Brain-state dependent multisensory perception

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https://tinyurl.com/Keil-IfADo-2021

To integrate or not to integrate?

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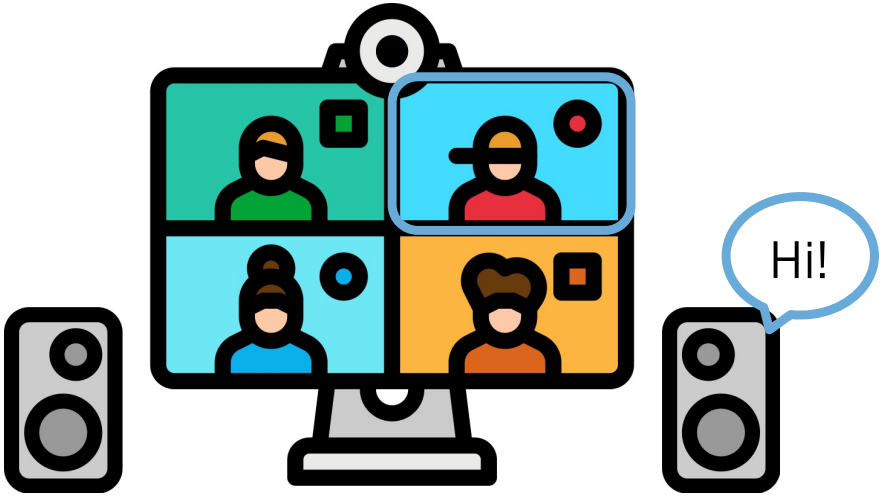

S_V S_A

P_V P_A

S_V S_A

P_{AV}

Hirst et al., 2020
Bizley et al., 2016

Part 1: (In)Congruent information

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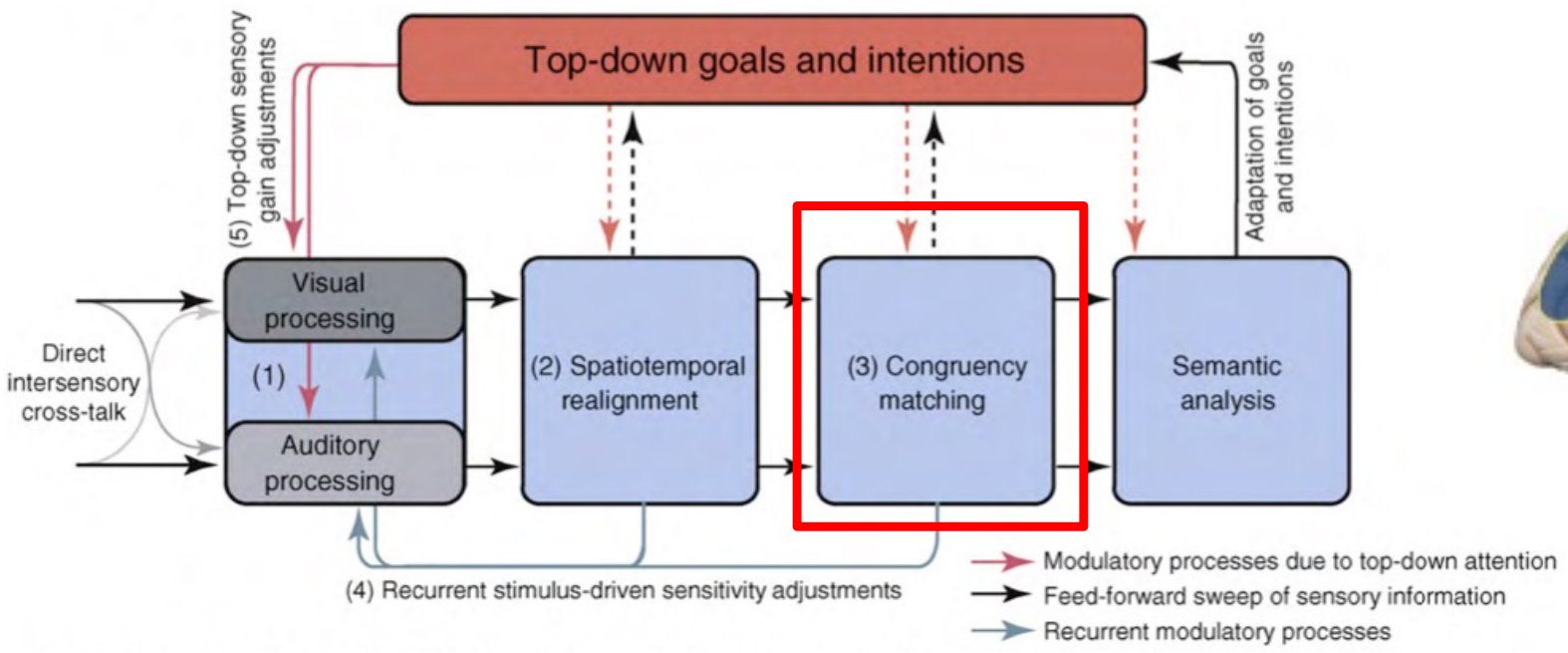
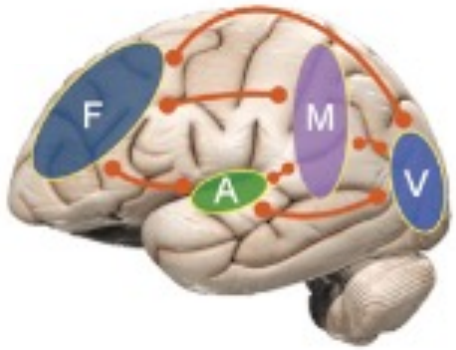
Starting point: When and where are multisensory signals integrated to a coherent and conscious subjective perception?





Senkowski et al., 2008; Talsma et al., 2010

Congruent vs. Incongruent Speech

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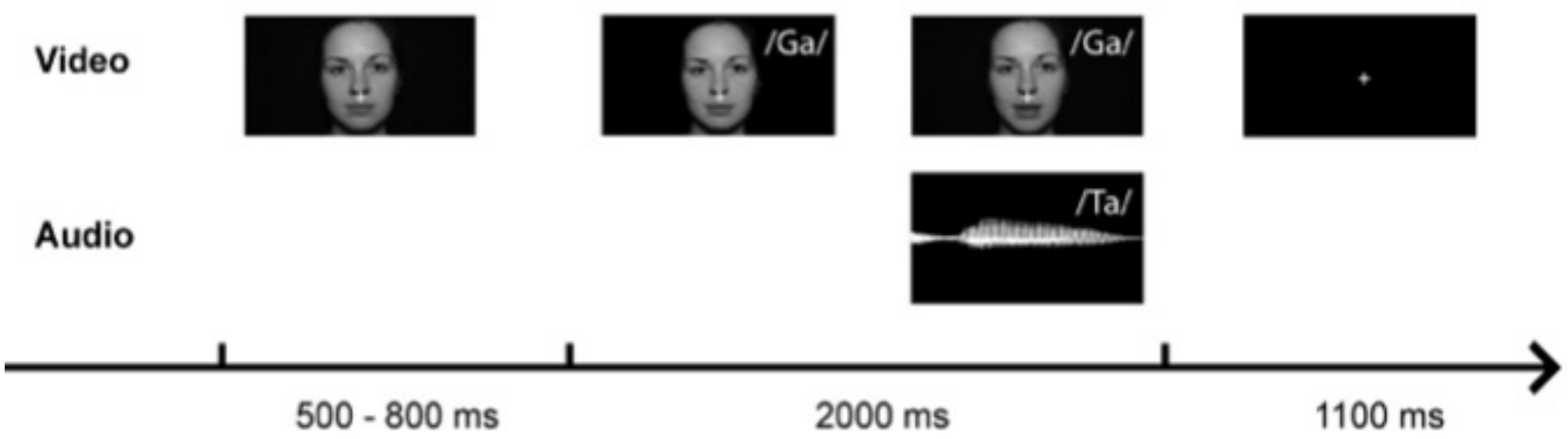
Starting point: When and where are multisensory signals integrated?

