
OUTLINE OF IMÉRA END-OF-RESIDENCY REPORT

YOUR RESEARCH

I held the Chaire Iméra/ILCB (Institute d'Études Avancées de l'Université d'Aix-Marseille et Institute of Language, Communication, and the Brain) during a seven-month residency between September 2022 and March 2023 for the purpose of carrying out the project entitled: *"Time to speak: investigation of speech movement timing in people who stutter"*. During this period, I interacted with very many researchers based at the ILCB and beyond. I attended the weekly Community Building Seminars at Iméra, the monthly Atelier Santé Mentale hosted by Dr Gabriella Crocco at Iméra, the monthly MRI meetings at the Centre Européen de Recherche en Imagerie Médicale (CERIMED) organised by Dr Marie-Hélène Grosbras, and the weekly lunchtime seminars at the ILCB. I was impressed by the highly diverse projects being undertaken by the scientists and artists who were also residents at Iméra and found the discussions at the Atelier Santé Mentale particularly stimulating. I had very many opportunities to discuss my project with researchers at the ILCB and in other parts of the university, which I describe below. In summary, my residency was a unique opportunity that resulted in a highly productive period of learning and collaboration. I am extremely grateful for the support I received from Iméra and ILCB that allowed me to spend such a formative and memorable time in Marseille among the community of scholars there. In particular, I thank Dr Enrico Donnagio, Dr Gabriella Crocco, and Dr Johannes Ziegler for their support. I was especially well supported on a day-to-day basis at the ILCB by Dr Marie-Hélène Grosbras and Dr Jennifer Coull who arranged many of the contacts for me with other members and helped me to navigate the academic world in Marseille. They also helped me to organise the workshop (see below) at the end of my residency. I would also like to extend my thanks to the other residents and staff at Iméra who made my stay there very smooth and enjoyable. Lastly, I thank all the researchers I met during my residency who continue to inspire me with their work.

There are several lines of research that are ongoing in my research group at the University of Oxford and I was able to present on each of them during my residency (see below for details). The focus of my research during the residency was on speech movement timing in the context of understanding developmental stuttering. Since returning to Oxford, the experiment that I wanted to discuss and develop during my residency has started and data collection is in progress. Furthermore, the contacts I made during my residency have continued and I will be returning to Marseille (i) in October 2023 for the Society for Neurobiology of Language conference, which is organised by members of the ILCB and (ii) in December to examine two PhD students (supervisors Belin & Runnqvist). I am confident that there will be further opportunities for future collaborations.

On the first day of my residency in September 2022, I gave a keynote talk at the Summer School organised for graduate students at the ILCB on my research of developmental stuttering. I was also able to attend other talks and one highlight was hearing Dr Johannes Ziegler's presentation on dyslexia, which is closely related to the disorders of language and speech that I study. I was introduced to many of the researchers working in Aix-Marseille Université that I wanted to meet. I had particularly useful discussions with Dr Serge Pinto from the Laboratoire de Parole et Langage based in Aix, which led to

an invitation to deliver a seminar there. Dr Pinto and I have very overlapping interests in speech motor control, and he has since advised me on eliciting and recording speech for clinical populations. I met with several graduate students to discuss their research projects during this meeting. It was an exciting and excellent introduction to the community of researchers based at the ILCB and elsewhere in Marseille all working on language and using cognitive neuroscience methods.

My presentation on stuttering and discussions of my project at the community building seminars and at the Atelier Santé Mentale provoked my thinking about stuttering in the context of traumatic experiences. It would be impossible to prove that trauma has caused children to stutter and the timing of the onset of stuttering at ages 2-3 when children start to produce connected speech is inconsistent with the idea that trauma is related to the acquisition of stuttering. Furthermore, there is strong evidence of a genetic component and causative variants in genes have been identified. Nevertheless, these discussions made me consider how the traumatic experience of stuttering during development could be important in the *persistence* of disfluencies that characterise stuttering. Anticipatory anxiety during speech production is well documented. But the potential trauma that comes from parental attitudes or negative experiences in public situations should be considered when looking at how stuttering is reinforced or learnt compared with recovery that occurs spontaneously in many individuals. The idea of acceptance and commitment therapy as a treatment should also be considered in this context. I therefore found these interactions with scholars outside of the narrow field of cognitive neuroscience of speech and language that I inhabit to be particularly fruitful. I cannot imagine another venue in which I would have gained this insight, so I am also grateful to colleagues for provoking these ideas.

