

**Formulário Relatório Final - Componente Científica**

**1. Identificação do Projecto**

**Referência do Projecto:** PTDC/MHC-LIN/3901/2014

**Investigador Responsável:** Sónia Marise de Campos Frota

**Instituição Proponente:** Faculdade de Letras da Universidade de Lisboa (FL/ULisboa)

**Data de Início:** 04-04-2016 **Data de Fim:** 03-12-2019 **Financiamento**

**Concedido:** €166.360,00

**2. Caracterização Sumária do Projecto**

**Objectivos do Projecto (indicar endereço electrónico do(s) site(s) criado(s), quando aplicável)**

Interest in research on early language development has been growing, and a key question relates to the characterization of language development in the specific case of language disorders. Speech perception abilities in the 1st year of life have been suggested to play a decisive role in speech segmentation (discrimination of phonetic units, syllables, words, phrases, and their sequencing), which in turn trigger word learning and syntax processing. Impaired discrimination abilities for any of these speech contrasts may thus lead to language deficits. Language deficits occur in a variety of neurodevelopmental disorders, including intellectual disabilities. Among the latter, Down Syndrome (DS) is by far the most common genetic cause of mental retardation, with a relatively high prevalence rate. Surprisingly, language impairments in DS are among the least studied, and research has mostly focused on vocal quality and speech production abnormalities. So far, the research focus has not included early language, and especially infant speech perception abilities, and thus early markers of language development in DS are largely unknown.

The Horizon21 project (H21) is the first in the national scope, and one of the very few in the world, to focus on the study of early language development in Down Syndrome. Unique features of the project, which still hold today, are (i) the observation of very young infants (from 5 months of age), (ii) the examination of language abilities in different linguistic domains, (iii) the combination of methodologies used, including behavioral and neurophysiological paradigms, together with developmental assessment tools, and (iv) the comparison of DS subjects' performance not only with typical developing children (TD) but also with groups of children at-risk for language impairments (AR), through the application of similar research protocols. Thus, the project aimed to contribute to the language development/impairment field of research by focusing on DS infant and toddlers speech processing abilities in different linguistic domains, using a multimethodology approach (traditional looking paradigms, eyetracking measures and ERP measures) to a set of potential early markers in a prospective study where infants tested from 5-6 months were followed until 30 months of age (or even later). Besides measuring their performance on a set of perception

tasks targeting speech sounds, stress, intonation, or prosodic phrasing early discrimination abilities, results on these tasks would be related to measures of later language outcomes (vocabulary, morphology, syntax, prosody).

In addition, the project had three larger goals in the long run, which naturally followed from the innovative nature of the proposed research program: (1) Given that previous research focused on TD, other neurodevelopmental disorders like Autism Spectrum Disorders and Language Impairment (formerly SLI), new data on DS infants/toddlers speech perception, in matched experimental conditions, might provide crucial insights for the understanding of language impairments and how they relate to cognitive abilities, and also for theories of language acquisition. (2) A prospective study examining language development in DS in different linguistic domains and in methodologically comparable ways to studies on other developmental disorders will attempt to determine whether early markers of language impairments have a broad general nature, or domain specific markers can be found (i.e., perception of prosodic features based on different types of auditory cues, like stress and intonation; prosodic features that involve sequencing and integration of information), depending on the etiology of the disorder, the type of language impairment (e.g., vocabulary, morphology, syntax), or other factors (such as nonverbal abilities). This investigation might thus increase our understanding of similarities and differences across early markers with potential clinical implications. (3) New and detailed knowledge of early language development in DS will identify relative strengths and weaknesses across the linguistic domains observed that may not only distinguish DS from other disorders, but also distinguish between individuals with DS, providing critical information for designing interventions to support language acquisition.

H21's findings are thus a major contribution to previous knowledge on early language acquisition and atypical development, with social, familial and individual benefits towards a more inclusive society. The multidisciplinary team, which includes the collaboration with professionals in neurodevelopment field, strengthens the potential of translational research with impact on the health and medical sectors. The web site of the Project (<http://labfon.letras.ulisboa.pt/babylab/horizon21/index.html>) was created as a platform for knowledge dissemination and outreach, both for the scientific community and the general public, to involve the community in the Project, to acknowledge partnerships, and to disseminate the outcomes of the project. These and all the project related activities were also announced in the Lisbon Baby Lab social media (Facebook and Instagram), and reflected in the Lisbon Baby Lab Newsletter. Research Gate has also been used as a platform for dissemination.

### **Breve descrição das actividades desenvolvidas bem como dos desvios ocorridos durante a execução do projecto**

The project included 5 tasks: (1) recruitment and early assessment of participants; (2) looking while listening experiments and (3) ERP experiments, two tasks devoted to experimental data collection; (4) assessment of later language abilities, where the language abilities of each infant/toddler that participated in tasks (2) and (3) were measured currently and at different points in development up to the age of 30 months (or even later on in development); (5) early markers of language development in DS, where analysis of data gathered in tasks 2, 3 and 4 were aimed at characterizing the language development profile in DS and identifying predictors of later language and communication outcomes.

The research protocol followed the main features of that used in the EBELa project, which was approved by the Hospital de Santa Maria (Centro Hospitalar Lisboa Norte) ethics commission and the Administração Regional de Saúde de Lisboa e Vale do Tejo ethics commission. The H21 project was also approved by Comissão de Ética para a Investigação da FLUL (1\_CEI2018).

During the first year of the project, the main focus of the research team was twofold: recruitment of participants and all the networking of collaborations related to this task (task 1), and the design and testing of the experimental paradigms (tasks 2 and 3). The beginning of the project's activities was prepared by a meeting with the project consultant Dr. Miguel Palha to examine and discuss in detail the goals, methods and procedures to follow, especially in what concerned the recruitment of participants. A methodology was put in place involving the clinical team from the Center for Child Development – 'Diferenças', the main center for Down Syndrome in Portugal. The procedures followed and progress made were assessed periodically, and changes were implemented when necessary as described below. Early assessment of DS participants through the CSBS DP checklist and the Griffiths 0-2year Scales as initially planned was implemented. However, it was soon found that the early administration of the Griffiths was not compatible with the participation in the experimental tasks within the same visit, thus requiring an extra visit to the lab that most caregivers were unable to do. Thus, the early assessment using the Griffiths had to be dropped from the research protocol. The paradigms of the 7 looking while listening experiments planned in the application were designed and underwent pilot testing and revision. Given the expected low numbers of DS participants, one of the eye-tracking tasks - the phonetic discrimination of a native and a nonnative segmental contrast – which involved high numbers of subjects was low ranked and priority was given to all the other tasks. The phonetic discrimination task was later excluded from the set of experimental tasks to maximize participation in 6 other experimental tasks. The paradigms of the ERP experiments initially planned were also designed and underwent pilot testing and revision. As for Task 2, the experiment related to phonetic discrimination was excluded. For the other ERP experiments, and given the absence of adult ERP studies for European Portuguese (EP) in these domains, adult testing was completed. Infant testing of TD participants started, as well as testing of DS participants. The activities related to task 3 were delayed due to the absence of the post-doc researcher that was away from Portugal for more than two months. Finally, and according to plan, the language abilities of the infants tested in experimental tasks were measured in intervals of 6 months, using the Portuguese Communicative Development Inventory (CDI) short form (infant and toddler) European Portuguese versions. For a subgroup of participants, their language and communication abilities were also measured with the Portuguese adaptation of the screening tool CSBS DP.

The first year was also a period of intense dissemination and outreach activity (see the detailed description file), with an article published presenting the project to the large DS community, invited talks and posters given at different social and professional forums (International CountDOWN Congress, Centro Hospitalar Lisboa Central, Conferência Anual da Rede Saúde), and research activities featured on the news, both on TV and national newspapers.

In the second year, the activities were distributed among the first 4 tasks, with a major focus on tasks 2, 3 and 4 as planned. An evaluation of the project's activities was discussed in a meeting with the project consultant Prof. Leonard Abbeduto (June 2018). The goals, methods and procedures implemented, and the results obtained so far, were examined in detail. Given that the recruitment of participants with Down Syndrome was a crucial point of concern, new

actions were implemented to promote the participation of families with infants and toddlers with Down Syndrome. Besides actions of dissemination, a new procedure put in place through the presence of a researcher at Diferenças to ensure a direct contact with the families and facilitate recruitment. The focus of the second year of activities was on implementation of the experimental paradigms and respective data collection (tasks 2 and 3), and the longitudinal assessment of later language abilities of the infants/toddlers tested (task 4). In addition, efforts have been directed towards working sessions and training activities involving team members, including those not based in Lisbon (for example, an EEG training course given by Dr. Andrew Hanson, from Newcastle University, UK, was promoted within the project). The final versions of looking while listening experiments were completed and data collection was in progress. With respect to TD participants, the experimental tasks involving eye gaze were closed with the exception of 2. As for the ERP tasks, the results from the adult studies were analyzed and a paper submitted. Infant testing of TD participants, as well as DS participants, was ongoing. The activities related to task 3 were again delayed given that the post-doc hired to work on this domain in the project had to be dismissed from her functions due to misconduct, a fact that led to the loss of data and extra demands of cross-checking of the work previously done in this area. Following the language assessment plan, the longitudinal assessment of language abilities of the infants tested was implemented. Overall, 32 CDI short forms were already collected, and pre-processing of the data proceeded on a regular basis upon receipt of the CDI forms. A first analysis comparing DS infants with TD participants and infants at-risk for language impairments was implemented.

A major activity in the second year was the organization of the 16th International Conference on Laboratory Phonology – LabPhon16, with the theme ‘Variation, development and impairment: Between phonetics and phonology’ (<http://labfon.letras.ulisboa.pt/LabPhon16/>). The conference was a major opportunity for discussion of language development and language impairment in typical development and developmental disabilities, including Down Syndrome.

The final year of the project, including the 8 additional months of extension granted, was devoted to all the 5 tasks. There was a continued focus on data collection (tasks 3 and 4) and longitudinal assessment (task 4), together with the first approaches towards the establishment of early markers of language development in DS (task 5). We have also strengthened the team’s involvement in training activities, which included a training session on Eyetracking using EyeLink systems. Presently, we have 46 participants registered in our database (although 10 could not participate in the research program). The data points collected for the experimental tasks were 111 (i.e., 111 experiments were run), and for the longitudinal language assessment 172, with an average of 8 data points per participant (for more details see the detailed description file attached). Importantly, the participants that entered the program and have not yet concluded it will be followed until they are 30 months of age. Furthermore, we are currently following a subgroup beyond 30 months of age, given that certain language abilities are not yet developed and the instruments used are able to capture further development because no ceiling effects have been found. Thus, further testing and longitudinal assessment will proceed and all the data processing and infant evaluation will feed the final analysis towards the identification of early markers of language development in DS (task 5). Experimental data collection with the looking while listening experiments proceeded in good pace, with the TD tasks all closed except one, and the DS segmentation task and word learning task in its final numbers. A proceedings paper on the DS word segmentation results has been already submitted. The exploration of DS infants eye gaze patterns to talking faces was pursued as a new task, given the data availability and the promising results obtained with TD

infants. A paper comparing DS and TD eye gaze findings will be submitted soon. Further difficulties arose with the ERP tasks, given that all the data collection from one of the adult studies had to be discarded due to experimenter error and a new data collection process started. Nevertheless, a paper on the other adult study was published, and data collection with infants and toddlers continued. According to plan, the longitudinal assessment of later language abilities of the infants tested proceeded. The analysis of considerable sections of the data from tasks 2, 3 and 4 yield several deliverables (i.e., presentations at national and international conferences, publications in peer-reviewed proceedings and journals).

