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FINAL SCIENTIFIC REPORT

Research Project:

The role of affective dimensions in the perception of facial expressions of emotion: Neuropsychophysiological, developmental, and neuroimaging examination of an affective predictive coding framework

Project reference 242/14

Oct./2015 – Dec./2020

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SCIENTIFIC REPORT

1. Introduction

The present report summarizes the scientific component of the project *The Role of affective dimensions in the perception of facial expressions of emotion: Neuropsychophysiological, developmental, and neuroimaging examination of an affective predictive coding framework* (242/14).

The project initiated in October 2015 and underwent an interruption, authorized by the BIAL Foundation, between October 2019 and September 2020 due to health reasons. The emergence of the COVID-19 pandemic in 2020 also dictated the need to cancel the final Phase 3 study of the project, due to lack of feasibility of the data collection, a change which was also authorized by the BIAL Foundation considering the progress achieved so far. The PI and the research team are extremely thankful to the BIAL Foundation for its support and particularly for the understanding shown during the periods of family health-related problems.

2. Overview of the project

The main goal of the project was to investigate the role of affective dimensions in the perception of Facial Expressions of Emotion (FEE), retaining the concept of emotional categories as an important level of analysis. The Predictive Processing/Coding (PP) framework, that describes brain function in terms of predictions about the inputs that will be received according to existing prior representations, may provide a unifying model of emotional processing, combining categorical and dimensional aspects and overcoming some inconsistencies in the current literature. To fulfil this goal, there were three phases in this project. Phase 1, composed by three studies was designed to assess how affective dimensions, such as arousal and valence, relate to (1) other facial features like the typicality of the face, (2) the presence of emotional or non-emotional content, and (3) emotional intensity. Phase 2 consisted of a cross-sectional study to assess the developmental evolution of FEE processing, covering over 100 children between 4 and 15 years old. As described below in this report, Phases 1 and 2 have been completed successfully. Finally, Phase 3 was intended as a multimodal EEG/fMRI study in adults, but was cancelled, with the agreement of the BIAL Foundation due to the COVID-19 pandemic. In the following sections, we will summarize the research finding of each of the phases of the project and list the scientific products that emerged as a result of the project, as well as the activities of public engagement that were carried out. Finally, the main publications of the project are included as annexes.

Overall, we have completed four of the five empirical studies planned in the project (the sole exception being the joint EEG-fMRI study from Phase 3, which was cancelled as described above), and the respective manuscripts are in the final stages of preparation before submission for publication – the interruption of the project meant that these submissions had to remain on hold, and since the COVID-19

pandemic the change in workflow has led to further delays, but the team is committed to finalizing these submissions in 2021. Nonetheless, we have published innovative theoretical and methodological articles on the application of Predictive Processing models to the field of Affective Neuroscience and Emotional Development, a core topic of the present project. This work has attracted considerable interest from the research community. For example, we have received a "Best talk award" at the 2019 Lancaster Conference on Infant and Early Child Development for a talk on Predictive Processing and Emotions, and a PhD project based on these concepts (PhD candidate Mariana R. Pereira) has been funded by the Portuguese *Fundação para a Ciência e Tecnologia* (FCT). In light of the above, the project team considers that, although the scientific productivity of the project remains to be completed, we have been able to provide a significant scientific contribution with the support of the BIAL Foundation.

3. Summary of research findings

Below we present summaries of the research findings for each study of the project. Given that each study has resulted in the preparation of a manuscript of a scientific article, we present the abstract of the study to provide an overview of the findings and include the corresponding full texts as annexes to the present report.

3.1. Phase 1, Study 1.1. Typicality and Affect

- *Manuscript (openly available online):*

Pereira, M. R., Paiva, T. O., Barbosa, F., Almeida, P. R., Martins, E. C., Baldeweg, T., de Haan, M., & Ferreira-Santos, F. (2018). Disentangling the role of face typicality and affect in emotional face processing: Self-reported and electrophysiological evidence [preprint]. *BioRxiv*, 378224. https://doi.org/10.1101/378224