My project proposal was highly related to the work of Dr Benjamin Morillon member of the ILCB based at the Institute of Neurosciences at La Timone. I was delighted to have the opportunity to meet with him several times during my stay and to visit the research group with Dr Daniele Schön and Dr Aurelie Bidet-Caulet. I spoke with the researchers, their graduate students, and attended a lab meeting. I was also able to facilitate a meeting between one of the researchers in this group and a colleague working on related projects in Oxford.

The project that I proposed uses magnetoencephalography (MEG) to provide information about neural processes at high temporal resolution. This is perfect for looking at speech perception but is more challenging in the context of speech production. My proposal was to use MEG to look at the internal timing of speech movements in people who stutter. Our aim is to investigate what happens in the brain immediately prior to speech movement execution and to compare these patterns of neural activity in people who stutter and fluent speaking control participants. MEG is the perfect modality for looking at these brain changes because it provides very precise timing information and is a silent imaging modality, which is important since background noise and rhythmic cueing can induce fluency in people who stutter (see below). We are planning to measure speech production and compare fluent and dysfluent utterances to see if we can detect differences in the neural processing that precedes each.

Since returning to Oxford, we have started our experiment and are using a novel method of eliciting dysfluencies in people who stutter by asking them to read pseudowords. These are words that obey the phonotactic rules of English, that is, they are legal sequences of speech sounds, but they do not have meaning in the language. By using two multisyllabic words that participants hold in mind for a period, we can look at motor preparation immediately before and after the cue they receive to produce these pseudowords in an unpredictable order. In previous work, this paradigm has elicited

stuttered speech about 50% of the time. Data collection is currently underway. My graduate student in Oxford who is working on this project, has completed a related behavioural project that she will present at the annual meeting of the Society for the Neurobiology of Language in Marseille in October 2023. This will be a future opportunity to share our data with the researchers in Marseille and gain their input into the project further. My graduate student is also very interested in pursuing a post-doctoral position in Marseille and the meeting will be an opportunity to introduce her to individuals who do highly related research.

As previously described, it is particularly striking to demonstrate that people who stutter can achieve complete fluency temporarily by changes in the ways they either hear their own speech or produce it. A striking feature of developmental stuttering is that complete fluency can be achieved by changing the way a person perceives his or her own speech. During my residency, I demonstrated to colleagues these dramatic effects achieved either by delaying auditory feedback of speech, altering its pitch, singing, speaking in unison with another speaker (choral reading), or speaking in time with a metronome. These temporary fluency enhancers suggest that the stuttering is caused by differences in how the brain predicts the sensory consequences of speech production or integrates ongoing sensory inputs to plan the motor outputs during speech. This work is very closely related to the work of Dr Schön in the domain of music cognition and ongoing work looking at rhythmic production to enhance perception that has been applied in the context of development and neurodevelopmental disorders e.g. dyslexia. It is also very similar to the effects demonstrated in patients with Parkinson's disease who show similar benefits for initiation of movements from external cues that can be auditory (marching rhythms) or visual (stripes on the floor, or stairs). I was able to discuss this with Dr Serge Pinto during my visit to Aix and the Laboratoire de Parole et Langage.

