UniCa PhD Book
XXXIII Cycle

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UniCa PhD Books 1

This volume reports, in brief, the experience of the students enrolled in the XXXIII cycle of the PhD courses at the University of Cagliari. The contributions are grouped by course and are preceded by a presentation of the coordinators of each PhD program. In two pages each student gives the reader an idea of his/her personal experience and of the results of his/her research.

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#1

UniCa PhD Book – XXXIII Cycle

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We were very honored when we were asked to write the introduction to this book. The concept of this volume stemmed from the close attention the University of Cagliari puts on post-graduation courses and in particular on PhD courses. Allowing our most worthy graduates to access highly professional PhD courses, is for us of crucial importance, not only for the future of our University, but most of all to achieve a high specialization to be spent in the world of research and in the regional, national and international workforce. In recent years, the policy of this University has greatly enhanced its focus on the internationalization of our courses, and it is highly rewarding for us to see that many European academies have started to share our cultural proposal of advanced education.

Our University has many talented students who deserve to be inspired and encouraged to nurture and enhance their potential. We must be grateful to the professors and researchers of our academy for working hard to maintain the standard level of our PhD courses so high, and for supporting our PhD students even in such difficult times caused by the COVID19 emergency.

This book summarizes some of the most interesting and stimulating research led by our PhD students, showing the high level of their skills. Of course, the ultimate scope of this volume is to support the growth and development of the Sardinian society thanks to the participation and work of our PhD students. We hope this cultural achievement may continue in the future, in order to support with growing strengths, the development of this land.

Maria Del Zompo
Chancellor of the University of Cagliari

Francesco Mola
Vice-chancellor of the University of Cagliari

PhD program in Chemical Sciences and Technologies

Coordinator: Prof. Stefano Enzo
Vicecoordinator: Prof. Carla Cannas

https://peolple.unica.it/dottoratinchimica/
https://www.uniss.it/node/8694

The PhD in Chemical Sciences and Technologies is the only PhD course in Chemistry in Sardinia, and since 2013-2014 it involves the universities of Cagliari (UNICA) and Sassari (UNISS) with a joint Agreement. It was established with the aim of training highly qualified young scientists in the chemistry issues throughout science and research, by giving an opportunity to young Italian and foreigner master-degree level candidates in order to plan and carry out a research project in the most advanced issues of chemical sciences and technologies. To this end the selected PhD students are accompanied and supported with a continuous experimental activity sustained by a tailored teaching path. The Board offer to the PhD students the possibility to interact with institutions, industries and scientists active in the national and international panorama, to spend a period in selected international laboratories and to participate to conferences, workshops and summer schools. The XXXIII cycle stands on 14 PhD students, 3 supported by UNICA, 3 by UNISS, 3 by Sardinia Region (RAS) and 5 more by MIUR (PON-RI Program) among which more than 70% have applied for the additional Doctor Europaeus title. During these three years several foreign students from Japan, China, India, Hungary and South Africa have been hosted. Several agreements were established and activated for cotutelle with various universities like Osaka, Cordoba, La Roja, Angers, Barcellona. It should also be acknowledged that three PhD students have been awarded for their thesis and activity at National Chemistry Congresses. At international level we also report the successful participation to the Vinci Program call that enabled our student to organize an international workshop on advanced materials.

The tough but necessary path to build a greener future

Andrea Beccu

My experience in the research field of organic chemistry started during my bachelor thesis, here I learnt what means to carry out an experimental work, stay many hours in the laboratory and, later, decide the next steps by analysing the results. During my master thesis I realized that science also means mix up different topics, because I had the opportunity to spend three months in Barcelona and expand my organic synthesis work with nanoparticles building. The years of my PhD demonstrated how challenging a scientific project can be, the idea of starting from a compound and try to reach a specific target through organic synthesis involves many tasks: design a pathway, study in depth the literature and test the ideas in the laboratory. Whenever the designed pathway proves to be unproductive the process needs to be rethought and the journey starts again. I spent nine months in Eindhoven where I worked on photochemistry, so, again, even if it still was organic synthesis, I worked with totally new methodologies.

The environmental impact of the production and non-production processes covers, as today, a main role into the international debate and it is a well-known argument even in the everyday life. On these years, the population around the world has reached a major consciousness about the huge consequences, in short and long time, that having bad behaviours in terms of energy consumption and waste production have on climate, plant and animal kingdoms, and even in human health. Today, recycling and house trash separation it is part of everyday life, while, just two decades ago, was not even strictly regulated.

That new feeling it is confirmed by the presence of eco-friendly products that it's possible to find in every fields (food, cosmetic, car, heating systems, energy production). Many classifications have been developed to recognize and sort all those products in terms of sustainability. However, in science, debate and concern about processes sustainability it's started long time ago, culminating, in chemistry, in the nineties with the twelve green chemistry principles, a guidelines about the design of products and processes that minimize or eliminate the use and generation of hazardous substances.

In this framework my goal is to develop a new methodology and catalyst for alcohol oxidation starting from a renewable material. Alcohol oxidation is a useful transformation used in chemistry to generate building units for useful compound as pharmaceuticals and bioplastics. In my thesis *Low environmental impact catalysed oxidation of biorefinery products*, the chosen starting material is glucose, from which, through a multi-step synthesis, should be possible synthesise the new catalyst. It is worth to mention that not only the starting material has been chosen focusing on low toxicity and renewable nature, but the whole synthetic process is designed looking for a low environmental impact. A critical step in chemical synthesis is to move from the laboratory scale (milligram to grams) to the industrial scale (kilograms to tons) in safety and keeping the processes efficiency, that step, called *technology transfer*, is planned to be carried out using *flow chemistry*, a special way to perform reactions that ensures a high safety and good result reproducibility in big scale. The technique consists in run the reactions in a continuously flowing stream. Pumps move reactant fluids into tubes, and where tubes join one another, the reaction takes place. I tried to couple flow chemistry with photochemistry, a growing topic which can be included in green chemistry. This technique consists in using light as energy source to perform reactions. Light is a free energy source, non-hazardous and his efficiency is extremely high compared to the classical thermal energy. An important aspect of photochemistry is that can be used to reveal new reaction pathways, inaccessible under thermal control and not just to replace known methodologies. Renewable materials as glucose, light and safe processes intensification are some of the ingredients needed to build a greener future.

Sulfur-based Electrodes and Electrolytes for Solid State Batteries

Laura Caggiu

Laura Caggiu is a PhD student of Chemistry at the University of Sassari (Supervisor Prof. Gabriele Mulas), in the framework of Cagliari-Sassari PhD in Chemical Science and Technology, whose Coordinator is Prof S. Enzo. Laura is enrolled in the so-called Industrial PhD program, funded by PON-Ri 2014/2020. Within this framework, her research activity is being carried out in collaboration with the Institut Charles Gerhardt of the Université de Montpellier, France, and Lithops Srl , a company based in Turin, where she spent several stage periods. The international experience was complemented by a traineeship abroad within the CO2MPRISE, MSCA project funded within the Horizon2020 scheme.

