+ 6 Excellence research projects in **Aix-Marseille!**

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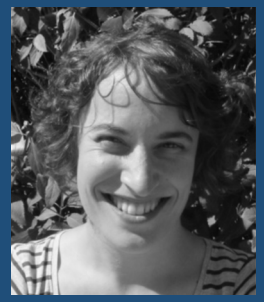
- 5 Consolidator Grants #ERCCoG 2021
- 1 Starting Grant #ERCStG 2021 (on top of the 3 projects selected earlier)

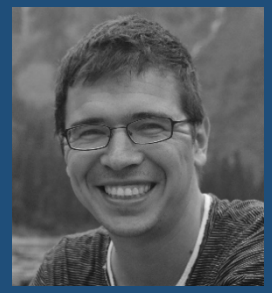
Anabela
BENSIMON-BRITO
"CARDIOCALC"

Raphaël
BEUZART-PLESSIS
"RELANTRA"

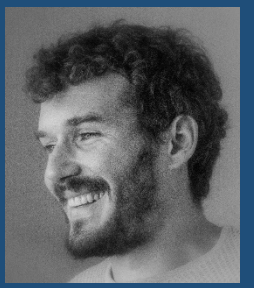
Sophie
BONNET
"HOPE"



Elodie
CHOQUET
"ESCAPE"



Alexis
LICHT
"DISPERSAL"



Benjamin
MORILLON
"SPEEDY"

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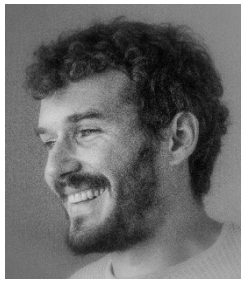

BENJAMIN MORILLON Project: ***SPEEDY***

Defining an integrated model of the neural processing of speech in light of its multiscale dynamics #ERCCoG

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"This interdisciplinary project will define an integrated model of speech processing by recording, modelling and manipulating neural oscillatory dynamics during perception of speech defined as a multiscale temporal signal. Dominant models of speech perception describe its underlying neural mechanisms at a static neuroanatomical level, neglecting the cognitive algorithmic and neural dynamic levels of description. These latter can only be investigated by considering the temporal dimension of speech, which is structured according to a hierarchy of linguistic timescales (phoneme, syllable, word, phrase). Recent advances in behavioural paradigms, computational modelling, and neuroimaging data analysis make it now possible to investigate the
cognitive algorithms and neural dynamics subtending the processing of speech. To define an integrated model of speech perception, this project seeks to: 1. record neural activity in humans with magnetoencephalography and intracranial recordings during perception of continuous speech; 2. quantify linguistic information at each timescale of speech with a computational model; and 3. estimate their respective and shared neural correlates with multivariate and directed connectivity analyses. Feasibility is ensured by an in-house access to neuroimaging and intracranial recordings as exemplified in the data on Figure 1 of this proposal. This project will critically test whether neural oscillations play a fundamental role in the computational processes of
perception and cognition. It will define the mapping between speech and neural timescales and reveal how information is transferred and combined along the linguistic computational processing hierarchy. It will overall specify –in terms of the nature of the information processed and of the dynamical hierarchical organization–the respective contributions of left and right hemispheric ventral and dorsal auditory pathways in speech processing."

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ALEXIS LICHT Project: ***DISPERSAL***

A climatic or tectonic control on early primate dispersal? A new approach to investigate species dispersal in deep time #ERCCoG

European Research Council
Established by the European Commission

"Recent studies show that the distribution of many modern terrestrial species can be explained by a handful amount of large-scale dispersals and that these episodes will likely become more numerous under climatic stress. However, the underlying mechanisms governing these dispersals remain nebulous. Long-distance dispersals across marine barriers, often referred to sweepstakes dispersals, have always been assumed to be an unpredictable process in which taxa overcome a geographic barrier in a random manner. Yet, there are many instances of dispersals across marine barriers that appear coordinated and non-random. New paleontological findings show that during a short time period marked by intense climate variations, 40 to 35 million years ago, Asian anthropoid primates and rodents crossed 500 km of Tethys Sea to reach Africa and 800 km of South Atlantic Ocean to reach South America. This proposal aims to build an empirical and theoretical basis for the origins and mechanisms of long-distance dispersals by resolving: **how did primates and other mammals disperse across two major seaways? What are the external forcing mechanisms that make transoceanic dispersals non-random?**