- McGurk-Effect: Compare congruent and incongruent speech signals



Roa Romero et al., 2016

Congruent vs. Incongruent Speech

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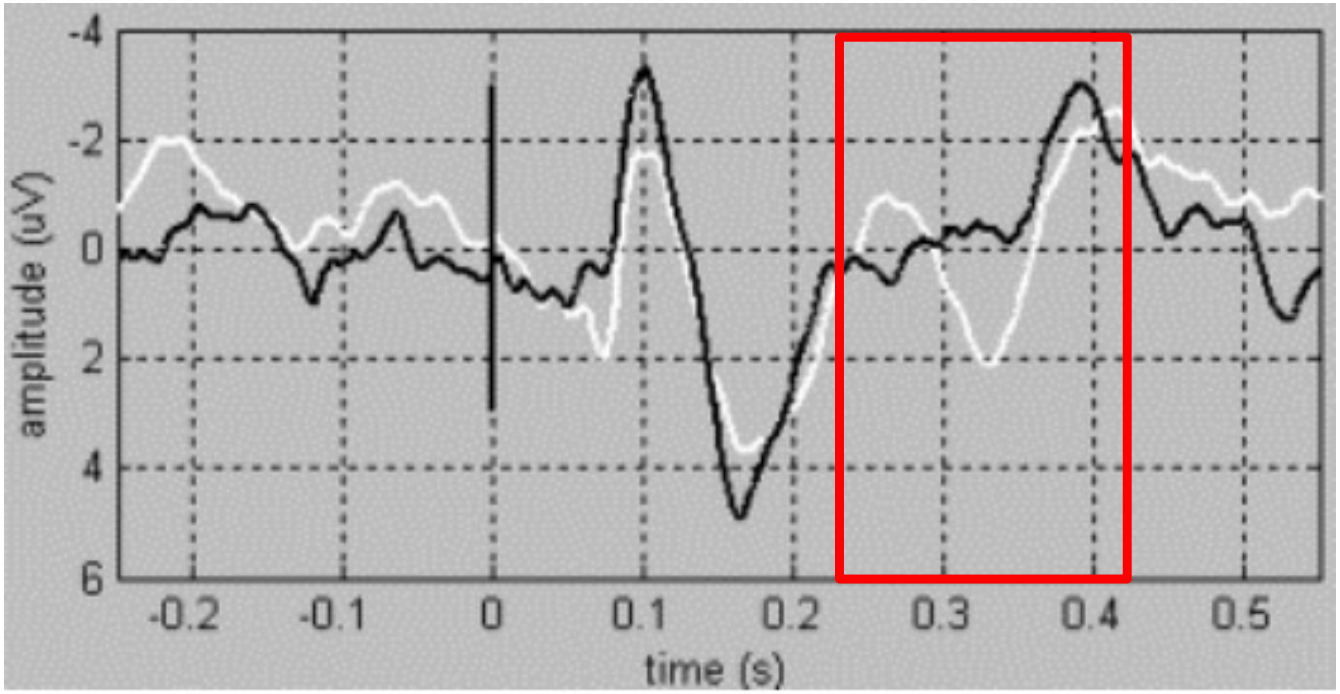
Late differences between congruent and incongruent audiovisual speech

- Timing of the difference depends on the ambiguity of the visual stimulus (AV comparison vs. congruency matching)



Van Wassenhove et al., 2003

Congruent vs. Incongruent Speech

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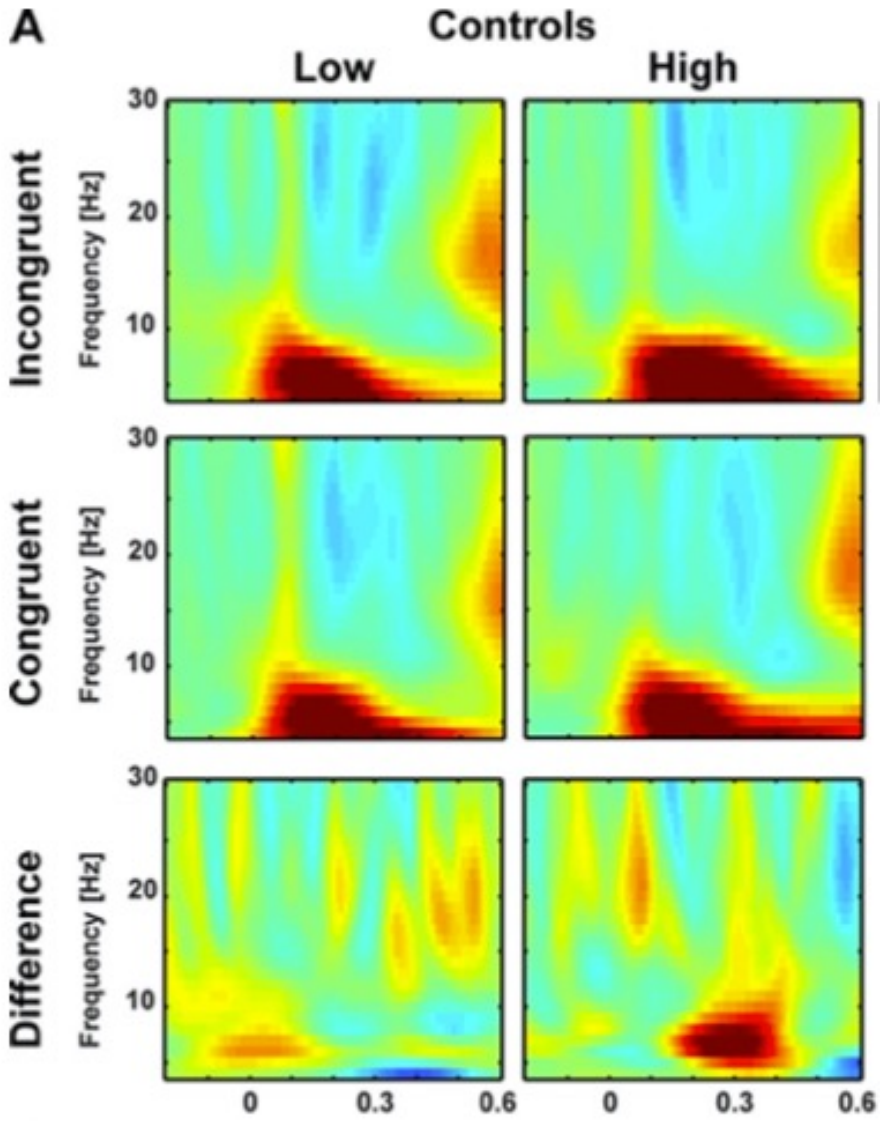
Late differences between congruent and incongruent audiovisual speech

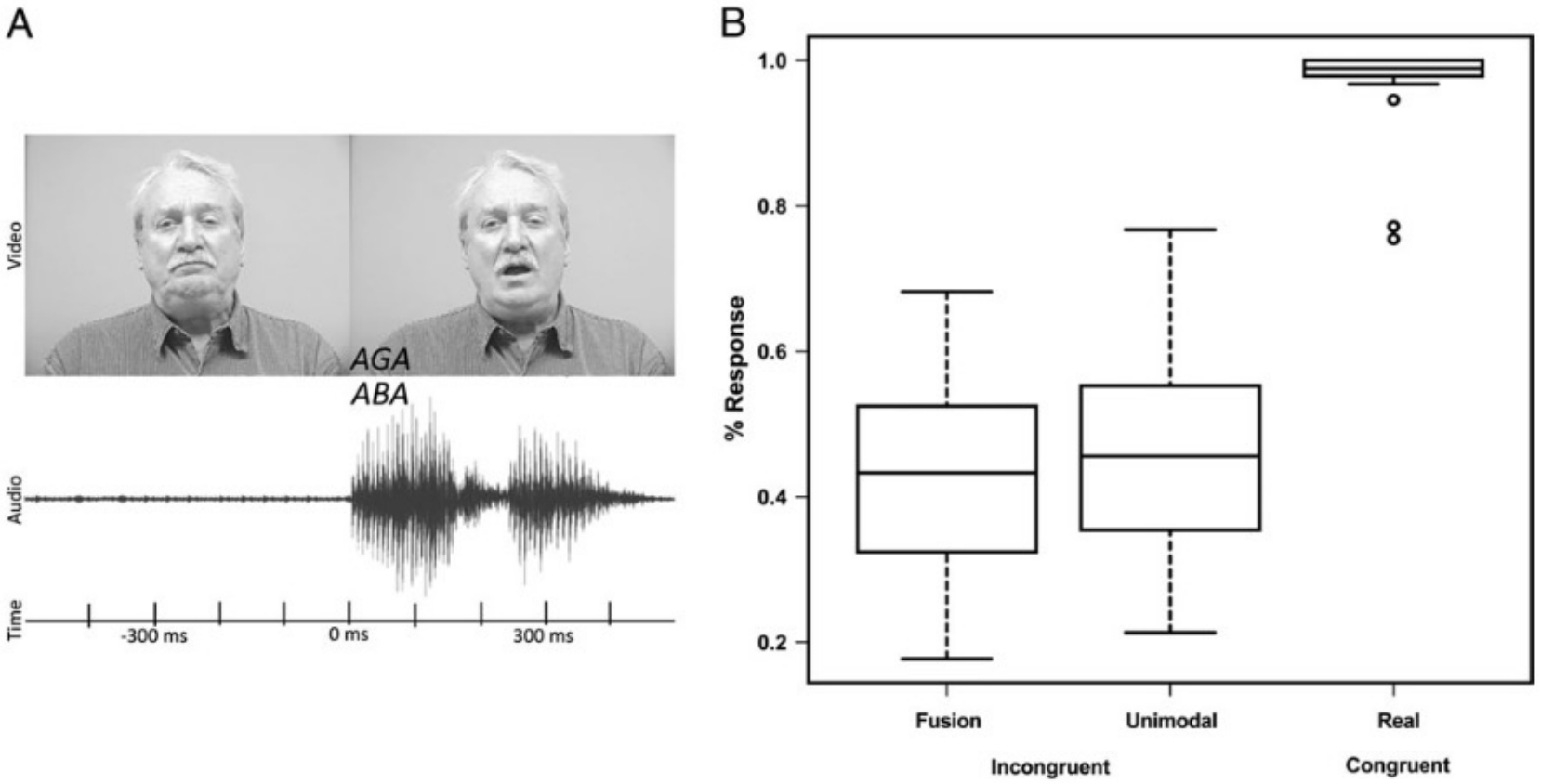
- Difference depends on the ambiguity of the visual stimulus
  - Only found in high **predictive** (i.e. low ambiguous) visual stimuli



