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Comm4CHILD

Fact Sheet 2023

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THE IMPORTANCE OF COMMUNICATION

The context we are born and grow up in plays a fundamental role in shaping our experience of the world. Each child, regardless of their level of hearing, is exposed to different languages, interactions and experiences that are influenced by a multitude of features. Children's language and general development are supported by early access to and opportunities for communication. For this reason, having access to communication is pivotal, especially during their early years. What accessible communication looks like, however, depends on the particular context and how individuals perceive the world. While hearing children, for instance, simultaneously process auditory and visual input, children with hearing loss mainly rely on the visual channel to perceive both their environment and linguistic information (Lieberman et al., 2014). Fully inclusive support for early language and communication must therefore account for different language development contexts, routes and opportunities.'

FACT 1: Communication is multimodal in nature, and it benefits from multimodal and multisensory support

Communication consequently relies on different modalities, i.e., channels through which meaning is made. They can be auditory, visual or tactile, meaning that communication does not just happen through language, but is equally supported by other multimodal resources, such as gestures, pointing, facial expressions, eye gaze, body movement, the use of objects, space and different forms of media as well as the use of touch (Mondada, 2019). Parents can make use of these multimodal resources that are naturally available to them when engaging with their child from the earliest stages of life.

This helps to create a meaningful environment for the child and provides them with learning opportunities in simple everyday interactions that are supported by multiple cues of communication in different modalities (e.g., Depowski et al., 2015). Lastly, professionals can help to improve parents' awareness of available communicative resources by using video feedback intervention (e.g., Wadnerkar Kamble et al., 2020). Providing parents with a visualisation of their own communicative behaviour in interaction with their child illustrates which communication strategies lead to more or less successful engagement with the child, and this is at the centre of **Nathalie's research project**.

FACT 2: Childhood deafness can impact social development

Although communication can be achieved through multiple modalities, children with hearing loss from hearing families can present delays in the development of theory of mind. Theory of mind (ToM) is the ability to understand and take into account one's own and other people's mental states, a skill that is important for social interactions. This ability develops through early social interactions, especially when caregivers talk to babies. Due to their hearing impairment, deaf children have limited access to spoken language. It is important to notice that deaf children with deaf parents who use a Sign Language do not present these limitations, as they have complete access to language (Courtin, 2000; Schick, B., De Villiers, P., De Villiers, J. and Hoffmeister, R., 2007; Courtin and Melot, 2014;). However, the vast majority of deaf children (around 95%) are born to hearing parents (Mitchell and Karchmer, 2004) who, unlike deaf parents, do not share their experience of perceiving the world and generally do not know any sign language, deaf children's access to language is often delayed. This (initial) lack of accessible language input for deaf children growing up in a predominantly hearing, non-signing family context is described as language deprivation and affects language and general development (e.g. Hall, M.L. et al., 2019). Early access to sound and language through early implantation and intervention has been found to be beneficial for improving language and cognition (Schorr et al., 2008). Moreover, intervention should be tailored to the specific child and family's needs (Machart, 2022). In France, for example, the choice of a specific speech and language rehabilitation is made by the caregivers. For this reason, it is fundamental to present all viable options to parents. After a choice has been made, the child will have to be exposed to the chosen method intensively and from the very early years. **Kristina's project** will focus on children who benefitted from early implantation and early intervention, to provide guidelines on which of the intervention properties (e.g., duration, frequency, family involvement etc.) should be included in interventions on Theory of Mind, language and cognition.

FACT 3: Deaf children with CIs are a highly heterogeneous group and need tailored approaches and support.

Hearing deprivation occurs also in cases of single-sided deafness, and CI implantation can partially restore hearing abilities. It is important to notice, however, that children with single-sided deafness will not face the same challenges as their peers with bilateral deafness, and should therefore be provided with a special learning and educational environment. **Irem's project** investigates the effects of single-sided deafness (SSD) on the brain with the use of EEGs.

Her research project investigates the cortical reorganization of children with SSD after intervention with a CI. She will study whether binaural hearing is partially restored in the auditory pathway of children four years and older. She will compare the performance of children with SSD with and without a CI to those with bilaterally normal hearing. Findings from the study could help to decide the appropriate intervention options for single-sided deafness during the critical period of children.