Laura received a Bachelor's Degree and Master's Degree in Chemistry at the University of Sassari in 2015 and 2017, respectively, defending relevant theses concerning the investigation of innovative materials for energy applications in Physical Chemistry group (Supervisor Prof. Gabriele Mulas). Laura started studying secondary batteries during her Master Degree traineeship, part of which was carried out at Institut Charles Gerhardt, where she performed the electrochemical characterization of the innovative synthesized materials (thiospinels, transition metal sulfides and oxysulfides).

The focus of the research activity as a PhD student still concerns new materials for secondary batteries and is now addressed to the investigation of several sulfur-based chemical systems, to be tested as elec-

trodes and electrolytes of the so-called sulfur-based secondary batteries. In a former step the attention was addressed to various sulfur-based compounds for different electrochemical application ($MgCr_2S_4$, Na_3PS_4, CMK3/S, V-Nb-O system and CB-S).

Then, the research activity was mainly focused to the syntheses and investigation of electrochemical properties of different compounds as new solid electrolytes (Na_3PS_4, $Na_{11}Sn_2PS_{12}$ and Na_4Ge_4). To this regard she spent 8 months at the Institut Charles Gerhardt, under the supervision of Prof. Lorenzo Stievano, a few weeks at the Department of Quantum Matter Physics of the Université de Genève, in the laboratory of Prof. Radovan Cerny.

A latter step of the research activity is being carried out in collaboration with an industrial partner, Lithops Srl, in whose labs the studied materials will be tested under pre-industrial conditions.

Investigated materials where synthesized mainly by mechanical treatment resorting to ball milling technique, and detailed structural characterization was carried out by XRD powder Diffraction. Electrochemical investigation was performed mostly by Electrical Impedance Spectroscopy.

She attended three international conferences, where she presented the results of her research work by an oral contribution and by a poster, and a national conference and two workshops, in which she presented both oral and poster contributions.

Caggiu L., *et al*., Solvent-Free Mechanochemical Approach towards Thiospinel $MgCr_2S_4$ as a Potential Electrode for Post-Lithium Ion Batteries. *Batteries,* 2020; **6**: 43.

New organic molecules for optoelectronic applications

Andrea Cocco

My name is Andrea Cocco and I'm a third year PhD student in chemical science. I was born in Cagliari in 1990 and I graduated in 2008. I've always been passionate about science and for this reason, I decided to enrol in the chemistry course of the Cagliari State University. My research plan is centred on the molecular design and synthesis of new organic materials and the prototyping of innovative optoelectronic devices. The main goal of this project is the accomplishment of high-performance OLED, using suitable methods for large-scale production. This multidisciplinary research involves a first phase of molecular synthesis and spectroscopical characterization, the creation of performing prototypes, the study and performance monitoring of the devices and ultimately the correlation between the microscopic photophysical processes and the devices performances. My work, started from the scientific collaboration between my two supervisors, prof. Francesco Secci head of the Synthetic Process & Development laboratory at the University of Cagliari and prof. Pier Carlo Ricci, head of the spin-off Elaborad and part of the optical spectroscopy group of the physical sciences department of our university. In this first part of my research, I dealt with the synthesis and spectroscopic characterization of new luminescent coumarins. Then, thanks to the establishment of a new collaboration born within this research project (Industrial doctorate PON 2018), I joined the Eli Zysman Colman group at the University of St. Andrews (UK) where I had the opportunity to develop my knowledge about the design and synthesis of new organic devices and in particular, our at-

tention was focused on the preparation of new TADF (Thermally Activated Delayed Fluorescence) emitters. TADF is a relatively new class of emitter materials that promise efficient and long-lifetime performance without the use of heavy metals. This research field started in earnest in 2012, and the first TADF emitters reached commercial status at the end of 2019. There are currently three main challenges with OLED emitters that TADF aims to solve: An efficient and long-lasting blue color emitter, low cost alternatives current red and green emitters and the development of soluble OLEDs that can be deposited using low cost ink-jet printing or other "wet" methods. Along this period, we investigated several potential TADF compounds with the aim to perform long-lasting blue emitters. Moreover, along my stay in St. Andrews I had the opportunity to acquire new competences on computing and different spectroscopical techniques, which were fundamental for the characterization of this type of high efficiency materials. Back to Cagliari, I followed working on computing studies and continuing on the synthesis of new luminescent organic materials. A part of my time is also devoted to design new OLED prototypes which will be soon published and included in my dissertation thesis titled *New Organic molecules for optoelectronic application*.

Synthesis of adsorbents and biocatalysts for water remediation

Giulia Rossella Delpiano

Bachelor's degree in chemistry in 2013 following a 6-month internship funded by Erasmus scholarship at the Institut de Chimie Moléculaire et des Matériaux d'Orsay (Université Paris Sud XI). In 2016 she obtained a Master's degree in Chemical Sciences at the University of Cagliari with a thesis concerning the synthesis of nanodevices for biomedical applications. During the years 2016 -2017 she worked at the Physics Department of the University of Cagliari for the synthesis of fluorescent nanosensors. In 2017 she started her PhD in Chemical Sciences and Technologies at the University of Cagliari with a project entitled "*Functionalized mesoporous materials for wastewater remediation*", in collaboration with the Bernal Institute of the University of Limerick (Ireland) and with the Portovesme srl industry (Portoscuso, Italy). In 2017 she worked for a short period at the Faculty of Chemistry and Chemical Engineering of the Babeş-Bolyai University of Cluj Napoca (Romania), thus starting a new collaboration.

Her research focuses on the removal of pollutants from water, extremely topical theme, especially in these times when environmental pollution has reached worrying levels. Giulia is focusing her research on the removal of two classes of pollutants namely, organic dyes and heavy metals. They are among the most widespread and harmful pollutants. Specifically, dyes are highly toxic as can have carcinogenic and mutagenic effects on living organisms even at low concentrations. In addition, due to their ability to absorb light, the spillage of dyes into surface waters reduces in depth penetration of the sun rays into the water, which alters the photosynthetic cycles and reduces the oxygen

supply in the water body. Heavy metals can enter in biological organisms through the food chain and can thus be assumed also by humans mainly through fish. Their accumulation in the body can lead to various diseases, such as hormonal or nervous system disorders, as well as various types of inflammations and tumors. Both these classes of pollutants are difficult to remove from surface waters through traditional methods. Giulia's work involves the synthesis of silica-based ordered mesoporous particles. Silica is an inert and environmentally friendly material and its mesoporous particles are generally characterized by a very large surface area (up to 1000 m^2/g) which can be easily modified by functionalizing their surface with a wide range of molecules depending on the pollutant to be removed. In particular, the immobilization of redox enzymes (e.g. laccases, peroxidases, etc.) leads to the formation of **biocatalysts** that are able to oxidize organic pollutants (as toxic dyes). Instead, the grafting of molecules carrying electrons donor atoms (O, N, S) gives rise to the production of **adsorbents** exploitable for the removal of heavy metal ions.

Lachowicz J.I., *et al.*, Adsorption of Cu2+ and Zn2+ on SBA-15 mesoporous silica functionalized with triethylenetetramine chelating agent. *Journal of Enviromental Chemical Engineering,* 2019; **7**: 103205.

