A novel combined Frequency-Following Response (FFR) and Mismatch Negativity (MMN) multifeature paradigm for efficient testing of speech encoding and phonetic discrimination.

Yesenia de Lourdes Torres Manriquez, Alejandro Mondéjar Segovia, Natàlia Gorina-Careta, Carles Escera

The processing of language in adults relies on a hierarchically organized auditory system capable of transforming acoustic signals into meaningful perceptual experiences. This process involves the encoding, pre-attentive processing and discrimination of fine-grained acoustic features in speech. Auditory evoked potentials (AEPs), provide a non-invasive method to assess auditory system integrity, allowing high temporal resolution recordings of neural responses to sound. While previous research has independently examined long-latency cortical potentials such as Mismatch Negativity (MMN) and the Frequency-Following Response (FFR), few have combined both measures within a unified paradigm using speech stimuli. The aim of this study was to evaluate the feasibility of simultaneously recording FFR and MMN responses using an integrated multifeatured-MMN paradigm with speech stimuli varying in phonological prototypicality.

The EEG of twenty-four healthy Catalan-speaking adults was recorded during two stimulation protocols: a classical FFR recording condition, with a single-token repetition, and a multifeature FFR-MMN condition. In this later condition, participants were presented with disyllabic stimuli consisting of a standard (/dado/) and four linguistic deviants differing in phonological prototypicality (/dad/, /dad̈o/, /daxo/, /dao/), and one acoustic deviant (/dã o/). EEG was recorded from 33 scalp electrodes at 20,000 Hz. The standard /dado/ was used in the classical FFR recording. FFR analyses focused on spectral amplitude at the fundamental frequency (F0 = 113 Hz; Envelope) and the first formant of /a/ (F1=688 Hz; Temporal Fine Structure) of the first syllable (/da/) at electrode Cz. MMN responses were derived from subtraction waveforms (deviant minus standard) to the second syllable, measured at Fz. Given non-normal data distributions, nonparametric statistics (Friedman and Durbin-Conover post hoc test) were applied.

Robust FFRs were observed in both conditions. F spectral amplitude did not differ significantly between conditions (p=0.162). However, the FFR to /da/ in the multifeature FFR-MMN condition, exhibited a significantly higher signal to noise ratio (SNR) compared to the classical FFR recording condition (4.79 vs 4.18; p= 0.028), suggesting a context related enhancement of encoding efficiency. All deviant stimuli elicited MMN responses, with cluster-based permutation test revealing distinct scalp topographies between native and non- native contrasts. This study validates a novel combined paradigm that effectively captures both FFR and MMN within a single recording session and offers a powerful, time-efficient tool for investigating speech encoding and discrimination in both clinical and developmental populations.

Assessing Suitable fNIRS Hyperscanning Paradigms in a Naturalistic Classroom Laboratory.

Brandon O'Hanlon, Barrie Usherwood, Liam Howard, Steph Ainsworth, Hannah Stewart

External behaviours alone cannot show that children are listening, especially in classrooms. However, enhanced neural synchronisation at temporal-parietal and temporal-frontal junctions have been shown to underly selective processes of listening to a talker to process the content, rather than the sensory level, of speech (Bell et al., 2020; Dai et al., 2018) demonstrating listening over hearing. Here, we are comparing listening paradigms to assess their suitability for naturalistic hyperscanning in a classroom.

We are hyperscanning dyads of one child (aged 6 to 12 years) and one adult; both hearing, neurotypical, and native English speakers. Each participant wears wireless fNIRS with 16 transmitters, 15 detectors and 8 short-distance detectors in a montage covering the temporal, frontal and parietal cortices. We are using throat mics to capture the timing of speech from participants, to be entered as offline triggers post hoc to the synchronised cortical data.

We are assessing three paradigms: In Paradigm 0 participants listen to a classroom-relevant recording of speech stimuli together; Paradigm 1 involves static turn-taking, where the child speaks whilst the adult listens, and vice versa; Paradigm 2 involves dyadic conversing, where the child and adult converse freely.

For each paradigm, we are calculating cortical shared listening between the child and adult using correlation coefficient matrices for brain-to-brain (through wavelet transform coherence) and brain-to-speech synchronization (through backwards modelling). In Paradigms 0 and 1 this will simply be each listener’s neural data. However, in Paradigm 2 this will be a concatenation of when participants were listeners, as marked by the throat mic trigger timings. We are using bootstrapping to check if synchronisation measures are biased by concatenation seams. We predict that child-adult dyads will show greater shared listening at temporal-parietal and temporal-frontal junctions when in congruent versus incongruent dyads, during each listening paradigm.