As planned, a workshop was held with the main goal of presenting and discussing the major project's findings with the local and international communities, deepen knowledge transfer and contribute to the dissemination of the H21 research program. NeuroD-WELL, the Lisbon Workshop on Early Language in Neurodevelopmental Disorders, was held at the School of Arts and Humanities of the University of Lisbon on November 8, 2019 (<http://labfon.letras.ulisboa.pt/NeuroD-WELL/index.html>). It brought together researchers and practitioners working on language development and neurodevelopmental disorders, from a multidisciplinary perspective (Clinical Linguistics, Cognitive Science, Linguistics, Neurolinguistics, Psycholinguistics, Psychiatry, Psychology, Pediatrics, Speech and Hearing Sciences, Speech Therapy, among others). It included two invited speakers, an open call for papers for oral and poster sessions, and a special session on Down syndrome.

Contributing to the achievement of one of the main goals of the project, dissemination and outreach, together with translational research were particularly promoted along this period, through the strong partnership with Diferenças ([https://diferencas.net/?page\\_id=215](https://diferencas.net/?page_id=215)), a new partnership with Centro de Estudos do Bebê e da Criança (Hospital D. Estefânia), invited talks directed to pediatricians, psychologists, speech therapists and other clinical staff, and participation in clinical meetings with submitted work (Lusíadas Clinical Summit). The project's research was featured on the news, both in the Saúde TV and a major daily newspaper (Jornal Público). Overall, the societal impact and diffusion of the project's activities and outcomes was quite strong, greatly overcoming the dissemination actions planned in the project's application.

## **Objectivos atingidos**

The H21 project is a research program to study of early language development in Down Syndrome through the examination of language and communication abilities in different linguistic domains. Related goals included the (i) the development/adaptation of experimental paradigms and language assessment tools, and (ii) the comparison of DS subjects' performance with typical developing children (TD) as well as with groups of children at-risk for language impairments (AR), through the application of similar research protocols. Thus the availability of findings for TD children, and in some studies also for adults, was a desideratum within the project.

The specific goals of the project were accomplished, and the challenges faced overcome: (1) establishing a networking procedure of participant recruitment of infants and toddlers with DS; (2) the set up of the Lisbon Baby Lab EEG lab; (3) the development/adaptation of experimental paradigms and language assessment tools to meet the needs of the project; (4) a novel contribution to profiling the development of DS infants and toddlers' abilities in the domains under study; (5) a contribution to the identification of early markers of language development

in DS, by means of measuring concurrent abilities and later outcomes; (6) the establishment of research dissemination and collaboration among the research, clinical and social communities laying the foundations for translational research in the field.

1. Infant studies typically face the challenge of recruitment. An even bigger challenge is faced when these studies focus on clinical groups, as in the case of H21. Through our partnerships with Diferenças and APPT21, together with other health institutions and individual collaborations, a procedure was put in place to allow a direct contact with potential participant families and introduce them to the project. Recruitment efforts were active during the 3 years of the project. Given that 321 babies with DS were born in Portugal between 2008 and 2017, with an average of 32 per year (source: Instituto Nacional de Saúde Dr. Ricardo Jorge), the project was able to recruit more than 1/3 of the babies with T21 in the whole country during the relevant time span. Considering that the research was exclusively based in Lisbon, we consider this recruitment rate a success.

2. A major achievement during the first year was the set up of the new Lisbon Baby Lab EEG lab that was fully equipped. This was possible due to funding from H21 and outside funding (QREN – PORLisboa, FLUL, and private fund raising). This new facility offers a baby-friendly environment using up to date equipment. Infants and toddlers could thus be tested on different tasks during the same visit of the lab, which greatly facilitated the collaboration of families and the data collection process.

3. The paradigms of the looking while listening and ERP experiments underwent pilot testing with infants and toddlers with DS. The age range for the word segmentation experiment and the word learning experiment was extended up to 24 months given the delayed emergence of these abilities according to preliminary findings. To our knowledge, we conducted the second study on word segmentation in DS (the only one published so far looked at English-learning toddlers), and the first studies on intonation discrimination, stress discrimination, and sensitivity to prosodic boundaries, as well as the first study on eye gaze patterns to talking faces with young infants with DS. The findings from the experiments that adapted traditional looking paradigms were published in journal papers (for TD and DS; *Journal of Child Language*, *Revista de Neurología*), book chapters, and a proceeding paper comparing TD, DS and AR has been submitted. The findings from eye-tracking experiments were reported in a journal paper recently accepted for publication (TD; *Journal of Portuguese Linguistics*), and two journal papers to be submitted soon (TD and DS). This research has also led to presentations at international and national scientific meetings. Two adult ERP studies were published in international journals (*Frontiers in Psychology*), and the findings therein reported set the stage for the interpretation of the infant and toddler data under analysis. The use of the Portuguese CDI short forms as a language assessment tool for infants and toddlers with DS yield promising results, which were presented at national and international meetings. Given that no ceiling effects have been found, data collection with older infants and toddlers was implemented both for CDI-I and CDI-II. The full data set is currently being analysed. The CDI instruments are now being used in the clinical assessment of infants and toddlers with DS, which is one of the most important outcomes of H21 in the domain of translational research. We have also used the Portuguese version of the CSBS screening tool providing the first data on DS for communicative development between 6 and 24 months using this tool.

4. The goals achieved allowed a contribution to the understanding of the knowledge of DS infants and toddlers' abilities in the domains under study. Profiling the development of DS infants and toddlers' language abilities is certainly a major breakthrough for research on

neurodevelopmental disorders, as well as clinical practice. For example, we have shown that the developmental path of word segmentation abilities in DS is not only delayed, but follows a pattern different from TD infants (Lancaster Conference on Infant and Early Child Development). DS infants and toddlers show a slow and protracted development of both receptive and expressive vocabularies in oral language, as well as of the emergence of word combinations, not only in comparison with TD but also with AR children (NeuroD-WELL, Clinical Summit). Besides the comparison with TD and AR language development profiles, we have the additional goal of providing specific CDI norms for language development (vocabulary and syntax) in DS.

5. The goals achieved also allowed a contribution to the identification of early markers of language development in DS. For example, the use of prosodic cues for word segmentation in DS correlated with better concurrent vocabulary scores (Speech Prosody, submitted), demonstrating that DS infants and toddlers may use prosody to promote word segmentation as TD infants do (Journal of Child Language), and this in turn may impact vocabulary development. Ongoing analyses are measuring the correlation between specific language abilities as shown by performance in experimental tasks and later outcomes.

6. Last but not least, the collaboration among the research, clinical and social communities achieved under H21 was well beyond the initially planned dissemination activities using the project website and some meetings with interested parties. A strong interaction with relevant stakeholders was achieved through many different means: dissemination papers, invited talks directed to pediatricians, psychologists, speech therapists and other clinical staff and participation in clinical meetings (International Congress CountDOWN, Jornadas do Centro de Estudos do Bebê e da Criança - Comunicação e Linguagem na Infância, Jornadas de Trissomia 21, Rede SAÚDE, Jornadas de Terapia da Fala, Lusíadas Clinical Summit), interviews and news on TV (CMTV, Canal Saúde ) and national newspapers (Correio da Manhã, Público). In addition, the Lisbon Baby Lab Newsletter, and the lab's Facebook and Instagram have brought the project's activities and outcomes to caregivers and the global society.

### **Realização Financeira (justificação sumária dos desvios ocorridos durante a execução do projecto)**

During the project execution period, the following changes to the initial application were requested and granted.

#### **(i) Human resources**

The human resources rationale was adjusted and a BI (30 months) was converted into a BPD grant (15 months) in the first year of the project. The post-doc hired to work on the ERP tasks had to be dismissed due to misconduct, a fact that led to the loss of data and extra demands of cross-checking of the work previously done in this area. This situation led to the estimated need of additional 6 months to accomplish the research plan established.

#### **(ii) Equipment**

Project funds contributed to the acquisition of a new eye-tracking equipment, given that the older equipment available was discontinued and not benefitting from customer support. This was implemented through budget changes across different budget categories. The equipment

arrived later than initially arranged, which required another 2 months for the execution of the research plan.

(iii) Workshop

The project workshop could only take place in November 2019, due to the circumstances that constrained the research program and the personal availability of the keynote speakers and project consultants. This was also a fact that required the additional extension of 2 months mentioned above.

## 5. Indicadores de Realização Física

Indicadores	Quantidade realizada
<b>A - Publicações</b>	
Livros	2
Artigos em revistas internacionais	5
Artigos em revistas nacionais	2
<b>B - Comunicações</b>	
Comunicações em encontros científicos internacionais	18
Comunicações em encontros científicos nacionais	14
<b>C - Relatórios</b>	4
<b>D - Organização de seminários e conferências</b>	8
<b>E - Formação avançada</b>	
Teses de Doutorado	0
Teses de Mestrado	0
Outras	3
<b>F - Modelos</b>	0
<b>G - Aplicações computacionais</b>	0
<b>H - Instalações piloto</b>	0
<b>I - Protótipos laboratoriais</b>	0
<b>J - Patentes</b>	0
<b>L - Outros</b>	
Database of early markers of language development	1



## 6. Publicações

Complete list of outputs organized by date within each of the categories indicated in the table under section '5. Indicadores de Realização Física'. URL available at the web site of the project: <http://labfon.letras.ulisboa.pt/babylab/horizon21/publicacoes.html>

### A. PUBLICAÇÕES

#### Livros

N/A

#### Artigos em Revistas Internacionais

Accepted - Cruz, M., Butler, J., Severino, C., & Frota, S. (In press). Eyes or mouth? Exploring eye gaze patterns and their relation with early stress perception in European Portuguese. To be published in the Special Collection *Laboratory Approaches to Portuguese Phonology* (Eleonora Albano & Didier Demolin, eds.) of the *Journal of Portuguese Linguistics*. [Submitted: September 2019; Accepted: January, 2020]

Published - Silva, S., Vigário, M., Leone-Fernandez, B., Jerónimo, R., Alter, K., & Frota, S. (2019). The sense of sounds: Brain responses to phonotactic frequency, phonological grammar and lexical meaning. *Frontiers in Psychology*, 10, 681, 28 March 2019. <https://doi.org/10.3389/fpsyg.2019.00681>

Published - Butler, J., & Frota, S. (2018). Emerging word segmentation abilities in European Portuguese-learning infants: New evidence for the rhythmic unit and the edge factor. *Journal of Child Language*, 1-15. doi:10.1017/S0305000918000181 <https://www.cambridge.org/core/journals/journal-of-child-language/article/emerging-word-segmentation-abilities-in-european-portuguese-learning-infants-new-evidence-for-the-rhythmic-unit-and-the-edge-factor/CC4C7F35A84C4969B88835B996BE8B1F>

Published - Lu, S., Vigário, M., Correia, S., Jerónimo, R., & Frota, S. (2018). Revisiting Stress “deafness” in European Portuguese – A Behavioral and ERP Study. *Frontiers in Psychology*, 9, 2486, Dec 10 2018. doi: 10.3389/fpsyg.2018.02486

Published - Butler, J., Severino, C., Correia, S., Vigário, M., & Frota, S. (2016). The emergence of early word segmentation abilities in typically developing infants and infants with Down syndrome. *Revista de Neurologia*, 62 (C01), p. C267, May 2016. Info: <http://www.neurologia.com/revista/62/C01>

#### Artigos em Revistas Nacionais

\* Published – Frota, S. (2017). Estudar o Desenvolvimento da Linguagem nos Bebés. *Descubra as Diferenças* (electronic journal), 26: e-pub, December 2017. <https://revistadescubraasdiferencasdezembro2017.wordpress.com/2017/12/12/estudar-o-desenvolvimento-da-linguagem-nos-bebes/>

\* Published – Frota, S. (2017). Horizonte 21 - Novas linhas de investigação em Trissomia 21. *Descubra as Diferenças* (electronic journal), 19:e-pub, May 2017.

