Hearing voices then seeing lips: disunity of subjective timing

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Introduction

Due to physical and neural delays, the sight and sound of speech causes a cachophony of asynchronous events in the brain. How can we still perceive voice and lipmovements as simultaneous?

Our converging evidence suggests that actually, we do not:

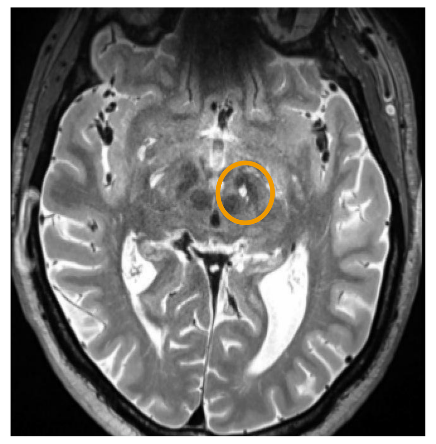
1) Case study: *dissociation* between subjective timing for two different *concurrent* tasks: Temporal order judgement and McGurk effect

2) Individual differences in neurotypical participants: *anti-correlation* of subjective timings for the above *concurrent* tasks

1) Case study

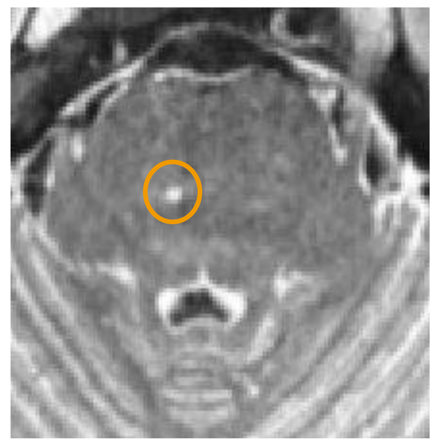
- Patient PH: male, retired pilot, 67 at time of testing. midbrain and auditory brainstem lesions. In 2008 began to experience voices leading lip-movements. Otherwise high-functioning, by neuropsychological assessment.

Subthalamic nucleus



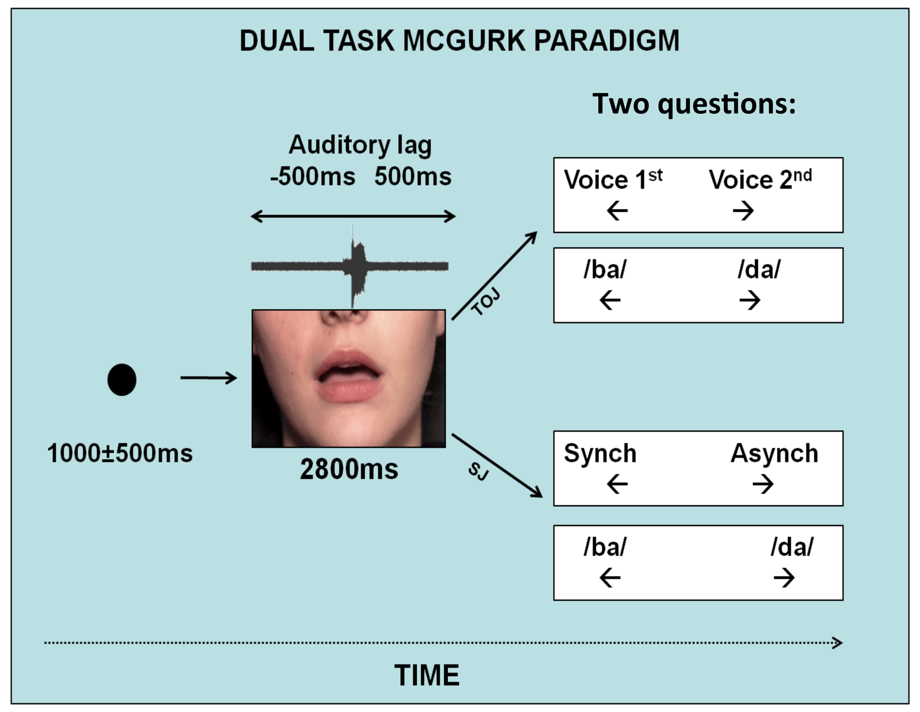
- High-resolution MRI: two small lesions
  - anterior-medial tip of the left sub-thalamic nucleus
  - Right dorso-medial pontine nucleus
  - Both regions may play a role in timing, audition or crossmodal interactions [1-3]