Paradigms that support this prediction may be considered a suitable design for naturalistic hyper-scanning experiments, informing future research involving deaf and hearing children.

Auditory Processing of Acoustic Cues and Speech recognition in Noise in Children with Mild to Moderate Hearing Loss.

Charlotte Benoit, Inès Sonzogni, Laurianne Cabrera

Speech-in-noise (SIN) perception is known to be affected by sensorineural hearing loss (HL). This is not only related to reduced audibility but also to impaired basic auditory mechanisms essential for speech processing that are affected by cochlear damage. The goal of the present study was to investigate the impact of SNHL in childhood on temporal and spectral processing, as well as SIN perception.

Preliminary results are presented with data collected among 12 children with mild-to-moderate SNHL and aged between 5 and 10 years. They were presented with four SIN conditions: consonant versus word identification in speech-shaped noise (SSN) versus 2-talker babble noise. In parallel, auditory temporal (amplitude and frequency modulations- AM/FM- fluctuating at 4 or 20 Hz) and spectral ripple density (tested at 0.5 or 2 ripple-per-octave) detection thresholds were measured, along with receptive vocabulary (using the Peabody Picture Vocabulary test) and nonverbal working memory measures (using the forward and backward versions of the Corsi test). Thresholds of children with SNHL were compared to those of children with normal hearing (NH) of the same age range.

As expected, children with SNHL performed more poorly than NH peers in all SIN tasks. They also showed worse FM and spectral detection thresholds but preserved or even improved AM detection. Preliminary analyses showed that SIN thresholds did not correlate with temporal or spectral cue detection, neither nonverbal working memory. Only a weak relationship between consonant identification and receptive vocabulary was found. Conclusions: As observed in previous adult studies testing the effects of acquired SNHL, our results in children with congenital SNHL showed that this condition affects FM and spectral processing, but that AM processing is relatively preserved. Children with SNHL displayed elevated thresholds in all SIN tasks used and a strong inter-individual variability. However, the analyses so far have not revealed any auditory or cognitive factor that emerge as dominant predictors of SIN in children with SNHL. To better capture inter-individual variability and fully assess the effects of age and development, data collection must continue.

Binaural temporal fine structure sensitivity development in children with developmental dyslexia.

Sheila Flanagan, Brian Moore, Angela Wilson, Fiona Gabrielczyk, Kanad Mandke, Usha Goswami

Speech-in-noise perception is known to mature over the first 10 – 12 years of life. In this age range, children with language and/or reading difficulties have been reported to experience poor speech-in-noise perception compared with controls. However, the underlying aetiology for this finding is debated. Binaural Temporal Fine Structure sensitivity (bTFSs) is known to be beneficial for attending to sound sources in challenging environments. For young normal-hearing adults (YHNA), the upper frequency limit of bTFSs is known to be around 1400 Hz. Research has found the upper frequency limit of bTFSs to be significantly lower (worse) for typically developing children than for YHNA, with age being a significant predictor of the upper limit. If poor bTFSs contributes to impaired speech-in- noise perception in dyslexia (DYS), poorer bTFSs would be expected in DYS. In contrast, the Temporal Sampling (TS) theory of developmental dyslexia predicts that the perception of bTFS of speech may be preserved in children with dyslexia. By TS theory, reduced sensitivity to low-frequency envelope modulations is the core auditory impairment regarding DYS. Methods: Binaural TFS sensitivity was measured using the Temporal Fine Structure-Adaptive Frequency (TFS-AF) test with 88 children aged 7-9.5 years (30 age-matched (CA), 20 male and 58 DYS, 31 male). Using a 2-up 1-down paradigm, the highest frequency at which interaural phase differences (IPD) of 30◦ and 180◦ could be distinguished from an IPD of 0◦ was assessed.

An LME model revealed no effect of group ($F(1,44) = 0.18$, $p= .68$), a significant effect of phase, with 30◦ lower than 180◦ ($F(1,44) = 214.83$, $p< .001$), and no phase by group interaction ($F(1,44) = 0.04$, $p= .84$). Conclusion: These results suggest that development of bTFSs is similar for DYS and CA children. Hence, the developmental pattern of bTFSs was supported, with the upper frequency limit of bTFSs in children compared to YNHA being significantly lower ($p < .001$) for both levels of phase difference tested (30◦ and 180◦). A smaller frequency range of bTFSs may limit the benefit gained from spectral release from masking contributing to the known speech-in-noise deficit found in children when compared with adults. However, bTFSs was not found to be additionally impaired in DYS, supporting TS theory.