Roa Romero et al., 2016

Illusion vs. No-Illusion

Bistable perception of ambiguous audiovisual speech

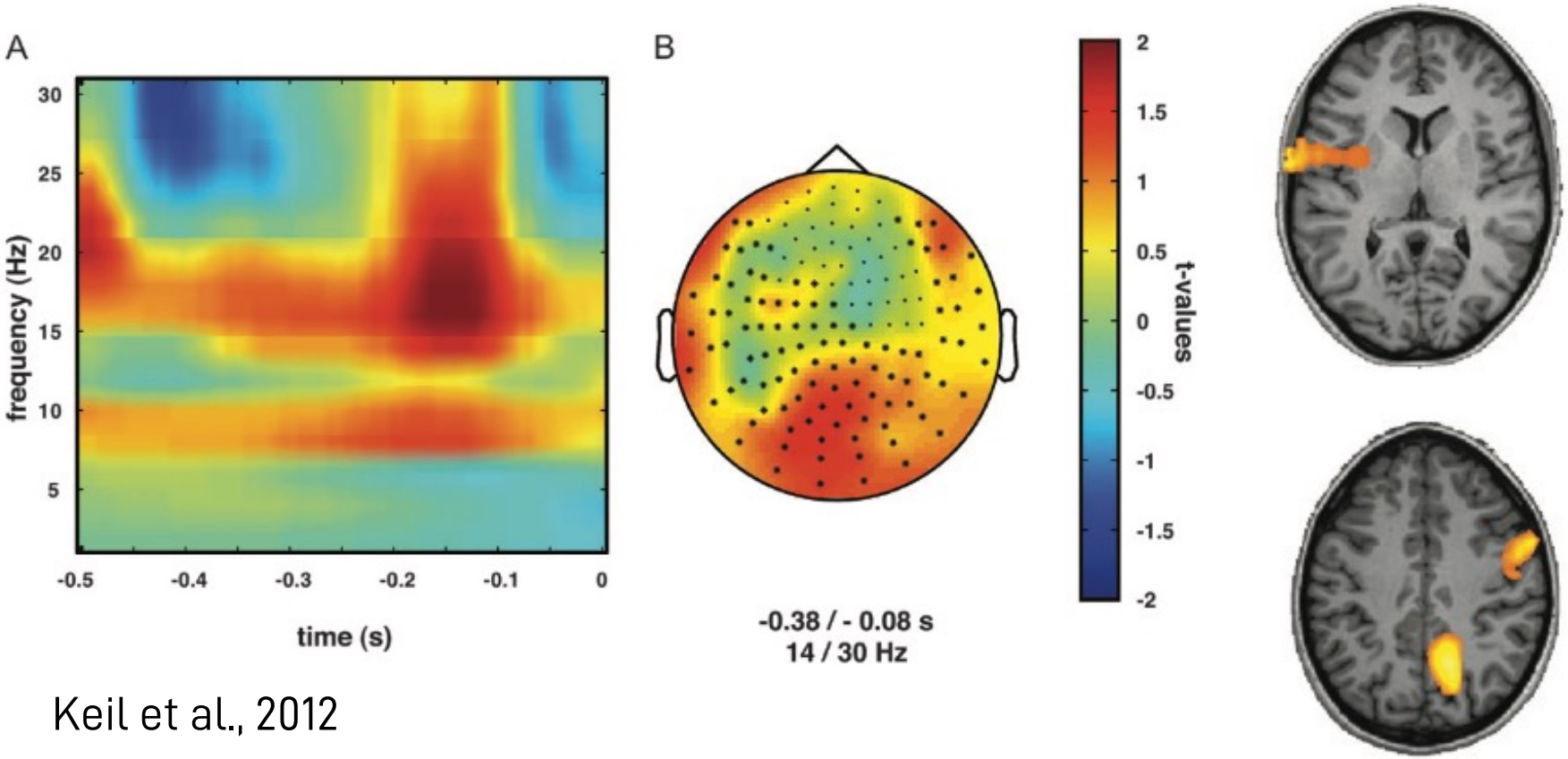


Keil et al., 2012

Illusion vs. No-Illusion

Bistable perception of ambiguous audiovisual speech: Brain state influences upcoming perception

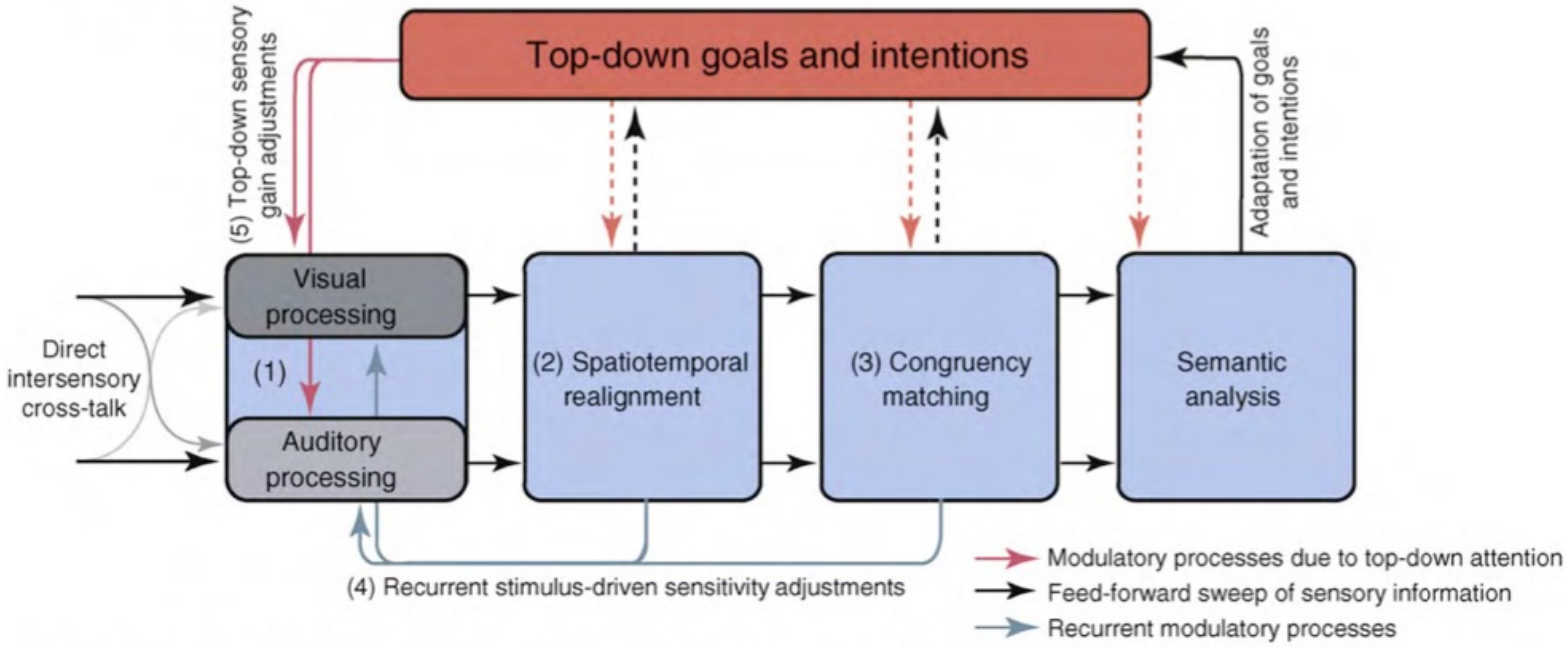
- Low-frequency power in sensory and association areas



Keil et al., 2012

Summary 1

- Multisensory perception involves multiple steps
  - Perception depends on stimulus properties
  - Brain state influencs stimulus processing and perception
- Problem: Speech stimuli are complex and require detailed processing