This project proposes a combination of paleoclimatic, paleogeographic, and paleontological approaches to evaluate the mechanisms of species dispersal and diversification in deep time, applied to the early dispersal of anthropoid primates. This research will set the founding steps of a holistic method to evaluate the mechanisms of all dispersal events in deep time, allowing new interpretations about the modern, past and future distribution of species; it will additionally solve one of the biggest mysteries in paleontology, as this episode ranks among the most pivotal events during all of primate evolutionary history."

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ELODIE CHOQUET Project: ***ESCAPE***

Exoplanetary Systems with a Coronagraphic Archive Processing Engine #ERCCoG

European Research Council
Established by the European Commission

"Determining the frequency of life in the Universe is one of the main challenges of the next decades. It requires a large high-contrast imager in space such as LUVOIR or HabEx, able to characterize dozens of nearby earth-like planets. The detection of such planets, 10^-10 fainter than their star and lost in the bright and varying glare of the star in the images, is a formidable challenge. In the race to remove the contaminating starlight, both the coronagraphic instrument and the image processing have a key role to play. Yet, the science and technological definition of these mission concepts relies entirely on the coronagraphic instrument to reject the starlight, assuming a simple gain of 10 in sensitivity with image processing based on 15-year-old techniques developed for the Hubble Space Telescope. The cost of this approach is a daunting wavefront stability requirement of 20pm rms and conservative exoplanet yield estimates.

With ESCAPE I propose to develop innovative image processing methods that make use of the specific hardware in these high-contrast imagers (their wavefront sensors and deformable mirrors) and of the data accumulated in their archives to bring a significant gain in starlight subtraction.

I will use the unique opportunity of the timely launch of the Roman Space Telescope during the ERC timeframe, which precisely includes the CGI technology demonstrator of high-contrast imaging in space, to demonstrate my methods and achieve 20x improved detection limits. In parallel I will deploy the ESCAPE methods on the public archives of the VLT-SPHERE and JWST NIRCam and MIRI coronagraphic instruments to deliver higher-grade data to the community, obtain new planetary systems discoveries, and constrain the giant planet population on scales yet-unexplored and comparable to the Solar System. These ambitious goals and timeline will pave the way for the implementation of the ESCAPE methods in the future space imaging missions and facilitate the determination of the frequency of life."

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SOPHIE BONNET Project: ***HOPE***

How do diazotrophs shape the ocean biological carbon pump? A global approach, from the single cell to the ecosystem #ERCCoG

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"Diazotrophs regulate marine productivity in 60% of our oceans by alleviating nitrogen limitation, contributing to carbon (C) sequestration through the N_2-primed Prokaryotic C Pump (PCP). Yet we do not know how much diazotroph-derived organic C (OC) is exported to the deep ocean, which prevents robust predictions of how the ocean contributes to CO_2 sequestration and climate change mitigation. This knowledge gap is due to the multiple and complex pathways by which diazotrophs are exported to the deep ocean, which quantification and drivers of variability are impossible to capture with current methods. HOPE will bridge this gap thanks to a new isotopic technique I developed and to a coupling between lab and in situ approaches examining processes occurring at different spatiotemporal scales, and capable of capturing both transient and seasonal features of the PCP. HOPE will:

1. Determine how various diazotrophs aggregate, sink and are remineralized by using an automated experimental water column I designed for this proposal,

2. Decipher by which pathways diazotroph-derived OC is exported to the deep ocean thanks to a pioneer approach combining single-cell isotopic analyses, in-depth microbiological characterization of sinking particles and geochemical budgets,

3. Investigate how environmental drivers control the whole process, from the surface diazotroph community up to their eventual export to the deep ocean, by deploying a cutting-edge autonomous platform, unique as it performs synoptic measurements both in and below the euphotic zone at high resolution (hourly/daily).