Calculation task performance under classroom-like environmental conditions.

Matteo Pellegatti, Visentin Chiara, Simone Torresin, Francesco Babich, Nicola Prodi

Multiple environmental factors, including air quality and acoustics influence learning performance in classrooms. A multidomain perspective is essential to understand how these conditions interact to affect cognitive outcomes, particularly in school-aged children. While previous studies often examined single domains in isolation, this research explored their combined effects on students' calculation performance.

A total of 192 students (aged 12–14 years) participated in a laboratory experiment within classroom-like chambers. They completed 24 addition and subtraction equations of varying difficulty under different CO concentrations (800 ppm vs. 2000 ppm) and three acoustic conditions representative of natural ventilation conditions in the classroom (Quiet, Birdsong, Playground).

Results showed that task accuracy was significantly influenced by equation difficulty and students' baseline calculation fluency, with easier problems and higher fluency associated with better performance. No significant effect of CO concentration or listening condition emerged on accuracy. In contrast, response times were affected by gender, school grade, task difficulty, and acoustic condition. Students responded faster to easy equations, with Grade VIII students outperforming Grade VII, and males responding faster than females. Critically, response times were significantly slower under Playground noise compared to Quiet, while no differences were observed between Quiet and Birdsong.

Overall, the findings highlight that calculation speed (here considered as a proxy of cognitive load) is sensitive to classroom-like acoustic environments, especially when competing activity sounds are present. The absence of CO effects suggests that the influence of air quality on cognition may depend on real-world ventilation dynamics and chronic exposure, reinforcing the importance of a multidomain approach to classroom design and research.

Children's Listening Behaviours During Dyadic Group-Work in a Noisy Classroom.

Megan Griffiths, Dr. Brandon O'Hanlon, Dr. Tom Beesley, Dr. Hannah Stewart

Hearing and listening are essential in many aspects of children's lives, but particularly in education. Research has been conducted into how children listen and the strategies they use to aid, or even enhance, their listening. However, these studies are traditionally conducted in laboratory settings that do not represent children's everyday listening environments. Here we present a study using motion-capture and eye-tracking to identify the behaviours elicited by children during dyadic communicative tasks in a naturalistic classroom research lab. We compare two methods to create natural conversation: using prompts, e.g. 'What is your favourite book or TV show, and why?'; and a cooperative spot-the-difference activity (Baker & Hazan, 2011; DiapixUK). Furthermore, we compare behaviour between three noise levels consisting of: quiet classroom activities; noisy classroom activities; and speech shaped noise. We hypothesise that, like adults (Hadley et al., 2019), participants will increase their looks towards their partner's mouth and lean in more in louder noise. We also hypothesise that the spot-the-difference task will limit the children's use of optimal listening strategies, as seen through decreased mouth gazes and leaning in compared to the conversation prompt condition. Finally, exploratory analysis will explore the influence of individual differences, such as speechreading ability. The results of this study will help us design future studies with deaf children and children with listening difficulties.

Complexity analysis of functional network development in endogenous high-density EEG of premature neonates.

Sarah Mashmoushi

The early development of sensory and functional networks in premature neonates is crucial for brain maturation. Before 28 weeks of gestational age (wGA), neural activity is predominantly driven by spontaneous endogenous generators. One such generator, theta temporal activity coalescent with a slow wave (TTA-SW), emerges between 24–26 wGA, peaks at 27– 30 wGA, and diminishes by 32–36 wGA. (Wallois et al., 2021) These oscillations are believed to play a crucial role in shaping early cortical connectivity. Our objective is to study how TTA-SW modulates brain functional integration across gestational age by assessing brain complexity during, and immediately after, the generation of TTA-SW.

The dataset included 46 preterm neonates recorded at Amiens University Hospital with 64-channel EEG. The neonates were grouped into three categories based on their age at the time of recording: 26–28 wGA (n=19), 29–30 wGA (n=14), and 31–32 wGA (n=13). TTA- SW events were detected manually, with onset defined as the beginning of the theta activity superimposed on the slow wave, and offset as the end of the slow wave component, marked by a zero-crossing. For each event, two complexity indices were calculated. First, a baseline was defined by selecting the 2-second segment with the lowest power within the 10-second period preceding the event. Two response windows were then considered: (i) the event itself, from onset to offset, and (ii) a 2-second segment of post-event background activity, starting 0.5 seconds after the end of the event.