Talsma et al., 2010

Part 2: Make it simpler

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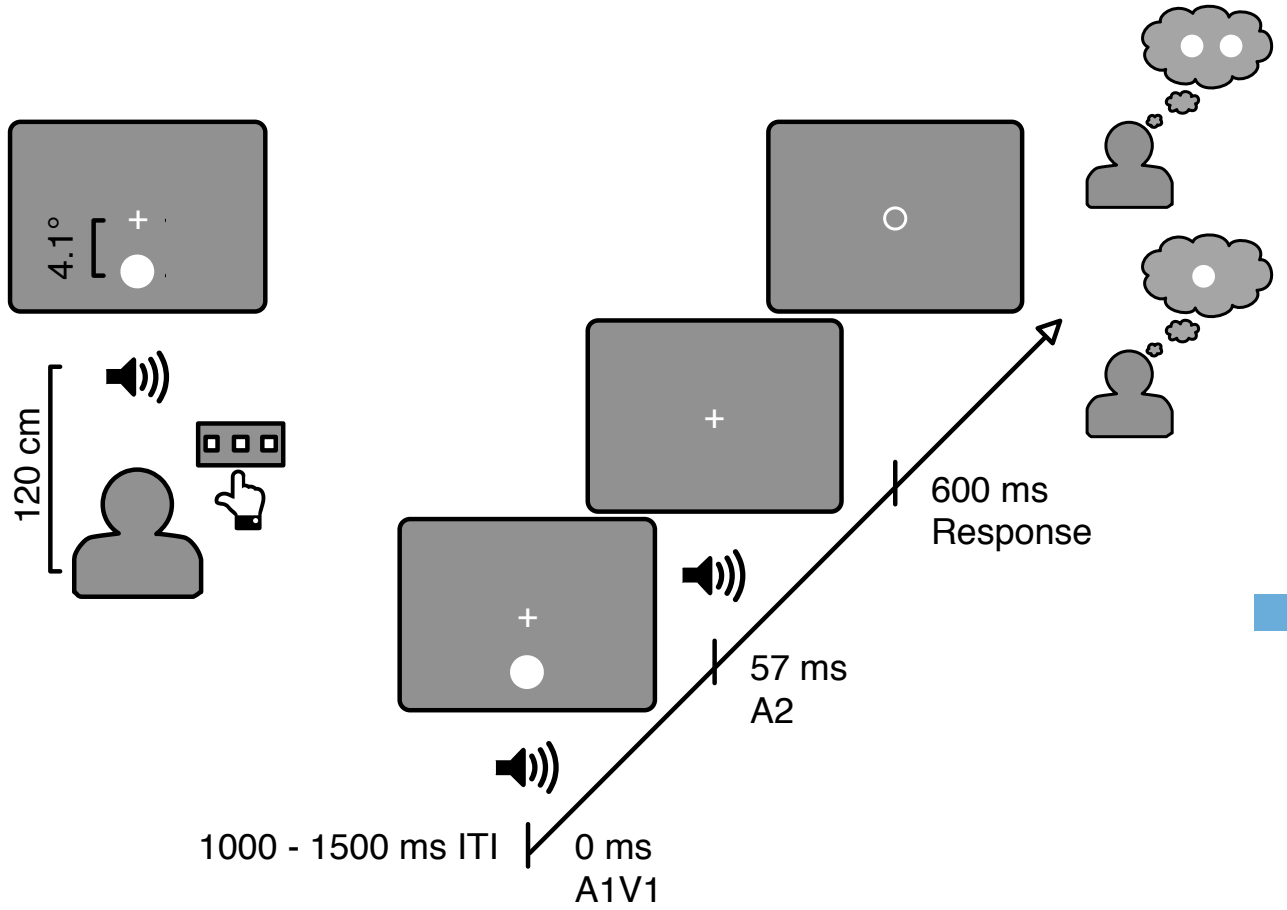
Sound induced flash illusion

- Combination of short auditory and visual stimuli
  - Simple visual discrimination task
  - Stimuli salient in isolation
  - Controls for response biases



Shams et al., 2000
Keil, 2020

Sound Induced Flash Illusion

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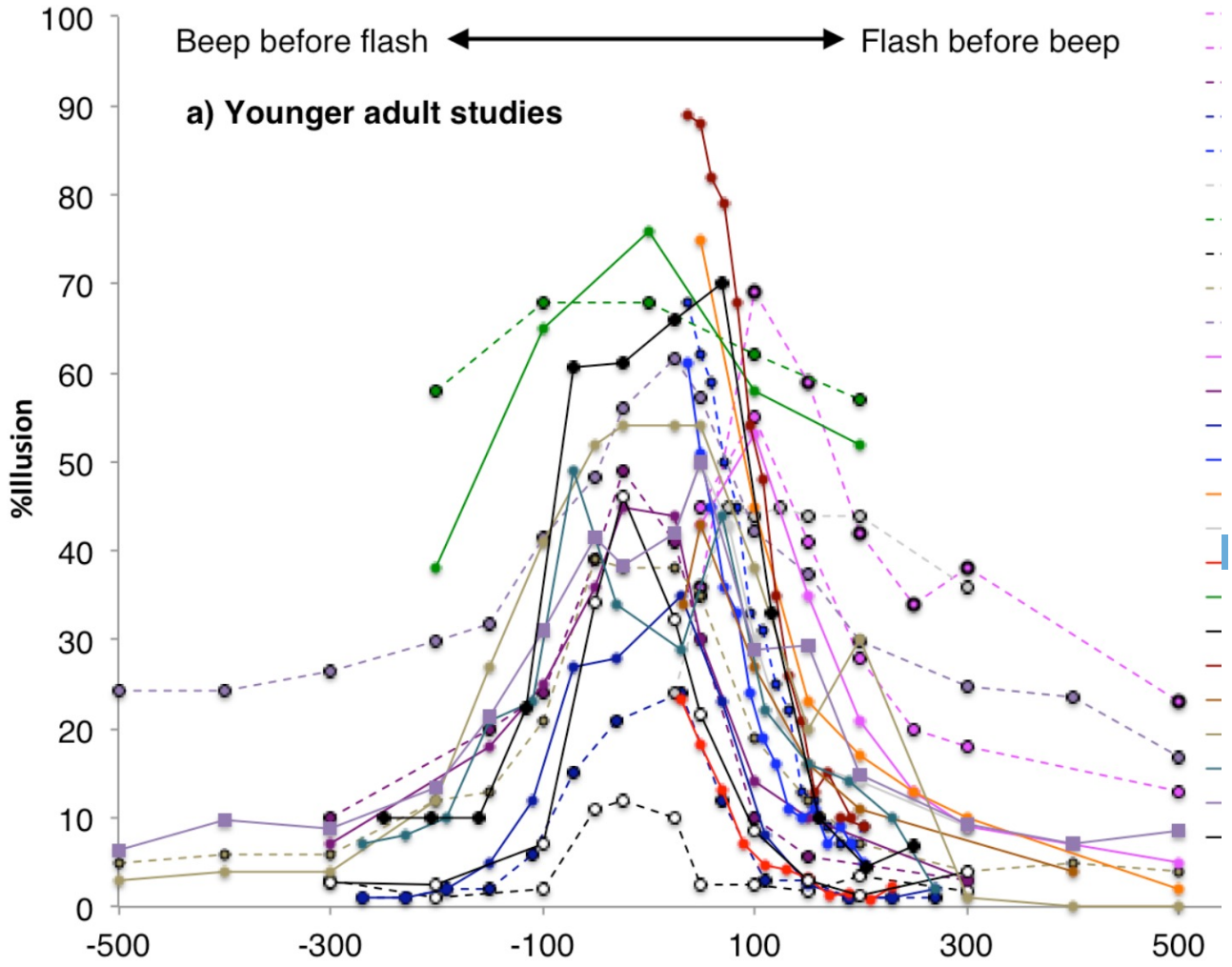
- ±100 ms SOA between auditory and visual stimuli results in illusion
  - Fission:
    2 auditory + 1 visual
    = 2 visual stimuli
  - Fusion:
    1 auditory + 2 visual
    = 1 visual stimulus



Hirst et al., 2020
Keil, 2020

Bistable perception: Illusion vs. No-Illusion

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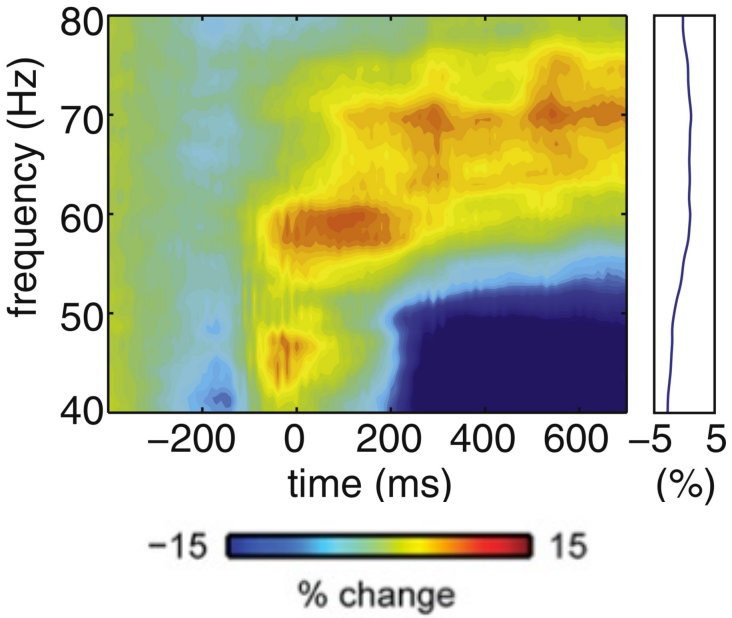