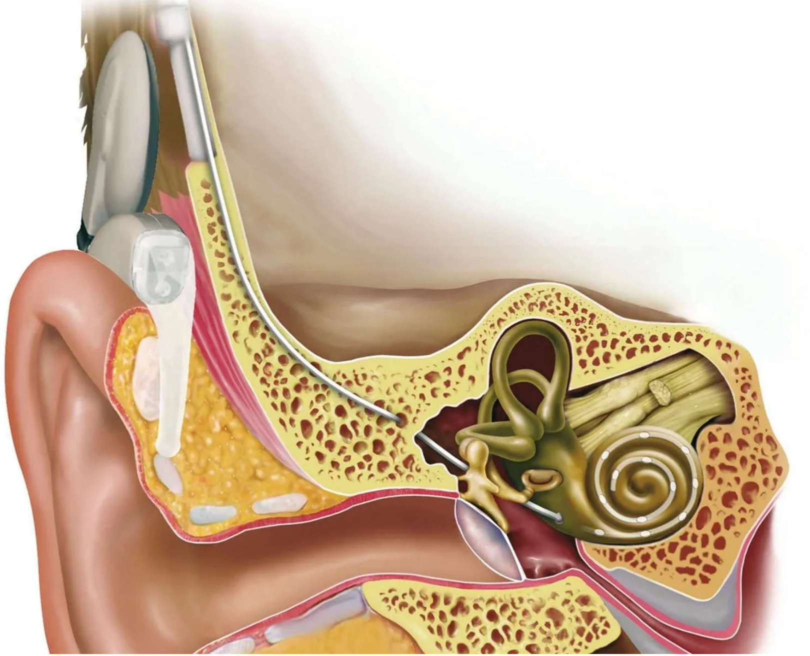
FACT 4: Automatic segmentation of the cochlea could enhance the accuracy and efficiency of cochlear implants surgery.

Even on a strictly biological level, each individual will present slightly different variations in their inner ear structures, which can pose some challenges in surgical settings. When approaching each future implantee, otologists must investigate patient-specific, preoperative cochlea measurements based on CT imaging to get insight into patients' anatomy (Neves, Tran, Kessler & Blevins, 2021). This practice could have a positive impact on the cochlear surgery outcome by minimising intra-cochlea damage and residual hearing loss (Heutink et al., 2020). However, the cochlea is characterised by its incredibly small structure and considerable inter-patient variability, making manual segmentation challenging, and posing difficulties for both radiologists and surgeons (Neves, Tran, Kessler & Blevins, 2021).

Yifan's project aims at implementing an automatic segmentation system that would have the potential to enhance the effectiveness of preoperative planning and overall segmentation accuracy.

FACT 5: Developmental brain plasticity defines multimodal processing following cochlear implantation.

Congenital, juvenile and adult-onset of deafness have all been linked to specific deficits in multisensory interactions. The sensory experiences within the early developmental critical periods will define sensory processing later in life, and these are the starting points for adaptation to neurosensory restoration, e.g. with hearing aids and cochlear implants. Impaired multisensory integration affects also the way how visual cues are integrated into auditory processing. Multimodal communication critically depends on these processes. The clinical result of hearing restoration with cochlear implants is impacted by cortical plasticity at the time of the therapy and is co-defined by the developmental steps taken within the sensory system before therapy. **Niloofar's project** investigates the influence of visual and auditory (cochlear implant) stimulation on the physiology of auditory and visual cortical areas in a feline congenital deafness model. In this project biomarkers of integration of auditory and visual stimuli into corticocortical processing are analysed in oscillatory activity before, at and after a sensory stimulus using time-frequency representation of the neuronal activity. With such markers, the success of the integration of the given modality can be used clinically with similar measures in human electroencephalography. Multimodal integration is one issue of congenital deafness, where an abnormal dominance of the spared modalities over the auditory modality is observed. To prevent this effect, and monitor the success of rehabilitation, objective measures are the critical tool.



NOISE AND POTENTIAL SUPPORTIVE PRACTICES

FACT 6: Noisy situations impact negatively speech perception for deaf people with CIs, creating additional cognitive load

Every interaction with family members builds socialisation skills and knowledge of the world in children and, for both hearing and deaf individuals, everyday speech understanding is a multimodal phenomenon that engages different abilities in different contexts. However, noise is a common feature of almost all environments where spoken communication takes place. For example, schools are an important place for socialisation and language acquisition for children, but they are often noisy and fraught with multiple sources of speech competing for their attention. When children develop language, they constantly learn new words. To be able to recognise them, they must be able to perceive the differences between sounds (Pittman & Schuett, 2013). **Julia's research** highlighted that when the speech sound suffers an alteration in the temporal and frequency structure, hearing participants found it harder to detect the contrast between phonemes, and new words would take twice the time to be learned. The tempo-frequency alteration presented in this research was similar to that of cochlear implants (Newman et al., 2020) or of noisy environments and, more than just slowing the learning of new words, it has increased the effort necessary to learn. **Lyan's research** investigates these aspects to help the creation of better policies and regulations regarding factors other than noise that also affect speech understanding.

