Ph.D. Position in cognitive neuroscience :

NEUROIMAGING STUDY OF ADAPTATION AND DECISION-MAKING PROCESSES IN PEOPLE WHO STUTTER

Application deadline : 23/05/2025. Starting date : 1/10/205

Abstract

Stuttering is a speech fluency disorder that affects approximately 3% of the population and typically appears between the ages of 3 and 6 (a neurodevelopmental disorder; Monfrais-Pfauwadel, 2014). While current research agrees that it is a neuromotor disorder (Civier et al., 2013; Max et al., 2004a), its exact etiology remains poorly understood. Better understanding of this disorder and its causes is crucial to improve diagnosis and treatment, and to limit its impact on the development and lives of people who stutter.

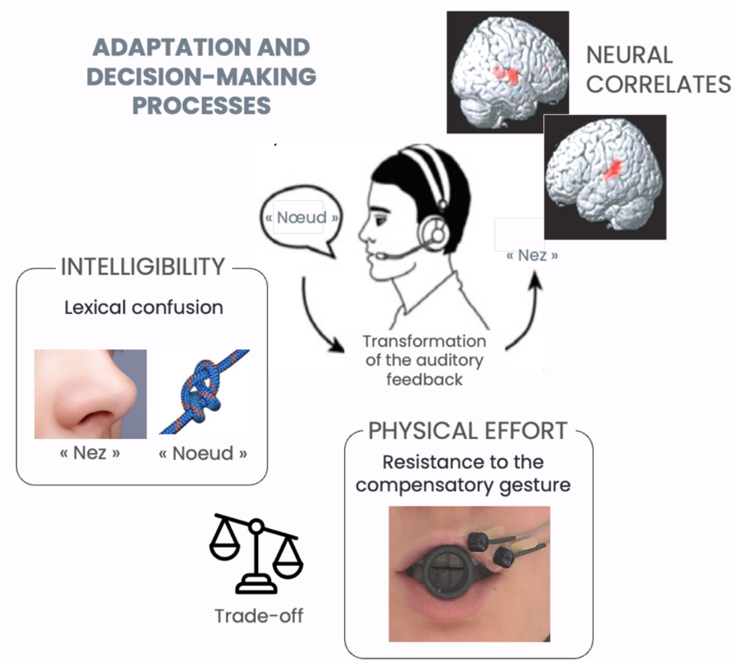
Among the various avenues explored, several studies suggest that stuttering results from – or is at least accompanied by – reduced sensorimotor adaptation abilities (Cai et al., 2012, 2014; Daliri et al., 2018; Daliri & Max, 2018; Kim et al., 2020; Loucks et al., 2012; Sengupta et al., 2016).

In line with this body of research, our project aims to test the hypothesis that speech adaptation to an altered auditory feedback involves a decision-making process based on a trade-off between two factors: on the one hand, the level of speech clarity deemed necessary or acceptable depending on the situation, and on the other hand, the level of effort required and perceived to compensate for the perturbation. We propose that the reduced adaptation observed in people who stutter may reflect a different compromise between effort and intelligibility, possibly due to an overestimation of the perceived effort, compared to typical speakers.

To test this hypothesis, we will conduct a neuroimaging study with two groups of adults (typical speakers vs. people who stutter). Participants will perform a speech production task with altered auditory feedback of their own voice. Two factors will be manipulated: (1) the level of speech clarity required by the situation (words that are either easily or highly confusable), and (2) the effort associated with the compensatory gesture (via mild resistance applied to the lips). Brain activity will be measured using functional MRI. We will compare the two groups in terms of compensation degree and involvement of brain networks associated with decision-making in the effort–intelligibility trade-off.

Keywords

Sensorimotor adaptation of speech, Decision-making, Stuttering, Motor control.



Context and objectives
Stuttering is a speech fluency disorder, most often neurodevelopmental (emerging between ages 3 and 6), affecting approximately 3% of the population, with higher prevalence in males and known genetic predispositions (SheikhBahaei, Millwater, and Maguire 2023). It is characterized by blocks, prolongations, or repetitions of sounds or speech segments (Mackay and Macdonald 1984), and physiologically, by atypical speech movements (Hutchinson and Navarre 1977; McClean, Goldsmith, and Cerf 1984) and increased muscular effort (Freeman and Ushijima 1978). The etiology of stuttering remains poorly understood and appears to be multifactorial. However, recent scientific studies agree that it is a persistent disorder of neuromotor origin (Civier et al. 2013; Max et al. 2004a), whose manifestation and severity are modulated by psychological and situational factors (Monfrais-Pfauwadel 2014).
Among the various neuromotor deficits identified—whether causes or consequences of stuttering—several authors have highlighted a sensorimotor deficit (Max et al. 2004b; Van Lieshout, Hulstijn, and Peters 1996): people who stutter (PWS) show reduced adaptation to auditory feedback perturbations (e.g., delayed auditory feedback; shifts in pitch or formants) or to sudden articulatory perturbations, both in terms of the degree of adaptation (Daliri et al. 2018; Daliri and Max 2018; Kim et al. 2020; Sengupta et al. 2016; Cai et al. 2012; 2014) and the speed of adaptation (Loucks, Chon, and Han 2012; Caruso, Gracco, and Abbs 1987; Sares et al. 2018). In contrast, certain auditory perturbations can significantly improve fluency in people who stutter (Kalinowski et al. 1993; Lincoln, Packman, and Onslow 2006; Stuart, Kalinowski, and Rastatter 1997). It remains to be better understood at which level(s) of these sensorimotor processes dysfunctions might occur.
Early studies explored the hypothesis that people who stutter have deficits in the auditory modality (Braun et al. 1997; Fox et al. 1996; Daliri and Max 2015a, 2015b; Mock, Foundas, and Golob 2015; Fox et al. 2000), in the somatosensory modality (De Nil and Abbs 1991; Loucks and De Nil 2006; Loucks and De Nil 2001), or in sensory integration (Falk, Müller, and Dalla Bella 2015; Aschersleben 2002). Other authors have suggested that people who stutter have difficulties in movement execution and control (Van Lieshout, Hulstijn, and Peters 1996; Namasivayam and Van Lieshout 2011), possibly due to internal models that are imprecise, unstable, or insufficiently activated (Max et al. 2004a), which prevent them from accurately predicting the sensory consequences of their motor commands and/or from effectively correcting them when errors are detected.

