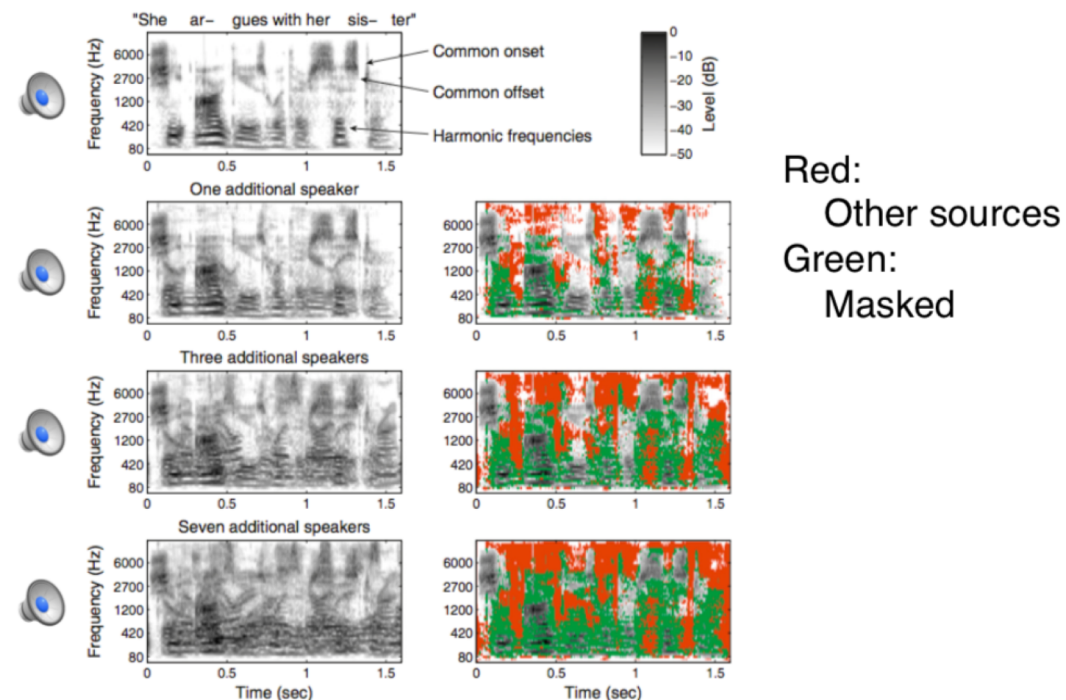


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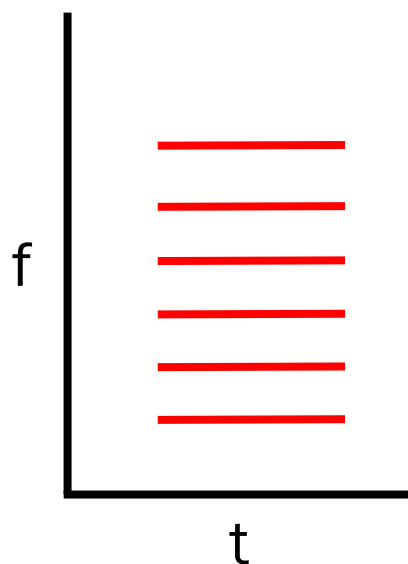


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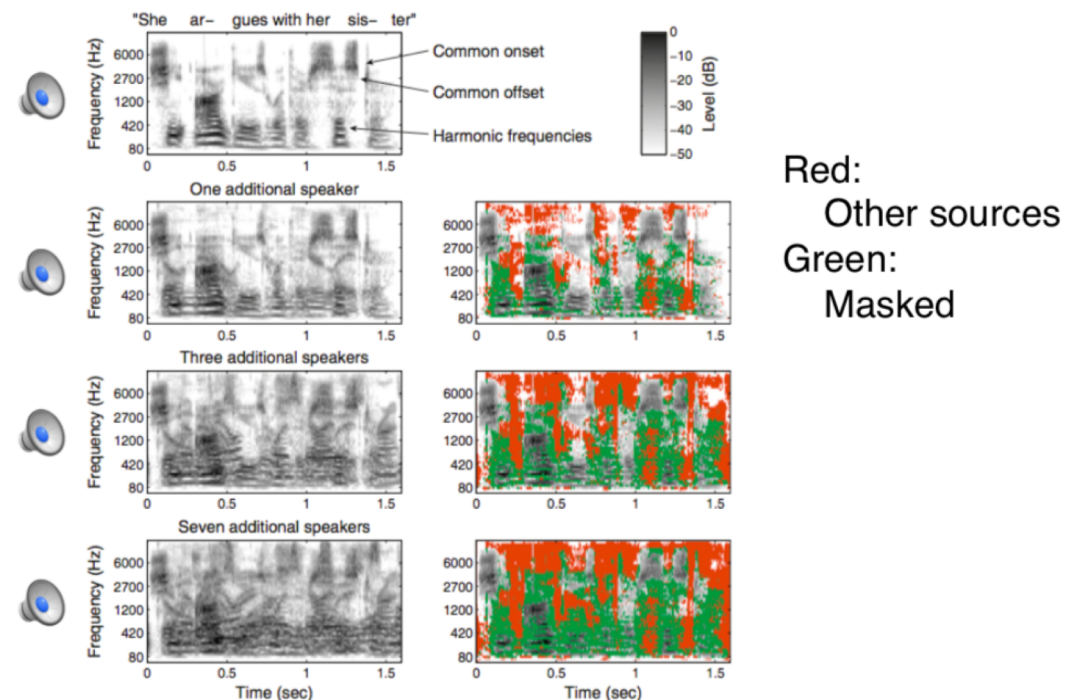


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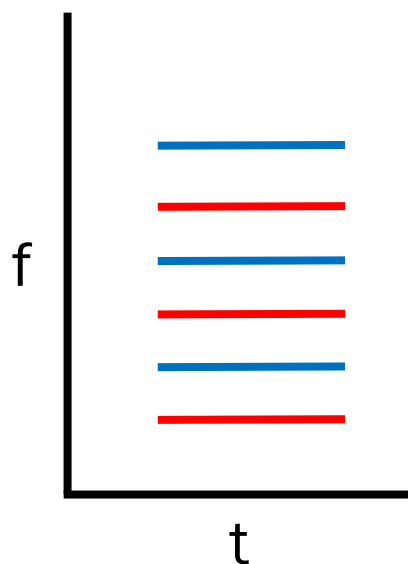