Phenolic-based Ionic Liquids: physico-chemical features and biological activity

Monica Demurtas

I got my master's degree in Pharmaceutical Chemistry and currently I'm a PhD student in Chemistry of the XXXIII cycle, under the supervision of Prof. Flaminia Cesare Marincola and Francesca Mocci. Before joining the PhD course, I worked for four years as research fellow at University of Cagliari in the Department of Life and Environmental Science as pharmaceutical synthetic, mainly on design, development and synthesis of antioxidant and antiproliferative molecules.

My PhD project concerns the physico-chemical and biological characterization of some Ionic Liquids (ILs) synthesized using natural phenolic acids as precursors. ILs are organic salts with a melting point below 100 °C and, due to this feature, are also known as “molten salts”. The remarkable properties of ILs, including extremely low vapor pressure, high thermal stability, wide temperature range as liquids, and tunable physicochemical characteristics, makes them suitable as solvents and/or reagents in many areas such as organic synthesis, catalysis and biocatalysis. More recently, the tunable nature of ILs has made these salts very attractive also in my field of interest, the pharmaceutical field.

The ILs under investigation in my PhD project were synthesized by me during my first year at the University of Cagliari and their melting and decomposition temperatures, water solubility, and antioxidant properties were characterized experimentally by a multidisciplinary approach. Additionally, the antioxidant properties were investigated by

calculating thermodynamic indexes related to the radical-scavenging mechanisms by using computational methods based on quantum chemistry. Besides the abovementioned physico-chemical properties, I also evaluated their biological properties such as cytotoxicity on both tumoral and healthy murine cells and their capability to interact with the Tyrosinase enzyme by using spectrophotometric methods.

In the light of the findings obtained during the first year of my PhD project, human cell line model represented a mandatory step to characterize the biological effects of Ils, in particular in view of their potential use in human applications. To this purpose, I spent eight months and half as visiting PhD at CICECO, Institute of materials of the University of Aveiro, where I developed more skills on cell cultures, in particular on MNT-1 human melanoma cells. In this context, I performed biological assays such as cytotoxicity test and extraction of cell metabolites to be analyzed on NMR-based metabolomic experiments. NMR cell metabolomics experiments are very useful to investigate the effects of these bioactive ILs at the level of cellular metabolic pathways.

The multidisciplinarity of my project led me to improve my skills on team working and I found very useful and stimulating the collaboration with a multicultural research group. During my PhD, I also had the opportunity to work as a tutor/assistant in academic courses and to improve my skills in teaching and support students' work in laboratory. Moreover, in 2019 and 2020 together with my supervisor Prof. Flaminia Cesare Marincola, I had the pleasure to participate and to organize the activities for the event of scientific divulgation " Women and girls in science" at University of Cagliari.

Demurtas M., *et al.* Indole derivatives as multifunctional drugs: Synthesis and evaluation of antioxidant, photoprotective and antiproliferative activity of indole hydrazones, *Bioorg. Chem.*, 2019; **85**: 568-576.

Computer simulation studies of micro-heterogeneous liquid mixtures

Leon de Villiers Engelbrecht

Leon Engelbrecht is originally from Wellington, South Africa. He graduated in Chemistry (M.Sc. *cum laude*, 2013) from the University of Stellenbosch (South Africa) and obtained his PhD. degree (2017) at the same institution under the supervision of Prof Klaus R Koch, specializing in nuclear magnetic resonance. He is currently pursuing a second doctoral degree at UniCa under the supervision of Prof Francesca Mocci and Prof Flaminia Cesare Marincola. To perform part of his research activity, he has spent research periods abroad at the PDC Center for High Performance Computing, KTH Royal Institute of Technology in Stockholm (HPC Europa 3 transnational access programme), and in the group of Prof Xiaoyan Ji, Luleå University of Technology. He attended the international "Computational Molecular Modeling" scientific summer school (Pula, 2019), where he presented a research poster. He has been involved as a tutor to support the students in a Phys-Chem lab undergraduate course and co-supervised the master thesis work of a graduate student at UniCa. Furthermore, he was involved in the ASL 2018 (Alternanza Scuola Lavoro) activity, introducing high school students to computational molecular modelling.

His current PhD. project concerns computer simulations of binary liquid mixtures, including both conventional molecular liquids, and ionic liquids and ionic liquid-based deep eutectic mixtures, specifically with the aim of understanding their interesting properties at the molecular level. Liquid mixtures are encountered in numerous industrial and research applications, notably as versatile solvents in chemical synthesis, precious metal extraction and chromatography. Often such mixtures

exhibit interesting or anomalous physical properties, e.g. higher- or lower-than-expected melting point, density or viscosity, due to particular molecular-level arrangements or self-association of mixture components, a condition often referred to as "micro-heterogeneity". The microscopic organization of the liquid in the mixtures is responsible of many properties, and we can use computer simulations as a powerful microscope to study at the molecular level their arrangement and explain the macroscopic behaviour observed experimentally.

Ionic liquids (IL), which are essentially ionic compounds (salts) that are liquid at temperatures below 100 °C, typically consisting of an organic cation and an inorganic anion; ethylammonium nitrate (EAN) is a prototypical example. Recent X-ray scattering experiments on binary mixtures of EAN with organic solvents, e.g. acetonitrile, revealed scattering features identified with long-range structural correlations, i.e. indicative of the presence of large molecular assemblies. We performed large-scale Molecular Dynamics (MD) computer simulations using a specially-developed computational model, consisting of up to millions of particles, in order to study the nature of the proposed molecular assemblies.

A related project concerns MD simulations of selected binary mixtures of two butanol isomers with di-*n*-butyl ether (DBE); these compounds are of considerable interest as fuel additives for internal combustion engines. Specifically, mixtures of either 1- or 2-butanol with DBE exhibit interesting differences in their anomalous volumetric properties. The MD simulations revealed these volumetric differences to coincide with significantly different butanol isomer self-association behaviour via hydrogen bonding interactions.

Engelbrecht L., *et al.* A ^{195}Pt and MD Simulation Study of the Solvation of $[PtCl_6]^{2-}$ in Water-Methanol and Water-Dimethoxyethane Binary Mixtures. *Inorg. Chem.*, 2018; **57**(19): 12025-12037.

Sardinian marble to purify Sardinian waters from toxic elements

Elio Fiorito

Elio Fiorito is a PhD student in analytical chemistry and surface sciences at the University of Cagliari and enrolled in the XXXIII doctoral program. He received his master's degree in biomolecular chemistry from the University of Catania in 2017. Currently, his research interests focus on studying of solid and liquid matrices for environmental applications, in particular for water remediation. He spent part of his PhD at the ETH Zürich in LSST group under the supervision of Professor Nicholas D. Spencer. His PhD project is carried out in collaboration with accredited laboratory "Laboratorio Chimico Nuorese", located in Nuoro, in agreement with BS QuarrySar Group. His project is fully funded by Italian Ministry of Research and University (MIUR) through PON-RI program.