Additionally, understanding the unique ways children who are deaf or hard of hearing are impacted by these factors can lead to better and more inclusive guidelines. Contextual and noise issues are common occurrences in schoolyards and classrooms, and present additional challenges to individuals who are deaf or hard of hearing, even with assistive hearing technology. In these situations, the sole effort of filtering between noise and speech can sometimes exhaust all the cognitive resources that would have been needed to understand spoken communication.

FACT 7: Cued Speech provides additional support to lip-reading, and can improve speech perception even in the absence of manual coding, in proficient users

Because of the reduced access to auditory information, deaf and Hard of Hearing people often rely upon visual cues to interpret spoken communication (i.e., lip-reading). For this reason, providing visual support to oral speech (e.g. subtitles added to video material) could be beneficial.Cued Speech (CS) is a visual communication system that supports spoken language and increases the tolerance to environmental noise (Bayard et. al 2019), developed to facilitate access to spoken language for people with hearing loss.

Early exposition to Cued-Speech, has been shown to improve children's phonological awareness and speech perception (Leybaert & Lasasso, 2010; Alegria et al., 1999; Nicholls and Ling, 1982; Périer et al., 1990), paving the way to spoken language proficiency (Leybaert et. al 2012). Previous studies found that Cued Speech training improves lipreading skills (Aparicio et al., 2012) and the ability to understand speech in noisy environments (Bayard et al., 2019), as manual information seems to allow for better encoding of phonological information. Recent results from **Cora's project** seem to suggest that Cued Speech facilitates audio-visual speech perception, initiating speech processing. Moreover, preliminary findings suggest that CS cues can be integrated into speech sounds, improving audio-visual speech perception in deaf or Hard of Hearing people fitted with cochlear implants or hearing aids. While the ability of CS to facilitate speech perception has been shown in multiple studies, few sources have also suggested that the benefits of Cued Speech would extend to the perception of speech without any manual gestures (Kos et al., 2009; LaSasso et al., 2010).

FACT 8: Auditory Verbal Therapy (AVT) can support speech perception in children with cochlear implants

A different type of intervention is Auditory Verbal Therapy (AVT). AVT focuses on auditory perception training, with the premise that auditory learning is key to the development of listening, speaking and language skills (Eriks-Brophy, 2004). While AVT is widely used and government-funded in some countries (e.g. Australia, Denmark, UK), there is still limited scientific evidence on its contribution to speech and language development (see Binos et al. for a systematic review). Although some studies show that AVT can have a positive impact on spoken language skills, it is difficult to generalize their findings due to limited evidence and a lack of well-controlled prospective studies. **Lucie's project** aims to provide additional knowledge about speech perception without cued speech gestures. Current results from this study also suggest that Auditory Verbal Therapy, an auditory-focused rehabilitation method, that emphasises auditory skills, could effectively support speech perception skills in deaf children with cochlear implants.

FACT 9: An automatic Cued Speech recognition and generation tool could facilitate access to Cued Speech and provide language accessibility for users

Although Cued Speech is not intrinsically difficult to learn, it does require practice and time to become fluent. Automatic recognition and generation of cued speech could enhance inclusivity (e.g., providing subtitles for cued speech, generating cues on top of existing videos, generating new videos for the given text), and online transliteration.
Such a tool would be useful in classroom settings, for example, where teachers could use existing educational content and overlap cues to make those content accessible for children with hearing impairment who use Cued Speech. It could also support parents and others to ease into communicating with the child before they can develop Cued Speech fluency themselves. **Sanjana's project** uses deep learning techniques for the recognition and generation of Cued Speech. In this process, she aims to develop a standalone architecture for automatic cued speech recognition which could then be integrated into applications for translation. Another of **Sanjana**'s goals is to develop a basic outline for a Cued Speech generator. The tool will be developed to be mindful of issues such as the fact that pointing a gadget at a child cueing might not put the child at ease, hence it will be necessary to find user-centric ways to integrate the recogniser and generator.