The complexity index was calculated using the PCIST (Perturbational Complexity Index – State Transitions) framework (Comolatti et al., 2019). In brief, singular value decomposition was applied to the baseline and response windows, retaining only principal components explaining at least 99% of the variance while discarding those with low signal-to-noise ratio. State transition quantification was then performed by embedding the signals in time and constructing distance matrices to detect and count transitions between brain states. The difference in the number of state transitions between baseline and response was summed across components to yield the final complexity index, reflecting the richness of brain dynamics in the response window.

The complexity index of TTA-SW events increased significantly between 26–28 and older gestational groups, reflecting maturation of local cortical circuits. However, no significant difference was observed between 29–30 and 31–32 wGA, suggesting stabilization of event complexity by 30 weeks. When setting the response as the 2-second segment after the end of the event, there is a significant difference with the older age group, indicating that by 31–32 wGA, background networks are more mature and capable of generating structured, complex activity after TTA-SW. These findings are in line with developmental studies showing a transition from discontinuous to more organized cortical activity over this gestational range.

TTA-SW emerges as a structured, developmentally regulated oscillation that both reflects and drives early cortical network formation. Its increasing complexity across gestational ages, coupled with growing post-event network organization, suggests that TTA-SW is not a random neonatal EEG feature but a key biomarker of neurodevelopment. This work under- scores the value of complexity index as a quantitative tool to assess early brain maturation and provides insights into the endogenous foundations of sensory and cognitive networks in preterm infants.

Detecting Mispronunciations: The Role of Place and Voicing of Articulation.

Katharina Kaduk, Rebecca Holt, Hannah J Stewart

Everyday communication is rarely delivered in isolated sentences and to communicate effectively the listener needs to track continuous speech and phoneme perception (MacPherson & Akeroyd, 2012; Madell & Hewitt, 2022). However, children's listening ability is usually assessed using sentence-repetition tasks primarily measuring speech intelligibility rather than the cognitive effort required to, for example, repair ambiguous words (Winn & Teece, 2021). Roebuck and Barry (2018) found that 7-13-year-olds with listening difficulties were less able to detect mispronunciations and nonsense words and struggled to sustain attention and process speech over the course of a 16-minute auditory-only story (Roebuck & Barry, 2018). To investigate how children perceive mispronunciations in continuous speech, we are developing a two-stage project. As a precursor to our planned ERP study using 10-minute narrated short stories, we are first validating the perceptual distinctiveness of mispronounced words using a controlled behavioural paradigm.

We will present the results from 20 typically developing children aged 6-11 years on a three-interval, three-alternative (odd-one-out) forced-choice response paradigm. Our stimuli consist of one (e.g. bus) and two syllable (e.g. magnet) nouns. The odd ones out are mispronunciations of the trials' noun, altered by systematically substituting the initial consonant from low (250–750 Hz; e.g. /m/, /n/, /b/), mid (1–2 kHz; e.g. /d/, /g/, /l/), or high (3–5 kHz; e.g. /s/, /f/, //) frequency bands of the speech spectrum (Olsen, Hawkins, & Van Tasell, 1987), often depicted in the 'speech banana'. In addition, mispronunciations do not yield real English words and follow a consonant-vowel-consonant (CVC) structure. We are measuring reaction times (RT) and accuracy.

We predict that detection difficulty increases when the substituted consonant is acoustically/perceptually close to the original noun. This will be evidenced by slower RT and lower accuracy for mispronunciations within-band or one band away from the original noun, compared to mispronunciations two bands away. We also predict slower RT and lower accuracy for the longer words (two-syllables) compared to the short words (one-syllable) due to greater working memory demands.

Early Cortical Specialization for Human Voice in Children with Cochlear Implants:

An fNIRS Study.

Indra Krönke, Maria Grünig, Willy Mattheus, Richard Scholz, Anja Hahne

The human voice – covering the full spectrum of vocalizations, from laughter and sighs to speech and song – constitutes a fundamental modality of social communication and is crucial for language acquisition. A specialized region within the auditory cortex, the temporal voice area (TVA), has been identified as selectively responsive for the processing of human vocalizations (Belin et al., 2000). This functional specialization has been demonstrated in adults and in children as young as five to six years (Raschle et al., 2014). However, the developmental trajectory of TVA specialization during early infancy is still poorly understood in normal-hearing children, its emergence in children with cochlear implants (CI) remains even less clear.