At the ILCB, I met with Dr Francois-Xavier Alario and Dr Marieke Longcamp and their students and collaborators to advise on analysis of their data obtained using transcranial magnetic stimulation during imagined or internal speech. I explained how to adjust the motor-evoked potential elicited by stimulation for background muscle contraction using linear regression. Their work is very closely related to work I have done using brain stimulation in a series of experiments of speech perception. I was invited to present this work at the Departmental Lunchtime seminar at the ILCB hosted by Dr Ruunqvist and Dr Benjamin Morillon. I attended related presentations from graduate students before my talk and had an opportunity to talk to students and faculty working on these topics or using these methods.

I presented my work informally at the lab meeting of Dr Pascal Belin, Bases neurales de la communication Team Leader at Institut de neurosciences de la Timone. We discussed the relationship between the structure of the motor cortex and the functional representation of the larynx in the human brain. I listened to presentations from graduate students about their related work on communication in marmosets, representation of voice in the human and nonhuman primate brains, and the exciting novel methods of analyses being developed. I will return in December 2023 to examine the thesis of one of the graduate students.

I was a keynote speaker at the Centre Européen de Recherche en Imagerie Médicale (CERIMED) annual MRI day meeting where I presented my research into the neural correlates of developmental language disorder. The one-day meeting involved poster presentations from graduate students and other early career researchers, where I enjoyed several interesting discussions. I attended the monthly seminars at CERIMED during which presentations about project proposals were made. I learnt about the

impressive breadth of brain imaging research supported at CERIMED and the state-of-the-art facilities and support for advanced methods of analysis.

During my residency, I learned that I had an interview for a grant from the Wellcome Trust for a large multicentre study using brain imaging and genetics to study children with developmental language disorder. I was fortunate to get input into my preparation for this interview and carry out practice interviews with several researchers in Marseille for which I was particularly grateful. Our previous work in the population has shown differences in the cerebellum in children with language learning difficulties. This work is highly related to the interests of Dr Elin Ruunqvist and we met several times to discuss it. Dr Ruunqvist has carried out a project highly related to one of my looking at language learning in the motor systems. I am hopeful that following further discussions we can develop a collaboration. During my visit in December 2023, I will also examine the thesis of one of her students on this topic.

I met with Dr Kristof Strijkers who has interests related to mine in terms of the role of the motor system in speech perception and also bilingualism. We discussed issues related to publications in our field and our roles as journal editors. This is another potential future collaboration that I would like to develop.

At Iméra, I had many fruitful discussions with Dr Shankar Raman about my project and he put me in contact with a retired linguist Dr Diana Lewis who had work previously in Oxford and then in Aix at the Laboratoire de Parole et Langage. We had much in common and continued to meet after Dr Raman had completed his residency. Since leaving Marseille, I have been in touch with Dr Frederic Jaëck about a highly related project he is involved in with children with language learning difficulties and I discussed the behavioural protocol with him and what the neuropsychological measures tell us. I learned a great deal about new methods in epidemiology from Dr Yulin Hswen and about the research of her partner in India, which is an area to which I hope to extent my research into developmental language disorders. I received invaluable advice on carry out such projects from them. I was also able to provide some coaching to Dr Hswen in the context of a work-related problem she was experiencing. I hope to maintain contacts with each of these researchers going forward.

To my great pleasure, I was able to complete my residency with a one-day workshop at Iméra to which many of the people mentioned above and several others not mentioned were invited. It was a memorable day and the highlight of my residency. My co-organisers Dr Marie-Hélène Grosbras and Dr Jennifer Coull work respectively on movement control and timing. This is very relevant to the study of stuttering and how we mentally represent time to coordinate and execute speech movements. We had talks from across the university from researchers at all levels. We were particularly keen that early career researchers had the opportunity to present their work in this forum also. The standard of the science presented was excellent and there was ample opportunity for subsequent discussion during and after the meeting. I met with several junior researchers to discuss and advise on career options. I learnt a great deal more about the high calibre of research being carried out at the ILCB and beyond. And the science provides a great context in which to think about several aspects of my research but most importantly was very informative for my projects. We received very positive feedback about the event from the attendees who noted how important it was to have the opportunities to hear about the work of local researchers, which spans many disciplines. It was a wonderful end to a remarkable stay in Marseille. I plan to implement much of what I have learnt into my ongoing research. I also hope to revisit, to continue and deepen collaborations with researchers who are based at the ILCB.

