Proposition de Master Recherche

"Using Hidden Markov Models to understand changes in visual attention to talking faces across the lifespan"

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General aim:

This project aims to use Hidden Markov Models (HMMs) to analyze data from a body of eye-tracking studies on selective attention to talking faces. The objective is to reveal the distinct attentional strategies employed by infants, children and adults when exploring a talking face under diverse linguistic conditions. This project will require the master's student to:

- Become knowledgeable in the theoretical field of selective attention, face perception and audiovisual speech perception from a developmental point of view (e.g., Birulés, Bosch, Pons, & Lewkowicz, 2020; Frank, Amso, & Johnson, 2014; Lewkowicz & Hansen-Tift, 2012).
- Learn to process eye-tracking data (in Matlab, R, etc.), and to use A. Coutrot's SMAC Matlab package for HMM-based analysis (Coutrot, Hsiao, & Chan, 2018), package available at: http://antoinecoutrot.magix.net/public/code.html
- Interpret, integrate and discuss the results with the theoretical background in a final master's thesis.

Practical information:

Candidates can either come from a data science or computer science background, or a cognitive science background, or an experimental psychology background, provided they have strong skills in visual and image processing, and data analysis. Prior knowledge about probabilistic models such as HMMs is a plus. Proficiency in written and spoken English is required. The 5-month internship will be funded at the usual rate.

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Theoretical context:

A talker's face provides a great deal of information; The eyes can help identify the talker and through its movements we can infer states of mind, attitudes, and potential intentions. On the other hand, looking at the mouth provides spatiotemporally and acoustically congruent auditory and visual speech cues that enhance the saliency of the speech signal. Exploring the distinct attentional strategies that infants, children and adults employ when perceiving audiovisual speech allows us to understand what information they are favoring at any given moment, and therefore it provides a window into the cognitive mechanisms that underlie the audiovisual processing of faces and language.

Prior research on the topic has mainly recorded and analyzed perceivers' eye gaze data to talking faces by computing proportions of total looking times (PTLT) to two a priori defined areas of interest (AOIs), respectively around the eyes and mouth of talking faces. It remains to be explored whether more fine-grained analyses – both spatial and temporal, beyond average looking time differences – could help better characterize visual exploration strategies at different stages of development.

The current project aims to explore this question by reanalyzing a large dataset of audiovisual speech perception studies – from 4-month-old infants to children and adults' data (Birulés, Bosch, Brieke, Pons, & Lewkowicz, 2018; Birulés et al., 2020; Fort, Ayneto-Gimeno, Escrichs, & Sebastián-Gallés, 2018; Pons, Bosch, & Lewkowicz, 2015) – using Hidden Markov Models (HMMs, example in Figure 1). This method is data-driven and is able to encode not only spatial but also temporal aspects of data, therefore providing a more complete description of the attentional patterns in perceivers' eye gaze. In this way, we aim to provide a more detailed and comprehensive explanation of the different exploratory strategies employed to process audiovisual speech at different stages of development and under different linguistic conditions.

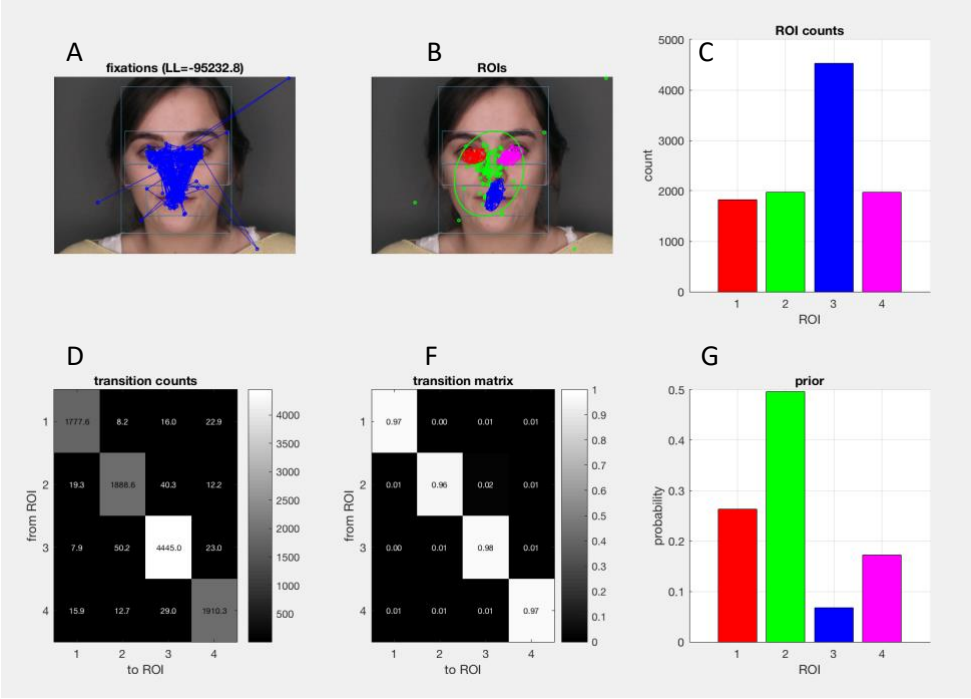

Figure 1. Example of a 4-state group-HMM output. The figure shows A) fixation locations, B) ROIs extracted by the HMM, C) fixation counts in each ROI, D) transitions counts between different ROIs, E) transitions probabilities between different ROIs G) and the prior distribution over ROIs. This example illustrates that the HMM-based analysis complements the classical eyes and mouth states with a new "rest of the face" state (in a 4-state HMM analysis).

Reference List:

Birulés, J., Bosch, L., Brieke, R., Pons, F., & Lewkowicz, D. J. (2018). Inside bilingualism: Language background modulates selective attention to a talker's mouth. *Developmental Science*, *22*(3), 1–11. https://doi.org/10.1111/desc.12755

Birulés, J., Bosch, L., Pons, F., & Lewkowicz, D. J. (2020). Highly proficient L2 speakers still need to attend to a talker's mouth when processing L2 speech. *Language, Cognition and Neuroscience*, *35*(10), 1314–1325. https://doi.org/https://doi.org/10.1080/23273798.2020.1762905

Coutrot, A., Hsiao, J. H., & Chan, A. B. (2018). Scanpath modeling and classification with hidden Markov models. *Behavior Research Methods*, *50*(1), 362–379. https://doi.org/10.3758/s13428-017-0876-8

Fort, M., Ayneto-Gimeno, A., Escrichs, A., & Sebastián-Gallés, N. (2018). Impact of Bilingualism on Infants' Ability to Learn From Talking and Nontalking Faces. *Language Learning*, *68*, 31–57. https://doi.org/10.1111/lang.12273

Frank, M. C., Amso, D., & Johnson, S. P. (2014). Visual search and attention to faces during early infancy. *Journal of Experimental Child Psychology*, *118*(1), 13–26. https://doi.org/10.1016/j.jecp.2013.08.012

Lewkowicz, D. J., & Hansen-Tift, A. M. (2012). Infants deploy selective attention to the mouth of a talking face when learning speech. *PNAS 109*(5), 1431–1436. https://doi.org/10.1073/pnas.1114783109

Pons, F., Bosch, L., & Lewkowicz, D. J. (2015). Bilingualism Modulates Infants' Selective Attention to the Mouth of a Talking Face. *Psychological Science*, *26*(4), 490–498. https://doi.org/10.1177/0956797614568320