Typically hearing infants aged 3–5 months (N = 39) and 7–9 months (N = 35) were presented with human-generated vocal stimuli (voice condition) and natural environmental sounds, such as rain or birdsong (non-voice condition). Neural activity was measured using functional near-infrared spectroscopy (fNIRS). The same paradigm was applied to children with CI, tested after 3–5 months (N = 30) and 7–9 months (N = 13) of implant experience.

Typically hearing infants aged 3–5 months did not exhibit significantly greater TVA activation for voice versus non-voice stimuli. In contrast, infants aged 7–9 months showed a clear selective response. In children with CI, TVA activation was observed not only after 7–9 months of implant experience but also after 3–5 months.

These findings indicate that neural specialization for processing human vocalizations in typically hearing infants emerges between 5 and 7 months, consistent with previous work by Grossmann et al. (2010). Children with CI, however, exhibit TVA specialization already after 3–5 months of implant experience, suggesting a faster development of voice-sensitive cortical processing compared to typically hearing infants. This acceleration may reflect the higher chronological age of CI children, which could confer more mature cognitive abilities, such as memory, category formation, attention, and enhanced visuospatial skills.

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Early Neural Markers of Word Learning in Children with Cochlear Implants: Evidence from the N400.

Niki Katerina Vavatzanidis, Franziska Petzet, Susen Marx, Ella Tabea Buske, Anja Hahne

Children with cochlear implants (CI) have been shown to acquire their first words faster than typically hearing (TH) peers, as demonstrated in previous ERP research using the N400 component (Vavatzanidis et al., 2018). The present EEG study systematically investigates the earliest time point at which the N400 effect, as a neural marker of emerging word comprehension, can be observed in CI children.

We tested three groups of early bilaterally implanted CI children (< 4 years at implantation) with 7, 10, and 12 months of hearing experience, alongside three age-matched TH control groups (10, 12, and 14 months). A picture–word paradigm (Friedrich & Friederici, 2005) was employed: children viewed an image followed by a congruent or incongruent auditory word. EEG was recorded from 9 scalp electrodes, and statistical analysis at Pz was performed using permutation tests. Stimuli included 44 familiar child-appropriate words and pictures. A more negative ERP amplitude in the incongruent condition ($p < .05$) was taken as evidence of an N400 effect, indexing successful word learning.

- CI children: Significant N400 effects were observed after 7, 10, and 12 months of hearing experience. However, children with congenital deafness exhibited the effect only after 10 months of hearing experience.

- TH children: A weak N400 was detectable at 12 months of age, but a robust effect emerged only at 14 months. At 10 months, the effect was not detectable. Conclusions: This study provides the earliest systematic evidence for N400 as a neural marker of word learning in CI children. Importantly, congenitally deaf CI children require approximately 10 months of hearing experience to establish a measurable vocabulary, which is still earlier than NH children (12–14 months). The accelerated development in CI children is likely supported by compensatory advantages of older chronological age, such as greater memory capacity and attentional control, enabling them to catch up rapidly with their NH peers despite delayed auditory input.

Exploring rhythm processing in early development:
Let's drum and dance together.

Claudia Iorio, Mohammadreza Edalati, Betania Georlette, Laurel Trainor, Sahar Moghimi, Barbara Tillmann

Recent research has investigated the link between rhythm processing in music and language, both in typical and pathological development. The atypical rhythm processing hypothesis suggests that disruptions in rhythm processing during early childhood may contribute to broader cognitive difficulties, including neurodevelopmental language disorders. Previous work has mostly investigated school-aged children or infants between 18 and 30 months, often relying on drumming tasks to assess rhythm production and movement recordings for rhythm perception. In this study, we investigate rhythm processing and production in infants (6–18 months). In a first task, infants are filmed while drumming to an isochronous sequence and an unfamiliar song, first with a caregiver and then with both parent and experimenter. Aiming to investigate whether infants can produce the correct period and be in phase with the music, we analyze 1) movements of the infants' hand, and 2) movements of other body parts, which might be more sensitive to capture their potential rhythmic production and synchronization. In a second task, infants are observed moving to familiar and unfamiliar songs: first dancing with the parent and experimenter, then encouraged to dance alone. Videos are processed with machine-learning software to extract quantitative measures of rhythmic movement and its alignment with the sound and the adult(s). Parents also complete questionnaires assessing their child's musical exposure and general cognitive-motor abilities (e.g., ASQ). This work extends rhythm development research with behavioral methods to a younger age range and may inform understanding of both typical and atypical developmental trajectories.