- *Abstract:*

Typicality, or averageness, is one of the key features that influences face evaluation, but the role of this property in the perception of facial expressions of emotions is still not fully understood. Typical faces are usually considered more pleasant and trustworthy, and neuroimaging results suggest typicality modulates amygdala and fusiform activation, influencing face perception. At the same time, there is evidence that arousal is a key affective feature that modulates neural reactivity to emotional expressions. In this sense, it remains unclear whether the neural effects of typicality depend on altered perceptions of affect from facial expressions or if the effects of typicality and affect independently modulate face processing. The goal of this work was to dissociate the effects of typicality and affective properties, namely valence and arousal, in electrophysiological responses and self-reported ratings across several facial expressions of emotion. Two ERP components relevant for face processing were measured, the N170 and Vertex Positive Potential (VPP), complemented by subjective ratings of typicality, valence, and arousal, in a sample of 30 healthy young adults (21 female). The results point out to a modulation of the electrophysiological responses by arousal, regardless of the typicality or valence properties of the face. These findings suggest that previous findings of neural responses to typicality may be better explained by accounting for the subjective perception of arousal in facial expressions.

3.2. Phase 1, Study 1.2. Affective properties of non-basic emotional facial expressions

- *Manuscript (Annex 1):*

Mazer*, P., Pereira*, M. R., Paiva, T. O., Paulino, F., Rodrigues, P., Martins, E. C., Barbosa, F., Almeida, P. R., & Ferreira-Santos, F. (In prep.). The Porto Affective Faces Set (PAFS): Validation of a set of facial configurations beyond basic emotion categories. [* joint first authorship]

- *Abstract:*

Currently, there are several databases featuring faces and facial expressions of emotion, providing variations of several features such as eye gaze, face direction, and the displayed emotion. The present work describes a new database that is constituted by a set of displays of the basic emotions, with different levels of intensity, as well as a set composed by affective but non-basic expressions. It aims to fill the need for a dataset that systematically controls and quantifies the affective properties of facial displays, supporting further research with a more hybrid approach to affective (rather than what is considered purely emotional) face processing. The procedure and contents involved in the creation of the database will be presented, as well as a validation study composed by ratings of emotional recognition accuracy, valence, arousal, intensity, and spontaneity. The results point out to satisfactory accuracy rates and an intensity effect as manipulated. Additionally, the arousal and valence ratings for the basic and non-basic sets provide a more complete and varied occupation of the affective space, allowing novel research questions to be addressed in future studies using these stimuli.

- *Stimuli set*: The PAFS stimuli set will be made freely available to the scientific community (conditional on signing a use agreement) for academic and research use at https://doi.org/10.17605/OSF.IO/GDPCA.

3.3. Phase 1, Study 1.3. Affect and Emotional Intensity

- *Manuscript (openly available online):*

Ferreira-Santos, F., Pereira, M. R., Paiva, T. O., Almeida, P. R., Martins, E. C., de Haan, M., Baldeweg, T., & Barbosa, F. (2020). What you morph is not what you get: Subjective and neural responses to facial expressions of emotion depend on perceived intensity/arousal (not on amount of morphing) [preprint]. *PsyArXiv*. https://doi.org/10.31234/osf.io/qda9m

- *Abstract:*

The behavioral and electrophysiological study of the emotional intensity of facial expressions of emotions has relied on image processing techniques termed 'morphing' to generate realistic facial stimuli in which emotional intensity can be manipulated. This is achieved by blending neutral and emotional facial displays and treating the percent of morphing between the two stimuli as an objective measure of emotional intensity. Here we argue that the percentage of morphing between stimuli does not provide an objective measure of emotional intensity and present supporting evidence from affective ratings and neural (event-related potential) responses. We show that 50% morphs created from high or moderate arousal stimuli differ in subjective and neural responses in a sensible way: 50% morphs are perceived as having approximately half of the emotional intensity of the original stimuli, but if the original stimuli differed in emotional intensity to begin with, then so will the morphs. We suggest a re-examination of previous studies that used percentage of morphing as a measure of emotional intensity and highlight the

value of more careful experimental control of emotional stimuli and inclusion of proper manipulation checks.

3.4. Phase 2: Neural responses to facial expressions in children and adolescents

- *Manuscript (Annex 2):*

Pereira, M. R., Maze, P., Garcez, H., Almeida, R., Torrinhas-Caldeira, I., Paiva, T. O., Martins, E. C., Barbosa F., Almeida, P. R., Baldweg, T., de Haan, M., & Ferreira-Santos, F. (In prep.). Affective processing of facial expressions of emotion between childhood and adolescence: A cross-sectional electrophysiological study.