The title of this project is "*Relevant surface reactions involving carbonates for heavy metals removal*" and aims to address two different critical issues present in Sardinia, namely: the high level of surface waters' toxic elements (often generally referred to as "heavy metals") close to abandoned mines of South West Sardinia and the waste disposal of the large amount of carbonate debris resulting from marble cutting processes in quarries of North Est Sardinia. As far as the first point, environmental footprint due to mining activity thereby leakage of toxic elements is a well-known and studied problem in Sardinia. One of the most prominent challenges regards polluted rivers, e.g. Rio Irvi, Rio Piscinas highly-polluted by Pb (lead), Zn (zinc) mainly originated from abandoned mine district of Montevecchio-Ingurtoso. Regarding the

second point, a high-content of calcium carbonate ($CaCO_3$) solid waste classified according to the Italian law as a "non-hazardous special waste" can be turned into a cheap and abundant resource for water remediation. It is noteworthy that this material should be considered as by-product, and not as a waste, according to this project's proposal and European directive 2008/98/EC (art. 5) "Waste Framework Directive".

The main goal of this project is to deepen the current knowledge on the interaction between carbonates, with emphasis on those originated in Sardinian quarries, and toxic element(s)-bearing water solutions with the purpose of understanding removal mechanism and retention capacity of this promising material. In this way a by-product material can be turned into a cheap and abundant source for water remediation. The ultimate purpose will be to develop a new device incorporating this promising material able to optimize the wastewater treatment technologies existing from an economic, efficiency and eco-friendly perspective. The idea of this project originated from a feasibility study conducted at the surface science group (https://dipartimenti.unica.it/scienzechimicheegeologiche/ricerca/gruppi-di-ricerca/2228-2/) that showed how calcium carbonate is a good sorbent able to catch and retain toxic elements, like lead, especially when concentration of the element is very high. This matches with the cases of highly polluted surface waters in South West Sardinia. This project is consistent with European circular economy strategy and ensures a prolonged and new life to what was supposed to be a waste material that would otherwise had been disposed. This is an opportunity to improve the resource efficiency and preventing as long as possible materials from becoming wastes.

Bio-surfactant-based lipid liquid crystalline nanoparticles for nanomedicine application

Marco Fornasier

Marco Fornasier got his M.Sc. in Chemical Sciences in 2016. He started working with Prof. Sergio Murgia in the beginning of 2017 as a research trainee and then he got his PhD Scholarship (POR-FSE) in October 2017. Since then, he was introduced to the soft matter field working in collaboration with several international groups. Marco was a guest PhD student in Lund University (Sweden, 15 months) and in Wroclaw University of Science and Technology (Poland, 2 weeks). Moreover, he visited Sapienza University as a guest researcher for short scientific visits in the last two years. Marco has published six papers in international journals and attended to more than ten international and national conferences, school and workshops to give oral (seven) and poster (five) presentations.

His PhD thesis *Bio-surfactants-based lipid liquid crystalline nanoparticles for nanomedicine applications* focuses on lipid self-assembly to produce nanoparticles suitable to deliver drugs and imaging probes in the human body. Briefly, when a drug is taken, it goes in all the districts of the body, without discriminating among the target site and "healthy" tissues. This fact brings to the so-called site effects and it decreases the efficacy and the applicability of the therapy. Moreover, the possibility to image certain areas of the human body for diagnostic purposes is the main principle of the imaging techniques, such as optical, magnetic resonance and ultrasound imaging. Regarding fluorescence optical imaging, a molecule called chromophore is able to absorb the incoming

light and emitting a new radiation that can be detected by the physicians. Indeed, this approach permits to image unhealthy tissues and organs to diagnose pathologies or illnesses. Both chromophores and the drugs can be put inside biocompatible carriers, such as the ones made by lipids. Indeed, lipids are biocompatible and biodegradable molecules that can form aggregates in the nanoscale (1 nanometer = 0.000000001 meter!) suitable to carry drugs or imaging probes. Such kind of nanocarriers have showed good potential in nanomedicine, improving the efficacy of the therapy and the imaging technique. A combinatory approach based on both therapy and diagnosis led to theragnostic (**thera**py + diag**nostic**s) platforms, which are able to deliver a therapeutical agent or the imaging probe in the target site and to image the phenomena happening in the cell.

Monoolein, a ubiquitous lipid, can be used to prepare different kind of nanoparticles such as cubosomes, hexosomes and vesicles. These nanoparticles require a polymer on their surface to prevent them to aggregate: these polymers are called stabilizers, since they actually stabilize the structure of the nanoparticle in water. Other additives can be added to the nanoparticles to change their architectures or to enhance their performance as drug carriers for several administration routes. The aim of Marco's PhD project was the evaluation of the effects of new stabilizers (polyphosphoesters and hemicellulose) and additives (bile salts) to the physico-chemical and biological properties of these kind of nanoparticles. The addition of these components to the nanoparticles can tune their features in order to improve their performance as drug carriers for topical (on the skin) and systemic (intravenous) administration.

Fornasier M., *et al.*, Cubosomes stabilized by a polyphosphoester-analog of Pluronic F127 with reduced cytotoxicity**,** *Journal of Colloid and Interface Science*, 2020; **580**: 286-297.

Toxic and trace elements in rice: analytical methods, bioconcentration, influence of irrigation techniques

Ilaria Langasco

Ilaria Langasco is a PhD student in Chemical Sciences and Technologies at the University of Cagliari/Sassari. She obtained a bachelor's degree and master's degree in Chemistry at the University of Sassari within the Prof. Gavino Sanna's group, in 2015 and 2017, respectively.

The principal theme of her PhD is focused towards the effect that changes on the nature of the irrigation method of rice play on the bioaccumulation of a number of toxic elements (like As, Cd, Al, Cr, Hg, Pb, Sb and Tl) or potentially toxic oligoelements (like Cu, Fe, Mn, Mo, Ni, Se and Zn) in rice kernels. The bioaccumulation of harmful elements in rice grain is the most threatening reason of health concern for the strong consumers of this staple food for the mankind. Three different irrigation methods have been taken into account (i.e. the continuous flooding of the soil, its periodical saturation and the sprinkler irrigation) as well as soils of different geopedological nature and pollution levels. In addition, the effect has been evaluated on a large number of rice genotypes. Elemental composition of different vegetal fractions of the rice plant, of soils and of irrigation waters has been evaluated using original and validated ICP-MS methods. From February to September 2019 she spent eight months at the Department of Analytical Chemistry of the University of Barcelona, under the supervision of Professor José Fermín López-Sánchez, head of a research group that has been dealing with of the speciation of the arsenic, which made it possible to expand her work by determining the nature and the amount of the

most representative speciated forms of the As in rice at varying of the irrigation method and the rice genotype using an high-performance liquid chromatography coupled to inductively coupled plasma mass spectrometry (HPLC-ICP-MS). The main goal reached in this period of study is to ascertain the possibility that, working only on the nature of the irrigation method of the rice plant, it is possible to obtain an environmentally friendly rice, characterized by both a minimum concentration of toxic elements and the highest level of food safety. The reported work captures the essence of her PhD studies. She participated in six international conferences (with a poster and an oral contribution), one national conference with a poster contribution and ten national and international workshops. During her PhD studies she has already published three papers in renowned international Journals, whereas other two papers have been submitted for the publication.