CONTACTS

- i. Contacts related to the project, *prior to the residency* (persons and laboratories or structures): within Aix-Marseille University and outside Aix-Marseille University;
Dr Marie-Helene Grosbras, Dr Pascal Belin, and Dr Benjamin Morillon
- ii. New contacts *made during the residency*: within Aix-Marseille University and outside Aix-Marseille University;
Dr Francois-Xavier Alario, Dr Aurelie Bidet-Caulet, Dr Jennifer Coull, Dr Serge Pinto, Dr Marieke Longcamp, Dr Elin Ruunqvist, Dr Daniele Schön, Dr Kristof Strijkers.
- iii. Iméra fellows with whom interactions were most intense.
Dr Yulin Hswen (Berkeley), Dr Shankar Raman (MIT), Dr Frederic Jaëck (AMU)

PARTICIPATION IN AND/OR ORGANIZATION OF SCIENTIFIC AND/OR ARTISTIC ACTIVITIES

- i. **Scientific/artistic activities organized by the resident and Iméra:**
→ Timing, Language, and Action Workshop/ Workshop/ 24 March 2023/ Masion Neuve, Iméra/ Dr J Coull and Dr M-H Grosbras (co-organisers) & other Members of ILCB (see below for details).
- ii. **Scientific/artistic activities organized by Iméra Program directors or other residents (including your presentations in CBS sessions):**
→ Community Building Seminar/ in-person/ "Time to Speak"/ 20 October 2022/ Iméra.
- iii. **Scientific/artistic activities outside Iméra during the fellowship, including contributions to seminars for Master students/PhD candidates:**
 - ⇒ Departmental Seminar to staff and students/ in-person/ "Imaging and stimulating the brain in people who stutter"/ 03 March 2023/ Laboratoire de Parole et Langage, Aix/ Aix-Marseille Université.
 - ⇒ Departmental Lunchtime Seminar/ in-person/ "Stimulating speech: auditory-motor interactions in production and perception"/ 03 February 2023/ Institute of Language, Communication and Brain/ Aix-Marseille Université.
 - ⇒ 13th annual scientific day of the Marseille INT-CERIMED MRI centre/ Keynote lecture in-person/ "Neural correlates of developmental disorders of speech and language"/ 14 October 2022/ CERIMED Campus Santé Timone, Marseille/ Institute de Neurosciences de la Timone, Centre.
 - ⇒ Institute of Language, Communication and Brain Summer School/ Keynote lecture in-person/ "Scanning and stimulating the stuttering brain"/ 01 September 2022/ Centre International de rencontres Mathématiques, Luminy/ Institute of Language, Communication and Brain, Aix-Marseille Université.
- iv. **Publications, publication projects, exhibitions or exhibition projects related to the residency:**

→ No publications at this point in time.

- v. **Activities of scientific mediation to the attention of the general public:**
→ Nothing planned.

ASSESSMENT OF THE RESIDENCE AND ITS MANAGEMENT

- i. Scientific/artistic and/or institutional opportunities opened by the residency;
I enjoyed the opportunity to meet scholars and artists across a very wide range of fields and develop meaningful relationships with them. I built friendships with the other residents that I believe will endure. I hope to meet with many of the individuals that I connected with during the residency in other places. I learnt from other residents about opportunities in other countries for me to explore also. I found it useful to hear about other projects when thinking about planning my own.
- ii. Difficulties encountered during the residency;
None.
- iii. Possible suggestions.
Keep the Community Building Seminars going throughout the term perhaps have fewer each week so there is longer to discuss each one.