- *Abstract:*

Facial expressions of emotion assume a crucial role across all development and although their salience is already visible in infancy, the acquisition of recognition and interpretation abilities of these social cues is gradual during childhood, transitioning from a valence-based discrimination to an establishment of the various emotional categories. Despite of the role of affective properties of the face such as valence and arousal in the processing, previous literature is still focused on comparing emotional categories without assessing the impact of these dimensions. The present study aims to replicate the work done by Batty and Taylor, in 2006, with children between 4- and 15-years-old, using an implicit processing task with facial expressions but presenting faces of anger and happiness, with low and high arousal, and expressions of calm and surprise, with unpleasant and pleasant versions. Electrophysiological data was recorded in order to understand the modulation of the P1 and N170 event-related potentials by the different emotional categories and affective properties. Our results corroborate the shift from P1 to N170 modulation, reflecting the changes in strategies; the occurrence of a valence-based modulation during childhood and a transitional pattern in teenagers, with patterns of modulation that resemble neither childhood nor adulthood; and sex differences, with boys showing higher amplitudes and longer latencies, with improved modulation by negative stimuli. The methodological implications of the present design and the more categorical approaches in uncovering the developmental path of affective face processing is discussed.

3.5. Theoretical and methodological publications

- *Article (Annex 3):*

Pereira, M. R., Barbosa, F., de Haan, M., & Ferreira-Santos, F. (2019). Understanding the development of face and emotion processing under a predictive processing framework. *Developmental Psychology, 55*(9), 1868–1881. https://doi.org/10.1037/dev0000706

- *Abstract:*

In the present work, we explore the development of processing of emotional facial configurations under a predictive processing (or predictive coding) framework. Predictive processing provides a new approach to brain function that has been used to explain a wide range of processes, from perception to socioemotional processing. The explanatory power of this framework for adult brain function is widely recognized, but it has yet to be systematically applied to understanding the developing brain. Studying the findings of developmental research under this framework may allow a deeper understanding of the predictive mechanisms and their ontogenetic course, and adds to knowledge on brain functions and developmental processes. Therefore, the goal of this work was to explore the potential complementarity

of predictive processing and development. Specifically, we focus on how the development of facial and emotion processing may be understood under a predictive processing framework. The processing of facial expressions was selected because of the developmental relevance of these stimuli, their impact on general emotional development, as well as the large body of literature on this topic (comprised of both well-established but also incongruent findings, which a novel approach may clarify). Considering the main findings of developmental research on the processing of emotion-related facial configurations under this framework, we argue that predictive processing is consistent with developmental evidence and provides a promising avenue for developmental research, as it reveals new questions in the fields of development and emotion processing.

- *Article (Annex 4):*

Ferreira-Santos, F. (2016). The role of arousal in predictive coding. *Behavioral and Brain Sciences, 39*. https://doi.org/10.1017/S0140525X15001788

- *Abstract:*

Within a predictive coding approach, the arousal/norepinephrine effects described by the GANE (glutamate amplifies noradrenergic effects) model seem to modulate the precision attributed to prediction errors, favoring the selective updating of predictive models with larger prediction errors. However, to explain how arousal effects are triggered, it is likely that different kinds of prediction errors (including interoceptive/affective) need to be considered.

- *Article (openly available online):*

Ferreira-Santos, F. (2015). Facial emotion processing in the laboratory (and elsewhere): Tradeoffs between stimulus control and ecological validity. *AIMS Neuroscience, 2*(4), 236–239. https://doi.org/10.3934/Neuroscience.2015.4.236

- *Summary:*

Viewing faces and facial expressions of emotion in natural contexts is quite different from the viewing conditions usually present in face perception experiments in the laboratory. But this is not a problem that is specific to face processing studies and stimuli. Indeed, any laboratory study is faced with issues of ecological validity. Ultimately it is a matter of the tradeoff between ecological validity and control of experimental conditions and extraneous variables. For face processing in particular, many different kinds of stimuli have been used in the literature, with varying degrees of proximity to natural viewing conditions, and each kind of stimulus offers specific advantages (e.g., precise stimulus control) and disadvantages (e.g., lower ecological validity).

- *Manuscript (Annex 5):*

Lee, K. M., Ferreira-Santos, F., & Satpute, A. B. (Under review). Predictive Processing models in Affective Neuroscience. *Neuroscience and Biobehavioral Reviews*.