<https://revistadescubraasdiferencasmaio2017.wordpress.com/2017/05/01/horizonte-21-novas-linhas-de-investigacao-em-trissomia-21/>

## **B. COMUNICAÇÕES**

Submitted – Frota, S., Pejović, J., Severino, C., & Vigário, M. (Submitted). Looking for the edge: Emerging segmentation abilities in atypical development. Submitted for the *10<sup>th</sup> International Conference on Speech Prosody*, May 25-28, Tokyo, Japan. [Submitted: December, 2019]

### **Comunicações em Encontros Científicos Internacionais**

Presented – Frota, S. (2019). Early markers of language development in typically and atypically developing infants and toddlers. Invited talk presented at the *Workshop on Language and the Brain (WoLB 2019)*, October 3-4, 2019, Vigo, Spain.

<https://tv.uvigo.es/video/5dd4fa601e19c03d1649a7cc>

Presented - Frota, S., Severino, C., Pejović, J., Butler, J., Vigário, M. (2019). Looking for the edge: Emerging segmentation abilities in atypical development. Talk presented at *Workshop on Early Language in Neurodevelopmental Disorders (NeuroD-WELL)*, November 8, 2019, University of Lisbon, Portugal.

Presented – Frota, S., Severino, C., Butler, J., & Vigário, M. (2019). Emerging word segmentation abilities in Down Syndrome. Talk presented at the *4th Lancaster Conference on Infant and Early Child Development*, August 21-23, 2019, Lancaster, UK.

Presented - Pejović, J., Cruz, M., Severino, C., & Frota, S. (2019). Selective attention to audiovisual communicative cues in infants with Down syndrome. An eye-tracking study. Talk presented at *Workshop on Early Language in Neurodevelopmental Disorders (NeuroD-WELL)*, November 8, 2019, University of Lisbon, Portugal.

Presented - Vigário, M., Butler, J., Severino, C., Uysal, E., & Frota, S. (2019). Infants discriminate utterances with and without internal prosodic boundaries: An eye-tracking study with delexicalized speech. Talk presented at the *4th Lancaster Conference on Infant and Early Child Development*, August 21-23, 2019, Lancaster, UK.

Presented - Vigário, M., Paulino, N., Severino, C., & Frota, S. (2019). Early language development in European Portuguese-learning infants and toddlers with Down Syndrome measured with the CDI. Talk presented at *Workshop on Early Language in Neurodevelopmental Disorders (NeuroD-WELL)*, November 8, 2019, University of Lisbon, Portugal.

Presented – Cruz, M., Butler, J., Severino, C., & Frota, S. (2018). Eyes or mouth? Exploring eye gaze patterns and their relation with early stress perception in European Portuguese. Talk

presented at *LabPhon16 - Variation, development and impairment: Between phonetics and phonology*, June 19-23, 2018, Faculdade de Letras da Universidade de Lisboa, Portugal.

Presented – Cruz, M., Filipe, M., Butler, J., Severino, C., & Frota, S. (2018). Early eye gaze patterns to talking faces in European Portuguese. Talk presented at *CPLOL 2018 – 10<sup>th</sup> European Congress of Speech and Language Therapy*, May 10-12, 2018, Cascais, Portugal.

Presented – Frota, S. (2017). Early perception of the prosody of statements and questions. Invited talk presented at the *Workshop on Prosody and Meaning (PaM)*, October 4-6, 2017, University of Konstanz, Germany.

Presented – Severino, C., Christophe, A., Vigário, M., & Frota, S. (2017). Prosodic structure constrains word segmentation beyond the utterance edge factor. Talk presented at *WILD – Workshop on Infant Language Development*, June 15-17, 2017, Bilbao, The Basque Country, Spain.

Presented – Vigário, M., Butler, J., Severino, C., & Frota, S. (2017). The role of phonotactic frequency and phonological grammar in infant word learning: An eye-tracking study. Talk presented at *WILD – Workshop on Infant Language Development*, June 15-17, 2017, Bilbao, The Basque Country, Spain.

Presented - Butler, J., Severino, C., Correia, S., Vigário, M., & Frota, S. (2016). The Emergence of Early Word Segmentation Abilities in Typically Developing Infants and Infants with Down Syndrome. Talk presented at the *Iberoamerican Congress of Neuropsychology*, June 1-4, 2016, University of Deusto, País Basco.

Presented – Frota, S., Butler, J., Lu, S., & Vigário, M. (2016). Infants' perception of native and non-native pitch contrasts: Tune, pitch accent or tone?". Talk presented at the *First Lancaster Conference on Infant and Child Development*, August 25-27, 2016, Lancaster University, Lancaster, UK.

\* Presented - Frota, S. (2015). Marcadores precoces de desenvolvimento da linguagem: Investigação do Lisbon Baby Lab. Invited talk presented at the *International Congress CountDOWN*, October 29-30, 2015, Calouste Gulbenkian Foundation, Lisbon, Portugal.

### **Pósteres em Encontros Científicos Internacionais**

Presented - Czeke, N., Zahner, K., Rimpler, J., Braun, B., & Frota, S. (2019). German infants fail to discriminate Portuguese rising vs. falling contours. Poster presented at the *4th Workshop on Infant Language Development (WILD)*, June 13-15, 2019, Potsdam, Germany.

Presented – Frota, S., Butler, J., Severino, C., Uysal, E., & Vigário, M. (2019). Infant perception of prosodic boundaries without the pause cue: An eye-tracking study. Poster presented at the *International Congress of Phonetic Sciences (ICPhS 2019)*, August 5-9, 2019, Melbourne, Australia.

Presented – Butler, J., & Frota, S. (2017). Early segmentation abilities in European Portuguese-learning infants: The impact of word and utterance level prosody. Poster presented at *WILD –*

*Workshop on Infant Language Development 2017*, June 15-17, 2017, Bilbao, The Basque Country.

Presented – Frota, S., Butler, J., Severino, C., & Vigário, M. (2017). Early language development in language-impaired, at-risk and typically development children measured with the European Portuguese MacArthur-Bates CDI Short Forms. Poster presented at *WILD – Workshop on Infant Language Development 2017*, June 15-17, 2017, Bilbao, The Basque Country.

### **Comunicações em Encontros Científicos Nacionais**

\* Presented – Frota, S. (2019). Escuta bebé! A descoberta da língua falada, antes da fala. Invited talk presented at *2<sup>as</sup> Jornadas do Centro de Estudos do Bebê e da Criança - Comunicação e Linguagem na Infância*, May 20, 2019, Fundação Calouste Gulbenkian, Lisbon, Portugal.

\* Presented – Frota, S. (2019). Desenvolvimento da linguagem na trissomia 21: Sinais precoces. Invited talk presented at *Trissomia 21: 3 Décadas a fazer a Diferença*, October 26, 2019, Auditório do IPDJ, Lisbon, Portugal.

Presented – Filipe, M., Cruz, M., Severino, C., Butler, J., & Frota, S. (2018). Eyes, mouth, or elsewhere? Young infants exploration of talking faces. Talk presented at *13<sup>o</sup> Encontro Nacional da Associação Portuguesa de Psicologia Experimental*, April 13-14, 2018, Universidade do Minho, Braga, Portugal.

Presented – Severino, C., Vigário, M., & Frota, S. (2018). A estrutura prosódica e a percepção infantil: Segmentação e desambiguação. Talk presented at the *I Jornadas Ibéricas de Audiologia*, April 27-28, 2018, Escola Superior de Tecnologia da Saúde de Coimbra, Portugal.

Presented - Vigário, M., Severino, C., Cruz, M., Filipe, M., Butler, J., & Frota, S. (2018). Marcadores precoces de desenvolvimento da comunicação e linguagem. Talk presented at *Ciência 2018 – Encontro com a Ciência e Tecnologia*, July 2-4, Centro de Congressos de Lisboa, Portugal.

Presented – Frota, S. (2017). From sounds to words: An eye-tracking study of infant word learning. Invited talk presented at *3<sup>a</sup> Semana da Inovação da ULisboa, RedeSAÚDE*, May 4, 2017, University of Lisbon, Lisbon, Portugal.

\* Presented - Frota, S. (2016). Investigar o desenvolvimento inicial da linguagem: Novos métodos, instrumentos e resultados. Invited talk presented at a discussion session on *Falar de Fala e Voz, I Jornadas de Terapia da Fala*, October 21-22, 2016, Centro Hospitalar Lisboa Central, Lisbon, Portugal.

Presented - Butler, J., Severino, C., Correia, S., Vigário, M., & Frota, S. (2015). The emergence of early word segmentation abilities in typically developing infants and infants with Down Syndrome. Talk presented at *1<sup>o</sup> Encontro de Alunos Colégio Doutoral Mente-Cérebro da Universidade de Lisboa*, December 2, 2015, University of Lisbon, Lisbon, Portugal.

## **Pósteres em Encontros Científicos Nacionais**

\* Presented - Frota, S., Severino, C., Pejović, J., Butler, J., & Vigário, M. (2019). Competências de segmentação de palavras em bebés com Trissomia 21. E-Poster presented at *The 2nd Lusíadas Clinical Summit*, November 16, 2019, Estoril, Portugal.

Presented - Pejović, J., Cruz, M., Severino, C., & Frota, S. (2019). Selective attention to audiovisual communicative cues in infants with Down syndrome. An eye-tracking study. Poster presented at *The 5<sup>th</sup> Meeting of the Mind-Brain College of the University of Lisbon*, November 12-13, 2019, University of Lisbon, Portugal.

\* Presented - Vigário, M., Paulino, N., Cruz, M., Severino, C., Pejović, J., Sousa, R., João, V., & Frota, S. (2019). Questionários do Desenvolvimento Comunicativo para o Português Europeu (Formas Reduzidas): Aplicação a populações típicas e atípicas. E-Poster presented at *The 2nd Lusíadas Clinical Summit*, November 16, 2019, Estoril, Portugal.

\* Presented – Frota, S. (2016). Horizonte 21: Desenvolvimento da Linguagem em bebés com Síndrome de Down. Poster presented at *3<sup>a</sup> Conferência Anual da Rede SAÚDE*, May 3, 2016, Reitoria da Universidade de Lisboa, Lisbon, Portugal.

Presented – Leone-Fernandez, B., Jerónimo, R., Lu, S., Correia, S., Vigário, M., Alter, K., & Frota, S. (2016). Prosody drives the CPS, not syntax. Poster presented at the *2nd PhD Students Meeting of the Mind-Brain College of the University of Lisbon*, November 28-29, 2016, Lisbon, Portugal.

Presented - Frota, S. (2015). Horizon21: Early language development in Down Syndrome [Horizonte21: Desenvolvimento da linguagem em bebés com Síndrome de Down]”. Poster presented at *1<sup>o</sup> Encontro de Alunos Colégio Doutoral Mente-Cérebro da Universidade de Lisboa*, December 2, 2015, University of Lisbon, Lisbon, Portugal.

## **C. RELATÓRIOS**

Final Report of the project Horizon 21 - Early language development in Down Syndrome [PTDC/MHC-LIN/3901/2014].

Report of the 3<sup>rd</sup> Year of the project Horizon 21 - Early language development in Down Syndrome [PTDC/MHC-LIN/3901/2014].

Report of the 2<sup>nd</sup> Year of the project Horizon 21 - Early language development in Down Syndrome [PTDC/MHC-LIN/3901/2014].

Report of the 1<sup>st</sup> Year of the project Horizon 21 - Early language development in Down Syndrome [PTDC/MHC-LIN/3901/2014].

## D. ORGANIZAÇÃO DE SEMINÁRIOS E CONFERÊNCIAS

### Conferências Internacionais/Workshops

*Lisbon Workshop on Early Language in Neurodevelopmental Disorders (NeuroD-WELL)*, November 8, 2019, FLUL, Lisboa, Portugal. Workshop of the project Horizon 21 - Early language development in Down Syndrome [PTDC/MHC-LIN/3901/2014].  
<http://labfon.letras.ulisboa.pt/NeuroD-WELL/index.html>

LabPhon16 - Variation, development and impairment: Between phonetics and phonology, Faculdade de Letras, Universidade de Lisboa, Lisboa, Portugal, June 19-23, 2018.  
<http://labfon.letras.ulisboa.pt/LabPhon16/>

Seminar, within *LabPhon16* by Len Abbeduto, consultant of the Project: *Characterizing the language abilities of individuals with intellectual disabilities in treatment studies*.