Our project aims to explore the hypothesis that the degree of speech adaptation to an altered auditory feedback results from a trade-off (decision-making process) between, on the one hand, the level of speech clarity considered necessary or acceptable in a given situation, and on the other hand, the level of effort required and perceived to compensate for the perturbation. Furthermore, we propose that the reduced adaptation observed in people who stutter reflects a different compromise between effort and intelligibility, particularly due to an overestimation of perceived effort compared to typical speakers.
To test this hypothesis, we aim to examine :
- In typical individuals, how the degree of compensation to an audio-motor perturbation of speech is influenced by (1) the level of speech clarity required by the communicative situation, and (2) the level of effort required to produce the compensatory gesture.
- Which brain regions and networks are involved in the perception of audio-motor perturbations, the sensation of speech effort, and the implementation of adaptive strategies reflecting a compromise between effort and intelligibility.
- In people who stutter, how increased effort perception may lead to lower levels of compensation compared to typical speakers.
- How brain activity in regions involved in sensory perturbation detection, effort perception, and decision-making processes may differ in people who stutter.

Method
The study will be based on a real-time altered auditory feedback speech adaptation paradigm, which has been widely used in previous studies on sensorimotor learning in speech production (see Caudrelier and Rochet-Capellan (2019) for a literature review). In this procedure, participants produce aloud words corresponding to pictures displayed on a computer screen. Their speech signal, modified in real time, is fed back to them through headphones.
Using this same paradigm, neuroimaging studies have identified various brain regions showing increased activity during speech production with altered auditory feedback, notably in temporal areas (Tourville, Reilly, and Guenther 2008), but also in motor areas, ranging from prefrontal and premotor regions (Toyomura et al. 2007) to supplementary and primary motor cortices (Zarate and Zatorre 2008). Functional magnetic resonance imaging (fMRI) offers the spatial resolution required to detect activity within these cortical areas.

The goal of our study is to extend these investigations by exploring:

1- How adaptation mechanisms are influenced by the communicative situation and the level of speech clarity it requires (by comparing the production of words that are either highly or minimally confusable), as well as by the effort associated with the compensatory gesture (by impeding compensation through a mild resistance applied to the lips).

2- How these mechanisms differ in people who stutter compared to typical speakers without speech disorders.

To do so, we propose using compressible plastic tubes inserted between the lips, such that the lip rounding movement required to produce the vowel [ø] (as in *nœud*) demands greater muscular effort. Previous studies have used similar "labial tubes"—though non-compressible—to induce articulatory perturbations in speech in adults (Savariaux et al. 1995, 1999), children (Menard, Perrier, and Aubin 2013), and specific populations such as the hearing-impaired or blind (Ménard et al. 2016; Turgeon et al. 2015).

Expected results

This work aims to contribute both fundamental knowledge—on how sensorimotor speech adaptation mechanisms can be understood as decision-making processes involving a trade-off between effort and intelligibility—and more specific insights to better understand the etiology of stuttering, particularly whether it may be linked, to some extent, to a distortion in the perception of effort during speech production, which could cause or accompany motor control difficulties.

Environment and supervision

The PhD candidate will be supervised by Maëva Garnier within the PCMD team at GIPSA-lab (http://www.gipsa-lab.grenoble-inp.fr/pcmd.php), as part of a project on speech adaptation mechanisms, in collaboration with Fabien Cignetti (GIN, Grenoble) and the IRMaGe platform (INSERM/CHUGA).

The protocol for the first fMRI experiment has already been established to obtain the necessary ethical approvals, allowing the work to start without delay. However, the PhD student will then be encouraged to show initiative and progressively gain autonomy in data analysis and the development of subsequent experiments.

We typically work with weekly progress meetings, complemented by closer interactions whenever needed.

Collaborations

- Collaboration with Fabien Cignetti, GIN
- Collaboration with the ENT Department of CHUGA (Prof. Ihab Atallah)
- Collaboration with speech-language pathologists in the Grenoble area

Application instructions

Details here : https://adum.fr/as/ed/voirproposition.pl?langue=&site=edisce&matricule_prop=65236

The application consists of a motivation letter, CV (with detailed list of courses related to speech or neuro-cognitive science), names and contact details of two references, and transcripts of grades from under-graduate and graduate programs.

Contact : Maëva Garnier
Email : maeva.garnier@gipsa-lab.fr
Phone : (+33) 4 76 57 50 61

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