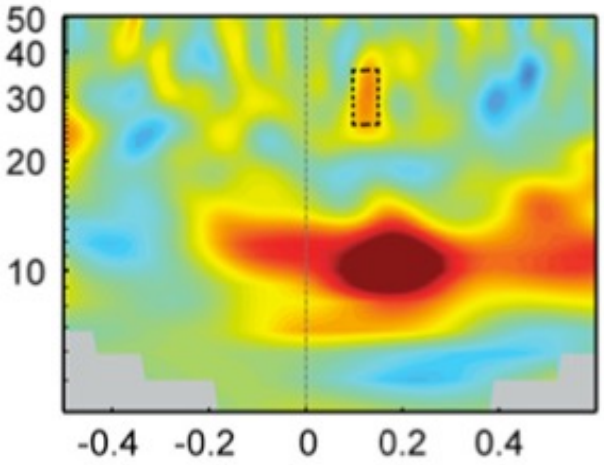

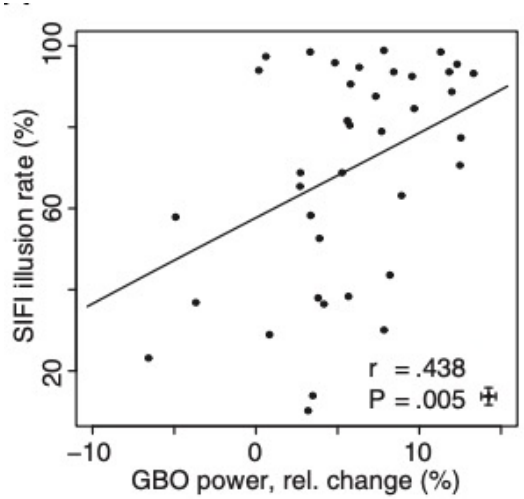

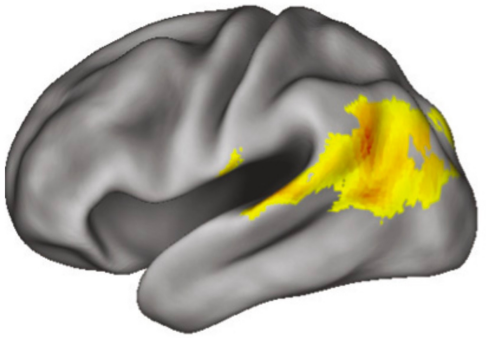

Integration of incongruent input: Illusion

- Increased gamma band power correlates with fission illusion
- Higher gamma band power for illusion vs. no-illusion perception

Balz et al., 2016a; Balz et al., 2016b

Bistable perception: Illusion vs. No-Illusion

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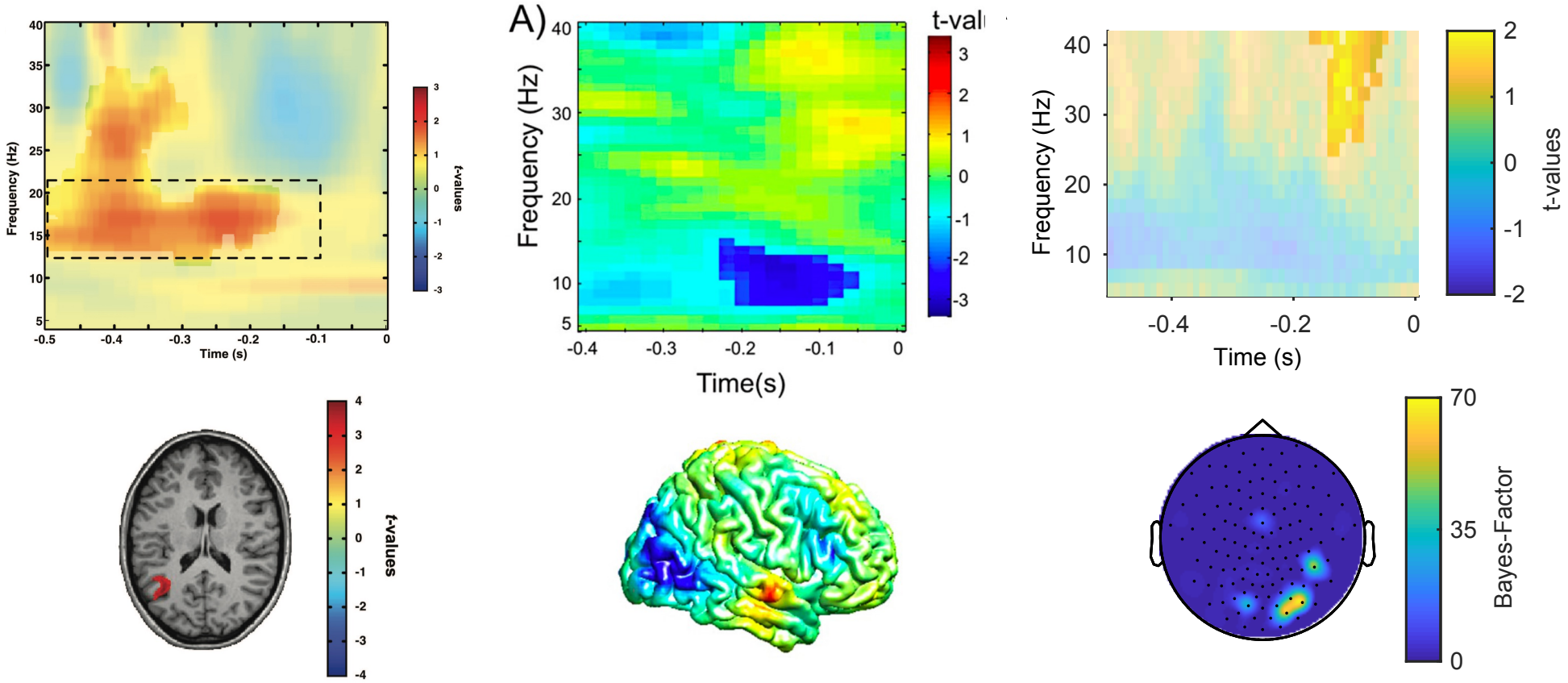
Brain state influences upcoming perception

- Low-frequency power in sensory and association areas



Keil et al., 2014; Lange et al., 2013; Kaiser et al., 2019

Bistable perception: Illusion vs. No-Illusion

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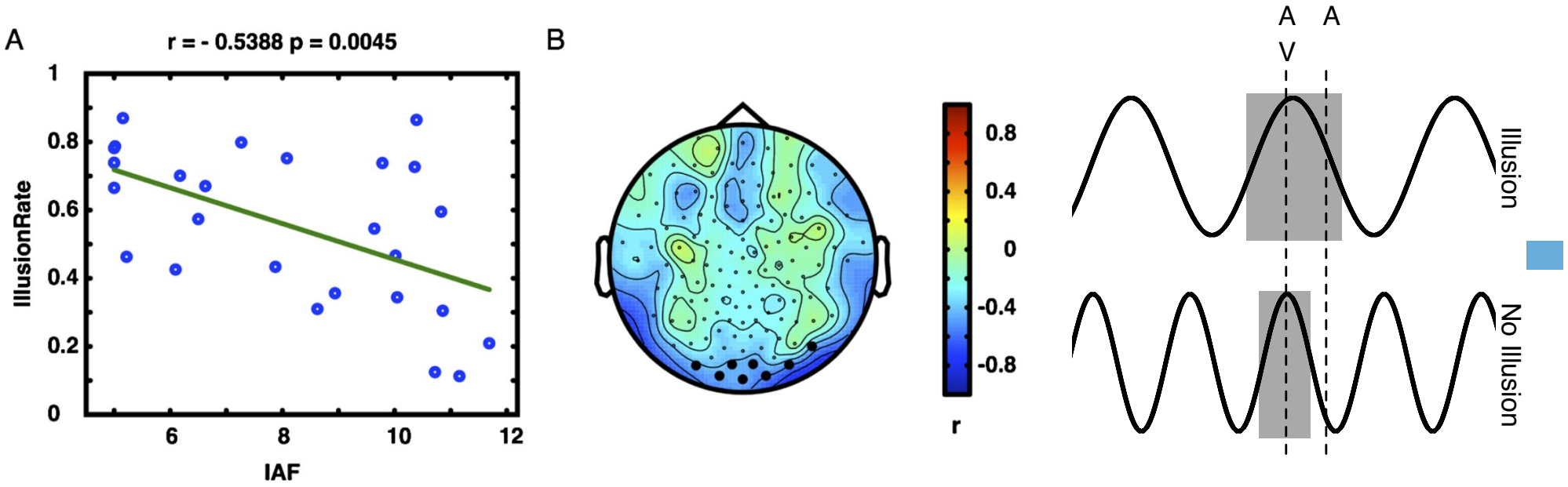
Brain state influences upcoming perception