### Cursos livres/Formação avançada

*STEM V – Summer Training in Experimental Methods*, Phonetics and Phonology Lab, Departamento de Linguística Geral e Românica, CLUL, Faculdade de Letras, Universidade de Lisboa, Lisboa, Portugal, September 2-7, 2019.  
<http://labfon.letras.ulisboa.pt/summerschool/2019/en/index.html>

*Eyetracking using EyeLink systems: software and training* (Kurt Debono, Research Support Specialist), FLUL, November 26-27, 2018.

*STEM IV – Summer Training in Experimental Methods*, Phonetics and Phonology Lab, Departamento de Linguística Geral e Românica, CLUL, Faculdade de Letras, Universidade de Lisboa, Lisboa, Portugal, September 3-7, 2018.  
<http://labfon.letras.ulisboa.pt/summerschool/2018/en/index.html>

Training in EEG (Curry 8 software) by Dr. Andrew Hanson (Newcastle University, UK), Lisboa, FLUL, February 14-23, 2018.

*STEM III – Summer Training in Experimental Methods*, Phonetics and Phonology Lab, Departamento de Linguística Geral e Românica, CLUL, Faculdade de Letras, Universidade de Lisboa, Lisboa, Portugal, September 4-8, 2017.  
<http://labfon.letras.ulisboa.pt/summerschool/2017/en/index.html>

### Parcerias

Partnership with Diferenças, promoting translational research ([https://diferencas.net/?page\\_id=215](https://diferencas.net/?page_id=215)), since 2015.

Partnership with *Centro de Estudos do Bebê e da Criança* (Hospital D. Estefânia), since 2018.

## **Sessões de trabalho**

Working session with Len Abbeduto (UC Davis Mind Institute), consultant of the Project, 2018.

Working session with Shuang Lu (Renmin University of China), member of the team, 2017.

Scientific meeting with the national consultant of the project (Dr. Miguel Palha) and with the clinical team of *Diferenças*, December 14, 2016, University of Lisbon, Lisbon, Portugal.

## **E. FORMAÇÃO AVANÇADA**

### **Teses de Doutoramento**

N/A

### **Teses de Mestrado**

N/A

### **Outras**

May 2019 – November 2019. Jovana Pejović, Post-Doc Researcher within the project Horizon 21 - Early language development in Down Syndrome [PTDC/MHC-LIN/3901/2014]. Supervisor: Sónia Frota (FLUL); Co-supervisor: Marina Vigário (FLUL).

May 2017 – April 2019. Cátia Severino, Post-Doc Researcher within the project Horizon 21 - Early language development in Down Syndrome [PTDC/MHC-LIN/3901/2014]. Supervisor: Sónia Frota (FLUL); Co-supervisor: Marina Vigário (FLUL).

December 2016-July 2017. Barbara Leone-Fernandez, Post-Doc Researcher within the project *Horizon 21 - Early language development in Down Syndrome* [PTDC/MHC-LIN/3901/2014], Laboratório de Fonética, CLUL/FLUL. University of Lisbon/Fundação para a Ciência e Tecnologia. Supervisor: Sónia Frota (FLUL); Co-supervisor: Marina Vigário (FLUL).

## **F. MODELOS**

N/A

## **G. APLICAÇÕES COMPUTACIONAIS**

N/A

## **H. INSTALAÇÕES PILOTO**

N/A

## I. PROTÓTIPOS LABORATORIAIS

N/A

## J. PATENTES

N/A

## L. OUTROS

Database of early markers of language development

### **Book chapters – International [included in ‘A. Publicações - Livros’]**

Published - Frota, S., & Butler, J. (2018). Early development of intonation: Perception and production. In P. Prieto & N. Esteve-Gibert (Eds.), *The Development of Prosody in First Language Acquisition* (pp. 145–164). Philadelphia/USA: John Benjamins. doi: [10.1075/tilar.23.08fro](https://doi.org/10.1075/tilar.23.08fro)

Published - Frota, S., & Name, C. (2017). Questões de percepção em língua materna. In M. J. Freitas & A. L. Santos (Eds.), *Aquisição de língua materna e não materna: Questões gerais e dados do português* (pp. 35–50). Berlin: Language Science Press. <http://langsci-press.org/catalog/book/160>

### **Proceedings - International [included in ‘A. Publicações – Artigos em Revistas Internacionais’]**

Submitted – Frota, S., Pejović, J., Severino, C., & Vigário, M. (Submitted). Looking for the edge: Emerging segmentation abilities in atypical development. Submitted for publication in the Proceedings of the *10<sup>th</sup> International Conference on Speech Prosody*, May 25-28, Tokyo, Japan. [Submitted: December, 2019]

Published - Frota, S., Butler, J., Severino, C., Uysal, E., & Vigário, M. (2019). Infant perception of prosodic boundaries without the pause cue: An eye-tracking study. Proceedings of the *International Congress of Phonetic Sciences (ICPhS 2019)*, August 5-9, 2019, Melbourne, Australia.

### **Dissemination/Outreach Activities**

[URL available at the web site of the project:

<http://labfon.letras.ulisboa.pt/babylab/horizon21/noticias.html>]

Besides the activities listed below, several talks and posters were also presented with the goal of disseminating the research developed within the project in the context of various target audiences. These outputs were marked with \* above and are also listed below.



## Talks and Posters

Presented – Frota, S. (2019). Escuta bebé! A descoberta da língua falada, antes da fala. Invited talk presented at *2<sup>as</sup> Jornadas do Centro de Estudos do Bebé e da Criança - Comunicação e Linguagem na Infância*, May 20, 2019, Fundação Calouste Gulbenkian, Lisbon, Portugal.

Presented – Frota, S. (2019). Desenvolvimento da linguagem na trissomia 21: Sinais precoces. Invited talk presented at *Trissomia 21: 3 Décadas a fazer a Diferença*, October 26, 2019, Auditório do IPDJ, Lisbon, Portugal.

Presented - Frota, S., Severino, C., Pejović, J., Butler, J., & Vigário, M. (2019). Competências de segmentação de palavras em bebés com Trissomia 21. E-Poster presented at *The 2nd Lusíadas Clinical Summit*, November 16, 2019, Estoril, Portugal.

Presented - Vigário, M., Paulino, N., Cruz, M., Severino, C., Pejović, J., Sousa, R., João, V., & Frota, S. (2019). Questionários do Desenvolvimento Comunicativo para o Português Europeu (Formas Reduzidas): Aplicação a populações típicas e atípicas. E-Poster presented at *The 2nd Lusíadas Clinical Summit*, November 16, 2019, Estoril, Portugal.

Published – Frota, S. (2017). Estudar o Desenvolvimento da Linguagem nos Bebés. *Descubra as Diferenças* (electronic journal), 26: e-pub, December 2017. <https://revistadescubraasdiferencasdezembro2017.wordpress.com/2017/12/12/estudar-o-desenvolvimento-da-linguagem-nos-bebes/>

Published – Frota, S. (2017). Horizonte 21 - Novas linhas de investigação em Trissomia 21. *Descubra as Diferenças* (electronic journal), 19:e-pub, May 2017. <https://revistadescubraasdiferencasmaio2017.wordpress.com/2017/05/01/horizonte-21-novas-linhas-de-investigacao-em-trissomia-21/>

Presented - Frota, S. (2016). Investigar o desenvolvimento inicial da linguagem: Novos métodos, instrumentos e resultados. Invited talk presented at a discussion session on *Falar de Fala e Voz, I Jornadas de Terapia da Fala*, October 21-22, 2016, Centro Hospitalar Lisboa Central, Lisbon, Portugal.

Presented – Frota, S. (2016). Horizonte 21: Desenvolvimento da Linguagem em bebés com Síndrome de Down. Poster presented at *3<sup>a</sup> Conferência Anual da Rede SAÚDE*, May 3, 2016, Reitoria da Universidade de Lisboa, Lisbon, Portugal.

Presented - Frota, S. (2015). Marcadores precoces de desenvolvimento da linguagem: Investigação do Lisbon Baby Lab. Invited talk presented at the *International Congress CountDOWN*, October 29-30, 2015, Calouste Gulbenkian Foundation, Lisbon, Portugal.

## Participation in exhibitions targeting pre-university students

*Futurália* 2019, 2018, 2017, 2016, 2015

*Descobre a ULisboa* 2019, 2018, 2017, 2016

## Open days/Lab visits

*Dia Aberto na FLUL* 2017, 2016

*Semana da Ciência e da Tecnologia* 2015. Ciência Viva, Agência Nacional para a Cultura Científica e Tecnológica.

## Newsletters

Newsletter no. 4 of Lisbon Baby Lab, 2018/2019.

[http://labfon.letras.ulisboa.pt/babylab/pt/files/news/Newsletter\\_4\\_2019.pdf](http://labfon.letras.ulisboa.pt/babylab/pt/files/news/Newsletter_4_2019.pdf)

Newsletter no. 3 of Lisbon Baby Lab, 2017.

[http://labfon.letras.ulisboa.pt/babylab/pt/files/news/LBL\\_Edicao\\_3\\_2017.pdf](http://labfon.letras.ulisboa.pt/babylab/pt/files/news/LBL_Edicao_3_2017.pdf)

Newsletter no. 2 of Lisbon Baby Lab, 2016.

[http://labfon.letras.ulisboa.pt/babylab/pt/files/news/LBL\\_Edicao\\_2\\_2016.pdf](http://labfon.letras.ulisboa.pt/babylab/pt/files/news/LBL_Edicao_2_2016.pdf)

## Project H21 on the News

TV program ‘Tenho um bebé. E agora?’ (Canal Saúde+), December, 2019:

<http://labfon.letras.ulisboa.pt/babylab/horizon21/reportagem.html>

*Público*, May 23, 2019 [https://www.publico.pt/2019/05/23/ciencia/noticia/lisboa-ha-laboratorio-estudar-desenvolvimento-fala-bebes-trissomia-21-1873856?fbclid=IwAR0dc8dTxYyjL9PfMH2zSba0T1k0Xa5FTtsXTU\\_x446y0EQpY0JUJmP3U5E](https://www.publico.pt/2019/05/23/ciencia/noticia/lisboa-ha-laboratorio-estudar-desenvolvimento-fala-bebes-trissomia-21-1873856?fbclid=IwAR0dc8dTxYyjL9PfMH2zSba0T1k0Xa5FTtsXTU_x446y0EQpY0JUJmP3U5E)

*Público*, May 24, 2019

<http://labfon.letras.ulisboa.pt/babylab/pt/files/pub.pdf>

CMTV channel: ‘Como é que os bebés aprendem a falar?’, March, 2016.

[https://www.cmjornal.pt/multimedia/videos/detalhe/como\\_e\\_que\\_os\\_bebes\\_aprendem\\_a\\_falar](https://www.cmjornal.pt/multimedia/videos/detalhe/como_e_que_os_bebes_aprendem_a_falar)

*Correio da Manhã*: ‘Como é que os bebés aprendem a falar?’, March, 2016.

[https://www.cmjornal.pt/mais-cm/domingo/detalhe/como\\_e\\_que\\_os\\_bebes\\_aprendem\\_a\\_falar](https://www.cmjornal.pt/mais-cm/domingo/detalhe/como_e_que_os_bebes_aprendem_a_falar)

## **8. Detailed description of research activities**

### **1. Introduction**

A detailed description of the research activities developed within the H21 project is presented in this document. The research plan was implemented through five tasks that are at the core of the research activities developed by the project team, under the broader goal of studying early language development in Down Syndrome (DS) through the examination of language and communication abilities in different linguistic domains.