Spanu A., *et al.*, Sprinkler irrigation is effective in reducing cadmium concentration in rice (Oryza sativa L.) grain: A new twist on an old tale? *Sci. Total Environ.*, 2018; **628-629**: 1567-1581.

Enzyme-based Electrochemical Biosensors

Francesca Meloni
Electroanalytical Chemistry

Graduated in Chemistry (Bachelor's degree) with a thesis titled "Stabilization and Characterization of Oscillating Dynamics in the Generation of Hydrogen from Sodium Borohydride Hydrolysis" under the supervision of Prof. Mauro Rustici. Graduated in Chemical Sciences (Master's degree) with a thesis titled "Amperometric Electrochemical Sensors and Biosensors for Histamine Detection" under the supervision of Maria Itria Pilo. Currently, PhD student in Chemical Sciences and Technologies at the University of Sassari under the supervision of Prof. Maria Itria Pilo and Prof. Antonio Zucca, with an eight-month research period at the Wrocław University of Science and Technology under the supervision of Prof. Joanna Cabaj. The research project is based on the *development of enzyme-based electrochemical biosensors for the determination of analytes of alimentary and biomedical interest*. The project includes the development of adequate synthetic approaches to precursors of conducting polymers and metallo-polymers as materials for the modification of electrode surfaces. The precursors are mainly thiophene-based derivatives (obtained by Suzuki and Sonogashira cross-coupling reactions) able to polymerize with electrochemical techniques. This type of materials is particularly suitable for the immobilization of biological elements such as enzymes, offering an environment that allows the retention of their activity, avoiding denaturation or misfolding processes. Now, the target analytes taken into account by our research group are histamine and epinephrine. Histamine is one of the most toxic biogenic amines, responsible of the so-called scombroid syndrome, and its concentration is used as an index to evaluate the freshness and quality of different food products. Instead, epineph-

rine, a well-known neurotransmitter and hormone of the catecholamine family, may be considered as a marker of presence of possible various diseases. The research, therefore, has as ultimate goal that of realising simple, inexpensive, rapid and portable analytical tools for the detection of (potentially) toxic species or indicators of possible diseases in order to minimize health risks, improving the quality of life.

Pilo M. et al. Conducting Polymers in Amperometric Sensors: A Review on the last ten years. Molecules, submitted

Fluorescent Platforms for metal cations detection

Mariangela Oggianu

Mariangela Oggianu (M.O.) graduated, with honors, in Pharmaceutical Chemistry on April 2016, at UNISS. On October 2017, she started her PhD Thesis "*Synthesis and Characterization of Luminescent Chemosensors for the detection of heavy metal ions"*, at the Department of Chemical and Geological Sciences (UNICA), under the supervision of Prof. Maria Laura Mercuri, Prof. Vito Lippolis and Prof. Francesco Quochi (Physics Department). She spent three months at the University of Valencia in the group of Prof. Eugenio Coronado (2019), and two months at the University of Angers (2020) under the supervision of Dr. Narcis Avarvari. Her research interests are focused on the design and development of optical devices, based on fluorescent organic dyes for the detection of metal cations in aqueous environment. Metal cations sensing is of great interest in different fields ranging from environmental chemistry to biomedicine, due to their physiological effects in living organisms. Among conventional sensing methods, fluorescent spectroscopy is a fast-growing technology showing remarkable advantages, such as fast response times, nondestructive analyses and remote operations. A material can be described as fluorescent when it absorbs light of a certain wavelength and emits light of a different wavelength. In this context, M.O. was focused on the design and fabrication of solid fluorescent probes to recognize metal cations in water solutions, in particular mercury and copper. A fluorescent probe is composed by two different parts: a receptor, able to interact with the cation (analyte), and a fluorescent unit, whose emission properties, such as fluorescence intensity and peak wavelength, are modified by the interaction with the analyte. Furthermore, a fluorescent probe

should fulfill crucial requirements such as selectivity, sensitivity, reversibility and good stability. Among different organic dyes, well known as fluorophores, M.O. studied Rhodamine (Rho) and Fluorescein (F), belonging to xanthene family and 1,4-Diketo-Pyrrolo [3,4-c] Pyrrole (DPP) derivatives, because of their excellent photophysical properties. In order to develop fluorescent solid probes, the first step is to synthesize novel fluorescent derivatives (Rho, F, and DPP) containing functional groups able to be covalently anchored to different solid supports *i.e* Nanoparticles, Metal Organic Frameworks (MOFs) and Silicon Supports. In the second step, the obtained devices have been tested in water solutions of different metal cations in order to evaluate their sensing capabilities and performances. Remarkably, M.O. fabricated a fluorescent device prototype, based on Fluorescein Isothiocyanate (FITC), grafted on silicon chips, able to recognize selectively, low concentration of Copper, in aqueous environment. This device is a turn ON-OFF fluorescent chemosensor showing a fluorescence quenching in presence of copper. During the period spent at the University of Angers, M.O. synthesized two novel DPP derivatives able to recognize Cu^{II} and Hg^{II}, respectively, with the aim to obtain solid fluorescent probes, by grafting DPPs on silica nanoparticles.

Oggianu M., *et al.*, Silicon-based on-Chip Fluorescent Sensors for Copper (II) Detection in Water, Submitted, 2020.

New complexes of transition metal ions,Pd(II), Pt(II) and Au(III), and terrae rare, Y(III), La(III) and Sm(II), with N-heterocyclic aromatic ligands.

Sara Pischedda
Chemistry

I did my master's degree at the University of Sassari and I'm currently carrying out my PhD studies in organometallic chemistry with Professors Antonio Zucca and Sergio Stoccoro in the same University. During my PhD, I have decided to spend a period in UK, in Manchester, to work in the Mills group, and in Leicester, to work in the Ortu's group to learn chemistry of terrae rare elements and the Schlenk's line technique.

The focus of my research is the synthesis and characterization of new coordination species with different classes of heterocyclic aromatic nitrogen ligands and the study of the properties of these compounds.

In particular, I'm interested to the isolation of cyclometallated complexes (classical or roll-over) via intramolecular C-H bond activation with metal ions in d^8 configuration, such as Pd(II), Pt(II) and Au(III).

For these reasons in my work: New complexes of transition metal ions, Pd(II), Pt(II) and Au(III), and terrae rare, Y(III), La(III) and Sm(II), with N-heterocyclic aromatic ligands, the study concerned two different classes of nitrogen ligands in specific: substituted 1-(pyridin-2-yl)imidazo[1,5-a]pyridines[1] and 6- substituted-2,2'-bipyridines.

These classes of nitrogen ligands where chosen for their ability to form chelate complexes with different metal ions with peculiars properties;

for example, the imidazo[1,5-a]pyridine nucleus is known in literature also for its photophysical activity.
In conclusion in my PhD thesis I will report the synthesis of new species of Pd(II), Pt(II) and Au(III) and Y(III), La(III) and Sm(II); their characterization in solution by NMR technique and in the solid state by X-ray diffraction. Their reactivity and potentially applications will also be reported.