- *Abstract:*

The neural bases of affective experience remain elusive. Early neuroscience models of affect searched for specific brain regions that uniquely carried out the computations that underlie dimensions of valence and arousal. However, a growing body of work has failed to identify these circuits. Research turned to multivariate analyses and machine learning algorithms, but these strategies, too, have made limited progress. Predictive processing (PP) models offer exciting new directions to address this problem. In this

article, we raise the question: if we assume that the brain operates as described by PP (involving hierarchical predictions and predictions errors), what are the consequences for experimental design and inference? Addressing this question revisits a decades old debate between systematic and representative design. Systematic design has been the dominant paradigm guiding affective neuroscience research. However, our theoretical analysis suggests taking a representative design approach in which ecological validity is crucial. Using PP as a lens, we evaluate experimental design in fMRI, reconsider "reverse inference", and suggest future directions for research in affective neuroscience.

4. Project outputs

Table highlighting the differences between expected and achieved output indicators:

Expected and achieved output indicators (number of actions)

Output indicators	Expected (according to application)	Achieved
Advanced training: PhD theses	1	1 PhD project funded by the FCT (2017-2021)
Advanced training: Master theses	2	5
Advanced training: Other	2 internships	3 internships
Organization of seminars and conferences	3 seminars	4 (2 seminars + 2 international symposia)
Actions of scientific dissemination	8 (2 public engagement actions; 1 presentation in an international scientific conference; 5 papers)	31 actions (2 public engagement sites, namely project website and Facebook page; 23 presentations in scientific meetings; 3 papers published; 1 paper under review; 2 public preprints)

Notes: 2 additional papers in preparation.

List of publications

The full list of publications and outputs is detailed in the points below (4.1 to 4.9).

4.1. Publications in international peer-reviewed journals

Pereira, M. R., Barbosa, F., de Haan, M., & Ferreira-Santos, F. (2019). Understanding the development of face and emotion processing under a predictive processing framework. *Developmental Psychology, 55*(9), 1868–1881. https://doi.org/10.1037/dev0000706

Ferreira-Santos, F. (2016). The role of arousal in predictive coding. *Behavioral and Brain Sciences, 39*. https://doi.org/10.1017/S0140525X15001788

Ferreira-Santos, F. (2015). Facial emotion processing in the laboratory (and elsewhere): Tradeoffs between stimulus control and ecological validity. *AIMS Neuroscience, 2*(4), 236–239. https://doi.org/10.3934/Neuroscience.2015.4.236

4.2. Pre-prints and manuscripts in preparation/under review

Lee, K. M., Ferreira-Santos, F., & Satpute, A. B. (Under review – currently in the second round of revisions). Predictive Processing models in Affective Neuroscience. *Neuroscience and Biobehavioral Reviews*.

(In prep.). The Porto Affective Faces Set (PAFS): Validation of a set of facial configurations beyond basic emotion categories.

(In prep.). Affective processing of facial expressions of emotion between childhood and adolescence: A cross-sectional electrophysiological study.

Ferreira-Santos, F., Pereira, M. R., Paiva, T. O., Almeida, P. R., Martins, E. C., de Haan, M., Baldeweg, T., & Barbosa, F. (2020). What you morph is not what you get: Subjective and neural responses to facial expressions of emotion depend on perceived intensity/arousal (not on amount of morphing). *PsyArXiv*. https://doi.org/10.31234/osf.io/qda9m

Pereira, M. R., Paiva, T. O., Barbosa, F., Almeida, P. R., Martins, E. C., Baldeweg, T., Haan, M. de, & Ferreira-Santos, F. (2018). Disentangling the role of face typicality and affect in emotional face processing: Self-reported and electrophysiological evidence. *BioRxiv*, 378224. https://doi.org/10.1101/378224

4.3. Organized Symposia and Seminars

Ferreira-Santos, F. (Org.) (2018, October). *Understanding facial expressions of emotion across development: Novel approaches and clinical implications* [Invited symposium]. XI Congreso Internacional y XVI Nacional de Psicología Clínica, Granada, Spain. http://www.aepc.es/PsClinicaXI/CVSIMP/CVSimp_En_74.html

Ferreira-Santos, F. (Org.) (2018, July). *Predictive processing approaches in affective neuroscience* [Symposium]. 4th International Conference of the European Society for Cognitive and Affective Neuroscience (ESCAN), Leiden, The Netherlands. https://escaneurosci.eu/leiden2018