#### (1) Tasks

1. Recruitment and early assessment of participants (Task 1)
2. Looking while listening experiments (Task 2)
3. ERP experiments (Task 3)
4. Assessment of later language abilities (Task 4)
5. Early markers of language development in DS (Task 5)

Task 1 was central to all others. It established the participants' database of the project. For DS infants and toddlers, it turned out to be an ongoing and challenging task along the 3 years of the project. Tasks 2 and 3 were directed to experimental data collection, based on the observation of looking time, eye movement and neural responses. The languages abilities of each infant/toddler that participated in Tasks 2 and 3 were measured concurrently and later on, at different points in development, according to the longitudinal plan defined in Task 4. Tasks 2, 3 and 4 thus ensure a massive data collection using a multi-methodology approach that combines looking time measures, eye-tracking measures, ERP measures, and language and communication assessment measures (e.g., CDI, CSBS DP, Griffiths). The research activities of these three tasks converge on an integrated database of DS early language development measures that is the focus of analysis in Task 5. Crucial to the understanding of language development in DS is the characterization of typical development for the same set of language and communication abilities. In the case of ERP measures, and in the absence of adult studies in the relevant domains, such studies also needed to be conducted.

The activities specific to each project task are described in section 2. Please note that, according to the initial planning, Task 4 depends on the moment and age of the infant/toddler as he/she entered the research. So, for some of the DS participants, data collection is ongoing as they have not yet reached 30 months of age. Furthermore, we are currently following a subgroup of participants beyond 30 months of age, given that certain language abilities are not yet developed and the instruments used are able to capture further development because no ceiling effects have been found. Thus, further testing and longitudinal assessment will proceed and all the data processing

and participant evaluation will feed the final analysis towards the identification of early markers of language development in DS (Task 5).

Other activities developed within the project, such as the organization of workshops, conferences, and other outreaching activities, as well as fully equipped EEG lab for baby research which H21 highly contributed to, are dealt with in section 3. In section 4 we describe how the project goals were achieved, and comment on the ongoing research and networking activities that were founded within the project and will persist beyond it.

## **2. Research activities by project task**

### Task 1. Recruitment and early assessment of participants

Recruitment of infant and toddler participants with DS revealed to be an ongoing and challenging task, that took a lot of efforts into establishing networks of collaborating partners, and issuing calls in social networks and the media. The first methodology put in place involved the clinical team from the Center for Child Development – *Diferenças*, the main center for Down Syndrome in Portugal, which would present the project's research program to potential participants. A call for collaboration was also issued to Hospital Santa Maria. Information about the project was delivered in hand to potential participant families, who were also directed to the project's website and the baby lab, for further information. Figure 1 shows the information initially made available to clinicians, and its revision after the periodic meetings to evaluate the procedures followed and progress made during year 1. This revision led to a simplification of the number of tasks, and visits to the lab, by participant, thus ensuring the participation of more families and, simultaneously, the collection of enough data points for the key experimental tasks included in the program. In year 2, a new procedure was put in place through the presence of a researcher at *Diferenças* to ensure a direct contact with the families and facilitate recruitment. The project researcher would visit *Diferenças* every other week. The association *Pais21* was also involved and issued a call for participation. Typical developing (TD) infant and toddlers were recruited from the general baby lab database and the network of collaborating institutions (e.g., pre- and post-birth activity centres, nursery schools), as well as the social media. Adult participants were recruited through mailing lists and the social media.

A total of 46 participants with DS were registered in our database (although 10 could not participate in the research program, for different reasons, with living very far away from Lisbon the most frequent one). The data points collected for the experimental tasks were 111 (i.e., 111 experiments were run), and for the longitudinal language assessment 172, with an average of 8 data points per participant. Table 2 details the numbers of participants per experimental tasks and language and communication assessment tool. All the children included in the program that are still below 30 months of age will be followed until 30 months, and a subgroup will continue to be followed beyond 30 months. It is estimated that another 80 new data points will be added (final evaluation with the Griffiths Scales, CDI-II forms and experimental tasks) until the end of 2020. Funding from the research group will be used to this end.

**Programa de Estudo do Desenvolvimento da Linguagem na T21**  
**Projecto Horizonte21**  
<http://labfon.letras.ulisboa.pt/babylab/horizon21/>  
**Colaboração com o Lisbon Baby Lab**

Sexo: \_\_\_\_\_ Idade: \_\_\_\_\_

O objectivo do Programa é estudar o desenvolvimento da linguagem nos bebés e crianças com Trissomia 21, através da forma como são percebidos os sons da língua.  
 Pretende-se encontrar sinais precoces que mostrem como vai ser o desenvolvimento da linguagem ao longo dos primeiros anos de vida. Estes marcadores precoces ajudarão a perceber que tipo de desenvolvimento da linguagem a criança irá apresentar.

**PASSOS A SEGUIR**  
 Nota: Cada criança deverá visitar o Baby Lab 3 a 4 vezes, após marcação com a equipa do Baby Lab (1 estudo do olhar, 1 estudo das respostas cerebrais/potenciais evocados, 1 estudo do look e avaliação final).

Idade (em meses)	5-6	6-7	8-9	12	19-24	30
Estudo do olhar (Acento) <sup>1</sup>	x					
<del>Estudo do olhar (Sons do Português)<sup>2</sup></del>		⌘		⌘		
<del>Estudo do olhar (Sons estrangeiros)<sup>2</sup></del>		⌘		⌘		
Estudo do olhar (Melodia) <sup>3</sup>			x			
Estudo do olhar (Palavra) <sup>4</sup>					x	
Estudo do olhar (Decl-Int) <sup>3</sup>	x					
Estudo do olhar (Segmentation)		×	x	×	×	
<del>Estudo de potenciais evocados (Acento)<sup>2</sup></del>	⌘					
<del>Estudo de potenciais evocados (Sons)<sup>2</sup></del>		⌘		⌘		
Estudo de potenciais evocados (Melodia) <sup>3</sup>			x			
<del>Estudo de potenciais evocados (Palavra)<sup>4</sup></del>					⌘	
Avaliação final						x
Questionários CSBS (1 página) CDI (1 página)	1ª visita 1ª visita + intervalos de 6 meses até aos 30 (por correio ou email)					
Última avaliação (opcional)	Aos 4 anos de idade (no Baby Lab)					

Sempre ao dispor, subscrevemo-nos atentamente.  
 Lisboa,  
 Equipa do Lisbon Baby Lab

Contacto do Lisbon Baby Lab:  
 labfon@letras.ulisboa.pt  
 Telf: 21-7920052 (ext. 11313)

Figure 1. Research program sent to collaborating clinicians and its revision during Year 1.

Table 1. Total of infant/toddler participants with DS tested: experimental tasks and assessment tools

Attention Task		35
Looking while listening	Looking time	36
	Eye-tracking	31
ERP		9
Parental reports	CSBS DP	62
	CDI-I	46
	CDI-II	42
Griffiths		22

### Task 2. Looking while listening experiments

The paradigms of the 7 looking while listening experiments planned in the application were designed and underwent pilot testing and revision. Given the expected low numbers of DS participants, one of the eye-tracking tasks - the phonetic discrimination of a native and a nonnative segmental contrast – which involved high numbers of subjects was low ranked and priority was given to all the other tasks (Figure 1). The phonetic discrimination task was later excluded from the set of experimental tasks to maximize participation in the other experimental tasks. The versions of the visual habituation paradigm and visual familiarization paradigm used to test intonation discrimination and word segmentation in the TD infants proved effective with DS infants and toddlers. Figure 2 illustrates the passage-first visual familiarization paradigm successfully used to test the emergence of word segmentation abilities in TD and DS children.



Figure 2. Visual familiarization paradigm used to test word segmentation.

As for eye-tracking, an anticipatory looking paradigm was used to test stress discrimination both in TD and DS infants. The word learning experiment used the visual choice paradigm previously tested with TD toddlers. Eye gaze patterns to talking faces constituted a further experimental measure that could be introduced given the data availability offered by the video reinforcers included in the stress discrimination task. These patterns were examined both for TD and DS infants, using several Areas of Interest (AoI) measures, as illustrated in Figure 3.



Figure 3. AoIs for the study of audiovisual communicative cues.  
From Pejovic et al., 2019.

Prior to looking while listening experiment, an attention task was run. The attention experiment is a visual orientation task implemented with the baby lab testing booth's central and lateral lights to test attention performance. This experiment was added to the overall procedure as an independent (non-linguistic) test to infant/toddler gaze behavior and attention skills.

The word segmentation experiment with TD infants was concluded and the results were published in the *Journal of Child Language*. It was demonstrated that prosody facilitated word segmentation, as evidence for segmentation was found as early as 4 months, but only for utterance-edge, that is the prosodically prominent position. By 10 months, evidence of the emergence of segmentation in utterance-medial position was found, showing that segmentation abilities are crucially modulated by utterance-level prosody in EP (Figure 4). DS infants and toddlers, however, exhibit a different developmental pattern. They show not only a delayed emergence of segmentation abilities, but no difference between edge and medial position in the younger ages (and even apparent advantage of medial over edge; Figure 5). The word segmentation findings were presented at international conferences (Lancaster Conference on Infant and Early Child Development, Workshop on Early Language in Neurodevelopmental Disorders, WILD – Workshop on Infant Language Development, Iberoamerican Congress of Neuropsychology), a preliminary conference paper was published (*Revista de Neurología*), and a full conference paper recently submitted comparing TD, DS and also at-risk infants and toddlers (Speech Prosody).

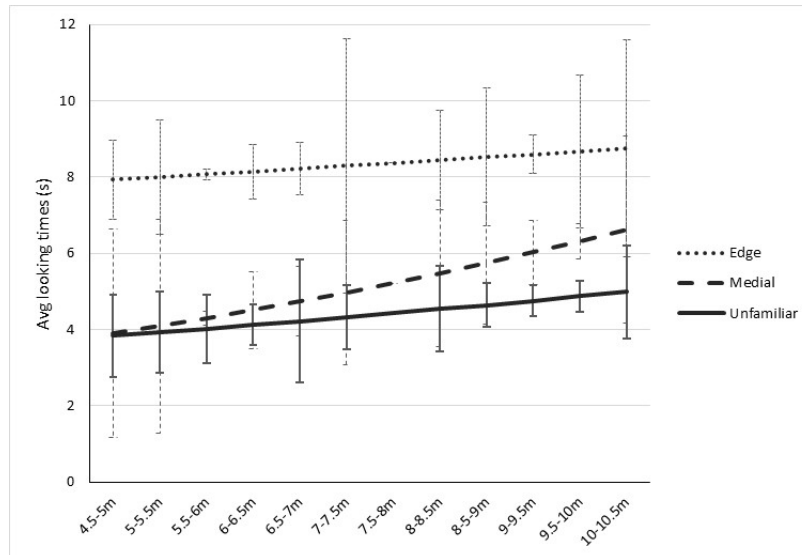


Figure 4. Average looking times (s) and standard error at half-month intervals for the three experimental conditions. From Butler & Frota (2018).

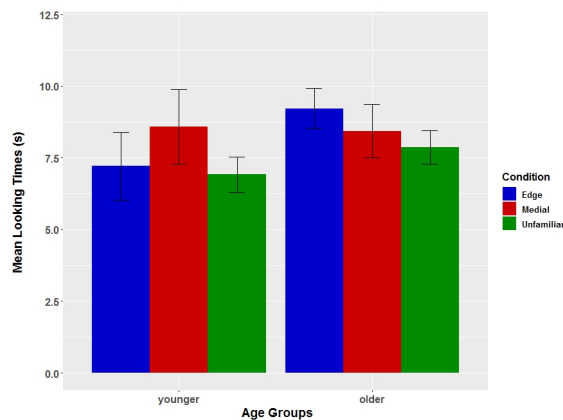


Figure 5. Mean looking times (s) for the three experimental conditions in the DS group by age (younger, older). Error bars represent standard error of the mean (+/-1). From Frota et al., submitted.