Exploring the impact of tactile stimulation on rhythm perception in newborns.

Hegde Monica, Mohammadreza Edalati, Arthur Foulon, Anne Kosem, Barbara Tillmann, Sahar Moghimi

Rhythm perception is fundamental for early development. In adults, rhythm perception and beat-based predictions are supported by sensorimotor mechanisms. Caregivers naturally pat infants to music, but it remains unclear whether infants integrate sensorimotor input into rhythm perception. This study investigates whether tactile stimulation modulates neural tracking of auditory rhythms of lullabies in newborns. We are currently testing full-term newborns (N = 15/40) and measure EEG in two conditions: (1) Auditory-tactile, where lullabies with a beat at 2 Hz (Beat Level at 120 BPM) are paired with patting at 1 Hz (Strong Beat at 60 BPM), alternating 4 beats of auditory-tactile (AT) stimulation with 4 beats of auditory-only (A); and (2) Auditory-only, where infants hear the lullabies without tactile input. We will analyze (1) neural responses to auditory and tactile stimuli separately and then (2) further explore whether alternating AT and A stimulation enhances neural tracking of lullaby rhythms and synchronization to the beat. We will compare coherence between EEG signals and the amplitude envelope and temporal spectral flux of the lullabies. Preliminary FFT analyses of infants' EEG show increased power around 1 and 2 Hz for the Auditory-Tactile in comparison with the Auditory-only condition.

Hearing at Risk: Prevalence and Impact of Acquired Hearing Loss in Adolescents.

Ugo Benrubi, Axelle Calcus

Adolescents and young adults are increasingly exposed to high-intensity recreational noise, potentially leading to acquired hearing damage. Currently, no study has documented the prevalence of such acquired hearing loss (HL) among French-speaking adolescents in Belgium. However, studies conducted in similar industrialized regions of the world indicate that 17 to 19% of adolescents may experience slight/mild acquired HL. One major concern regarding slight/mild HL, as detected through pure-tone audiometry, is that it often goes unnoticed by the affected individuals. Research has shown that people who do not perceive any hearing issues are less likely to engage in protective behaviors that could safeguard their hearing. Moreover, even a slight degree of HL is significantly associated with poorer academic performance and speech recognition abilities.

A total of 188 adolescents (12–20 years) completed otoscopy, pure-tone audiometry, distortion-product otoacoustic emissions (DPOAEs), a speech-in-noise task (Children's Coordinate Response Measure, CCRM), and questionnaires on noise/music exposure and tinnitus (Noise Exposure Structured Interview, NESI ; Tinnitus Handicap Inventory, THI).

Analyses followed a preregistered plan (OSF: https://doi.org/10.17605/OSF.IO/2PV6A).

One participant (0.53%) exceeded the 35 dB HL PTA threshold, and 4.2% showed subclinical impairment (15–35 dB HL), significantly below the 15% prevalence reported in other industrialized cohorts. Speech-in-noise performance improved with age, particularly under informational masking, but PTA was not associated with speech-in-noise ability. As expected, DPOAEs correlated with PTA, but not with noise exposure. Music exposure predicted elevated PTA thresholds and greater tinnitus severity, while general noise exposure did not. Importantly, tinnitus severity (THI scores) correlated with poorer speech-in-noise performance in the two-talker condition, independent of PTA and DPOAEs.

Moderate or more severe hearing loss was rare, but subclinical deficits and tinnitus were already detectable in Belgian adolescents. Music exposure emerged as a key risk factor, associated with both higher thresholds and more severe tinnitus. Tinnitus severity, in turn, was linked to reduced speech-in-noise abilities, suggesting its potential as an early indicator of suprathreshold auditory dysfunction. These findings highlight the importance of preventive strategies targeting safe listening habits and the need for assessments beyond pure-tone audiometry to identify adolescents at risk.

How activity, age and acoustics shape speech and noise levels in active classrooms.

Visentin Chiara, Nicola Prodi

The sound environment of primary school classrooms is primarily shaped not only by teacher speech but also by the activity noise generated by the students themselves. While this activity noise reflects the interactive nature of learning, it can challenge speech perception, concentration, and ultimately task performance and learning. This study investigates the acoustic environment of 26 primary school classrooms (grades II-V) during lessons, using Gaussian Mixture Models to separate speech and activity noise across 93 homogeneous activity periods.

