Leading or Lagging: Temporal prediction errors are expressed in auditory and visual cortices

MAX-PLANCK-GESELLSCHAFT

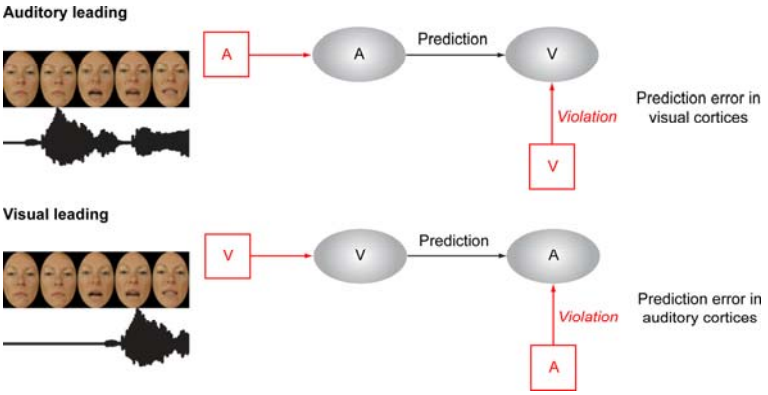
Hwee Ling Lee & Uta Noppeney
Max Planck Institute for Biological Cybernetics, Tübingen
hwee-ling.lee@tuebingen.mpg.de

Max-Planck-Institut für biologische Kybernetik
Cognitive NeuroImaging

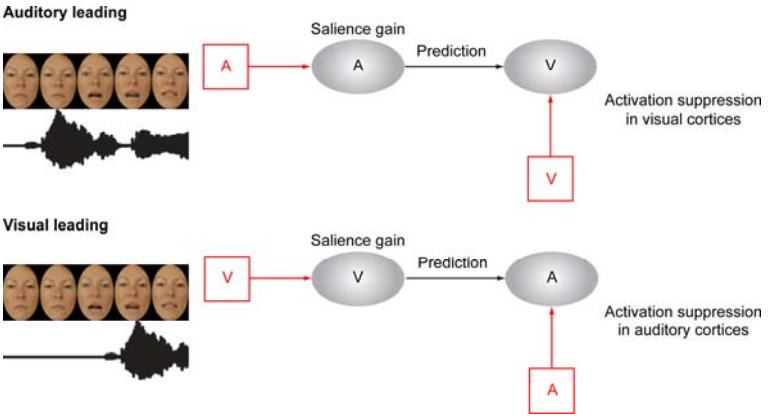
Introduction

We used audiovisual asynchrony manipulations to arbitrate between the following two hypotheses:

Predictive coding [1, 2]: reducing error between the brain's predictions of its multisensory environment and the actual sensory inputs. An audiovisual temporal misalignment that violates the natural statistical regularities should induce a prediction error signal. For visual leading asynchrony, we would expect a prediction error signal in the auditory cortex, and vice versa.



Biased competition [3]: temporally misaligned auditory and visual signals should compete for processing resources. For visual leading asynchrony, we would expect an increased BOLD signal in the visual system indexing the higher salience of the leading visual signal which then suppresses the temporally incompatible auditory signal, and vice versa.



fMRI Results

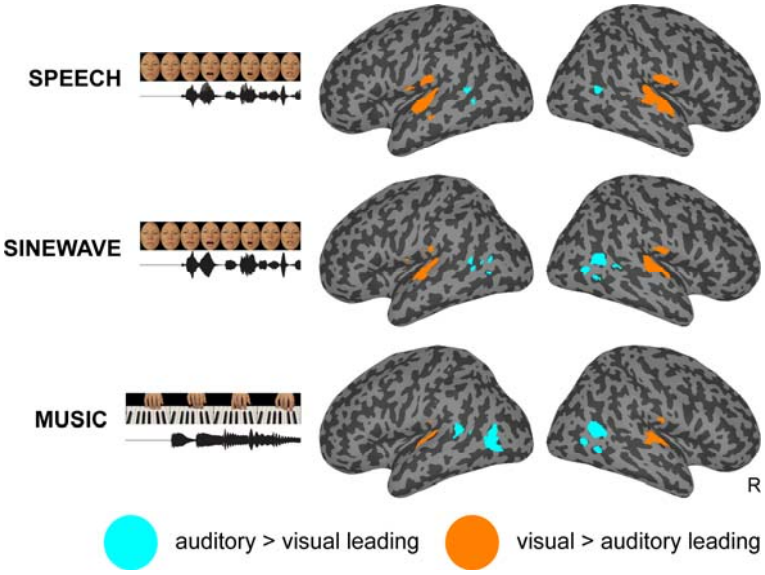


Figure caption: Activation showing auditory > visual leading (cyan) and visual > auditory leading (orange) for speech, sinewave speech and music rendered on a flattened brain .

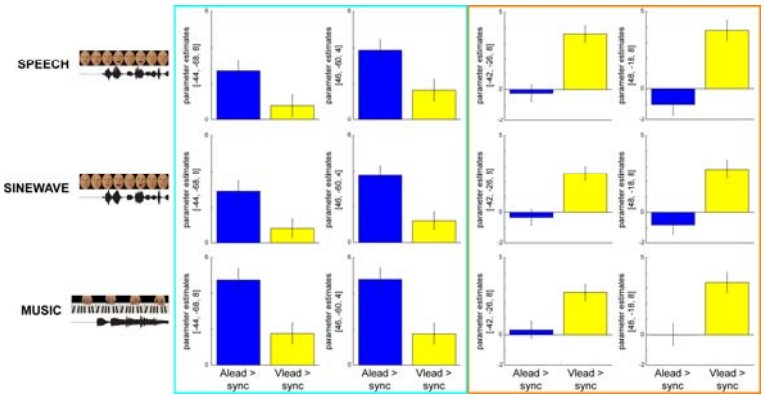


Figure caption: Parameter estimates (in arbitrary units) bar plots showing auditory leading > synchronous (blue) and visual leading > synchronous (yellow) for left (1st column) and right (2nd column) V5 / hMT+, and left (3rd column) and right (4th column) Heschl's gyri.

Experimental Design & Data Analyses

- 37 subjects participated in the fMRI study.
- A 3-by-3 factorial design manipulating stimulus class (speech, sinewave speech and music) and temporal synchrony (synchronous (0 ms), auditory leading (-240 ms) and visual leading (+240 ms)).
- Random effects analyses, 2nd level ANOVA, $p<0.05$ corrected at cluster level within the asynchrony system (auditory + visual leading > synchronous for speech + sinewave speech + music).

Summary

- We observed increased activation for auditory relative to visual leading conditions in bilateral V5 / hMT+.
- We observed increased activation for visual relative to auditory leading conditions in bilateral Heschl's gyri.
- Our results show support to the predictive coding hypothesis.

References

1. Friston, K. (2010). The free-energy principle: a unified brain theory? Nature Review Neuroscience, 11(2): 127-138.
2. Rao, R.P. and D.H. Ballard (1999). Predictive coding in the visual cortex: a functional interpretation of some extra-classical receptive-field effects. Nature Neuroscience, 2(1): 79-87.
3. Desimone, R. and J. Duncan (1995). Neural mechanisms of selective visual attention. Annual Reviews Neuroscience, 18: 193-222.