Infant's perception of intonation was shown to be a precocious cue- and language-dependent ability in TD infants (book chapter published, John Benjamins; presentations at international meetings: Workshop on Prosody and Meaning, Lancaster Conference on Infant and Child Development, Workshop on Infant Language Development). The findings for DS infants so far point to a similar early discrimination ability. These findings were presented at international and national conferences (Workshop on Language and the Brain, Jornadas Trissomia 21: 3 Décadas a fazer a Diferença).

Early stress perception in TD infants shows an iambic preference that agrees well adult findings (see below). A paper on this study is now ready for submission (given that we longitudinally followed the 5-6 months tested until they were 30 months and only included those that did not show any language delay or impairment according to the assessments made). TD infants also demonstrated an ability to discriminate prosodic boundaries at a very young age (a Proceedings paper was published, and the findings presented at several conferences: Lancaster Conference on Infant and



Early Child Development, International Congress of Phonetic Sciences). TD toddlers' word learning abilities were shown to be mostly guided by phonotactic frequency patterns (findings presented at WILD - Workshop on Infant Language Development). The studies with DS infants are ongoing, with the word learning study nearly concluded.

The examination of TD infants' eye gaze patterns to talking faces, and their relation to linguistic tasks, provided novel findings. As expected, 5-6 month-olds look mostly to the eyes (European Congress of Speech and Language Therapy, Encontro Nacional da Associação Portuguesa de Psicologia Experimental). However, the looks toward the mouth differ among those that show the dominant iambic preference in the stress discrimination task and those that do not show it (LabPhon16 - Variation, development and impairment: Between phonetics and phonology; paper accepted at Journal of Portuguese Linguistics). Importantly, a first study comparing audiovisual communicative cues in TD infants and infants with DS suggests a similar selective attention pattern but differences in general attention processes (Workshop on Early Language in Neurodevelopmental Disorders; a paper is ready for submission).

By and large, deliverables related to this task include 2 papers published and 1 accepted, 1 book chapter, 1 proceedings paper (plus one submitted) and 15 presentations at international conferences.

### Task 3. ERP experiments

The paradigms of the ERP experiments were designed and underwent pilot testing and revision. Similarly to the looking while listening experiments, the experiment related to phonetic discrimination was excluded. For the other ERP experiments, and given the absence of adult ERP studies for European Portuguese (EP) in these domains, adult testing was completed. In the case of infants with DS, priority was given to the processing of prosodic boundaries experiment (related to the CPS ERP component), given the potential relation between the role of prosody in word segmentation, the ability to process prosodic boundaries, and the development of the lexicon and syntax.

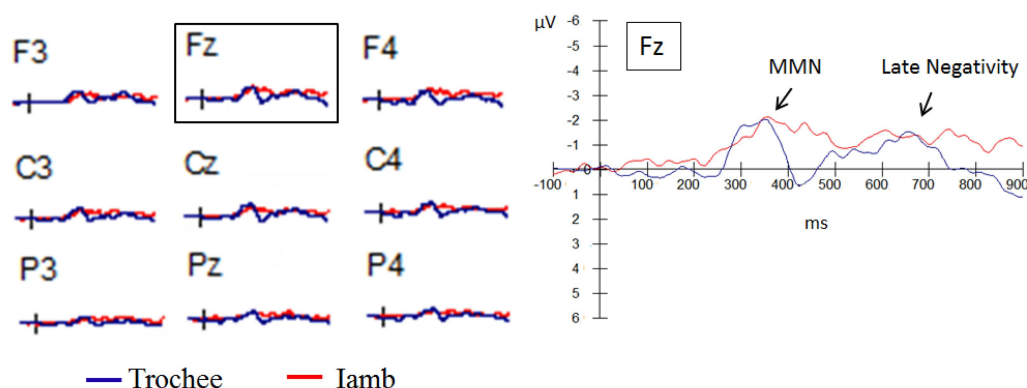


Figure 6. Grand-average difference waves (deviant minus standard) of the frontal electrodes (F3, Fz, and F4), the central electrodes (C3, Cz, and C4) and the parietal electrodes (P3, Pz, and P4) for the trochaic and iambic stress patterns. From Lu et al., (2018).

First, adults were tested to establish adult performance and examine potential developmental changes. While behavioral studies have shown no discrimination of stress patterns by adults, ERP studies have shown that adults discriminate stress patterns in a MMN task (paper published in *Frontiers in Psychology*). Stronger effects for the iambic pattern are apparent in both cases, in line with findings for infants' stress perception (Figure 6).

Adults were also tested for processing of prosodic boundaries, and word processing. Although the testing for the former was completed and a preliminary analysis indicated a prosodically driven CPS effect (Students Meeting of the Mind-Brain College of the University of Lisbon), due to experimenter error the data had to be discarded. A new data collection is completed and data processing and analysis was initiated. As for word processing, findings show that phonological grammar, phonotactic frequency and lexicality, in this order, define the time course of word processing (Figure 7).

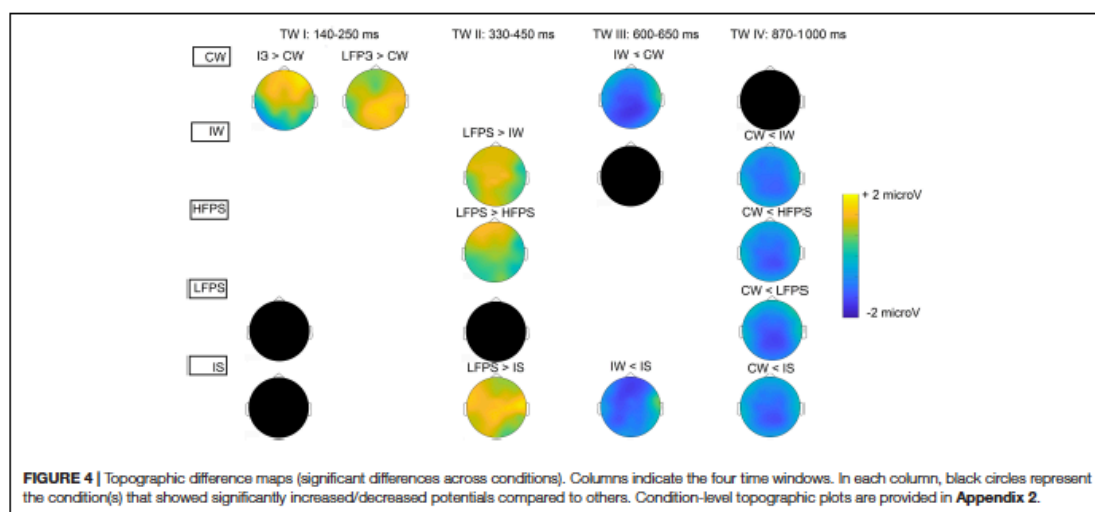


Figure 7. The time course of word processing: IS (Illegal Sequences), LFPS (Low Frequency Pseudowords), HFPS (High Frequency Pseudowords), IW (Incongruent Words), CW (Congruent Words). From Silva et al., (2019).

The word processing TD infant data is currently under analysis, and data collection is almost completed for stress discrimination. Infant data collection for CPS is ongoing.

Deliverables related to Task 3 include 2 journal papers published and presentations at national conferences.

#### Task 4. Assessment of later language abilities

Following the language assessment plan, language abilities of the infants tested in Tasks 2 and 3 were measured concurrently and later in intervals of 6 months. The Portuguese Communicative Development Inventory (CDI) short form (infant and toddler) European Portuguese versions were used to obtain receptive and expressive vocabulary measures, as well as a measure of word combination. Language and communication abilities were also measured with the Portuguese adaptation of the screening tool CSBS DP. Moreover, the Griffiths Mental Development Scales-Extended Revised (GMDS-ER, Portuguese version) is used to

obtain a comprehensive measure of mental development in different areas, including language. See Table 1 above for the numbers of data collection points currently available in the longitudinal language assessment program. On average, 5 data points per participant have been collected (depending on the age of entry in the research program, participants might have between 4 and 7 data points). Given that final assessment with the Griffiths is yet to be done for around 1/3 of the DS children, as they have not yet reached 30 months, the data points collected are in line with the initial plan.

Data analyses of the CDI data have pointed to a developmental profile for DS, which not only distinct from TD, but also from infants and toddlers at risk (AR) for language impairments (Figure 8). These findings have been presented at national and international meetings, including clinical meetings (Workshop on Early Language in Neurodevelopmental Disorders, WILD – Workshop on Infant Language Development, Lusíadas Clinical Summit).

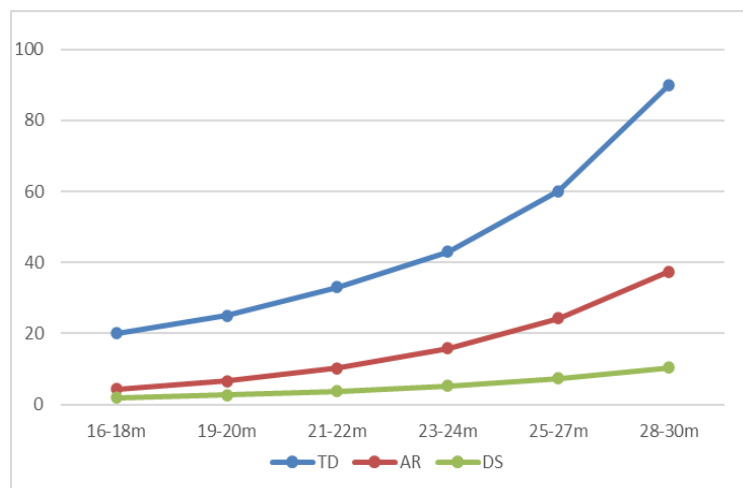


Figure 8. Developmental trends for expressive vocabulary: 50<sup>th</sup> percentile. From Vigário et al., (2019).

The CSBS data is currently under analysis. Preliminary findings indicate a developmental profile where the Speech domain evolves as an area of weakness, whereas the social domain evolves from relatively lower to higher scores as an area of strength. The results for the Speech domain are consistent with the CDI findings.

Further longitudinal assessment will proceed until all the DS participants reach the age of 30 months, and for a subgroup beyond 30 months of age, given that certain language abilities are not yet developed and the instruments used are able to capture further development because no ceiling effects have been found. All the longitudinal assessment data is feeding the final analysis towards the identification of early markers of language development in DS.

Deliverables related to Task 4 include 5 presentations at national and international conferences.

## Task 5. Early markers of language development in DS

Contributions to the understanding of early language development in DS have been put forward for most of the domains under analysis. In particular, it was shown that the developmental path of word segmentation abilities crucially differs from TD, which is potentially one of the factors underlying the low vocabulary scores of DS toddlers until quite late in development. Another potential factor related to general attention processes as revealed by eye gaze patterns to talking faces, which also differ from TD patterns. However, it was also shown that that DS infants and toddlers seem to be sensitive to prosody (intonation discrimination, prosodic boundaries), and to be able to use it to promote word segmentation. The identification of relative strengths and weaknesses in the DS language development profile has implications for the clinical domain, in particular for designing interventions to support language development.

As the results obtained in Task 5 are related to Tasks 2, 3 and 4, the deliverables for this task have already been mentioned above. Upon the closing of the longitudinal assessment, final analyses will establish what the best predictors of later language and communication outcomes are for DS children.

### **3. Other activities**

In this section, we describe other activities developed within the project, such as the organization of workshops, conferences, and other outreaching activities, as well as the fully equipped EEG lab for baby research which H21 highly contributed to. Some of these activities were initially planned in the application; others resulted from needs that arose during the implementation of the research plan, and from opportunities that had to be grasped due to their positive impact on the project goals and achievements, and on the academic, clinical and social networking to be maintained beyond the project execution time range to ensure the success of translational research.

(i) First consultant's meeting. December 14, 2016.

Meeting with the clinical team of *Diferenças*. December 14, 2016.

(ii) Second consultant's meeting. June 20, 2018.

Working session with Len Abbeduto (UC Davis Mind Institute). June 20, 2018.