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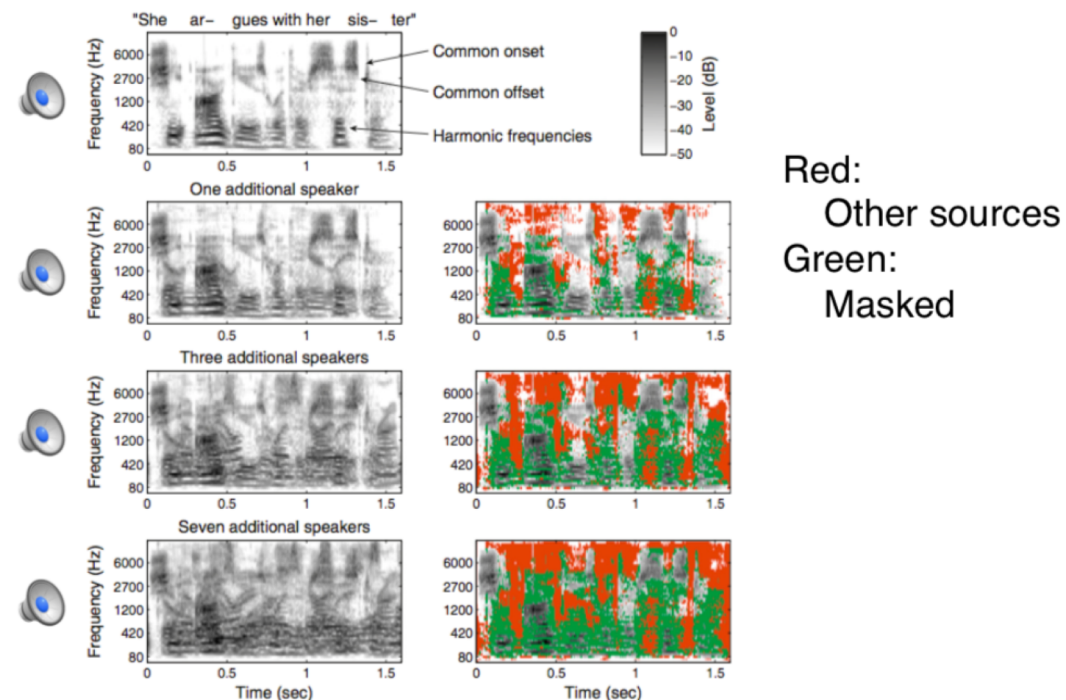


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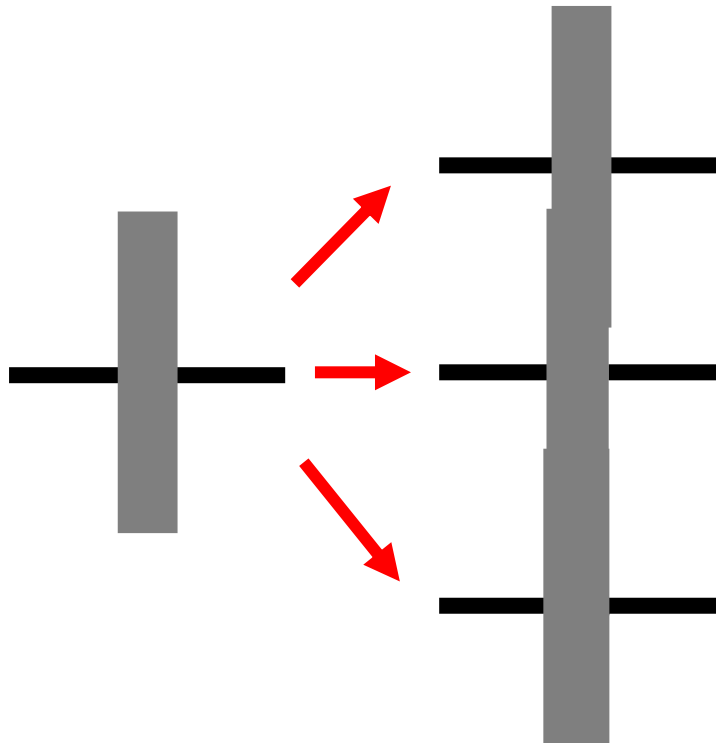


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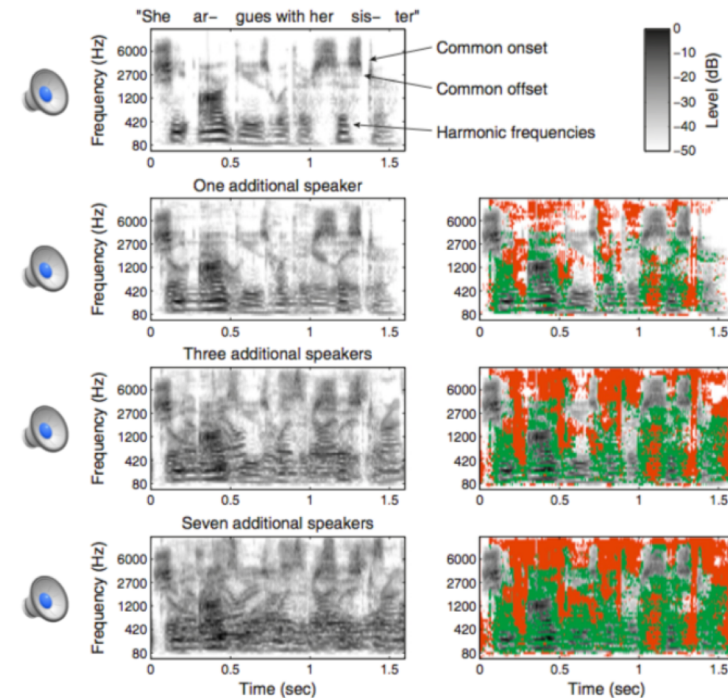


Illusion categories (roughly speaking...)

1. Sequential grouping
2. Simultaneous grouping
3. Perceptual filling-in



One intuitive view of inferring a target source from a mixture:
2) Estimate parts of source that are masked.



Problem set structure

1. Review existing illusions at

<http://www.mit.edu/~mcusi/935/2020/illusionlab1/>

Write a sentence explaining each concept/illusion (10 total).

2. Create a new illusion

Ask a new scientific question about perception.

Design your illusion, and make a webpage demonstrating and explaining it to your classmates.

Meeting with course staff: bring ideas and an initial illusion.

Problem set structure

3. Gallery exchange

- First, leave short comments as if you were:
 1. a study participant describing their experience
 2. an experimenter analyzing the results
 - You are not grading the assignment
- Second, respond to the comments on your own illusion:
 1. what do the participants' reports imply for your question?
 2. next steps – idea to improve the illusion or next research question

4. Feedback

Any questions about assessment?

- Grade breakdown at <http://www.mit.edu/~mcusi/935/2020/illusionlab1/rubric.html>
- Learning objectives are based on the process of knowledge creation in perceptual science
- It is important that you can:
 1. Explain how illusion design/resulting perceptual experience could lead to a scientific conclusion about perception
 2. Program the synthesis of sound sequences, by combining and adapting code from previous problem sets
 3. Ask a simple question about perception (connect concepts)
- If your illusion doesn't lead to a clear conclusion, that's totally fine.