Pontine nucleus



Method

- Stimuli: typical McGurk stimuli [4]:
  - Congruent and incongruent combinations: movie of lip-movements [ba], [ga] paired with audio /ba/, /da/.
- Variable auditory lag:
  - 9 levels, range ±500ms, randomised.
- Dual task:
  - Timing judgement and phoneme identification
- Timing judgements, two types:
  - Temporal Order Judgement (TOJ) or Simultaneity Judgement (SJ). Blocked, counterbalanced
- Dependent measures:
  - TOJ & SJ → Point of Subjective Simultaneity (PSS)
  - Phoneme judgements → Optimal timing for McGurk effect (tMcG)



Comparison of PH with controls

a) Timing Judgment:

- Temporal order judgment (TOJ) :
  - PH: ~200ms auditory lead (auditory lag required for subjective synchrony)
  - Healthy: ~Veridical
- Simultaneity Judgments (SJ):
  - PH: 44ms auditory lag
  - Healthy: slight auditory lead

b) McGurk:

- PH requires opposite visual lag for maximal McGurk, consistent with pathological auditory slowing.
- PH outside all healthy 95%CI's

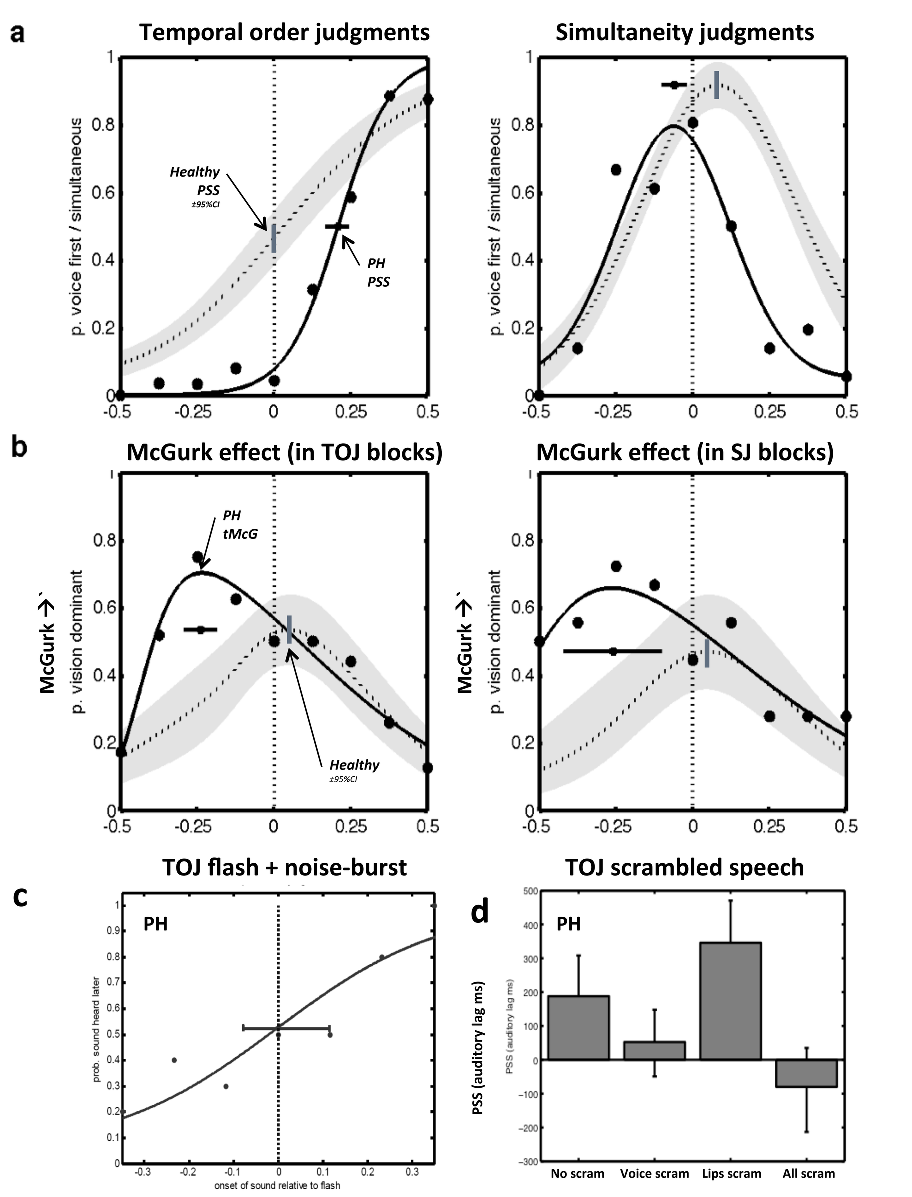
Timing discrepancy (PSS - tMcG):