[1] Pischedda S., Stoccoro S., Cinellu M. A., *et al*., synthesis and characterization of Pd(II), Pt(II), and Au(III) complexes with 3-substituted 1-pyridylimidazo-[1,5-a]pyridine ligands; COGICO XXVIII, Firenze, 15-20/07/2018.

Design, synthesis and characterization of novel building blocks for supramolecular assemblies

Enrico Podda

Enrico graduated in Chemical Sciences (M. Sc.) in 2017 after an exchange period at the University of Nottingham with a thesis on macrocyclic chemistry. Then he started his PhD in Chemical Sciences and Technologies at the University of Cagliari in the field of Supramolecular Chemistry. During his studies, Enrico had the chance to undertake some periods abroad at the Imperial College London and at the University of Southampton. The study of supramolecular systems, held together by non-covalent interactions, started with the design of novel building blocks with various shapes and number of donor moieties. The selected donors were then prepared by means of organic synthesis and characterized by analytical tools. The project was carried over by reacting the organic linkers with various Lewis acids. When metal ions were used, a number of discrete and polymeric assemblies were prepared. The designed shape and functionalities of the starting materials guaranteed the predictability of the final network in some cases. Interestingly, some products exhibited less predictable environments and were deeply studied by means single-crystal X-ray diffraction analysis. In the case of potential metal-based porous solids, namely Metal-Organic Frameworks, the study of the structural features was enhanced by the inclusion of luminescent fragments providing a potential application of such systems as sensors.

On the other hand, the synthesized organic linkers were employed for the fabrication of supramolecular assemblies upon reaction with three-coordinated boron species. The successfulness of such approached allowed to obtain discrete and polymeric materials characterized by B-N dynamic covalent bonds. In order to better understand the reactivity of the newly synthesized polypyridine derivatives, they were self-assembled with organic acids leading to organic co-crystals. Moreover, the reactivity of the organic linkers towards halogen and interhalogens was investigated confirming the versatility of such system in supramolecular chemistry. Besides the pyridyl-based neutral linkers, a new family of carboxylate derivatives was prepared, and its reactivity towards metal ions explored. Interestingly, reactions with transition metal ions produced coordination polymers with intriguing structural features. These and the other findings obtained during the PhD are enclosed in the thesis "*Design, synthesis and characterization of novel building blocks for supramolecular assemblies*".

Podda E., *et al.*, Supramolecular assemblies tailored by dipyridyl-1,2-4-thiadiazoles: influence of the building blocks in the predictability of the final network, *Supramolecular Chemistry*, 2020; **32**(4): 267-275.

PhD program in Civil Engineering and Architecture

Coordinator: Ivan Blečić
Vice coordinator: Roberto Deidda

https://dottorati.unica.it/dotticar/

The PhD in Civil Engineering and Architecture places the territory and the built environment at the centre of scientific interest, understood as a complex research field including the historical and contemporary built systems, road and hydraulic infrastructural works, the environment and the natural and man-made landscape, with particular attention to the interconnections between environment, economy and society. The vast field of investigation stimulates an interdisciplinary vision of the topics addressed and favours the integration between basic and applied research. The cultural and scientific heritage of the Doctorate is manifested in the scientific production concerning, among others, the recovery and enhancement of historical and contemporary building fabrics, the conservation and protection of the architectural and landscape heritage, architectural composition, urban and territorial planning , urban studies, management of water resources and transport, the protection and safety of territories from adverse weather events, static and dynamic safety, with significant repercussions not only on the academic level, but also on the institutional and social level.

Within this context, the primary objective of the Doctorate is research training and the acquisition of methods and tools for conducting research projects, together with highly qualified teaching skills. Particular attention is paid to the consolidation of the autonomous capability to conduct original research programs on the topics covered by the Doctorate. The doctoral researches by PhD students are conducted in collaboration with the international scientific community and are aimed at providing specialised contributions to the advancement of the scientific research, but also at providing concrete answers to technical and operational problems in relation to sustainable development and territorial governance.

In this sense, the Doctorate also pursues technical-operational objectives, coherently with the professional connotation and service to the territory of the disciplines of civil engineering and architecture, in which basic research is combined with applied research, with significant social repercussions. These objectives aim to strengthen the abilities of PhD students to identify the existing relationships and interconnections between engineering, architectural, technological, environmental, economic and social aspects.

The advanced training acquired during the doctoral course and the constant stimulus deriving from the interdisciplinary context that characterizes the Academic Board, contribute to the formation of researchers able to address complex problems concerning the management of the territory and its transformations in its broadest sense and compatible with sustainable development.

In addition to the natural academic opportunities in Italian and foreign universities and research institutions, the experience gained during the doctorate makes PhD graduates particularly competent for managerial roles in public administrations, with skills to operate in various capacities on the territory (for example in territorial planning; resource management, transport and mobility; protection, safety and protection of the territory and landscape), as well as for that vast private technical-professional and entrepreneurial world that operates in the territorial and environmental field.

Stochastic inversion of TDEM data with non-trivial prior

Peng Bai

Peng Bai has completed the bachelor study in Geophysics, at Chengdu University of technology, China, from 2009-2013. During this period, he learned the basics of geophysics systematically and mainly focuses on the simulation of finite different forward of wave equation in a simple medium by computer.

During 2013-2017, he has completed the master study in Earth detecting and information technology, at China University of Geoscience (Beijing), China. Continuing the bachelor research, he was interested in the Elimination of the overlying complicated geologic tectonic disturbance to the underlying strata imaging, during this period. From 2018 to now, He is studying for his PhD at the university of Cagliari, Italy. His reach subject is about the stochastic inversion of time-domain electromagnetic data. During this period, he has studied abroad, at the University of Aarhus, Denmark.

His PhD focuses on the development of stochastic strategies for the electromagnetic (EM) data inversion with the inclusion of complex a-priori information.

Currently, the used approaches for the reconstruction of the physical properties of the subsoil from EM data collected at the surface are deterministic. So, a unique solution is inferred from the data. This is possible, despite the severe ill-posedness of the problem, via regularization. Regularization formalizes the prior information available about

the investigated medium and allows the selection of a solution among the many compatible with the data. This approach is very fast and provides valid results over the large areas (typical of modern surveys). However, the used prior information is quite simple (regarding, e.g., the solution smoothness/sharpness) and it is difficult to have a proper estimation of the reliability of the final features.

These problems could be effectively solved by adopting a stochastic approach. In this case, the result is not just one model, but, instead, an ensemble of models all compatible, at the same time, with the available prior information and the geophysical data. By studying the statistical solution (the ensemble), it is possible, for example, to calculate the probability of having a particular feature. To do that, it would be enough to analyze the occurrences of that feature across the different realizations.

Moreover, a large part of the PhD will be devoted to the formalization of geostatistical prior information via the use of Multiple-Point (geo)Statistical (MPS) approaches. In this way, realistic characteristics will be effectively imposed to the solution. Geostatistics will allow also incorporating, in a natural way, additional pieces of information not directly brought by the geophysics (e.g., from boreholes). The PhD is in collaboration with the University of Aarhus (experts in geostatistics) and Aarhus Geofisica srl (a R&D-oriented company active in airborne EM surveys).