Questions to ask yourself in order to understand an illusion

Illusion design

- What are plausible possibilities for perceptual interpretations of this sound sequence? i.e. what's ambiguous about the sound?
- What variables are changed, what is held constant?

Conclusions

- What patterns in the sound sequence lead to grouping or segregation or filling-in?
- In this illusion, what assumptions is the auditory system using to solve the ill-posed problem?

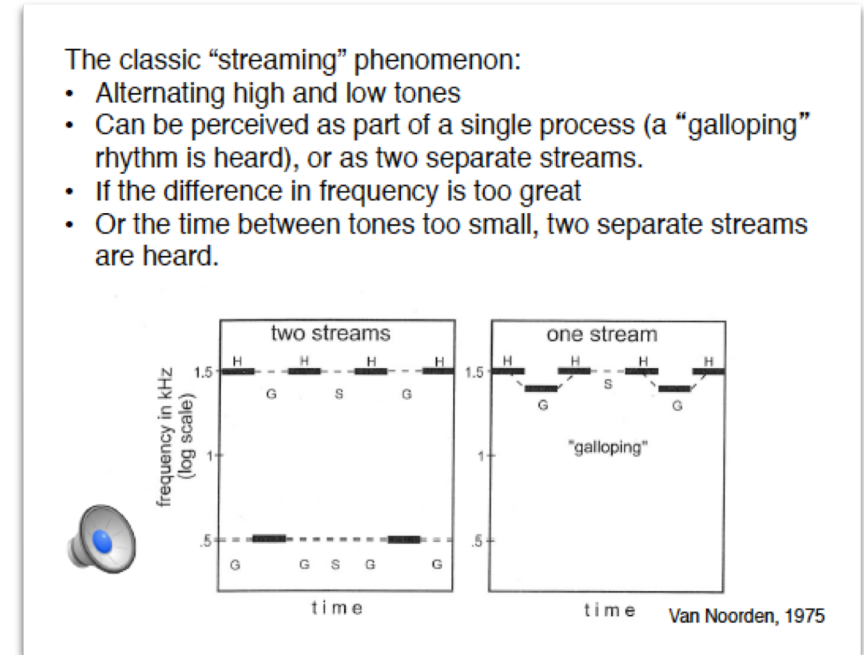
Illusion run-through

1. Sequential grouping
2. Simultaneous grouping
3. Perceptual filling-in

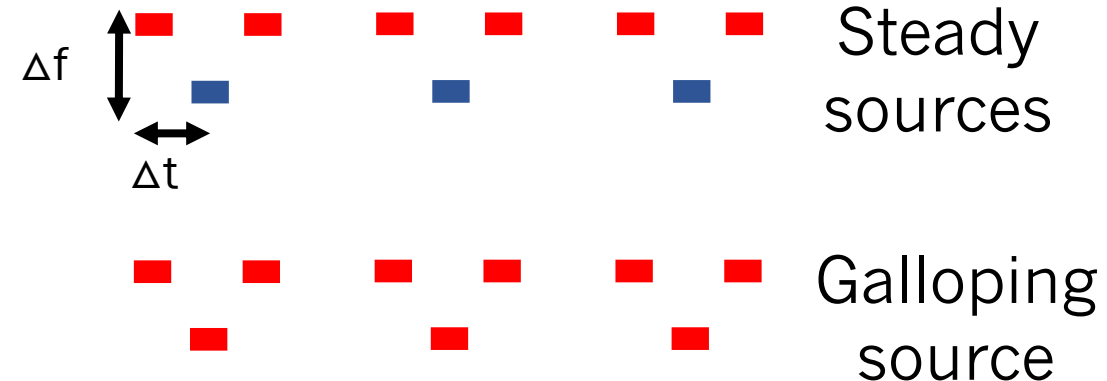
Sequential grouping

ABA streaming

1. Vary the difference in frequency (Δf) and timing (Δt) between the tones.
- When is there grouping (galloping) and when is there segregation?



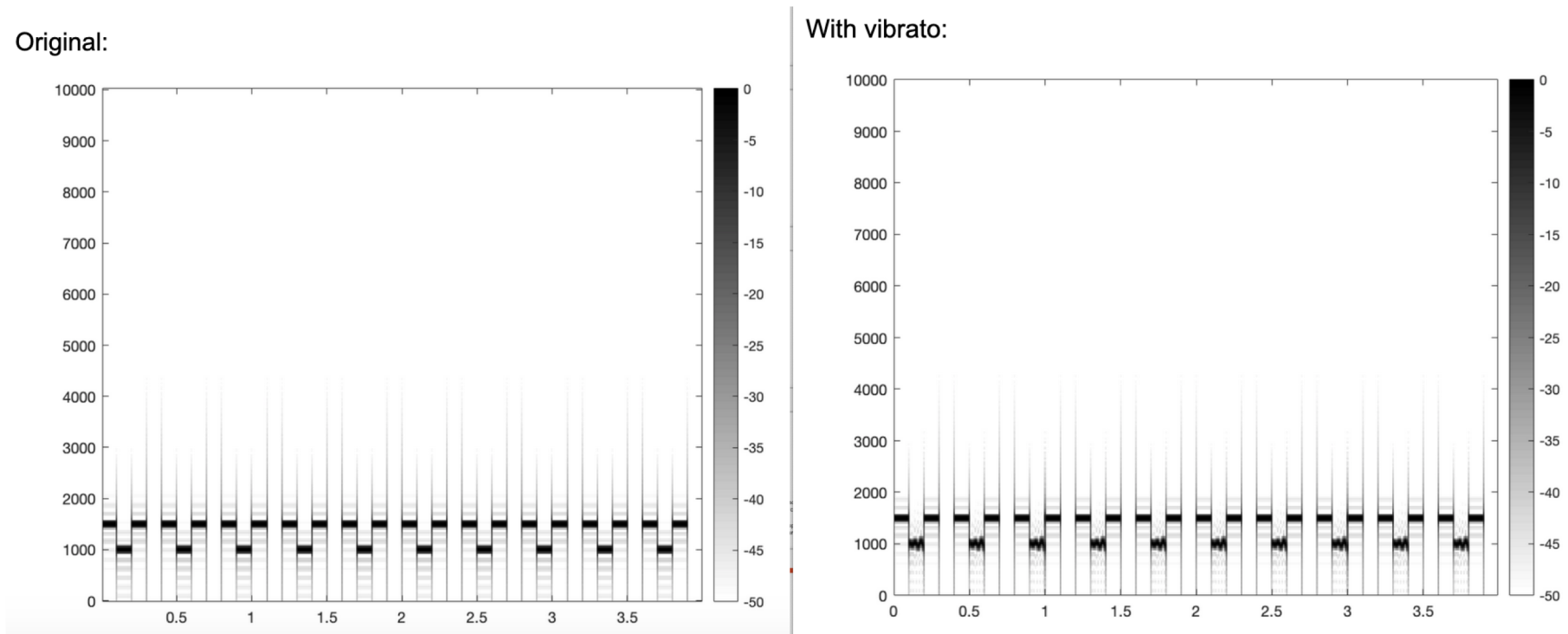
Possible perceptual interpretations:



2019: variant on sequential grouping

- Can vibrato make it easier for tones to segregate?