- PH sig. > healthy older controls [Crawford t(5)=2.24, p<0.05, one-tailed].

c) Specific to speech (TOJ veridical for flash and noise bursts)

d) TOJ: auditory lag eliminated with fourier-phase-scrambled lips

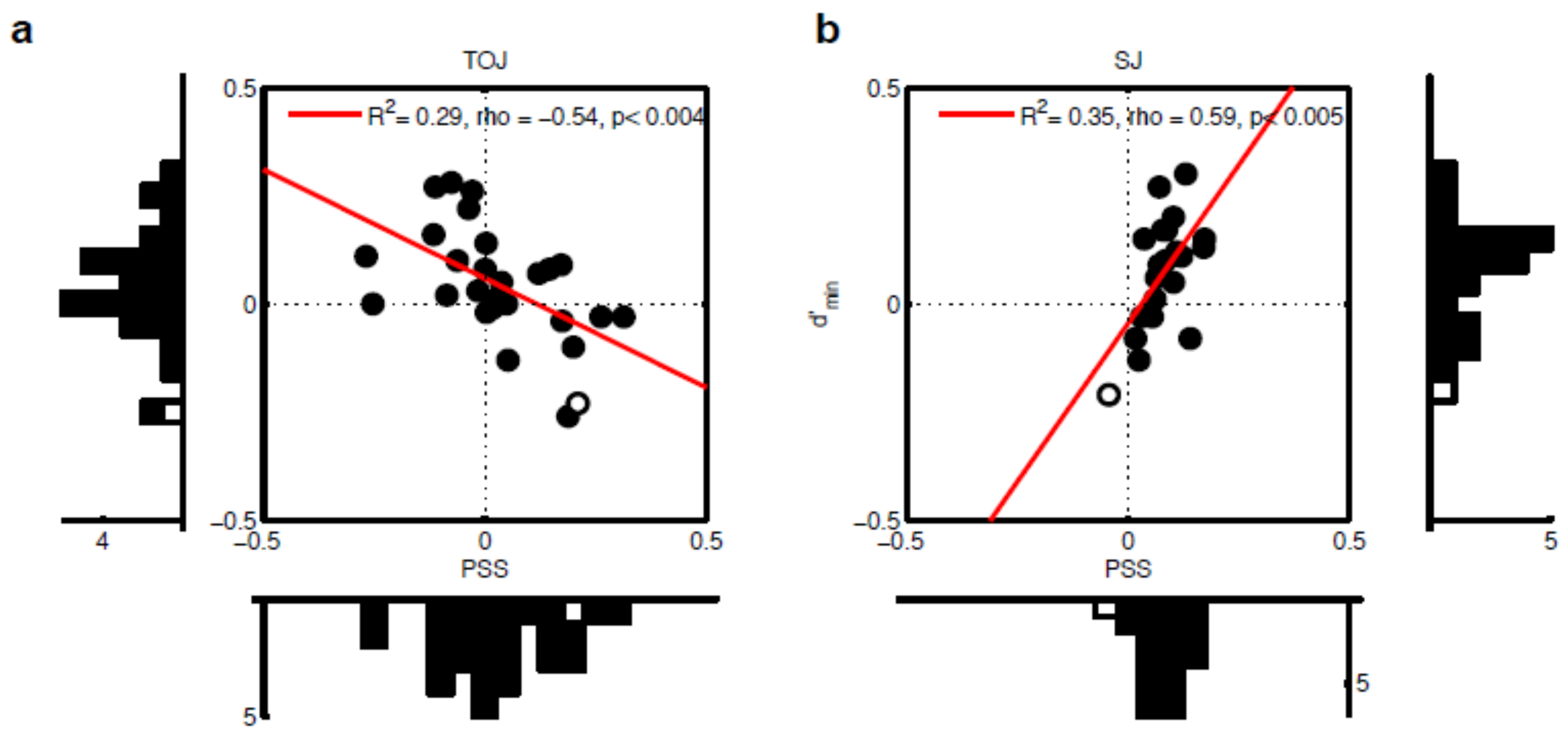
Plots compare PH with healthy adults (21 young, Mean 25yr + 6 older mean 56yr)