29th August 2023

Date of report



Signature of the resident

See attached details of the Workshop

Timing, Language, and Action Workshop

Timing is essential for the smooth coordination of neural and motor processes involved in action execution. The brain's ability to time actions is related to the integration of information across sensory modalities and involves generation of predictive signals to anticipate future events. Timing ability is essential for successful performance of movements in music, and dance, and for speech production and perception. Intelligible speech requires precise timing of movements of the articulators. In addition, the perception of timing cues in speech provides important information about meaning in language comprehension. Understanding the role of timing in action and language production and perception can provide us with a better understanding of the brain processes involved, how the brain integrates information across sensory and motor domains and, ultimately, may inform interventions aimed at improving performance across a range of contexts and in disorders.

We are planning a workshop to discuss the role of timing in the guidance of actions generally and specifically in speech and language. The aim is to bring together researchers across the community who are tackling these topics with different research methods and in different groups of people. We are inviting short presentations from members of the ILCB on these topics and plan a wide-ranging discussion.

Program

9:00 – 9:30 *Arrival and coffee, Cafétéria de la Maison Neuve*

9:30 – 9:45 Kate Watkins, ILCB/Iméra Chair

Welcome and Introduction

9:45 – 10:15 Jenny Coull, Laboratoire des Neurosciences Cognitives, CNRS, AMU

Constructing a sense of time through action

10:15 – 10:45 Helene Wilquin, Laboratoire de Psychologie Clinique, de Psychopathologie et de Psychanalyse & Laboratoire des Neurosciences Cognitives, AMU

Motor timing in schizophrenia

10 :45 - 11 :15 Nicolas Meirhaeghe, Institut de Neurosciences de la Timone, AMU

Neural correlate of prior experience in timing behavior

11:15 - 11:45 *Coffee à la cafétéria de la Maison Neuve*

11:45 – 12:15 Benjamin Morillon, Institut de Neurosciences des Systèmes, INSERM, AMU

Neural dynamics of predictive timing and motor engagement in music listening

12:15 – 12:45 Elin Runnqvist, Laboratoire Parole et Langage, CNRS, AMU

Connecting movement and cognition through performance monitoring of hybrid actions

12:45 – 14:00 *Lunch à la cafétéria de la Maison Neuve*

14:00 – 14:30 Kristof Strijkers, Laboratoire Parole et Langage, CNRS, AMU

The spatiotemporal dynamics of language production vs perception

14:30 – 15:00 Isaih Mohamed, Institut de Neurosciences des Systèmes, AMU

Bridging verbal coordination and neural dynamics.

15:00 – 15:30 Margaux Le, Laboratoire des Neurosciences Cognitives & Centre PsyClé, AMU

Influence of rhythmic background on handwriting in children

15:30 – 16:00 *Coffee à la cafétéria de la Maison Neuve*

16:00 – 16:30 Gaelle Alhaddad, Laboratoire des Neurosciences Cognitives, AMU

Handwriting performance in Biscrptuals: The Role of Executive Functions and Fine Motor Skills

16:30 – 17:00 Adrien Meguerditchian, Laboratoire de Psychologie Cognitive, AMU

Language & action: what does research in nonhuman primates tell us?

17:00 – 18:00 *Wine & Cheese and Discussion*

Organisers

Jenny Coull

Marie-Helene Grosbras

Kate Watkins

Attendees

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Helene Wilquin helene.wilquin@univ-amu.fr

Short report

This was a very successful workshop. It brought together researchers from across the Aix-Marseille Université, from the ILCB, LPL (Aix) and INT (La Timone), to share their current research. Many of the researchers knew of each other but had not met in person so this was a nice opportunity to forge stronger links. The topic of Timing in Language and Action has relevance for several fields as demonstrated by the program. The science presented was cutting edge, interdisciplinary, and exciting. The standard of the presentations was very high. New ideas for collaborations were discussed as a result of this workshop, which is a strong indication of its success.