<http://www.mit.edu/~mcusi/illusionlab1/gallery/p3.html>



Simultaneous grouping

Harmonic mistuning

1. Start with a harmonic tone and vary the frequency of one component
- What is the assumption that the auditory system might be making?

Sounds in the world are often harmonic. The brain seems to assume that frequencies that are harmonically related belong to the same acoustic event.

When one frequency is not harmonically related to a bunch of others, it segregates perceptually.

18 Isolation of a frequency component based on mistuning.



2019: variant on harmonic mistuning

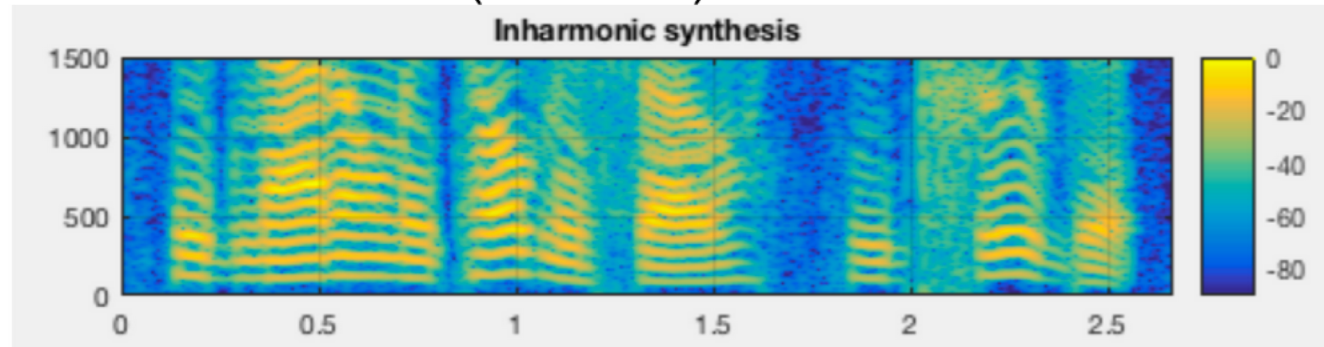
Do mistuned unresolved harmonics segregate from speech?

<http://www.mit.edu/~mcusi/illusionlab1/gallery/p1.html>

Original (mistune the 3rd harmonic in speech by 8)%:



Next I mistune the ninth (unresolved) harmonic of the same utterance by 6, 12, 24, 30, and 50%.

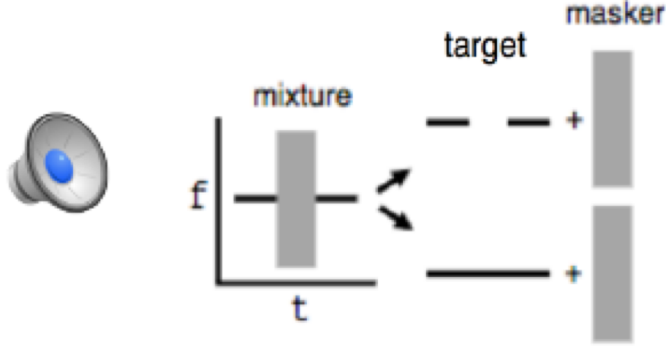


Filling in Continuity Effect

1. Increase the level of the masker until the tone sounds continuous
- What are some possible perceptual interpretations?
 - What might be the assumption the auditory system is using?

Filling In

The Continuity Effect: When noise occurs during a gap in a tone, we hear the tone continue through the noise.



Multiple explanations are physically consistent with stimulus.

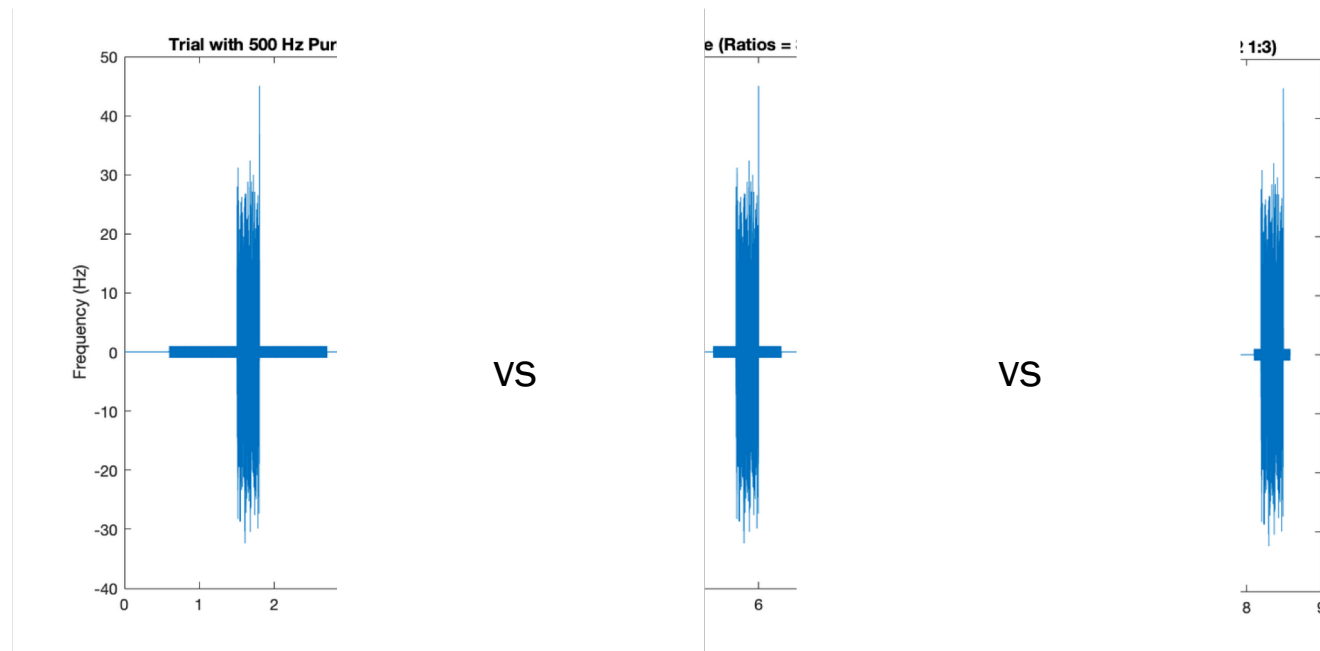
- The brain is inferring that the tone's absence is best explained by masking, and so it is filled in.
- Only works if the noise contains frequencies close to those of the tone, and is sufficiently high in level.