Summary:

Lesion reveals dissociation: auditory slowing (consistent with pathology) in McGurk, versus opposite auditory speeding for TOJ

2) Individual differences



Black symbols: healthy (young and older); White: PH

a) TOJ sessions: Negative correlation. TOJ probes distinct mechanisms

b) SJ sessions: Positive correlation. Perceived simultaneity may depend on quality of integration

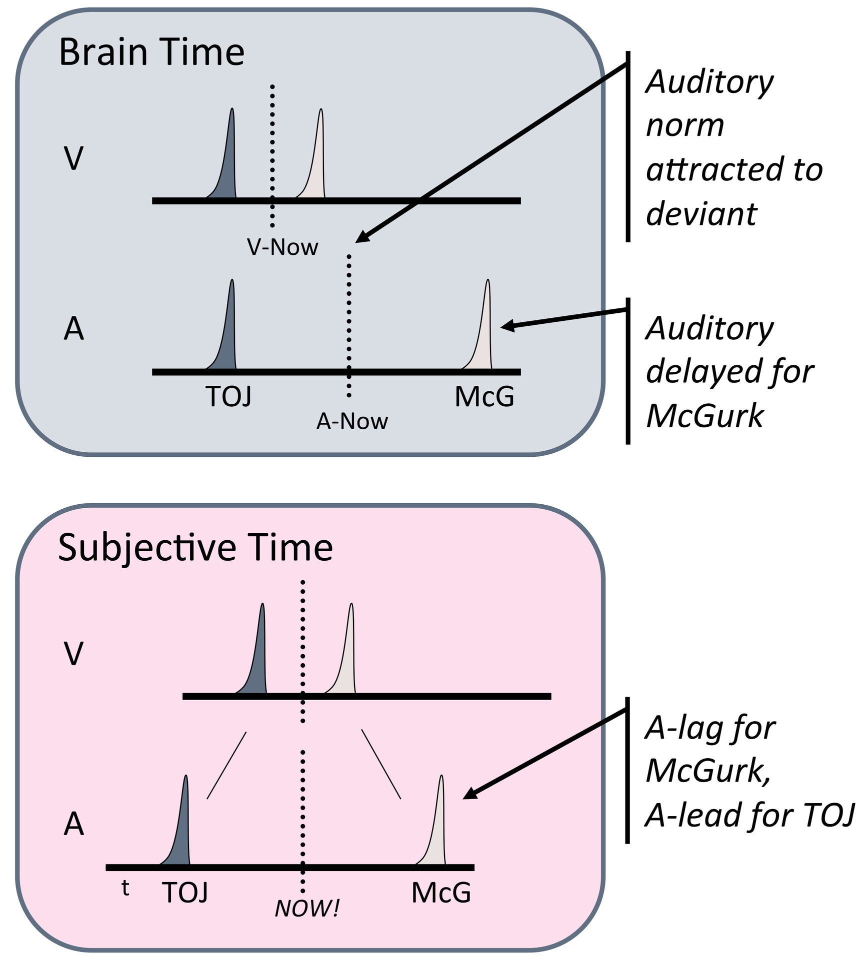
A challenge for existing theories

Theory	Prediction
✗ Unity assumption [5]	
✗ Unified timing [6-7]	association and +ve correlation
✗ Temporal recalibration [8-9]	
✗ Independent local timing [10-12]	dissociation and null correlation
✓ *Temporal renormalisation theory?*	*Dissociation and –ve correlation*

Proposed Temporal Renormalisation theory

- Different tasks subject to different delays
  - e.g. McG and TOJ tasks
- Modalities synchronised to their unimodal norms
  - Norm represents best guess at 'when was now'

→ apparent repulsion of timings for different tasks:
  - If one signal is delayed, others will seem to be speeded, relative to the norm



Conclusions

- Subjective timing depends on discrete mechanisms subject to their own neural delays
- There is no apparent unity of subjective timing: We can *concurrently* experience the same external events as happening at different times.
- We cannot correct delays, though we can compensate for them
- Via renormalisation, senses are synchronised *on average*

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