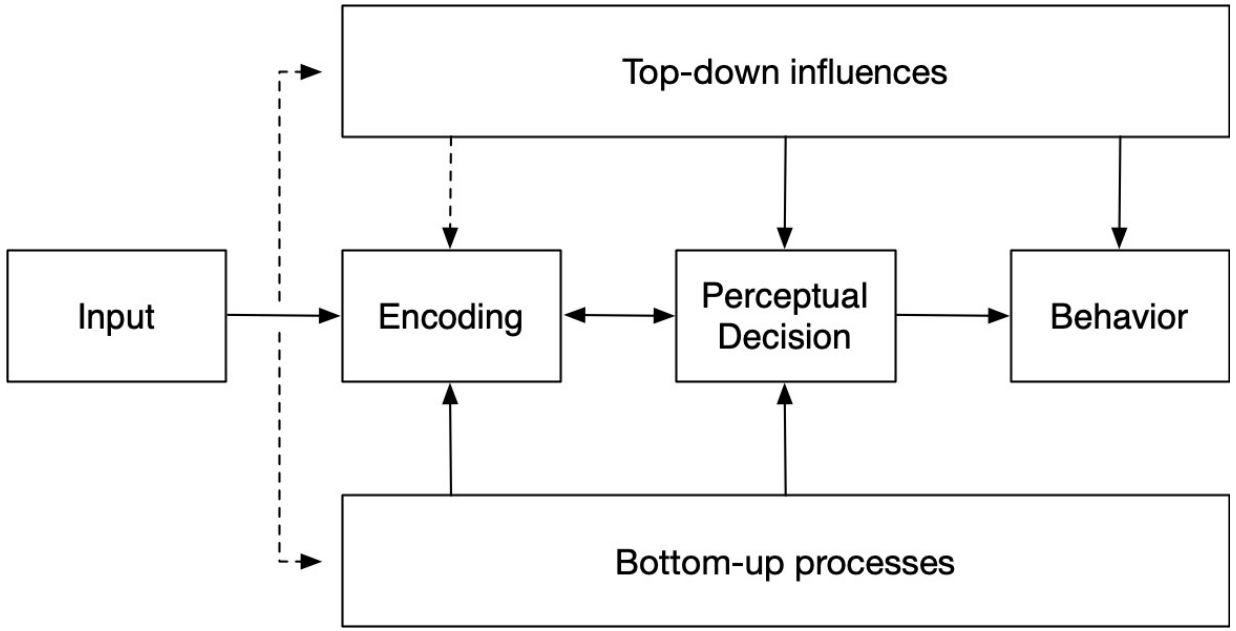
- Low-frequency phase duration in sensory areas



Keil et al., 2017

Summary 2

- Multisensory perception depends on the brain state
  - Bottom-up: Induced gamma-band power reflects integrated perception
  - Top-down: Ongoing alpha/beta-band oscillations influence sensory encoding and processing
- Problem: Can we change the brain state?



Part 3: Change the state

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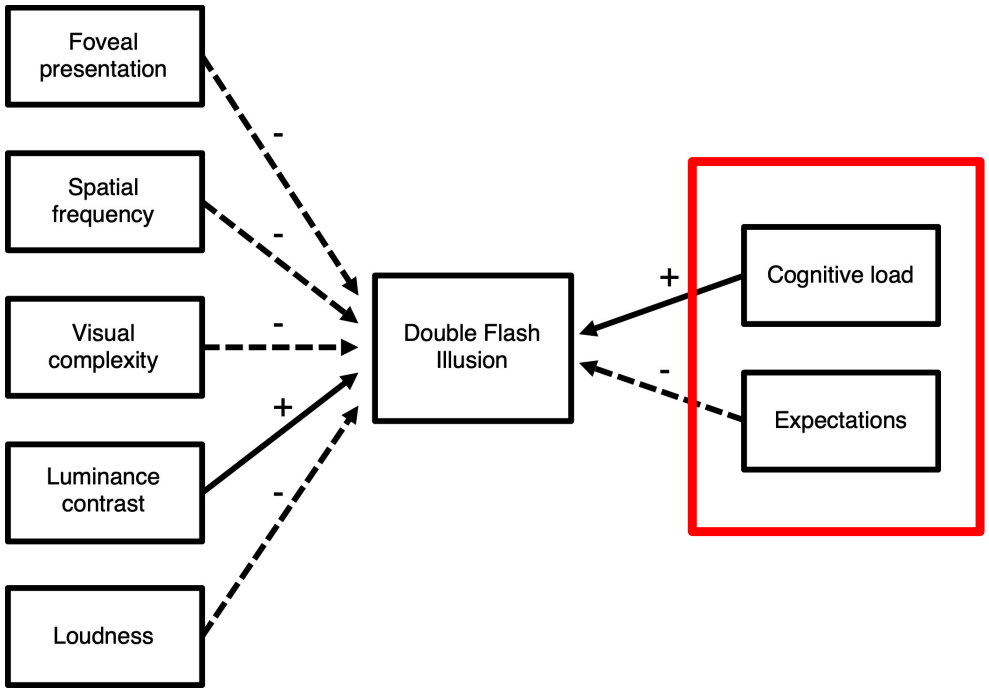
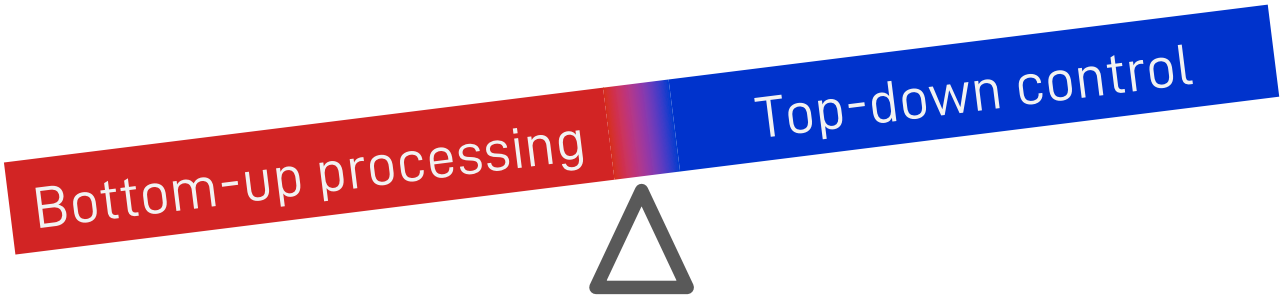
Stimulus properties Cognitive Influences



Modulate cognitive processes to change the brain state



Michail, 2021
Keil, 2020

Influence of Cognitive Load

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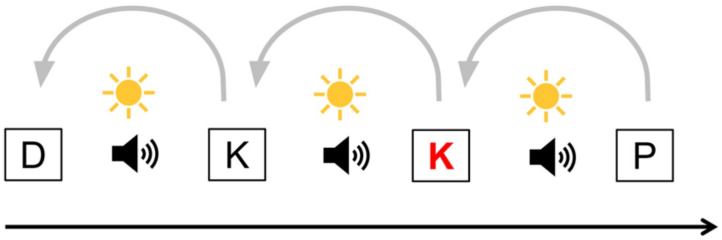