Warren et al. 1972

2019: variant on continuity illusion

Does changing the ratios between tone and noise durations affect/inhibit perceptual filling-in?

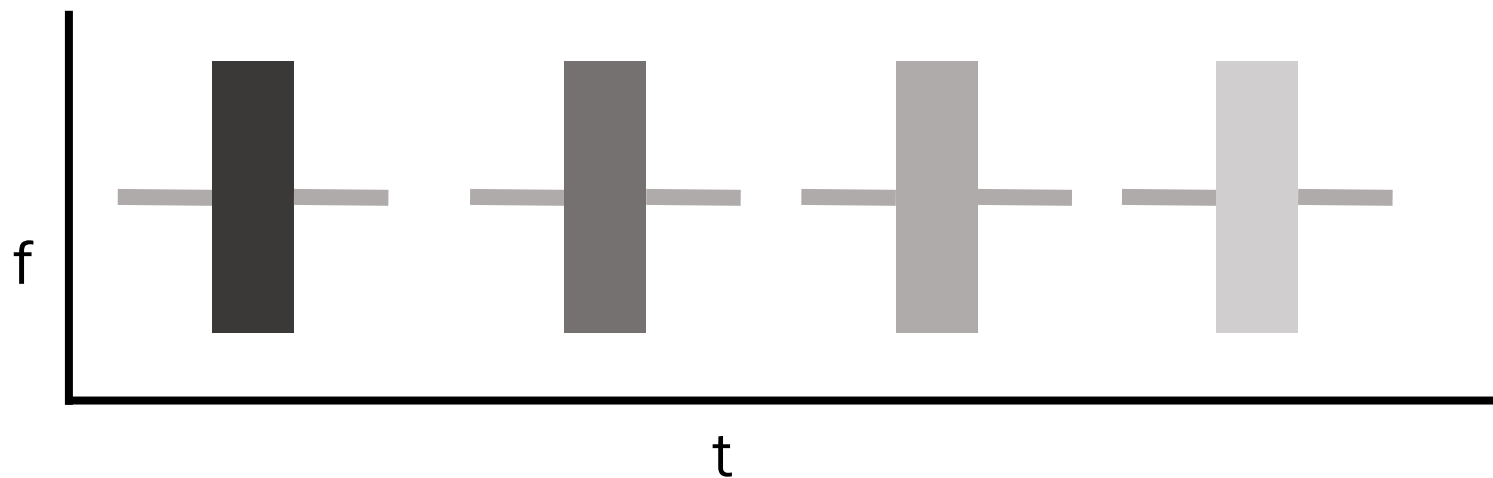
<http://www.mit.edu/~mcusi/illusionlab1/gallery/p2.html>

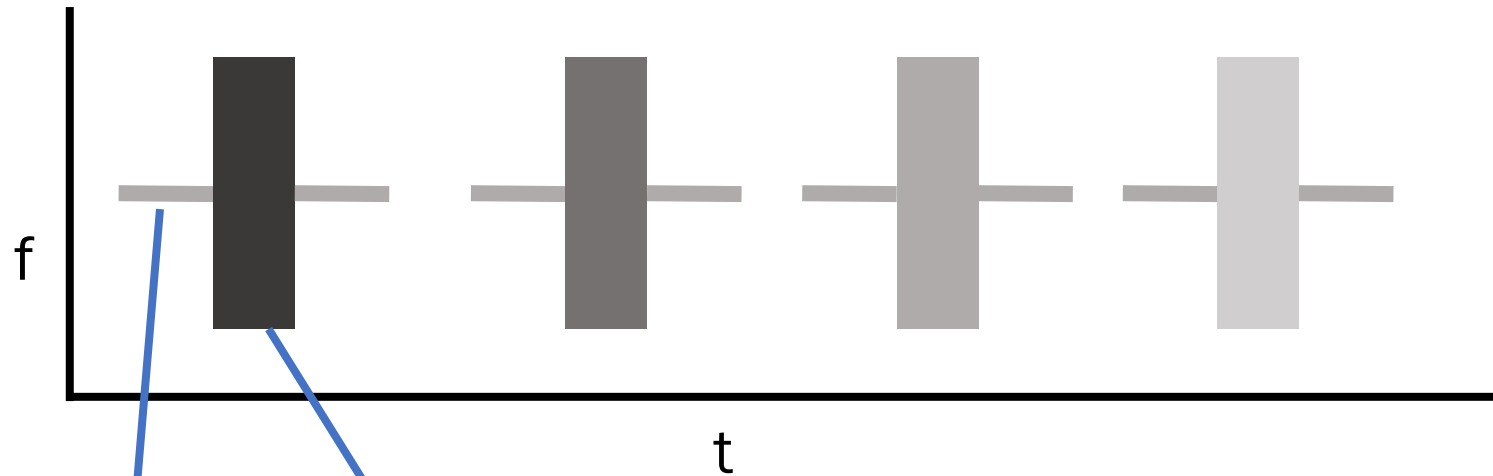


Code example: continuity illusion

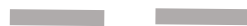
How to go from generating tones & noise on the problem set to the sequence of sounds that comprise an illusion

Common illusion motif: play the same snippet of sound with only the “threshold” variable changing in each iteration





Tones
P.Set 1, #2a



Noise
P.Set 1, #3



Plan:

Synthesize each part with the correct duration based on pset
Concatenate each of the sounds to make the sequence