OTHER LANGUAGE DEVELOPMENT ASPECTS IN DEAF INDIVIDUALS

FACT 10: Spelling skills could be supportive of reading development in children

Auditory processing and speech perception can be limited in deaf children, even in those who wear Cochlear Implants (Pisoni et al., 2008), especially in spoken dictation tasks (Wass et al., 2019). At school, the majority of classroom time is used to support the development of reading skills (i.e., decoding, fluency and reading comprehension), while little space is given to spelling. However, reading and spelling skills have been shown to be mutually beneficial. Previous literature showed that improving the accuracy of phonological representations in deaf children had a positive impact on their spelling skills. For example, deaf children with cochlear implants or exposed early to Cued Speech at home (Hayes et al., 2011; Simon et al., 2019; Colin et al., 2013; Leybaert & Lechat, 2001) reportedly achieved spelling abilities equivalent to those of typically hearing peers. However, spelling error analysis revealed differences between deaf and typically hearing children that suggest that phonological strategies were less used by deaf children to spell words in alphabetic languages. However, few studies investigated the strategies that occur in the creation of new orthographic representations in deaf children (Wass et al., 2019). In the first study of **Elodie's project**, results showed that French-speaking deaf children were able to acquire new orthographic representation after little exposure to reading (confirming the results of Wass et al., 2019 for English). Interestingly, deaf children performed better than typically hearing peers in the recognition task, suggesting that they used resources beyond phonological cues to memorise specific orthographic information. Further investigation will be needed to understand what those strategies are.

ACT 11: Meaningful assessment of deaf children's language and communication takes context and language exposure into account

Most spelling assessment tools for French-speaking children at the end of primary school in Belgium include dictation tasks. To provide reliable reports, assessment tools should be able to accurately reflect children's spelling skills, bypassing cognitive mechanisms that may be affected by hearing status. For this reason, one of the goals of **Elodie's project** is the elaboration of a standardised tool based on a written picture naming task, to assess spelling skills at the end of primary school.

The need for reliable and valid assessments to determine the linguistic development of deaf children is also one of the main interests of **Elettra's project**, specifically for children who use CIs and come from plurilingual families. Although they might be using another language or languages for most of their day, this group of children tends to be only assessed in the community language (e.g., English, in the UK where **Elettra's project** is based). Multilingual children, whether hearing or deaf, are a highly inhomogeneous group. Some of them develop both (or more) languages simultaneously, switching between them with no effort, some others show to perfectly understand all of them but decide to only use one to reply to questions and interactions, with no regard to which language was used to initiate that interaction. Although contextual factors can play a role in determining part of these occurrences, they fall short of explaining the differences, as it can even happen that siblings, exposed to similar experiences, develop their languages at different speeds. Multilingualism has no "normative timeline". Still, deaf multilingual children with CI are only assessed in the community language to ascertain whether they fit a standard that was developed for their Hearing, monolingual peers. **Elettra's project** investigated the amount of exposure that those children have to each language during their daily lives, as predictive of their development in each language (i.e., if the child speaks French for 14 hours a day and English for 4, we could expect them to be more proficient in French).

Among other goals, the study aims to compare the language experience that children have with their results in formal assessment, to see whether the assessments themselves could be found reliable or not. The overall intention of the project is to investigate and describe the rich tapestry behind multiple language acquisition in children with CIs, what influences it and what can be done to support children and families, all while acknowledging their specific context, backgrounds and language habits.

FACT 12: Embodiment-based training could support the acquisition of new sounds in deaf children

When developing a second language, the ability to perceive and produce new speech sounds has been found to be one of the most challenging aspects of second language acquisition (Hoetjes & van Maastricht, 2020). Similar to what happens in the case of deaf children who are trained to use spoken communication, second language acquisition involves the process of learning to perceive and produce new speech sounds. Individuals learning a second language might have difficulty with the new speech sounds and word stress patterns that are present in the target language. Similarly, children with hearing disabilities might have difficulties perceiving and producing speech sounds due to the limitations of their auditory system. Research on second language acquisition has demonstrated that body movements can enhance speech production of new speech sounds (Li et al., 2021; Xi et al., 2020). Furthermore, findings from **Marie-Joe's project** suggest that embodiment-based training may improve the perception and production of new speech sounds. Similarly, incorporating body movements into the learning process for deaf children, as done in clinical methods (Claire André-Faber, 2006), can improve the learning experience and alleviate the challenges that deaf children often face in learning to perceive and produce new speech sounds. Therefore, it is recommended that teachers and parents use body movements while communicating with deaf children to create a more interactive and engaging learning environment, especially as it has been shown to assist in the acquisition of new mathematical concepts (Tran et al., 2017)