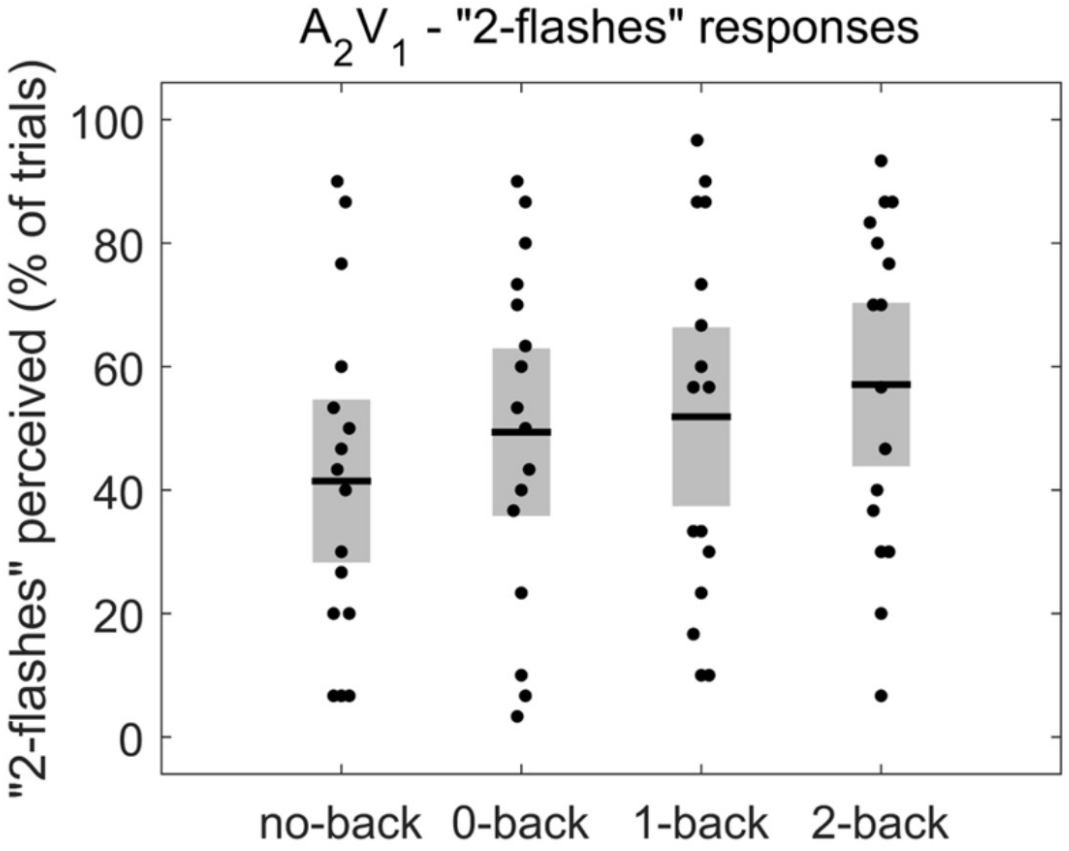

- N-back task increased cognitive load and depletes resources
- Cognitive load increases the SIFI

Michail & Keil, 2018

Neural Mechanisms of Cognitive Load

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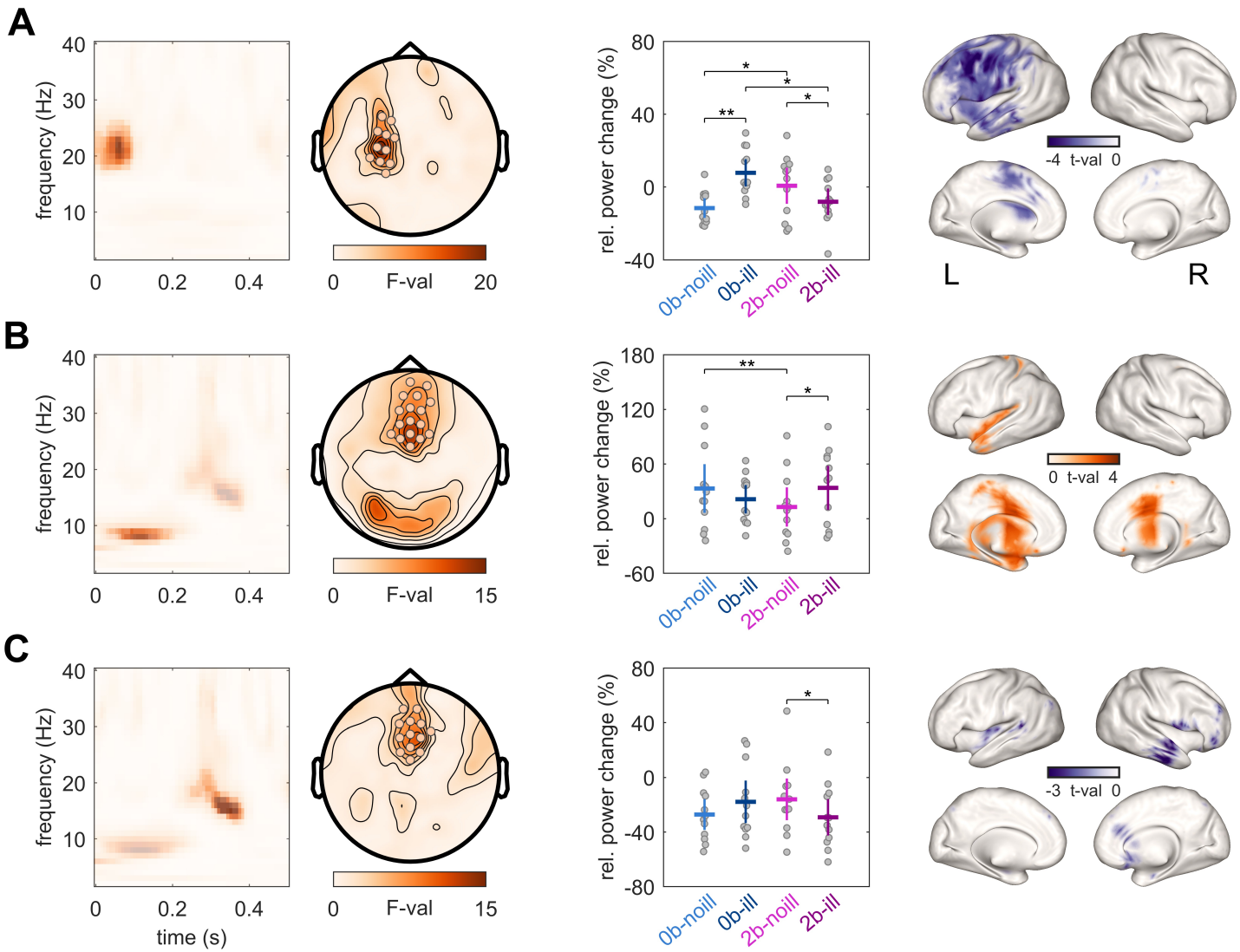
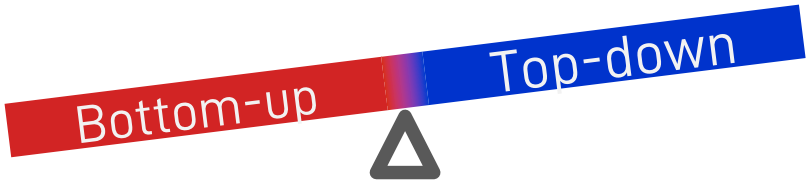
- Replication: Cognitive load increases the SIFI
- Theta and beta power reflect interaction between load and perception