Ferreira-Santos, F. (Org.) (2018, February). *Seminário Científico Projeto AffectiveFaces / Laboratorio de Neuropsicofisiologia* [Seminar]. Faculty of Psychology and Education Sciences of the University of Porto, Portugal. https://sigarra.up.pt/fpceup/en/noticias_geral.ver_noticia?p_nr=39017

- *2018 Seminar talks:*
    - "Psicofisiologia do testemunho ocular", Pedro Bem-Haja & Isabel Santos (CINTESIS, Universidade de Aveiro)
    - "Perceção subjetiva da intensidade emocional de expressões faciais de emoção: Dados neurofisiológicos e de auto-relato", Fernando Ferreira-Santos (Universidade do Porto)

Ferreira-Santos, F. (Org.) (2017, February). *The Predictive Mind and Emotion: Predictive Coding approaches in Affective Neuroscience* [Seminar]. Faculty of Psychology and Education Sciences of the University of Porto, Portugal.

- *2017 Seminar talks:*
    - "What is Predictive Coding? An active inference approach to explanation in Psychology and Neuroscience", Fernando Ferreira-Santos (University of Porto)
    - "Neural processing of facial expressions of emotion and Predictive Coding", Mariana R. Pereira (University of Porto)
    - "Prediction in auditory emotional processing", Ana P. Pinheiro (University of Lisbon)

- "Emotion inside out: From cartoon neuroscience to the predictive brain", Lisa Feldman Barrett (Northeastern University)

4.4. Presentations in scientific meetings (talks/posters/abstracts)

Mazer, P., Pereira, M. R., Torrinhas-Caldeira, I., Garcez, H., Almeida, R., Paiva, T. O., & Ferreira-Santos, F. (2019, September). *Frontal alpha asymmetry and emotional symptoms: a cross-sectional study with children between 4 and 15 years old* [Poster presentation]. Cognitive and Developmental section joint conference from British Psychological Society, Stoke on Trent, United Kingdom.

Pereira, M. R., Torrinhas-Caldeira, I., Garcez, H., Almeida, R., Mazer, P., Martins, E. C., de Haan, M., Barbosa, F. & Ferreira-Santos, F. (2019, September). *Emotional symptoms and affective face processing in children and adolescents: A cross-sectional ERP study* [Paper presentation]. Cognitive and Developmental section joint conference from British Psychological Society, Stoke on Trent, United Kingdom.

Pereira, M. R., Torrinhas-Caldeira, I., Garcez, H., Almeida, R., Mazer, P., Martins, E. C., Barbosa, F., de Haan, M., & Ferreira-Santos, F. (2019, May). *The influence of child-parent attachment in early and late processing of facial expressions of emotions: an ERP study with children between 4- and 15-years-old* [Poster presentation]. The Future of Neuroscience, Attachment and Mentalizing – from research to clinical practice, London, United Kingdom.

Pereira, M. R., Barbosa, F, de Haan, M., & Ferreira-Santos, F. (2019, August). *Predictive Coding and emotional face processing in infancy* [Paper presentation]. 4th Lancaster Conference for Infant and Early Child Development, Lancaster, United Kingdom.

Almeida, R., Garcez, H., Torrinhas-Caldeira, I., Pereira, M. R., & Ferreira-Santos, F. (2018, October). *Examining the role of empathy on the neural correlates of emotional face perception in adolescence* [Paper presentation]. XI Congreso Internacional y XVI Nacional de Psicología Clínica, Granada, Spain.

Garcez, H., Torrinhas-Caldeira, I., Almeida, R., Pereira, M. R., & Ferreira-Santos, F. (2018, October). *Attachment and neural affective face processing in school-aged children* [Paper presentation]. XI Congreso Internacional y XVI Nacional de Psicología Clínica, Granada, Spain.

Mazer, P., Pereira, M. R., Martins, E. C., Paulino, F., Rodrigues, P., & Ferreira-Santos, F. (2018. October). *Designing facial expression stimuli for basic and clinical research: Preliminary data on the Porto Affective Faces Set* [Paper presentation]. XI Congreso Internacional y XVI Nacional de Psicología Clínica, Granada, Spain.