Results show that activity type strongly modulates the sound environment: teacher-led instruction and group work generated the highest noise levels, while quiet work was lowest. On average, activity noise reached 50 dB(A), with large variability driven by class-specific behaviours. Speech levels were consistently higher in interactive contexts and decreased by nearly 5 dB from Grade II to Grade V, underscoring developmental influences on classroom acoustics. Importantly, classrooms with greater speech clarity (C50) exhibited lower levels of activity noise, suggesting that acoustic design can moderate classroom activity noise patterns.

These findings highlight how the perception of active classroom sound environments is shaped by both activity patterns and acoustic conditions. They emphasise the need for acoustically ergonomic learning spaces that support communication, well-being, and inclusion, particularly for younger children.

Investigating Infants' Responses to Infant-Directed Communication Using Eye-Tracking.

Betania Georlette, Mohammadreza Edalati, Nolane C. Richard, Rafael Romàn-Caballero, Laurel J. Trainor, Miriam D. Lense, Barbara Tillmann, Fabrice Wallois, Sahar Moghimi

Infant-directed (ID) communication, including both singing and speech, provides infants with rich multisensory input that supports bonding, captures attention, and scaffolds early cognitive and social development. Singing, in particular, is characterised by strong rhythmic and melodic cues, which may uniquely shape infants' perceptual engagement. Building on prior work (i.e., Lense et al., 2022), this study examines how French-speaking infants visually respond to ID communication, with a specific focus on the role of rhythmic properties. Fifty Infants from 5 to 18 months were exposed to videos of women singing and speaking while their gaze was recorded using eye-tracking. Analyses addressed the relationship between gaze dynamics and rhythmic features of the stimuli, including auditory cues (spectral flux of singing and speech) and visual cues (head and facial movements).

To examine this relationship, we applied a multivariate Temporal Response Function (mTRF), predicting infants' gaze velocity from naturalistic audiovisual signals. Results showed that visual information alone significantly predicts gaze behaviour. For ID singing, adding auditory rhythmic information (i.e. temporal-spectral flux) improved model predictions, suggesting that infants' attention is guided not only by visible cues but also by the underlying temporal structure of the music. In contrast, for ID speech, adding the temporal-spectral flux did not improve model predictions.

Findings indicate that infants' gaze is predominantly influenced by visual cues, yet rhythmic properties of singing further contribute to the way attention is structured. This rhythmic organisation may provide an important foundation for the emergence of early communicative and social skills.

Neonatal learning of speech sound patterns.

András Ambrus, Tóth Brigitta, Polver Silvia, Winkler István, Haden Gabor Peter

The automatic capacity to extract, encode and utilize statistical properties of the ever changing sensory environment, known as statistical learning (SL), is a fundamental ability already present from birth. Detecting longer recurring auditory patterns consisting of as many as 10 pure tones is proved to be present in newborn babies. This can be explained by learning the transitional probabilities between tones, i.e., by SL. Whereas pure tones only provide information about pitch transitions, speech includes a wealth of acoustic information. This study investigated whether sleeping newborns (N= 35; up to 2 days of age) detect regularities in speech-like sound sequences, comparing neural responses to regularly recurring and random pseudo-syllable sequences. Using time-locked EEG measures, we found that neonates show distinct electrophysiological responses to regular versus random patterns, indicating that the neonatal auditory system is sensitive to structured syllable sequences. These findings suggest that even at a very early age, infants can exploit redundancies in speech input, an ability underpinning later language acquisition. While it remains to be established whether the detection of structured syllable sequences emerges earlier than in the tone-based version of the task (as observed in our pilot study), the present results provide an important step toward identifying early neural signatures of pattern learning in speech. Such responses may serve as potential biomarkers of language learning capacities in early infancy, offering a window into the developing mechanisms that support speech segmentation and grammar acquisition. Beyond their theoretical relevance, these results underscore the methodological value of the current paradigm: it provides a robust, non-invasive, and replicable tool for probing the infant brain's capacity to extract structure from continuous auditory input. This paradigm can be extended to assess individual differences and atypical trajectories, contributing to the early identification of infants at risk for language disorders.

Phonological feature encoding depends on the sensory modality available during the first year of life.