Structural Optimization of Composite Steel Truss and Concrete Beams

Mariangela Deligia

I graduated in structural engineering at the University of Cagliari and I wrote my MSc dissertation thesis, in collaboration with the University of Alberta Geotechnical Centre in Edmonton (Canada), on a numerical simulation carried out to describe the response of a peat layer underlying a railway embankment. After graduation, I worked for some engineering companies with many years of experience in the fields of civil and infrastructure planning and design. At the same time, since I have always been fascinated by new concepts and innovative technologies, I occasionally collaborated with the University of Cagliari at small research projects.

The object of my research is the *Structural Optimization of Composite Steel Trussed Concrete Beams with Variable Section*. My PhD program consists on a period of research at the University of Fuzhou (China), which it has not been undertaken yet, and on a 6-months collaboration with a company. Last year (2019), I was welcomed at the Metal.Ri in Bitetto (BA): the company developed the MTR® system which consist on a dedicated software and on a 3 types of composite steel truss concrete beams. The experience within the company leads to deeply understand the behavior and the complexities on the modelling and the design of these particular set of beams. Understanding these issues represented the starting point for the optimization.

Composite steel truss and concrete beams represents a structural typology of composite beams, consisting on a steel truss embedded in a concrete matrix cast in situ. The steel truss behave as the reinforcement

of the beam and it can be divided into three main components: a) a bottom chord, constituted by a steel plate or a precast concrete plank; b) an upper chord, composed by a system of ribbed or smooth rebars; c) the web diagonals, a system of ribbed or smooth steel rebars welded to the upper and bottom chords to form the shear reinforcement of the truss.

The beam is cast directly on site and its main practical advantages are that it is partially pre-fabricated, self-supported during the concrete cast and easily applicable to long spans. These advantages allow to speed the construction schedule, to simplify the management of the site, to reduce the cost of labour and, consequently, to lower the general costs.

The hybrid steel trussed concrete beam differs from the traditional reinforced concrete beam because the static behaviour varies with the construction phase. Two phases have to be considered: the phase I, during concrete casting, when the truss act as a self-supported steel beam mainly subjected to its own weight and the weight of the wet concrete; the phase II, after concrete cure and maturation, when concrete and steel contribute together to the mechanical response of the composite beam.

I am currently working on the solution of a structural optimization problem using a genetic algorithm solver. Starting from the general Euler-Bernoulli beam theory applied to non-prismatic beams, a solution is to be studied for the above-mentioned composite beams, taking into account both construction phases. The parameters to be optimized are related to the shape of the beam (section height and width).

Fostering and planning a smart growth strategy in islands contexts

Giulia Desogus

I am currently a PhD student and my research interests are focused on urban planning, smart urbanism and urban metabolism. I graduated in Architecture at the Polytechnic of Turin (2014) after a research period in Tokyo (Japan). Subsequently, I worked in Mumbai (India) in the Dharavi slum for Sameep Padora & Associates and URBZ Studios. Also, in India I studied at the Sinhgad College of Architecture in Pune and I attended the Summer School in Auroville. Since then I have continued research, holding a Master's in Strategic Environmental Management at the University of Padua (2017) and two scholarships (2016, 2017) at the DICAAR, University of Cagliari (Italy). During this time, I started to focus attention on smart urbanism. During my PhD experience (started on September 2017) I have focused my attention on the smart territorial components in a controllable dimension such island system. These analyzes were strengthened during the study and research period abroad (Trinity College, Dublin, Ireland). In this context, it was possible to analyze the islands structural inhomogeneities with the repercussions in the socio-economic context which, obviously, suffers from all the factors related to the insularity. The research thesis (entitled "*Smart island. Analysis for insular context development*") was carried out under the supervision of Professors Corrado Zoppi and Pasquale Mistretta. However, the PhD in Civil and Environmental Engineering and Architecture, favors several collaborations that allow me to broaden the research field and strengthen your knowledge. In this way my research has also grown thanks to the help of Professor Chiara Garau (University of Cagliari, Italy) and Professor Federico Cugurullo

(Trinity College, Dublin, Ireland) both experts in smart urbanism. The thesis is part of the research on island territories and their smart planning. In fact, since the first Smart Island World Congress (Calvià, Mallorca, 2018), the scientific community has focused on the challenges that the islands - which have serious and permanent natural or demographic handicaps - have to face with the aim of reaching the levels of development of non-island territories in sectors such as urban planning and socio-economic development. To reduce this gap, both the Treaty on the Functioning of the European Union (2012) and various studies in the scientific literature specify the need to strengthen economic, social and territorial cohesion between island territories. With these premises, the thesis, starting from the analysis of the structural problems related to the disadvantages of the islands, aims to relate the island smart paradigm and the indicators referring to the territorial cohesion policy. This served to formulate guidelines that allow on the one hand the identification of these paradigms in relation to the smart island and on the other hand the application of these in large island contexts. This objective represents an innovative contribution as to date there is no clear identification of these study areas in the literature, and their subsequent application in the context of territorial cohesion. Finally, the results of the study are presented and discussed showing how the paradigms, referred to the smart island, identified and analyzed with the key to interpreting the territorial cohesion policy, allow the drafting of univocal guidelines of the large Mediterranean islands.

Desogus G., Mistretta P. Nella Città che cambia: la forma è strategica per lo sviluppo e la crescita. Cagliari: CUEC, 2017. ISBN: 978-88-9386-033-8.

Scenarios, strategies and actions to counter the depopulation and marginalization of inland and rural areas

Nicolò Fenu

Architect, Urban designer, PhD candidate in civil engineering and architecture at the DICAAR of the University of Cagliari. In 2009 he completed the Master in Advanced Studies in Urban Design at ETH in Zurich. Since 2017 he has been carrying out research and teaching assistance activities at the University of Cagliari and Sassari on the issues of inner areas and low-density territories. He has gained a decade of experience in the field of participatory urban research and all phases of architectural project management in international contexts mainly in Switzerland, Holland and Italy. Co-founder of Sardarch Spin off of the University of Cagliari, a laboratory specialized in research and urban regeneration, which applies multidisciplinary approaches by stimulating the involvement and participation of active citizens, with whom he published the books "Towards an urban planning of collaboration "(2015) and" SPOP - snapshot of depopulation in Sardinia "(2016). Barbagia archipelago Italia. (2019). The volume on COVID and inner areas published by Lettera Ventidue is coming soon. He was part of the project of the collective "Arcipelago Italia" presented at the XVI Architecture Biennale in Venice, inside the Italian Pavilion for a Citizen's House as a place for the health of Barbagia located in Ottana.

A major phenomenon that has taken on considerable importance is the gradual consolidation of a process of redistribution of the population

within the Italian national territory and specifically the Sardinian one, especially to the detriment of the small municipalities of the inner's areas.

Rural depopulation is a systemic phenomenon. The main challenges faced by rural regions - poor access to public services, poor accessibility, lack of economic competitiveness and precarious innovation and governance - are indeed both the causes and symptoms of demographic decline. (ESPON2017)

The research path is structured into the construction of a conceptual interpretative framework of policies and strategies at different scales for rural territories, inner areas and inner peripheries, creating a framework and a taxonomy of possible policies.