Pereira, M. R., Barbosa, F., de Haan, M., & Ferreira-Santos, F. (2018. October). *The development of emotional face perception: A predictive processing approach* [Paper presentation]. XI Congreso Internacional y XVI Nacional de Psicología Clínica, Granada, Spain.

Torrinhas-Caldeira, I., Almeida, R., Garcez, H., Pereira, M. R., & Ferreira-Santos, F. (2018, October). *Neural responses to facial expressions of emotion in young children* [Paper presentation]. XI Congreso Internacional y XVI Nacional de Psicología Clínica, Granada, Spain.

Ferreira-Santos, F., & Martins, E. C. (2018, September). *Predictive Processing and the nature of psychological concepts* [Paper presentation]. Psychopathology, Meaningfulness, and Understanding: International Interdisciplinary Conference, Portucalense University (UPT), Porto, Portugal.

Ferreira-Santos, F. (2018, July). *The role of arousal in the perception of facial expressions of emotion: An affective predictive processing approach* [Paper presentation]. 4th International Conference of the European Society for Cognitive and Affective Neuroscience (ESCAN), Leiden, The Netherlands. https://escaneurosci.eu/leiden2018

Pereira, M. R., Paiva, T. O., & Ferreira-Santos, F. (2018, July). *The role of affective dimensions and face typicality in emotional face processing: An ERP study* [Paper presentation]. 4th International Conference of the European Society for Cognitive and Affective Neuroscience (ESCAN), Leiden, The Netherlands. https://escaneurosci.eu/leiden2018

Ferreira-Santos, F. (2018, February*). Perceção subjetiva da intensidade emocional de expressões faciais de emoção: Dados neurofisiológicos e de auto-relato* [Paper presentation]. Seminário Científico Projeto AffectiveFaces / Laboratorio de Neuropsicofisiologia (FPCEUP), Porto, Portugal.

Ferreira-Santos, F., de Haan, M., Baldeweg, T., Barbosa, F., Martins, E. C., Almeida, P. R., Paiva, T. O., & Pipa, F. (2018). *Investigating the role of affective dimensions (arousal and valence) in the neural processing of facial expressions of emotion* [Abstract]. Program and Abstracts of the 12th Symposium of the BIAL Foundation.

Ferreira-Santos, F. (2017, November). *Affective dimensions and the neural response to facial expressions of emotion: Developmental and electrophysiological evidence* [Invited paper presentation]. Psychology Department Meeting, Midsweden University, Östersund, Sweden.

Ferreira-Santos, F. (2017, September). *The role of affective dimensions in the neural response to facial expressions of emotion: An affective predictive coding approach* [Invited paper presentation]. Lehrstuhl für Psychologie I: Biologische Psychologie, Klinische Psychologie und Psychotherapie, Julius-Maximilians University of Würzburg, Germany.

Ferreira-Santos, F. (2017, May). *Arousal and the Predictive Brain* [Paper presentation]. Meeting of the Interdisciplinary Affective Sciences Lab, Northeastern University, Boston, MA, USA.

Ferreira-Santos, F. (2017, May). *Do Cérebro Triuno ao Cérebro Preditivo: 27 anos de Neurociência Afetiva* [Invited paper presentation]. Ciclo de Seminários Freud, Psicanálise e as Neurociências, Instituto de Filosofia, Faculdade de Letras da Universidade do Porto, Portugal.

Pereira, M. R., (2017, May). *O efeito diferencial da tipicalidade da face e a ativação percebida na resposta neuronal a expressões faciais de emoção* [Paper presentation]. IX Jornadas de Neurofisiologia, Escola Superior de Saúde, Instituto Politécnico do Porto, Portugal.

Ferreira-Santos, F. (2017, February). *Methodological challenges for the predictive scientist: Rethinking experimental design to study Predictive Coding* [Paper presentation]. Meeting of the MEG Unit, Brain Imaging Center, Goethe University Frankfurt, Germany.

Ferreira-Santos, F. (2017, February). *What is Predictive Coding? An active inference approach to explanation in Psychology and Neuroscience* [Paper presentation]. Seminar The Predictive Mind: Predictive Coding Approaches in Affective Neuroscience, Porto, Portugal.

Ferreira-Santos, F. (2016, May). *Can categorical and dimensional accounts of emotion be unified? Preliminary data and the promise of affective predictive coding* [Poster presentation]. Animal and Human Emotions (International School of Neuroscience "Sir John Eccles" & International School of Ethology), Erice, Sicily, Italy.