In its final stage, HOPE will use the generated data to provide global, spatially resolved estimates of the contribution of diazotrophs to overall OC export. Based on my expertise at the interface between microbial oceanography and geochemistry, HOPE has the potential to deliver a multidisciplinary and ground-breaking knowledge leading to potential scientific-based recommendations to fight climate change."

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RAPHAËL BEUZART-PLESSIS Project: *RELANTRA*

Relative Langlands Functoriality, Trace Formulas and Harmonic Analysis #ERCCoG

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"The Langlands program is a web of vast and far-reaching conjectures connecting seemingly distinct areas of mathematics that are number theory and representation theory. At the heart of this program lies an important principle called functoriality, that postulates the existence of deep relations between the automorphic representations of different groups, as well as related central analytic objects called automorphic L-functions. Recently, a new and particularly promising way to look at these notions, and that has come to be called the relative Langlands program, has emerged. It essentially consists in replacing groups by certain homogeneous spaces and to study their automorphic or local spectra.

As for the usual Langlands program, trace formulas are essential tools in the relative setting both to tackle new conjectures than to deepen our understanding of the underlying principles. A main theme of this proposal would be to make fundamental new contributions to the development of these central objects in the local setting notably by: (1) Studying systematically the spectral expansions of certain simple versions especially in the presence of an outer automorphism (twisted trace formula) (2) Developing far-reaching local relative trace formulas for general spherical varieties making in particular original new connections to the geometry of cotangent bundles. These progress would then be applied to establish new and important instances of relative Langlands correspondences/functorialities. In a slightly different but related direction, I also aim to study and develop other important tools of harmonic analysis in a relative context, including Plancherel formulas and new kind of Paley-Wiener theorems, with possible applications to new global comparison of trace formulas and factorization of automorphic periods."

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ANABELA BENSIMON-BRITO Project: *CARDIOCALC*

The fundamentals of cardiovascular calcification: from cells to therapy #ERCStG

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"With this project I propose to identify fundamental mechanisms of cardiovascular calcification (CVC) and new therapeutic targets using zebrafish as a model system.

CVC, characterised by progressive calcification of the soft tissue causing impaired blood circulation[1, 2], is a frequent form of cardiovascular disease. Because the pathophysiology of CVC is highly heterogeneous, the exact cell types and signalling pathways triggering tissue calcification are still unknown, thus limiting therapy options[3]. Most studies on CVC rely on *in vitro* systems, which fail to reproduce the multicellular environment, or mammalian *in vivo* models, limited for live-imaging and high-throughput analyses.

By combining my expertise in cardiovascular research and bone biology, I propose to use zebrafish as a model to elucidate the multifactorial mechanisms of CVC, focusing on different developmental stages and cardiovascular tissues. **In Aim 1, I will use a broad array of zebrafish genetic models to characterise the cellular dynamics, molecular mechanisms and functional impact of CVC *in vivo***. I will also study the role of specific cell populations present in regenerating valves and human valve implants with CVC. **In Aim 2, I propose to identify new local and systemic therapeutic strategies to block/reverse CVC,** taking advantage of the zebrafish amenability for genetic manipulation and high-throughput screening. I will recruit bone-degrading cells to the CVC site and determine their potential to reverse tissue calcification. Moreover, I will select a short list of small molecules identified in a large-scale screen in zebrafish and will test their therapeutic potential in cardiovascular cells derived from hiPSCs of CVC patients.

Altogether, with this interdisciplinary approach, I expect to bring a new perspective on the mechanisms and therapeutic targets to block/reverse CVC, which could have a considerable impact on the European population, severely affected by these diseases."

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