Invited talk, within *LabPhon16*, by Len Abbeduto, consultant of the Project: *Characterizing the language abilities of individuals with intellectual disabilities in treatment studies*.

(iii) Final consultant's meeting. November 8, 2019.

Meeting with members of the clinical team of *Diferenças*. November 8, 2019.

(iv) *LabPhon16 - Variation, development and impairment: Between phonetics and phonology*, Faculdade de Letras, Universidade de Lisboa, Lisboa, Portugal, June 19-23, 2018.

The Project co-organized the 16<sup>th</sup> International Conference on Laboratory Phonology – LabPhon16, with the theme ‘Variation, development and impairment: Between phonetics and phonology’ (<http://labfon.letras.ulisboa.pt/LabPhon16/>). The conference was a major opportunity for discussion of language development and

language impairment in typical development and developmental disabilities, including Down Syndrome.

(v) *Lisbon Workshop on Early Language in Neurodevelopmental Disorders (NeuroD-WELL)*, November 8, 2019, FLUL, Lisboa, Portugal. Workshop of the project Horizon 21 - Early language development in Down Syndrome [PTDC/MHC-LIN/3901/2014].

<http://labfon.letras.ulisboa.pt/NeuroD-WELL/index.html>

NeuroD-WELL issued an open call for papers. It brought together researchers and practitioners working on language development and neurodevelopmental disorders, from a multidisciplinary perspective (Clinical Linguistics, Cognitive Science, Linguistics, Neurolinguistics, Psycholinguistics, Psychiatry, Psychology, Pediatrics, Speech and Hearing Sciences, Speech Therapy, among others). It included two invited speakers, one of them a specialist in language in Down Syndrome (Vesna Stojanovik, University of Reading), oral and poster sessions, and a special session on Down syndrome.

(vi) Training activities

The research team was involved in training activities for the academia and general public, within the STEM Summer school. The project also provided the means for advanced training of team members in EEG and Eye-tracking.

*STEM III – Summer Training in Experimental Methods*, Phonetics and Phonology Lab, Departamento de Linguística Geral e Românica, CLUL, Faculdade de Letras, Universidade de Lisboa, Lisboa, Portugal, September 4-8, 2017.

<http://labfon.letras.ulisboa.pt/summerschool/2017/en/index.html>

*STEM IV – Summer Training in Experimental Methods*, Phonetics and Phonology Lab, Departamento de Linguística Geral e Românica, CLUL, Faculdade de Letras, Universidade de Lisboa, Lisboa, Portugal, September 3-7, 2018.

<http://labfon.letras.ulisboa.pt/summerschool/2018/en/index.html>

*STEM V – Summer Training in Experimental Methods*, Phonetics and Phonology Lab, Departamento de Linguística Geral e Românica, CLUL, Faculdade de Letras, Universidade de Lisboa, Lisboa, Portugal, September 2-7, 2019.

<http://labfon.letras.ulisboa.pt/summerschool/2019/en/index.html>

*Training in EEG (Curry 8 software)* by Dr. Andrew Hanson (Newcastle University, UK), Lisboa, FLUL, February 14-23, 2018.

*Eyetracking using EyeLink systems: software and training* (Kurt Debono, Research Support Specialist), FLUL, November 26-27, 2018.

(vii) Outreach activities

Spreading of the project research goals and results for the larger (non-)scientific community was not only achieved through the project website, but also through talks and lectures, posters, dissemination papers, newsletters, lab visits, as well as interviews and news reports featured in the media.

Talks, lectures and posters:

Frota, S. Marcadores precoces de desenvolvimento da linguagem: Investigação do Lisbon Baby Lab. Invited talk presented at the *International Congress CountDOWN*, October 29-30, 2015, Calouste Gulbenkian Foundation, Lisbon, Portugal.

Frota, S. Investigar o desenvolvimento inicial da linguagem: Novos métodos, instrumentos e resultados. Invited talk presented at a discussion session on *Falar de Fala e Voz, I Jornadas de Terapia da Fala*, October 21-22, 2016, Centro Hospitalar Lisboa Central, Lisbon, Portugal.

Frota, S. Escuta bebé! A descoberta da língua falada, antes da fala. Invited talk presented at *2<sup>as</sup> Jornadas do Centro de Estudos do Bebé e da Criança - Comunicação e Linguagem na Infância*, May 20, 2019, Fundação Calouste Gulbenkian, Lisbon, Portugal.

Frota, S. Desenvolvimento da linguagem na trissomia 21: Sinais precoces. Invited talk presented at *Trissomia 21: 3 Décadas a fazer a Diferença*, October 26, 2019, Auditório do IPDJ, Lisbon, Portugal.

Frota, S. Horizonte 21: Desenvolvimento da Linguagem em bebés com Síndrome de Down. Poster presented at *3<sup>a</sup> Conferência Anual da Rede SAÚDE*, May 3, 2016, Reitoria da Universidade de Lisboa, Lisbon, Portugal.

Frota, S., Severino, C., Pejović, J., Butler, J., & Vigário, M. Competências de segmentação de palavras em bebés com Trissomia 21. E-Poster presented at *The 2nd Lusíadas Clinical Summit*, November 16, 2019, Estoril, Portugal.

Vigário, M., Paulino, N., Cruz, M., Severino, C., Pejović, J., Sousa, R., João, V., & Frota, S. Questionários do Desenvolvimento Comunicativo para o Português Europeu (Formas Reduzidas): Aplicação a populações típicas e atípicas. E-Poster presented at *The 2nd Lusíadas Clinical Summit*, November 16, 2019, Estoril, Portugal.

Dissemination papers:

Frota, S. Horizonte 21 - Novas linhas de investigação em Trissomia 21. *Descubra as Diferenças* (electronic journal), 19:e-pub, May 2017.

<https://revistadescubraasdiferencasmaio2017.wordpress.com/2017/05/01/horizonte-21-novas-linhas-de-investigacao-em-trissomia-21/>

Frota, S. Estudar o Desenvolvimento da Linguagem nos Bebés. *Descubra as Diferenças* (electronic journal), 26: e-pub, December 2017.

<https://revistadescubraasdiferencasdezembro2017.wordpress.com/2017/12/12/estudar-o-desenvolvimento-da-linguagem-nos-bebes/>

Newsletters:

Divulgação da acção do laboratório e dos seus projectos para a comunidade em geral, publicada através do web site e do Facebook do laboratório, das mailing lists de instituições parceiras, incluindo escolas, centros de saúde, hospitais, associações, entre outras, e das famílias de bebés.

Newsletter nº 2 of Lisbon Baby Lab, 2016.

[http://labfon.letras.ulisboa.pt/babylab/pt/files/news/LBL\\_Edicao\\_2\\_2016.pdf](http://labfon.letras.ulisboa.pt/babylab/pt/files/news/LBL_Edicao_2_2016.pdf)

Newsletter no. 3 of Lisbon Baby Lab, 2017.

[http://labfon.letras.ulisboa.pt/babylab/pt/files/news/LBL\\_Edicao\\_3\\_2017.pdf](http://labfon.letras.ulisboa.pt/babylab/pt/files/news/LBL_Edicao_3_2017.pdf)

Newsletter no. 4 of Lisbon Baby Lab, 2018/2019.

[http://labfon.letras.ulisboa.pt/babylab/pt/files/news/Newsletter\\_4\\_2019.pdf](http://labfon.letras.ulisboa.pt/babylab/pt/files/news/Newsletter_4_2019.pdf)

Open days/Lab visits:

Dissemination of the H21 project.

Público alvo: a comunidade.

*Semana da Ciência e da Tecnologia* 2015. Ciência Viva, Agência Nacional para a Cultura Científica e Tecnológica.

*Dia Aberto na FLUL* 2016

*Dia Aberto na FLUL* 2017

Público alvo: pre-university students

*Futurália* 2019, 2018, 2017, 2016, 2015

*Descobre a ULisboa* 2019, 2018, 2017, 2016

Interviews and news reports featured in the media:

*Correio da Manhã*: ‘Como é que os bebés aprendem a falar?’, March, 2016.

[https://www.cmjornal.pt/mais-cm/domingo/detalhe/como\\_e\\_que\\_os\\_bebes\\_aprendem\\_a\\_falar](https://www.cmjornal.pt/mais-cm/domingo/detalhe/como_e_que_os_bebes_aprendem_a_falar)

*CMTV* channel: ‘Como é que os bebés aprendem a falar?’, March, 2016.

[https://www.cmjornal.pt/multimedia/videos/detalhe/como\\_e\\_que\\_os\\_bebes\\_aprendem\\_a\\_falar](https://www.cmjornal.pt/multimedia/videos/detalhe/como_e_que_os_bebes_aprendem_a_falar)

*Público*, May 23, 2019 (directly focusing on Down Syndrome)

[https://www.publico.pt/2019/05/23/ciencia/noticia/lisboa-ha-laboratorio-estudar-desenvolvimento-fala-bebes-trissomia-21-1873856?fbclid=IwAR0dc8dTxyYjL9PfmH2zSba0T1k0Xa5FTtsXTU\\_x446y0EQpY0JUJmP3U5E](https://www.publico.pt/2019/05/23/ciencia/noticia/lisboa-ha-laboratorio-estudar-desenvolvimento-fala-bebes-trissomia-21-1873856?fbclid=IwAR0dc8dTxyYjL9PfmH2zSba0T1k0Xa5FTtsXTU_x446y0EQpY0JUJmP3U5E)

The screenshot shows a news article from the Portuguese newspaper Público. The article is titled "Em Lisboa, há um laboratório a estudar o desenvolvimento da fala de bebés com trissomia 21" (In Lisbon, there is a laboratory studying the development of speech in babies with trisomy 21). The article is categorized under "LINGUAGEM" (Language). The text of the article states: "O projecto Horizonte 21 pretende encontrar elementos cruciais nas perturbações da fala nos bebés com trissomia 21 e contribuir assim para o acompanhamento clínico destas crianças ao nível da linguagem." (The Horizonte 21 project aims to find crucial elements in speech disorders in babies with trisomy 21 and contribute to the clinical follow-up of these children at the level of language). The author is identified as Teresa Sofia Serafim, and the article was published on May 23, 2019, at 21:10. The article has 1257 shares. Social media sharing icons for Facebook, Twitter, LinkedIn, Pinterest, Email, Print, and WhatsApp are visible at the bottom right of the article preview.

*Público*, May 24, 2019

<http://labfon.letras.ulisboa.pt/babylab/pt/files/pub.pdf>



TV program *Tenho um bebé. E agora?* (Canal Saúde+), December, 2019 (directly focusing on Down Syndrome)  
<http://labfon.letras.ulisboa.pt/babylab/horizon21/reportagem.html>

### Reportagem sobre o projeto Horizonte 21, no programa 'Tenho um bebé. E agora?' (Canal Saúde+)



(viii) Other platforms for dissemination

Lisbon baby lab Facebook (<https://pt-pt.facebook.com/LisbonBabyLab/>)

Lisbon baby lab Instagram (<https://www.instagram.com/p/BvRgegDHv88/>)

The H21 project on Research Gate (<https://www.researchgate.net/project/Horizon21-Early-language-development-in-Down-Syndrome>)

(ix) The EEG lab for baby research fully equipped

This new facility offers a baby-friendly environment using up to date equipment. The H21 project provided substantial funding for the buying the equipment.

(x) Major partnerships with the clinical sector

Partnership with *Diferenças* ([https://diferencas.net/?page\\_id=215](https://diferencas.net/?page_id=215)), since 2015.

Partnership with *Centro de Estudos do Bebê e da Criança* (Hospital D. Estefânia), since 2018.

## 4. Goals and outputs

The H21 project is a research program to study of early language development in Down Syndrome through the examination of language and communication abilities in different linguistic domains. Related goals included the (i) the development/adaptation of experimental paradigms and language assessment tools, and (ii) the comparison of DS subjects' performance with typical developing children (TD) as well as with groups of children at-risk for language impairments (AR), through the application of similar research protocols. Thus the availability of findings for TD children, and in some studies also for adults, was a desideratum within the project.