Silence: 0.5 seconds

Tone: 0.4 seconds

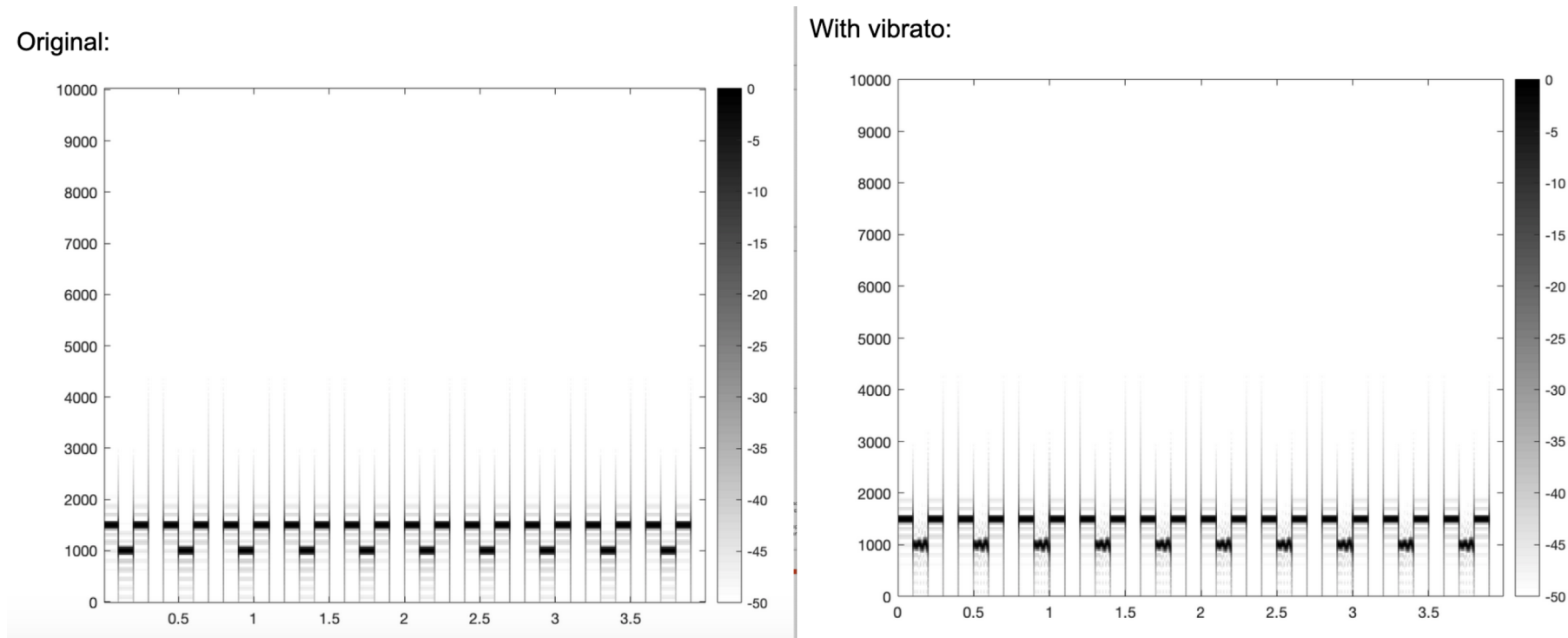
Noise: 0.1 seconds

Brainstorming

- Maybe you've asked a question in class that you could answer yourself by making an illusion!

Brainstorming

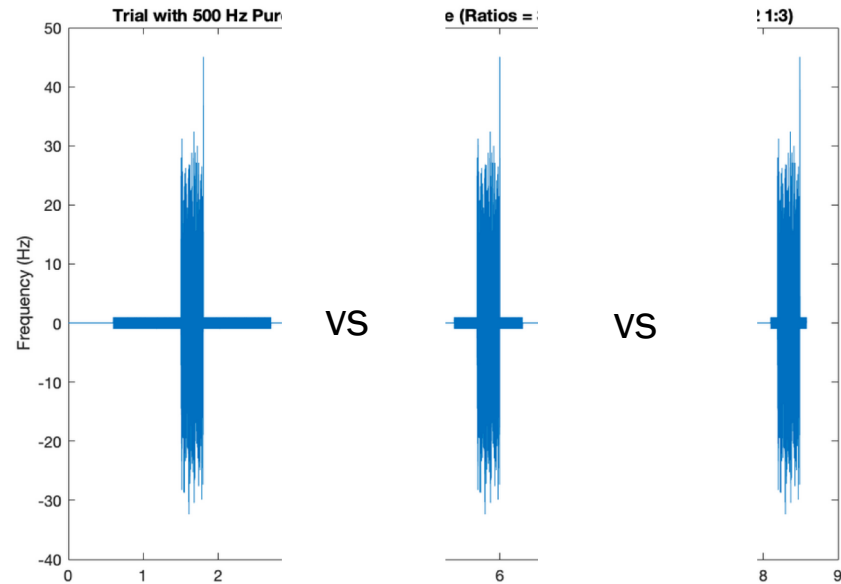
- Start by making an existing illusion and then make a variant of that illusion that answers a new question



<http://www.mit.edu/~mcusi/illusionlab1/gallery/p3.html>

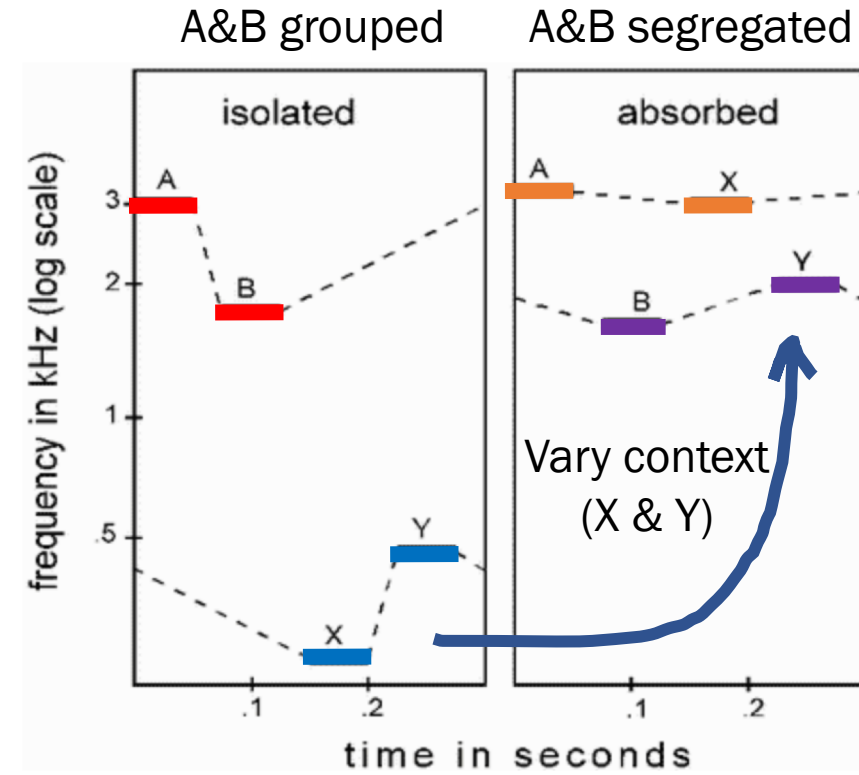
Brainstorming

- How does context affect the interpretation of a particular section of sound?



<http://www.mit.edu/~mcusi/illusionlab1/gallery/p2.html>

Possible perceptual interpretations when Δf and Δt between adjacent tones A & B remains constant.