SENSORY INTEGRATION TO SUPPORT SPEECH PERCEPTION

FACT 13: Auditory-somatosensory integration in individuals with hearing impairment may be related to their hearing ability

It is still unknown how impaired hearing abilities affect the development of auditory-somatosensory integration. Previous studies have shown that orofacial somatosensory inputs related to speech articulatory movements alter the perception of speech sounds (Ito et al., 2009; Trudeau-Fisette et al., 2019). Since speech production and perception mechanisms are closely linked, such auditory-somatosensory integration in speech perception may be developed along with speech production acquisition. **Monica's project** investigates the role of auditory-somatosensory interaction and integration in speech perception and production in individuals with hearing impairment and examines the relationship between somatosensory effect and speech abilities in relation to their hearing situation. **Monica**'s findings confirm the role of auditory-somatosensory integration in typically hearing individuals where the somatosensory effect in speech perception appears to be related to the production performance (Ashokumar, Guichet, et al., 2022) and likely recalibrates production mechanisms (Ashokumar, Schwartz, et al., 2022). In individuals with hearing impairment, the somatosensory effect seems limited in the context of current experiments. From the initial findings with individuals with hearing impairment, speech perception abilities and production performance appear to be related to their hearing level. This suggests that the development of auditory-somatosensory integration may be related to the development of their hearing ability.

The findings from this study could help to improve the existing speech rehabilitation practises by considering the role of orofacial somatosensory inputs in speech perception and production.

FACT 14: Vibrotactile stimuli can improve speech intelligibility in suboptimal hearing situations.

On the topic of multisensory stimulation, **Alina's project** investigated two groups of adults, one hearing, and one deaf who use cochlear implants, showing that a vibrotactile signal which follows the speech signal could improve speech intelligibility in difficult listening situations. The findings support results from previous studies (Cieśla et al., 2019; Fletcher et al., 2019, 2018; Guilleminot and Reichenbach, 2022) and could be used in future to develop vibrotactile aids, which could constitute a useful tool for rehabilitation. Audio-tactile approaches could be used in speech therapy, for example, to aid language acquisition. Moreover, tactile inputs are expected to be helpful in noisy classroom situations, to support auditory speech perception or replace visual cues when no eye contact with the speaker (e.g., teacher) can be made.

MEET THE TEAM

IREM ADALILAR

ESR 1

With a background in Audiology, Irem is investigating brain reorganizations and potential differences in the neural generators between children with single-sided deafness with a CI and those without a CI.
Irem is based in Leuven, Belgium, where she works at KU Leuven.
She enjoys photography, playing the piano and travelling.

YIFAN WANG

ESR 2

After having studied Engineering and Computer Science in France and the UK, Yifan discovered a passion for the medical field, which brought him to the Medizinische Hochschule Hannover (MHH), Germany. His project uses deep learning networks to achieve an automatic cochlea segmentation pipeline on CTs.

NILOOFAR TAVAKOLI

ESR 3

Niloofar studied Biomedical Engineering and found her passion in Neuroscience and especially EEG studies. Her current project aims at unravelling neural mechanisms of cross-modal plasticity in the deaf animal model. She works at The Department of Experimental Otology at Hannover Medical School and Institute of AudioNeuroTechnology (VIANNA) and is a keen music connoisseuse, having introduced at least a couple of the other ESRs to Iranian folk songs.

ALINA SCHULTE

ESR 4

A Neuroscientist to her core, Alina is currently based in Eriksholm Research Center, part of Oticon, Denmark, where she looks into how combined auditory and vibrotactile speech stimuli can enhance intelligibility. She is interested in learning the neural basis of these phenomena. When she is not working, she enjoys being in nature, listening to music, dancing and practicing yoga.

CORA CARON

ESR 5

Cora studied Biology and Neuroscience between Brazil and France, specialising in EEG. She is currently based in Brussels, working on understanding how Cued-Speech perception interacts with audio-visual speech processing and how it impacts listening efforts in noise. Cora has an energetic and supportive personality, and her laughter is an unmistakable sound for all the other ESRs.