Alessandra Federici, Marta Fantoni, Chiara Battaglini, Francesca Collesei, Giacomo Handjaras, Eva Orzan, Benedetta Bianchi, Giovanni Di Liberto, Davide Bottari

Native phoneme categories are typically established in the first year of life, guided by the statistical distribution of speech sounds in the environment. But what happens when auditory experience is absent during this sensitive period? Is the window postponed until auditory access is restored later in development, or does it close independently of auditory experience? In cases of congenital deafness (CD), infants rely exclusively on visual speech cues in early ontogeny. If the sensitive period for phoneme category acquisition is modality-independent and close even in the absence of auditory experience, CD children should have acquired only visually distinguishable phoneme categories, and not those requiring acoustic cues. To test this hypothesis during naturalistic speech processing, we recorded EEG responses to continuous audio and audiovisual speech in 37 hearing children (HC) and 38 cochlear implant users, half with CD and half with acquired deafness (AD). Only CD participants were auditory-deprived during their first year of life.

We used multivariate temporal response function modelling, to predict individual EEG responses from acoustic and phonological features: acoustic envelope, phoneme onsets, and, depending on modality, voicing (i.e., voiced vs. voiceless) for visually indistinguishable consonant pairs in the auditory condition, or place of articulation (i.e., alveolar vs. labial) for visually distinguishable pairs in the audiovisual condition. Successful encoding of each feature was quantified as the additional EEG predictive gain obtained by including each phonemic predictor.

Phoneme onset information improved prediction across all groups and conditions, indicating that this basic aspect is encoded regardless of early auditory experience. By contrast, phonetic features processing depended on input during the first year: unique auditory contrasts (voicing in the auditory condition) were encoded only by HC and AD, whereas visually available contrasts (place in audiovisual condition) were encoded by all groups, including CD.

These results indicate a modality-independent sensitive period for phoneme category acquisition: infants form categories from the speech features accessible to them during the first year of life (auditory or visual), thus contrasts absent during that window are not successfully encoded during naturalistic speech processing.

These findings highlight the biological basis of phonological categorization and reveal that restoring auditory access after a period of congenital deprivation does not reinstate typical phoneme discrimination, ultimately indicating that the underpinning circuitry matured employing the information available during the sensitive period.

Study of processing skills and developmental auditory responses in deaf children with cochlear implants and prelingual onset (Sparci).

Carolina Leal, Deborah Vickers

This PhD study examines the link between auditory processing, specifically spectro-temporal discrimination, and speech and language outcomes in children with cochlear implants (CIs). Using a novel non-speech-based test (cSTRIPES), the research evaluates its reliability and feasibility in paediatric CI users and explores its potential as a proxy for speech-in-noise perception and vocabulary development. The study also investigates voice cue perception, discrimination, and gender categorization, and their relationship to spoken language outcomes. A third objective assesses how individual factors such as socio-economic status and residual hearing influence speech-in-noise and vocabulary performance over time, using latent variable profiling. The test battery includes cSTRIPES, CCRM, CAPT, BPVS, Renfrew Word Finding Vocabulary, and a voice discrimination task adapted for English-speaking children with CIs. Assessments are conducted at two time points to track developmental changes. Findings aim to inform clinical assessment and intervention strategies for children with CIs, particularly those with spoken language difficulties. Only preliminary finds can be presented at this stage.

The influence of tempo on neural encoding of rhythmic hierarchy in neonates.

Mohammadreza Edalati, Fabrice Wallois, Alban Gallard, Maya Psaris, Arthur Foulon, Laurel J. Trainor, Sahar Moghimi

Perceiving time intervals and structure of rhythmic patterns are of fundamental developmental importance, for instance for language, music, and social skills. Rhythm experience starts very early, during the prenatal period of development with the auditory system becoming functional as young as 24-25 weeks gestational age. We have recently shown that the neural following of auditory rhythm develops progressively during the third trimester of gestation, and that importantly its emergence might be tempo dependent (Saadatmehr et al. 2024, J Neuroscience). In the current study, we further address the impact of tempo on neural following of the rhythmic structure comparing neural responses of newborns to those of adults in a high-density EEG study. To address the impact of tempo on neural synchronization at two stages of neurodevelopment, we used the same repeating 6-beat ambiguous rhythmic pattern at two tempi, with the beat frequency equal to 3.33 Hz and 6.66 Hz for slow and fast tempi, respectively. We found stronger neural synchronization at the faster frequency in neonates, while adults exhibited stronger neural synchronization at the slower frequency. We conclude that tempo (cycle duration) plays an important role in the neural coding of the rhythmic hierarchy at the early stage of neurodevelopment and that neural synchronization to slower periodicity improves with age. These results shed light on early neural capacities for coding temporal regularities and together with our previous studies highlight the fast evolution of rhythm processing during this phase of neurodevelopment.