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Communication for **C**hildren with **H**earing **I**mpairment to optimise **L**anguage **D**evelopment

POLICY BRIEF
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Policy Brief

Optimising the communicative skills and social inclusion of children with hearing loss

The World Health Assembly adopted a 2017 resolution recognizing hearing loss as a priority worldwide health issue. Children with hearing loss present significant risks for delayed language acquisition or deprivation, and reductions in educational achievement, socio-emotional development, and well-being. Current intervention plans fail to prepare those children for academic achievement and social participation in contemporary society where the diversity of their needs is increasing. **Comm4CHILD** is a consortium implementing an innovative approach for optimising the communicative skills and social inclusion of children with hearing loss. **Comm4CHILD** addresses the large inter-individual heterogeneity in brain plasticity, cognitive resources, and linguistic abilities and social context, and takes full advantage of this heterogeneity to support efficient communicative skills in children with hearing loss. This research brief summarizes findings and reflections from **Comm4CHILD** projects to influence future policy decisions.

Recommendations

- Advocate for the use of multi-modal and multi-sensory information to support speech perception while learning and communicating, especially in noisy environments.
- Advances in research and technology open new ways and opportunities to treat and support children with hearing loss. The implementation of these new methods and techniques should be encouraged in clinical practices. Clinical guidelines should reflect the latest advances in technology. Simplified and accessible information should be provided for parents and care givers in a timely manner.
- Treatment and rehabilitation approaches: All relevant and available options should be made transparent to parents and caregivers so that they are able to make informed decisions.
- It is important to consider individual resources and providing specific intervention strategies rather than focusing on fixing sensory deficits.

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Research results

The Importance of Communication

Communication plays an important part of everyday interactions and is usually multi-sensory in nature. Using multimodal resources in communication creates a meaningful environment and provides children with learning opportunities. The work of **Nathalie Czeke (University of Leeds, United Kingdom)** aimed to identify the moments of joint attention as well as strategies in multimodal communication. The project indicates the need for more informed guidance on how to make communication more accessible to the children by using multimodal cues and resources, leading to successful engagement. Her work also emphasizes the importance of considering individual resources and providing specific intervention strategies rather than focusing on fixing sensory deficits.

Theory of mind is the ability to understand and take into account one's own and other people's mental states. The project of **Kristina Burum (University of Oslo, Norway)** showed that some children fitted with cochlear implants may display difficulties in language performance and phonological working memory, but that early social interactions may enable them to reach theory of mind understanding comparable to typically developing hearing peers. This project highlights the importance of supporting early social interactions through family-centered actions that are sensitive to the family's choice of intervention, while also recognising the importance of early access to spoken language that can be provided by cochlear implants.

Multimodal communication relies heavily on multisensory processing and integration. **Niloofar Tavakoli (Hannover Medical School, Germany)** investigated the interdependency between developmental brain plasticity during the critical period and multimodal processing following cochlear implantation. Biomarkers of integration of auditory and visual stimuli into corticocortical processing were analysed in animals.

Cochlear implantation can partially restore hearing abilities, which is one of the ways to enable communication for deaf individuals. The accuracy of the cochlear implant surgery is essential to successful outcome. Currently, the preoperative cochlea measurements are based on CT imaging and manual segmentation. To further improve accuracy and efficiency, the project of **Yifan Wang (HörSys, Germany)** aimed to apply a deep learning based fully automatic localization/segmentation system capable of localizing/segmenting cochlea structure throughout entire 3D CT scans with rapid inference speed. It will have a high clinical potential to enhance effectiveness of preoperative planning and overall accuracy of segmentation by complementing the manual methods. A real-time automatic landmark detection algorithm has been developed and will be released.

Hearing loss comes in many different types and configurations, sometimes requiring very different treatment approaches. One example is single-sided deafness, where only one ear is affected. **Irem Adalilar (KU Leuven, Belgium)** investigated how the brains of children with single-sided deafness re-organise after they are fitted with a cochlear implant. The variability in how each child's brain compensates after intervention is important to understand, because it may change how clinical decisions are made. For example, if the treating clinician knew that the brain was not re-organising well after intervention, they could incorporate more multi-sensory training for that specific child.

Noise and Potential Supportive Practices

Complex or loud sound environments are particularly challenging for children with hearing loss. Schools and other environments where children learn typically have high levels of background noise, meaning that the brain has to work hard to separate a target voice from the background. While the brain works hard to understand speech, there may be less cognitive capacity available for learning, right when it is needed the most. Over time, this high level of effort can lead to fatigue and eventually disengagement from the task. Even at moderate levels of noise which would not be problematic for a child with typical hearing, a child with hearing loss may find it impossible to keep up with the voice of their teacher, friends, or parents. For this reason, it is important to understand what kind of support is available for children to succeed at school.

Most English-speaking adults know about 20,000 – 30,000 words. In the first decade of life, children learn several of these new words every single day, mostly by hearing them. **Julia Chiossi (Oticon, Denmark)** looked in detail at exactly how children learn new words. She found that children with hearing loss had difficulties recognizing that a word was new, or that a new word was different to words that they already knew. At the same time, when children with hearing loss did recognize words as new, they were just as fast to learn as the children with typical hearing. This finding shows that children with hearing loss are well able to take advantage of supportive practices if they are provided.