MONICA ASHOKUMAR
ESR 6

Before arriving at Gipsa Lab in Grenoble, France, Monica studied Biomedical Engineering and Auiology in India and the UK. Her project investigates the role of auditory-somatosensory interaction and integration in speech perception and production in individuals with hearing impairment and examines the relationship between somatosensory effect and speech abilities in relation to their hearing situation. Monica is a soft-spoken, gentle soul, whose pragmatism never fails to impress her colleagues.

LYAN PORTO
ESR 7

One of the three Linguists in the group, Lyan studied in Brazil and the Netherlands before settling in Belgium to work at KU Leuven. His project looks into the role of cognition in audiovisual speech language perception using a realistic listening scenario.
Lyan is a very talented musician and a great friend to all the other ESRs.

JULIA CHIOSSI
ESR 8

Julia has a background in Audiology and Speech-Language Pathology and is currently working between Oticon Medical, Denmark, and the University of Oslo, in Norway. Her project investigates the interchanges between phonological perception and cognitive abilities during the auditory detection and learning of new word forms in situations of increased listening effort.

KRISTINA BURUM
ESR 9

With a background as a Speech Pathologist and project manager for the Croatian Association of the Deafblind Persons, Kristina is currently working at the University of Oslo, Norway. Her project investigates the relationship between theory of mind, language and cognition in deaf and deafblind children (Usher syndrome) with CI. It also aims to relate different intervention properties to different levels of theory of mind, language and cognitive skills.
Kristina's pragmatism often leads to quotes that quickly become part of the familal vocabulary of all the other ESRs.

SANJANA SANKAR
ESR 10

Sanjana studied Electronics and Communication Engineering with a specialization in Design and Manufacturing, soon venturing into Artificial Intelligence and Speech Processing. She is currently working at Gipsa Lab, in Grenoble, France, on a project that aims to use deep learning techniques for automatic recognition and generation of Cued Speech. Sanjana has a bubbly personality and a deep understanding of her subject, which she patiently explains over and over to those of us with more limited coding experience.

ELETTRA CASELLATO
ESR 11

Elettra studied Neuroscience in Italy and Australia, soon focusing on brain plasticity after cochlear implantation and Neuroethics. Her project investigates the acquisition of multiple spoken languages in deaf children with CIs who are part of plurilingual and multicultural families. She is based in Leeds, UK, and spends most of her free time at the climbing gym with Nathalie (ESR12), where they practice ASL and BSL standing on the opposite ends of the bouldering area.

NATHALIE CZEKE
ESR 12

Nathalie is the second Linguist in the group. She has studied in Germany, soon flying to Canada to work at the Baby Speech Lab of the University of British Columbia, Vancouver, Her project investigates the multimodal ways of communication that are naturally used in interactions between hearing parents and deaf children. Nathalie loves everything outdoors and is a keen runner, swimmer and cyclist, soon participating in her first Iron Man. She also doubles in climbing, because why not.

ELODIE SABATIER
ESR 13

Elodie studied Linguistics in France, soon developing an interest in speech production and perception. She is currently working in Brussels, with a project on orthographic learning and spelling acquisition in deaf-or-hard-of-hearing children. The project will result in the creation of a spelling test with a written image naming task and a fine-grained analysis of spelling errors to infer the strategies used by the students.
Elodie is deeply interested in pretty much everything and, together with Lucie, Cora and Marie-Jo, has learned Cued Speech during her first years of PhD.

LUCIE VAN BOGAERT
ESR 14

Lucie has a background as Speech and Language Pathologist and is currently based in Grenoble, France, where she works at the CNRSLPNC lab and at CNRS Gipsa-lab. Her project looks into Speech perception and production in children with cochlear implants using different speech and language rehabilitation approaches (i.e. Auditory Verbal Therapy or Cued Speech). Lucie is very enthusiastic always sports the best dungarees.

MARIE- JOE KFOURY
ESR 15

Marie-Joe studied Psychology in Lebanon and France before embarking on her current project, which she works on at the Centre Comprendre et Parler in Brussels, Belgium. Her study aims to investigate the role of body movements in perceiving and producing new phonological contrasts and to develop guidelines for parents and practitioners to support interactions during speech therapy and everyday life situations. Marie-Joe is a keen traveller and speaks multiple languages. She also prepares the most delicious treats, to the joy of all.

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