The P2LINK project – The Perception-Production Link in Early Infancy:

A language acquisition oral-motor intervention study

Marina Vigário[1], David Casimiro Andrade[2], Marisa Filipe[1],

Sónia Frota[1] & the P2LINK team[1,2,3]

[1]Center of Linguistics, School of Arts and Humanities, University of Lisbon, Portugal, [2]Faculty of Dental Medicine, University of Porto, Portugal, [3]Collegium de Lyon, France

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Introduction

. Early **speech perception** → foundational role in language acquisition with cascading effects on language outcomes [1, 2, 3, 4, 5]:

Speech discrimination & Processing abilities in the 1st year of life → Developing attunement to the perceptual properties of the native language → Learning of phonetic, prosodic & phonological categories → Bootstrap word learning & syntactic processing

. **Experimentally induced oral-motor impairments have recently been found to compromise speech perception** in early infancy [6].
. Prior work has mostly focused on phonemes; generalizability and potential cross-domain impact of sensorimotor influences is yet unknown.
. The effects of long-term oral-motor impairments on the development of speech perception abilities and their impact on language acquisition are also still unknown.

. Oral-motor impairments are found in clinical populations with oral-motor dysmorphologies (e.g., hypotonia, tongue protrusion, and short palate).

Figure 1 – Open mouth and tongue protrusion, hypotonic lips, incomplete lip closure in DS (taken from [8]).

. Therapeutic interventions - rapid maxillary expansion (RME) device, palatal plates and pacifier-shaped devices have been proposed to treat these conditions in infancy, as in the case of Down Syndrome (DS) [7, 8].

Figure 2 –RME device: (a) before expansion; (b) at maximum expansion (taken from [9])

. No study has yet examined whether and how these interventions, and the devices used, may impact perceptual development and language acquisition.

P2LINK project main goals:

(1) Expand the testing of sensorimotor influences on infant speech perception to a **novel phoneme contrast**, and beyond segmental phonology including prosodic distinctions (> **perception of word stress** and **intonation contrasts**);

(2) Offer the first study on **whether infants spontaneously move their tongue when listening to speech**;

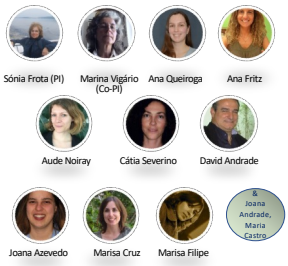
(3) Measure the **relation between later language outcomes and the impact of sensorimotor influences on early speech perception**;

(4) **Design and test a pacifier-shaped device** that may be amply used in **clinical populations** to improve oral morphology, and that is **validated from the auditory-motor perspective as not restricting perceptual abilities;**

(5) **Assess the benefits of the device** both for oral morphology and language development through **a longitudinal intervention study with infants with Down Syndrome.**

- ✓ Using a combination of non-invasive methods (eye gaze, eye-tracking, ultrasound imaging, parental reports, developmental scales – see Figs. 3-5);
- ✓ Taking advantage of tested experimental paradigms, language assessment instruments and norming or reference data for Typically Developing (TD) and European Portuguese-learning infants with Down Syndrome (DS), developed at the Lisbon Baby Lab – LBL (CLUL/FLUL) [5, 10, 11, 12];
- ✓ Building on prior extensive work from the Faculty of Dental Medicine, UPorto team [8, 9, 13] (see Fig. 6).

The team



The research program

. A series of studies of sensorimotor influences in typically developing 6-month-olds (see Figs. 7-9).
. Combining cross-sectional and longitudinal designs, experimental online measures of auditory processing, measures of tongue shape/movement, and parental reports and language assessment tools
+ a longitudinal intervention study (see Fig. 10).

Participants:
~170 TD infants, recruited by the LBL team;
~25-30 DS infants, recruited with partner institution Center for Child Development – 'Diferenças'.

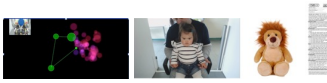


Figure 3 – Images from previous perception experiments run at the LBL, using eye tracking and eye gaze methods.

Figure 4 – CSBS and CDI-I questionnaires adapted and validated to European Portuguese by the LBL team.

Figure 5 – Ultrasound image of the tongue using Articulate Instruments' Micro (manufacturer's material).

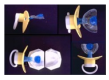


Figure 6 – Modification of the traditional plate like a pacifier-shaped device by Andrade and colleagues [13] (taken from [8]).

Series of studies on sensorimotor influences on speech perception (TD)

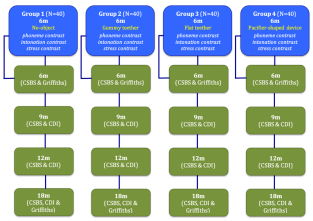


Figure 7 – Flowchart of the studies of sensorimotor influences on speech perception in typically developing infants. Experimental studies in blue and language assessments in green. Each column, different group of participants.

Ultrasound imaging study

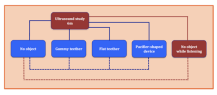


Figure 8 – Flowchart of the ultrasound imaging study to characterize tongue placement while listening/not listening to speech.

Figure 9 – Illustration of devices used for experimentally induced oral-motor impairments: flat teether (A) and gummy teether (B) (from [19]), and pacifier-shaped device (C) (from [8, 13]).

Intervention study

. Using an intraoral scanner (IOS) device, individual 3D printed plates will be produced for each infant (Fig. 9C);
. The oral-motor intervention: repeated daily use of the modified pacifier-shaped plate; minimum of 1-2 hours per day (along the lines of [7, 8, 13]). Minimum duration of the plate therapy = 4 months (see Fig. 10);
. Immediately prior to the beginning of the intervention, oral-morphological features are assessed (following [6]) + ultrasound imaging study and the speech perception experiments, following the same procedures as with TD infants (see Fig. 8).

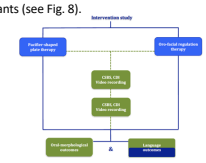


Figure 10 – Flowchart of the intervention study with DS participants.

Every 3 month:
. 5-minute video samples (to be analysed with ELAN);
. CSBS-DP and CDI data (to be compared with data from the reference sample of the H21 project [12]).

The outcomes of the project will

- ✓ advance current knowledge on the perception-production link in typical language acquisition and in language impairments;
- ✓ deliver applications of benefit to various child health conditions characterized by oral-motor impairments (e.g., Down Syndrome, Mobius and Pierre Robin Syndromes, Congenital Cerebral Palsy);
- ✓ foster the early identification of language impairments, supporting new and more effective interventions;
- ✓ contribute to a better health and education prospect in an inclusive society (United Nations Sustainable Development Goals – 2030, #3 & #4).

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Contact addresses: sfrota@edu.ulisboa.pt; mvigario@edu.ulisboa.pt; labfon@letras.ulisboa.pt