Ferreira-Santos, F., de Haan, M., Baldeweg, T., Barbosa, F., Martins, E. C., Almeida, P. R., Paiva, T. O., & Pipa, F. (2016). *Can dimensional and categorical models of the perception of facial expressions of emotion be integrated in an affective predictive coding framework?* [Abstract]. Program and Abstracts of the 11th Symposium of the BIAL Foundation.

4.5. Awards

Best Talk Award – Lancaster Conference on Infant and Early Child Development 2019 (Lancaster, UK) for the work:

Pereira, M. R., Barbosa, F, de Haan, M., & Ferreira-Santos, F. (2019, August). *Predictive Coding and emotional face processing in infancy* [Paper presentation]. 4th Lancaster Conference for Infant and Early Child Development, Lancaster, United Kingdom.

Link to announcement: https://www.facebook.com/LCICD/posts/1384342955062617

4.6. PhD Projects

Mariana R. Pereira, "Predictive Coding and the ontogeny of facial emotion processing: Neuroimaging and electrophysiological studies in infants and adults" (funded by Fundação para a Ciência e Tecnologia [FCT]: PD/BD/135429/2017).

4.7. Master's Dissertations

Almeida, R. (2018). *Through adolescent eyes: An electrophysiological study of emotional face processing and the role of empathy* [Master's dissertation, University of Porto]. Repositório Aberto da Universidade do Porto. https://hdl.handle.net/10216/116919

Garcez, H. (2018). *Neural processing of emotional faces in school aged children: Disentangling the effects of emotional category, valence, and arousal* [Master's dissertation, University of Porto]. Repositório Aberto da Universidade do Porto. https://hdl.handle.net/10216/116826

Rocha, A. (2018). *O efeito de traços de ansiedade na avaliação e identificação de expressões faciais de emoção com diferentes níveis de intensidade emocional* [Master's dissertation, University of Porto]. Repositório Aberto da Universidade do Porto. https://hdl.handle.net/10216/112757

Torrinhas-Caldeira, I. (2018). *Respostas neuronais a expressões faciais de emoção em crianças de idade pré-escolar: Efeitos de valência e ativação* [Master's dissertation, University of Porto]. Repositório Aberto da Universidade do Porto. https://hdl.handle.net/10216/116832

Peres, J. (2017). *Psicopatia e o défice no processamento de expressões faciais de emoção: uma abordagem à luz do modelo triárquico da psicopatia* [Master's dissertation, University of Porto]. Repositório aberto da Universidade do Porto.https://hdl.handle.net/10216/108470

4.8. Completed Internships

Completed curricular internships of the Integrated Master in Psychology (FPCEUP) at the Laboratory of Neuropsychophysiology, FPCEUP:

- 2017-2018: Helena Garcez
- 2017-2018: Rita Almeida
- 2016-2017: Nuno Velho

4.9. Public Engagement

Project Website and Social Media. The project website (http://affectivefaces.joomla.com) has been active throughout the project as a central resource in public engagement and outreach. However, as the Joomla.com platform has been purchased by CloudAccess.net, this free website has been terminated. As such, we have designed a new project website at https://affectivefaces.wordpress.com.

Social Media. The project's Facebook page (https://www.facebook.com/affectivefacesproject) has been instrumental to communicate the project to the general public. The project's presence on the academic social network ResearchGate continues to allow dissemination of project findings and updates.

Media coverage. The project was featured in several news outlets (news clippings: at the FPCEUP website: https://sigarra.up.pt/fpceup/pt/NOTICIAS_GERAL.VER_NOTICIA?p_nr=41157; at the BIAL Foundation website: https://www.bial.com/com/bial-foundation/media/news/researchers-supported-by-the-bial-foundation-carried-out-a-project-to-find-how-facial-expressions-ar/).

6. Annexes

The articles/manuscripts of the project that are not openly available online can be found below as listed:

- Annex 1 – Mazer et al. (In prep.)
- Annex 2 – Pereira et al. (In prep.)
- Annex 3 – Pereira et al. (2019). *Developmental Psychology*.
- Annex 4 – Ferreira-Santos (2016). *Behavioral and Brain Sciences*.
- Annex 5 – Lee, Ferreira-Santos, & Satpute (Under review). *Neuroscience and Biobehavioral Reviews*.