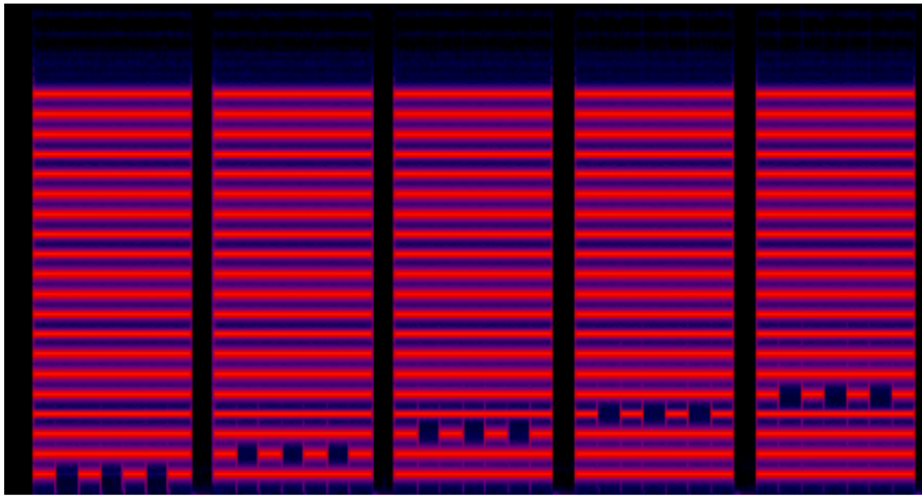


#2 on the list of illusions you need to write a sentence for

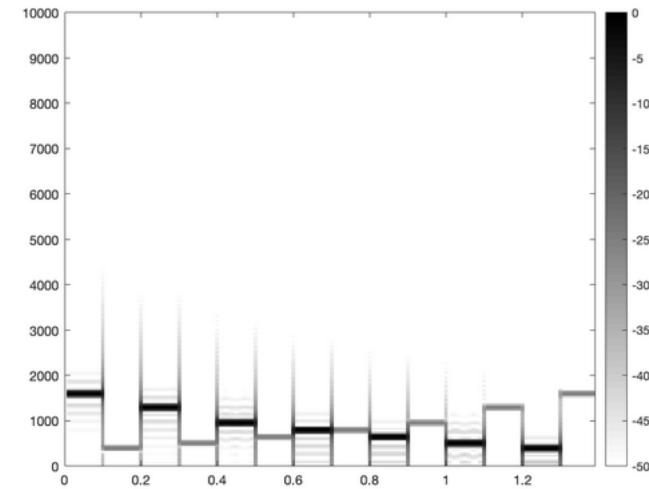
Brainstorming

- How does the auditory system resolve conflicting patterns?
- Combining illusions, different kinds of information, other class concepts

“Cancelled harmonics” Illusion



Is amplitude a more dominant grouping cue than frequency proximity?

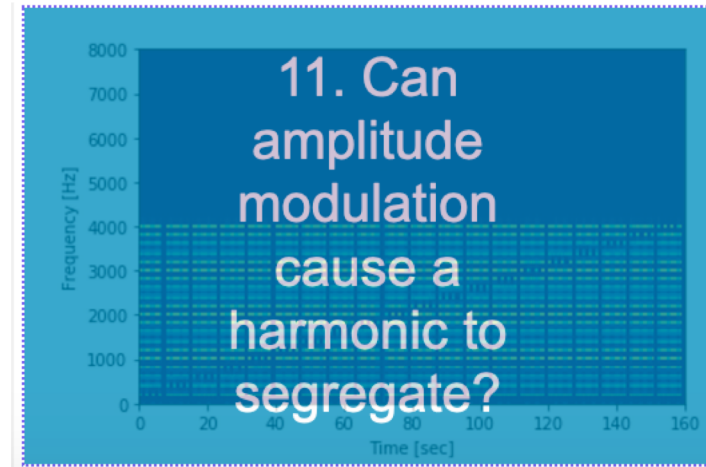
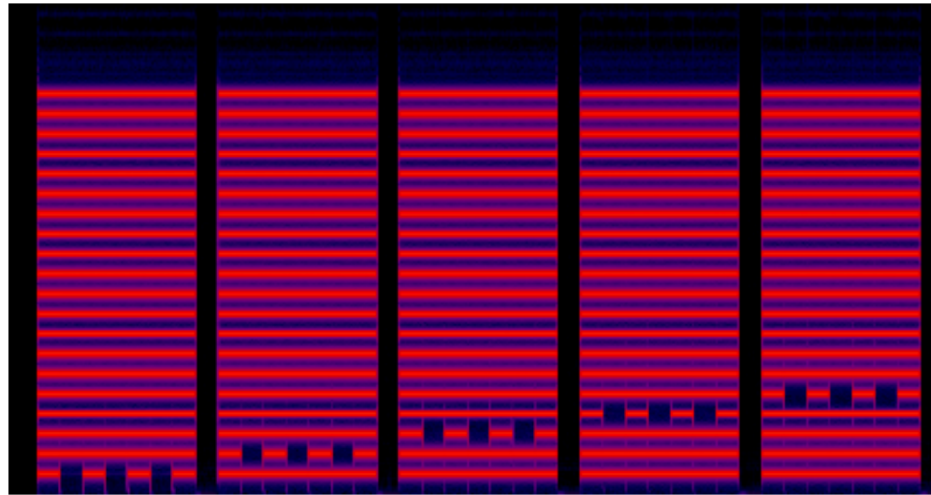


<http://www.mit.edu/~mcusi/illusionlab1/gallery/p5.html>

Brainstorming

- How strictly must a pattern be followed to produce grouping?
- Finding thresholds of segregation and grouping (e.g. mistuned harmonic)

“Cancelled harmonics” Illusion



<http://www.mit.edu/~mcusi/illusionlab1/gallery/p11.html>

- What are the interpretations over a range of settings for some variable? Are there cases where we experience multiple perceptual interpretations (multistability)?