Lyan Porto (KU Leuven, Belgium) investigated the role of the communication environment by constructing an artificial audio-visual 3-D environment in which children could observe and participate in conversations while the number of simultaneous talkers was manipulated. He has developed and validated a set of virtual audiovisual test material which has its own value for future research. His data will have implications for how supportive practices should be mindful of the number of communication partners that are present in a child's immediate vicinity.

Human verbal communication involves extensive visual as well as auditory elements, and we can generally tolerate much more noise if we are able to see as well as hear the person we are speaking to. Support during rehabilitation may take advantage of multimodal inputs. On the other hand, therapies such as auditory-verbal therapy emphasize the need for auditory stimulation. Several studies examined the use of cued speech (a form of manual gesture which reinforces speech sounds) and auditory-verbal therapy as potential supports for children learning in noisy environments.

Cora Caron (Université libre de Bruxelles, Belgium) used neural recordings to show that cued speech can act as a temporal cue that allows the listener to focus more on precise times when the most important parts of the speech are occurring. Listeners with hearing loss could tolerate more noise when cued speech was present compared to absent, particularly when the lip movements were not visible. **Lucy Van Bogaert (CNRS, France)** found that children using cochlear implants had the best performance on tasks involving discriminating and repeating speech sounds when they had been trained using auditory-verbal speech therapy. To reach a similar level of performance using cued speech, they had to be highly trained in cued speech.

Sanjana Sankar (CNRS, France) has developed a model using artificial intelligence which can both recognize as well as generate cued speech, and will investigate whether this model could be a useful tool for children with hearing loss.

While children have access to more senses than sound alone, they can tolerate higher levels of noise. On the other hand, auditory therapy may also be effective. Together, these studies demonstrate the importance of exploring the sensory abilities of children, and exploiting multimodal approaches when indicated, so that children can be supported better while learning.

Other Language Development Aspects

If children with hearing loss have accurate phonological representations of speech, they tend to have good spelling skills. Compared to children with typical hearing, phonological strategies are less used by children with hearing loss to spell words in alphabetical languages. The project of **Elodie Sabatier (Université libre de Bruxelles, Belgium)** showed that French-speaking children with hearing loss are able to acquire new orthographic representation after little exposure to reading, and the learning process and strategies can be different from children with typically hearing. To best support language development for these children, it is crucial to have meaningful assessments of the relevant skills (including spelling ability) so that treatment plans can be developed for individual needs. This takes context and language exposure into account. To measure children's spelling skills reliably and accurately, a standardized test to assess spelling abilities for French-speaking children with hearing loss is developed and being validated.

When learning any new language, it is crucial to be able to accurately perceive and produce new speech sounds. For children with hearing loss, both language perception as well as production abilities can be limited. Recognizing this, **Marie Joe Kfoury (Centre Comprendre et Parler, Belgium)** has found that whole-body movements that are related to specific speech sounds could help children accurately perceive and produce specific speech sounds. This intriguing finding could improve interaction and result in engaging and dynamic learning situations for children who are struggling with learning to hear and produce new sounds.

Just like all children in communities worldwide, some children with hearing loss grow up in multi-lingual households and communities. While this is usually understood as a good thing for most children, there is not much research looking into this for children with hearing loss. Furthermore, outcome measures that affect clinical decisions may be performed in the language that the child is not best in, possibly leading to inappropriate care pathways. To look into this, **Elettra Casellato (University of Leeds, United Kingdom)** measured the amount of exposure to multiple languages that children using cochlear implants in multi-lingual households actually experienced.

Sensory Integration to Support Speech Perception

While it is well known that being able to see the person you are talking to allows you to tolerate a higher level of background noise, there is also evidence that providing speech-related sensory input via other senses can also benefit speech perception. **Monica Ashokumar (CNRS, France)** found that gentle haptic stimulation on the face, corresponding to the types of facial movements typically made during speech production, have the capacity to influence both the perception as well as the production of speech sounds. **Alina Schulte (Eriksholm, Denmark)** also used haptic representations of speech on the fingertips. She was able to show that people with normal hearing as well as cochlear implant users could understand speech in the presence of more background noise when using the additional tactile input compared to the auditory speech alone. In both cases, it seems that speech-related information can be helpful even when presented via the skin, and may allow the listener to more easily isolate a single voice among many.

Now that many people are wearing smartwatches and other wearable computing devices that incorporate microphones and haptic stimulators, following this line of research further may provide benefits to children who need to listen to a teacher in a noisy classroom, for example.

https://comm4child.ulb.be

Reflections and other lessons learned

In addition to the research results above, several important learning points have been identified from the informal observations and reflections of the Early-Stage Researchers of the project.

- Significant gaps exist between the latest knowledge in research and what happens in clinical practice. This has been observed in terms of clinical guidelines not always reflecting latest advances in technology, and what information is provided for parents/carers. Efforts should be made to ensure these gaps are closed.

- Clinicians can show bias to a particular rehabilitation approach that limits parents/carers being provided with detailed information about all options available. As a result, parents/carers can be restricted and less empowered in their role as shared decision makers.

- Tools and resources used with parents/carers are not always accessible in design and content and efforts should be made to simplify these.

- The medical model of disability, where hearing loss is viewed as a problem that needs fixing, still prevails when supporting deaf and hard-of-hearing infants and children. Efforts should be made to adopt principles from the social model, placing importance on a child's social background and recognizing that one size does not fit all.


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