The specific goals of the project were accomplished, and the challenges faced overcome: (1) establishing a networking procedure of participant recruitment of infants and toddlers with DS; (2) the set up of the Lisbon Baby Lab EEG lab; (3) the development/adaptation of experimental paradigms and language assessment tools to meet the needs of the project; (4) a novel contribution to profiling the development of DS infants and toddlers' abilities in the domains under study; (5) a contribution to the identification of early markers of language development in DS, by means of measuring concurrent abilities and later outcomes; (6) the establishment of research dissemination and collaboration among the research, clinical and social communities laying the foundations for translational research in the field.

1. Infant studies typically face the challenge of recruitment, which is even bigger when studies focus on clinical groups, as in the case of H21. Through our partnerships with Diferenças and APPT21, together with other health institutions and individual collaborations, a procedure was put in place to allow a direct contact with potential participant families and introduce them to the project. Given that 321 babies with DS were born in Portugal between 2008 and 2017, with an average of 32 per year (source: Instituto Nacional de Saúde Dr. Ricardo Jorge), the project was able to recruit more than 1/3 of the babies with T21 in the whole country during the relevant time span. Considering that the research was exclusively based in Lisbon, we consider this recruitment rate a success.

2. The paradigms of the looking while listening and ERP experiments underwent pilot testing with infants and toddlers with DS. To our knowledge, we conducted the second study on word segmentation in DS (the only one published so far looked at English-learning toddlers), and the first studies on intonation discrimination, stress discrimination, and sensitivity to prosodic boundaries, as well as the first study on eye gaze patterns to talking faces with young infants with DS. Two adult ERP studies were concluded and published. Their findings set the stage for the interpretation of the infant and toddler data. The use of the Portuguese CDI short forms as a language assessment tool for infants and toddlers with DS yield promising results. Given that no ceiling effects have been found, data collection with older infants and toddlers was implemented both for CDI-I and CDI-II. The CDI instruments are now being used in the clinical assessment of infants and toddlers with DS, which is one of the most important outcomes of H21 in the domain of translational research. We have also used the Portuguese version of the CSBS screening tool providing the first data on DS for communicative development between 6 and 24 months using this tool.

3. The goals achieved allowed a contribution to the understanding of the knowledge of DS infants and toddlers' abilities in the domains under study. Profiling the development of DS infants and toddlers' language abilities is certainly a major breakthrough for research on neurodevelopmental disorders, as well as clinical practice. For example, we have shown that the developmental path of word segmentation abilities in DS is not only delayed, but follows a pattern different from TD infants. DS infants and toddlers show a slow and protracted development of both receptive and expressive vocabularies in oral language, as well as of the emergence of word combinations, not only in comparison with TD but also with AR children. Besides the comparison with TD and AR language development profiles, we have the additional goal of providing specific CDI norms for language development

(vocabulary and syntax) in DS, which is now entirely feasible given the data collected within the project.

4. The goals achieved also allowed a contribution to the identification of early markers of language development in DS. For example, the use of prosodic cues for word segmentation in DS correlated with better concurrent vocabulary scores, demonstrating that DS infants and toddlers may use prosody to promote word segmentation as TD infants do, and this in turn may impact vocabulary development. Ongoing analyses are measuring the correlation between specific language abilities as shown by performance in experimental tasks and later outcomes measures through language assessment tools.

Last but not least, the collaboration among the research, clinical and social communities achieved under H21 was well beyond the initially planned dissemination activities using the project website and some meetings with interested parties. A strong interaction with relevant stakeholders was achieved through many different means: dissemination papers, invited talks directed to pediatricians, psychologists, speech therapists and other clinical staff, participation in clinical meetings, interviews and news on TV and national newspapers, the Lisbon Baby Lab Newsletter, and the lab's Facebook and Instagram that have brought the project's activities and outcomes to caregivers and the global society.

Below we list the **main outputs of the project**. The outputs fall into four categories: research facilities, resources for early language development in research, educational, clinical settings and for the general public, advanced training positions, and publications. This section concludes with a comparison between the planned outputs and the outputs actually produced.

### ***Research facilities***

Updated eye-tracking equipment  
New EEG baby lab fully equipped

### ***Resources for early language development***

- European Portuguese version of the CSBS DP screening tool tested with infants and toddlers with DS; the DS developmental profile highlights areas of weakness and strength.
- European Portuguese CDI short forms tested with infants and toddlers with DS, providing their specific developmental profile compared to the TD norms; specific CDI norms for language development in DS.
- The H21 project website, where all project-related information and all the outputs are available: <http://labfon.letras.ulisboa.pt/babylab/horizon21/index.html>
- Database of early language development data in DS (including discrimination abilities for stress and intonation, word segmentation abilities, processing of prosodic boundaries, word learning, general attention, audiovisual processing, and their relation to development of vocabular and syntax).

### ***Advanced training***

Advanced training was promoted through the opening of research grants (BPD).

#### Advanced research positions within the project

Barbara Leone-Fernandez (BPD), December 2016-July 2017

Cátia Severino (BPD), May 2017-April 2019

Jovana Pejović (BPD), May 2019-November 2019

#### Other advanced training

*Training in EEG (Curry 8 software)* by Dr. Andrew Hanson (Newcastle University, UK), Lisboa, FLUL, February 14-23, 2018.

*Eyetracking using EyeLink systems: software and training*, by Kurt Debono (Research Support Specialist), FLUL, November 26-27, 2018.

### ***Publications and Communications***

Book chapters – 2 (international)

Papers in International Journals – 4 (plus 1 in press)

Papers in National Journals - 2

Proceedings (international) – 1

Communications in international meetings – 18

*e.g., Lancaster Conference on Infant and Child Development, Iberoamerican Congress of Neuropsychology, International Conference on Phonetic Sciences (ICPhS), WILD - Workshop on Infant Language Development, Workshop on Language and the Brain, Conference on Laboratory Phonology, European Congress of Speech and Language Therapy.*

Communications in national meetings – 14

*e.g., Encontro Nacional da Associação Portuguesa de Psicologia Experimental, Jornadas Ibéricas de Audiologia, Jornadas do Centro de Estudos do Bebê e da Criança - Comunicação e Linguagem na Infância, Jornadas de Terapia da Fala, Lusíadas Clinical Summit, Jornadas de Trissomia 21: 3 Décadas a fazer a Diferença.*

A comparison between the planned outputs and the outputs actually produced is shown in Figure 9. The strong dissemination and outreach vein of the Project is shown in Figure 10.

It can be seen that with two exceptions (national journals and master thesis) in all output categories the outputs produced outnumber the outputs initially planned in the application. The exceptions are explained by strategic decisions made. In what concerns master thesis, a decision was made to convert the BI grant initially planned into another BPD grant. Given the required training and specialization to attain the project's goals, the focus of advanced training was at the post-doctoral level. As to national papers, it was a strategic decision of the team to concentrate efforts on international publications, and thus 5 international papers two book chapters were already published (4 were initially planned). Presently, there is a further paper in press at an international journal, a proceedings paper submitted, and 2 other papers are in progress and will be shortly submitted to international journals.

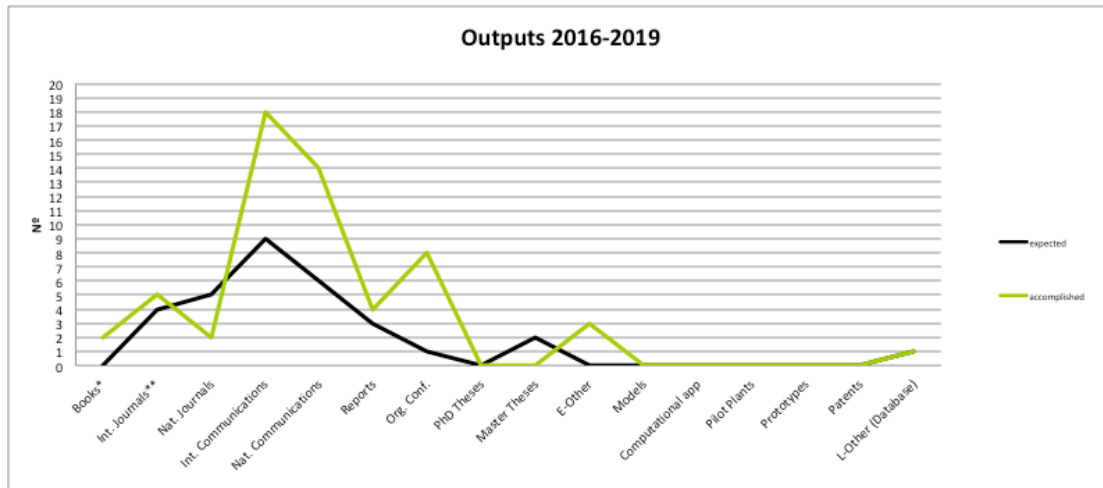


Figure 9. Outputs produced according to the types defined in Table 5. Indicadores de Realização Física).

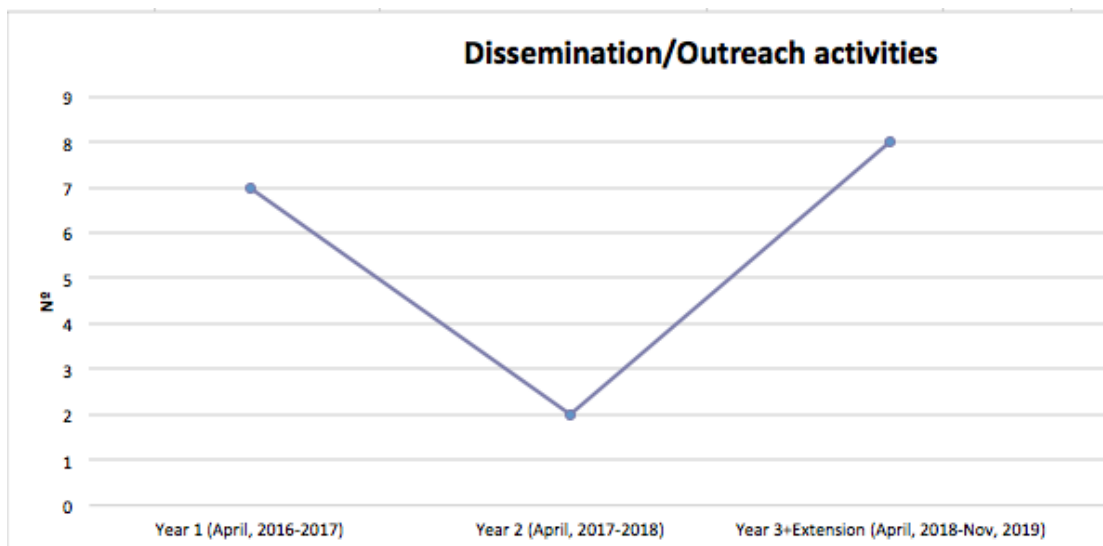


Figure 10. Dissemination and outreach along the project's execution period.

There were two other main outputs of the H21 project. The organization of the 16<sup>th</sup> International Conference on Laboratory Phonology – LabPhon16, with the theme ‘Variation, development and impairment: Between phonetics and phonology’ (<http://labfon.letras.ulisboa.pt/LabPhon16/>). The conference was a major opportunity for discussion of language development and language impairment in typical development and developmental disabilities, including Down Syndrome. With 500 abstracts submitted and an international audience of more than 300 participants, the Conference was a central moment for discussion and dissemination. Last, but perhaps the most important output of all, were the foundations laid for a strong collaboration between researchers and clinicians, and the opportunities and bridges for the implementation of translational research. A recent outcome, beyond the end of the execution period of the Project, is the participation of members of the project research team in the *XXVI Jornadas de Pediatria – Pediatria translacional 2020*, of the Departamento de Pediatria of Hospital Santa Maria (13-14 February, 2020).