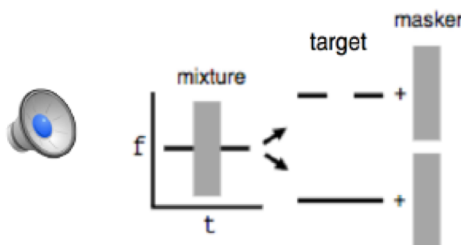
Brainstorming

- Vary the type of sound in the illusion

Basic continuity effect

Filling In

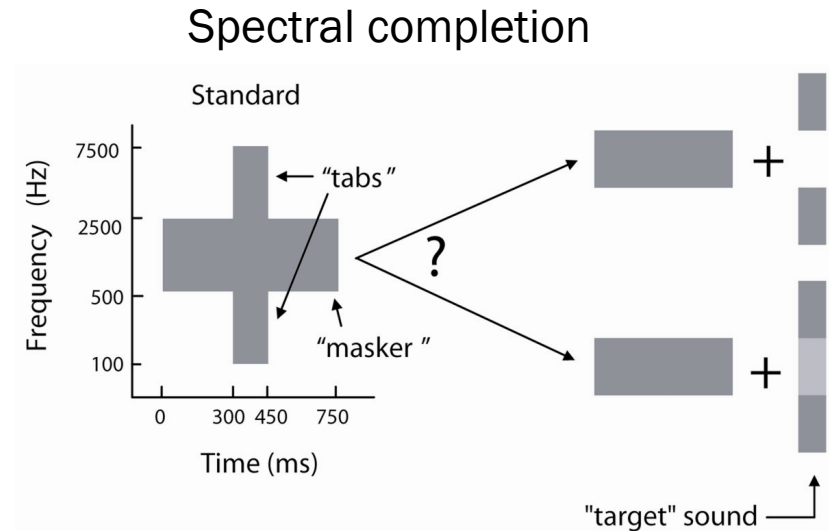
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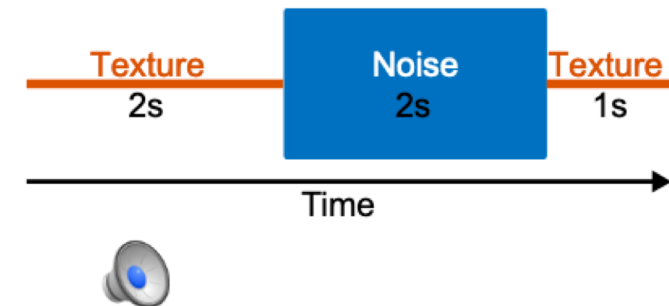
- The brain is inferring that the tone's absence is best explained by masking, and so it is filled in.
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Warren et al. 1972



Sound Texture Restoration → more naturalistic sounds

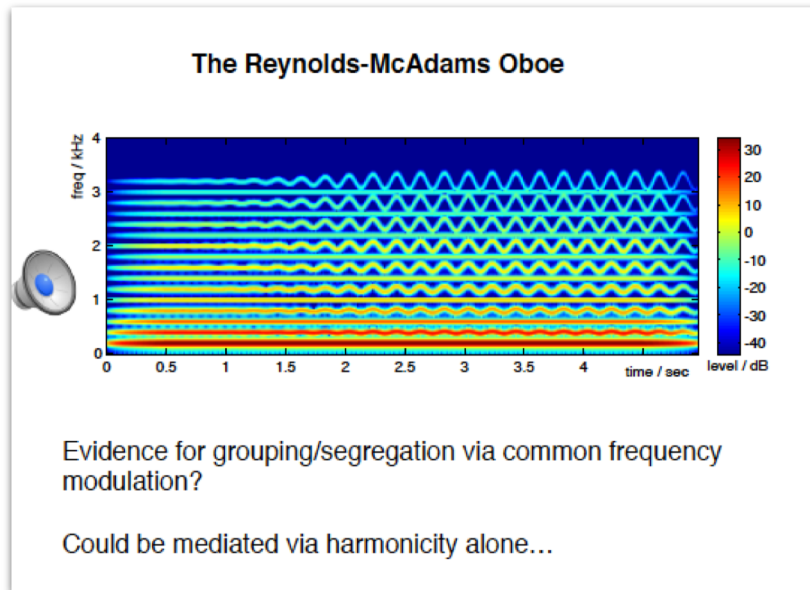
Humans hear the texture continue during the noise:



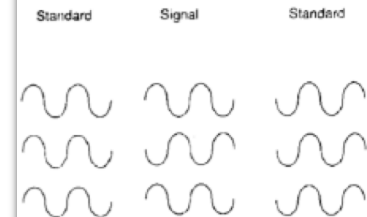
Texture is not actually present during noise!

Brainstorming

- Can you make an illusion that distinguishes between possible (scientific) interpretations of another illusion, refining our understanding of perception?



Can listeners detect incoherent FM in inharmonic complexes?



- Listeners cannot detect FM incoherence for mistuned (inharmonic) tones.
- Suggests that we do not use FM per se for segregation.

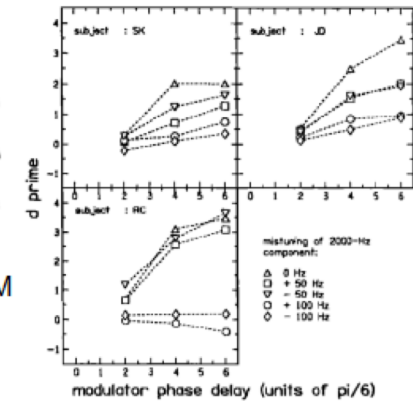


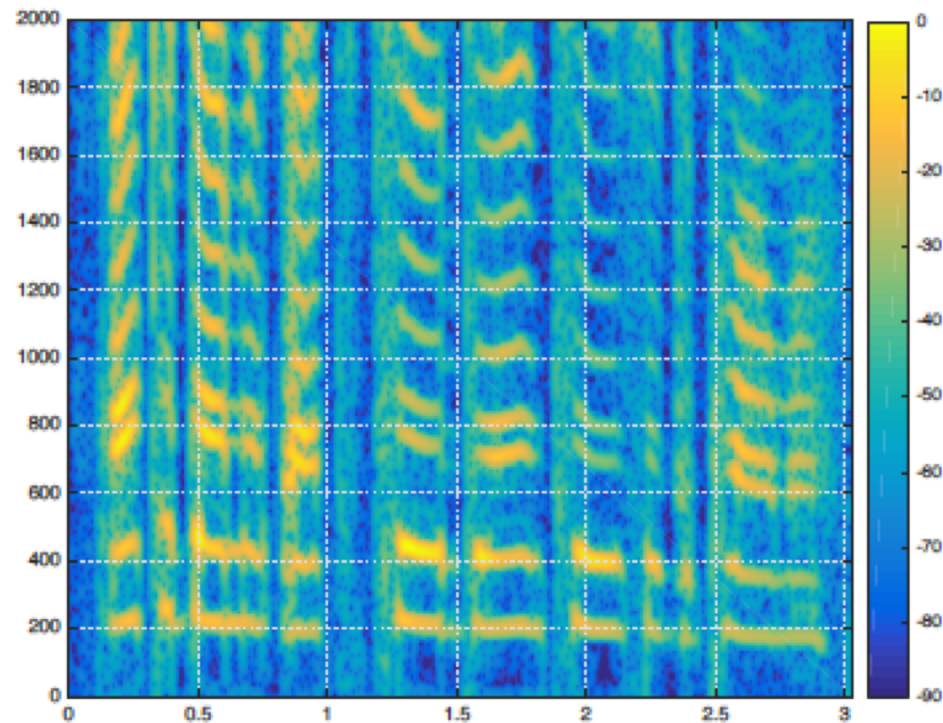
FIG. 3. As Fig. 2, for the five complexes of experiment 2. The five complexes differ in the degree of mistuning of the center component of a 1500 + 2000 + 2500-Hz complex.

Carlyon, 1991

Brainstorming

- What are common patterns in sounds produced on Earth?

Similar effects for speech - a single mistuned harmonic segregates from the rest of speech:



Popham et al.,
2018