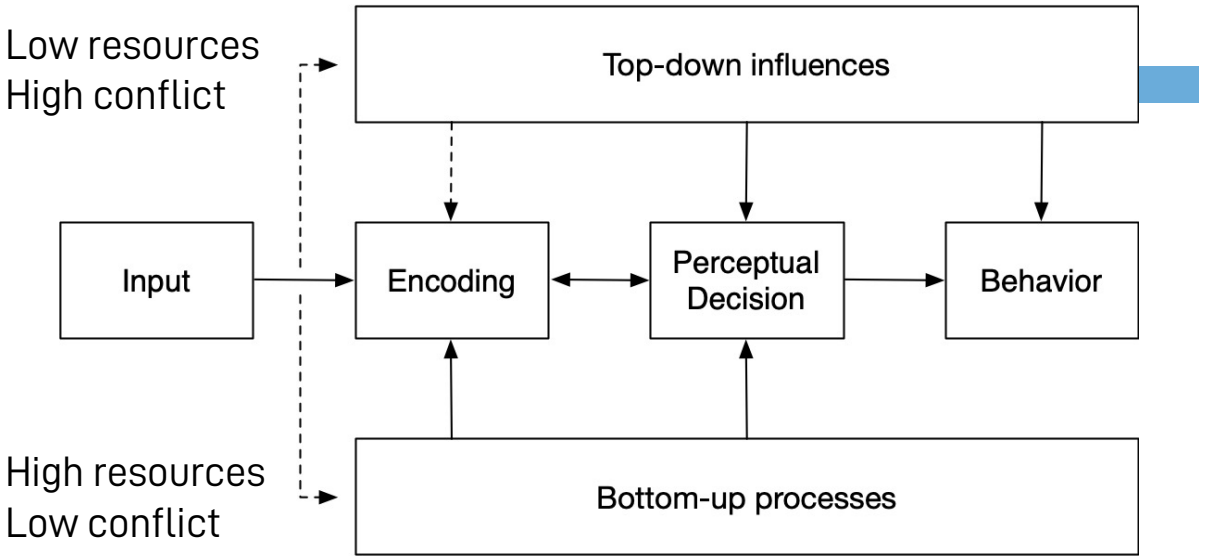


Michail & Keil, 2020

Summary 3

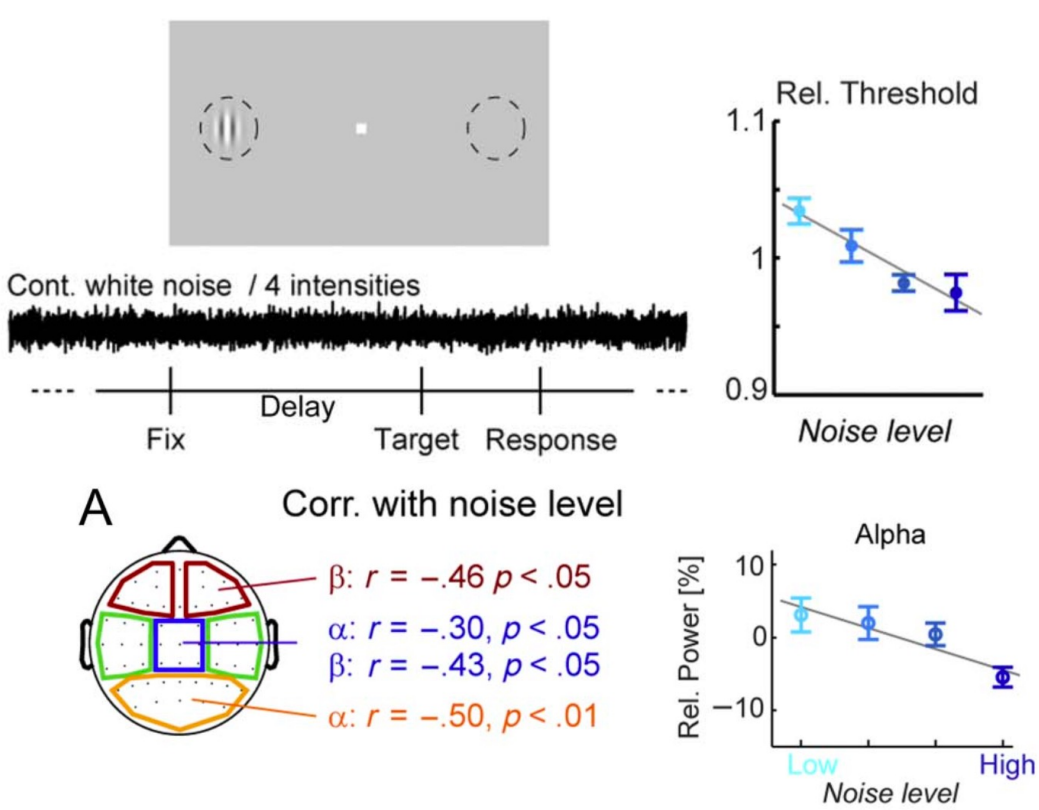
- Multisensory perception depends on the brain state
  - Depleting cognitive resources influences integration, but not initial processing
  - Cognitive load leads to increased demand of top-down resources to resolve intersensory conflict
- Next step: Directly modulate neural activity

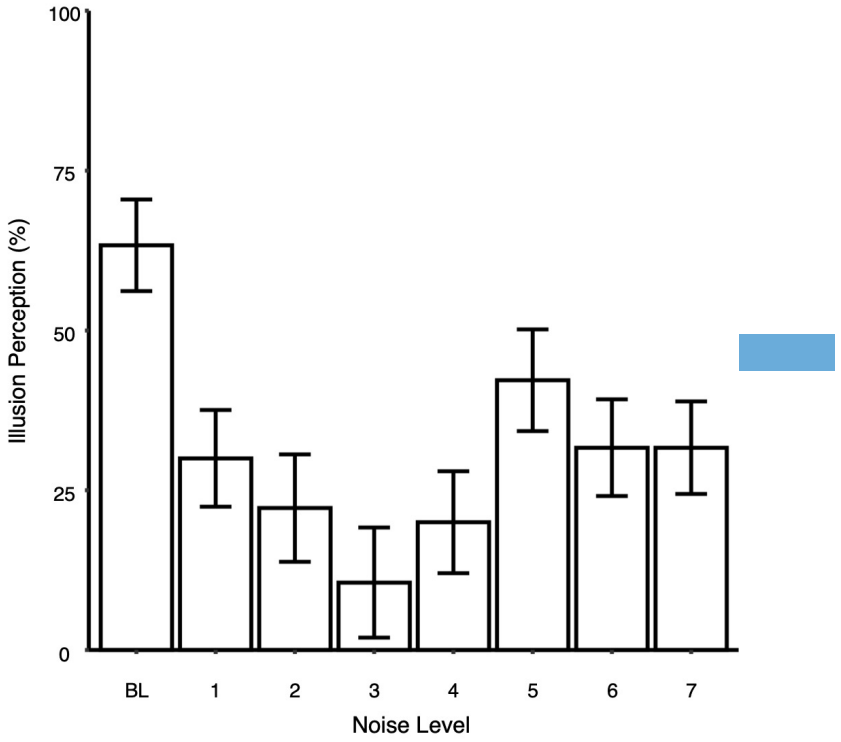




Idea: Stochastic Resonance

- Intermediate noise improves information transfer in complex systens (Moss et al., 2004)
  - What is the underlying mechanism?





Gleiss & Kayser, 2014; Keil et al., in prep.

Proposal: Interplay between excitability, arousal, and cognitive control

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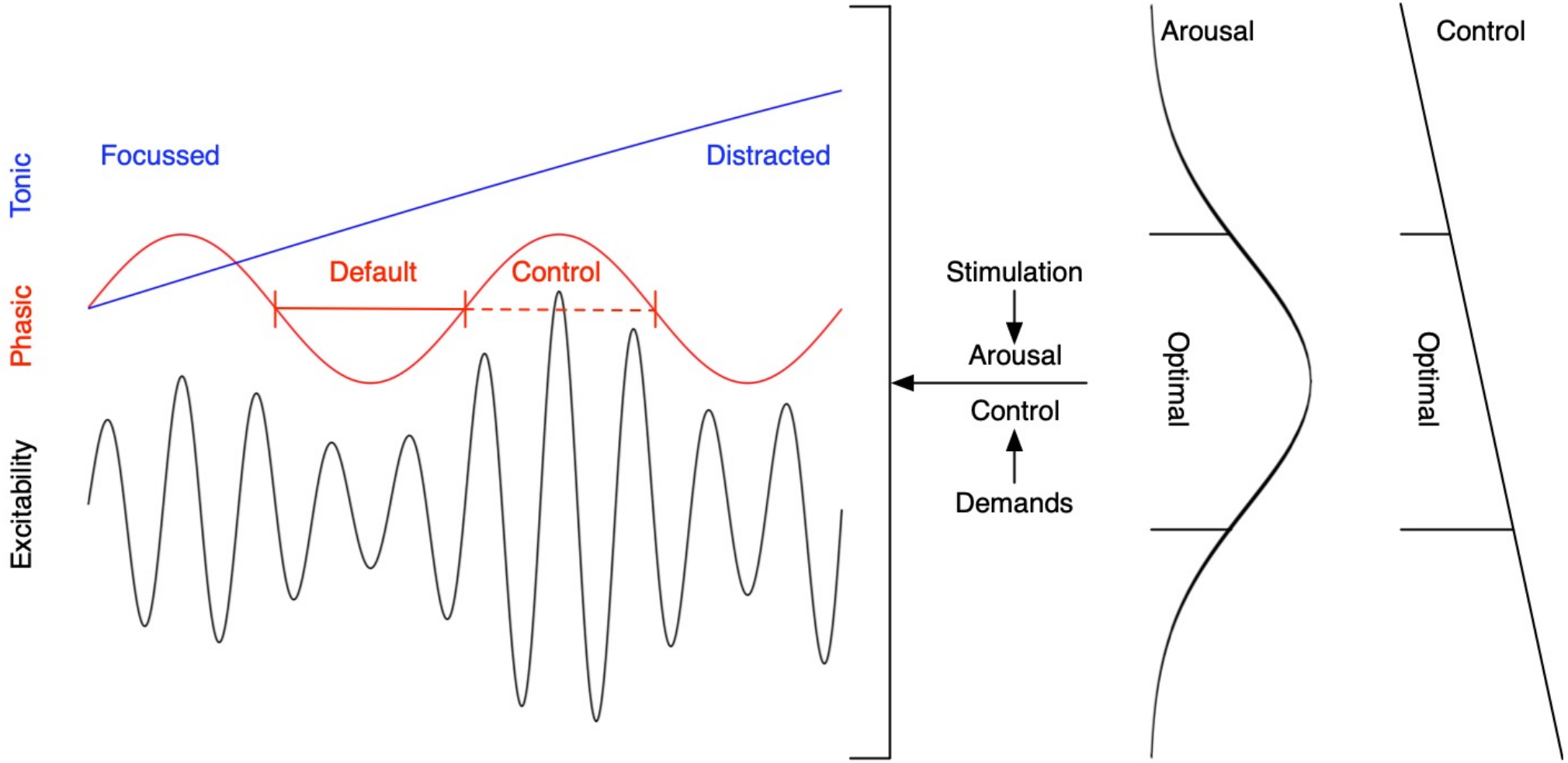

Thank you!

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Joshua Lorenzen, Merle Schuckart and
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Dr. Mathis Kaiser, Dr. James Moran,
Dr. Georgios Michail

Deutsche Forschungsgemeinschaft

KE1828/2-1 (2014-2016)
KE1828/4-1 (2016-2021)
KE1828/5-1 (?)

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