The analysis starts from a critical rereading of the classification criteria of inner areas, which only geographically draw the weak territories, focusing only on the level of criticality of the offer of services and their periphery. The research aims to overturn the paradigm in the choice and identification of the intervention (type of policies and planning) by building a framework for action based on qualitative and potential aspects that start from the territorial capital of each individual place.

The research also studies and experiments within the territory of Sardinia innovative and experimental policies that act on infrastructural, human and social capital. Specifically, the figure of the community manager is experimented in rural areas, the policies of housing at 1 euro and how the two policies can find interaction.

Forms of engagement and shared modification of public space.

Andrea Manca

Andrea Manca is an architect and PhD student in Civil Engineering and Architecture. He graduated in 2016 with a final project which investigates the relationship between the project of public space and urban communities in the context of unconventional actions. His research and practical experience continued with an internship at the architectural firm Ar-cò in Milan and in two years as Research Assistant at DICAAR of Cagliari, participating in several projects led by prof. Cesarina Siddi, and as a Teaching Assistant for university courses in the field of Architecture, Urban Design and Urban Geography.

The doctoral research *Forms of engagement. Shared modification of public space and hybridization practices* (supervised by prof. Maurizio Memoli and prof. Giovanni Battista Cocco) stands in the disciplinary-scientific area of Architectural and Urban Design and provides for a theoretical-operational contribution from Urban Geography. The investigation identifies its problematic field in the public space, "synecdoche of the urban dimension" and considers the project, understood as a poetic, poietic and political act, in the perspective of the engagement of citizens. A triangulation in which the production of urban space as a social and collective act is also reflected in architectural practice; a "doing with" that can be evoked through the "poetic of with": to co-conceive, co-design, co-build, co-manage, hybrid practices which contemplate a multiplicity of actors, processes and tools. The theoretical hypothesis identifies in these practices the coexistence of three knowledge: expert, common and political. This convergence feeds projects characterized by a potential persistence of engagement and to do this it refers to the double nature

of form: digital and physical form. With the same potential of digital dynamics, also the physical form can accept and promote modifications capable of address the inclusion of the inhabitants towards prolonged temporalities in an incremental, adaptive, polyvalent and non-linear way. The research methodology assumes a hypothetical-deductive investigation system, with an interpretative-comparative approach and an experimental-operational approach. The research is structured in three parts: a theoretical corpus, an experimental part of case studies analysis and the identification of an operational hypothesis, for answering the main research questions: what we need to consider in order to define effective, lasting, inclusive processes and projects and create synergies between actors and space? What are the digital and physical forms that allow you to pursue these results? During a research period at ENSA Paris-La Villette, the case study "Réinventons nos places!" was investigated. This is a modification project of seven important Parisian squares by an experimental design approach aimed at collective participation in the conception and design phases. The second case study is "El Campo de Cebada" in Madrid. The different nature of the case studies made it necessary to define a relationship matrix for the construction of a broad and comprehensive reasoning framework. As for the operational phase, the goal was the definition of an experimental framework/scenario capable of expressing example qualities of intervention, through the identification of models and strategies for collective involvement in projects of spatial modification.

Space to Learn: recycling utopias from 1950s Latin America universities

Marco Moro

Trained in Cagliari, I received a MSc with distinction from Universität für Angewandte Kunst in Urban Strategies (2015), including one semester as visiting scholar at University of Auckland (New Zealand). Besides tutoring architectural design and theory of architecture in Cagliari and London, I led the Fall Urban Design-Studio as visiting lecturer at Universidad Católica del Norte in Antofagasta (Chile, 2018), whose results have been presented at the 16th Venice Biennale under the title 'Through the looking-glass. Alteraciónes del proyecto territorial en la región del Norte Grande'. Since the early educational and professional experiences, learning spaces have been the focus of my investigations across the divide of the contemporary urban and rural conditions. I received research fellowships on the subject, including the collaboration for "Laboratori Artigianali della Miniera di Serbariu" (Carbonia, under construction), and a grant for the renovation project of Campus S. Ignazio, (Cagliari). From this perspective, the ideal of the 'campus' has been questioned as a paradigm for understanding, exploring and challenging a non-well defined urban condition which seems to have given momentum to higher education environments through its architectural features. How does the discipline of architecture respond to the changing reconfigurations of learning, which are spatial as much as political, social and economic?

On these premises, the research framework has been developed over the long period as visiting researcher at Anglia Ruskin University (UK), Universidad Católica del Norte and Pontificia Universidad Católica de Santiago (Chile). As a well-known fact, campus design has

represented the epicentre of urban and architectural development in South America, since university was considered a driving force of the region's modernization. Firstly, by collecting primary sources from international archives (MIT Archives, PUC Santiago, AA London), this research rediscovers very little-explored examples from the late 1950s conceived in Chile and Argentina. Surprisingly, these universities and their architects faced postwar academic reforms as a pretext to anticipate a critical thought about flexibility, adaptability, openness, and informality: all concepts that would become imperatives in the decades to come within the architectural discourse on learning environments. Secondly, what this thesis wants to prove through critical design analysis is that these episodes opened alternatives towards multiple and even diverging architectural responses: suspended pavilions, complex megastructures, permeable envelopes, inside-carved volumes incorporating rituals of learning in their urban interiors. Finally, this thesis intends to review the direct involvement of some Italian architects/academics that operated behind the scenes of those campus projects: Ernesto N. Rogers and Enrico Tedeschi among others, will be discussed as figures that, enacting a pedagogical and professional relationship between Italy and Latin America, acted as catalysts for the crisis of the Modern Movement from its core (Moro, 2019). Accordingly, *Space to Learn. Architectures of Higher Education between Italy and Latin America in the late 1950s* aims to investigate the project of informal education tracing intersections between postwar architectural discourse, pedagogical models and unexplored influences on the conceptualization of space in contemporary higher education environments. In doing so, a final contribution of this thesis will be offered by a collection of speculative designs as tools to imagine possible narratives (rather than a mere brief) as a basis for the future expansion of the Universidad Católica del Norte city campus, Antofagasta (Chile).

Moro M., Detrás del momento de seducción. La pedagogía como proyecto no teórico en Ernesto N. Rogers y Enrico Tedeschi, *ARTEOFICIO*, 2019; 15: 30-35.

Influence of hydrological changes on water resources

Dario Ruggiu

My name is Dario Ruggiu, I am 29 years old and I am about to conclude my PhD in Civil Engineering and Architecture. After I graduated in Civil Engineering with a specialization in Hydraulics, I immediately started with my research within my PhD, focusing especially on the study of hydrological changes caused by climate and land use change on the regional territory. Specifically, my research attempts to understand how much the current water availability in Sardinia is going to be modified by climate and land use change, ascribable to human actions and climatic variability. I spent eight months out of three years of my PhD period in Patras, Greece, where my work was developed with the help and contribution of the local University research team.

The title of my research is *Influence of hydrological changes on water resources*: it is an attempt to predict in which way water resources will vary in Sardinia.

I studied, precisely, how the frequency of annual runoff could vary following the well-known climate and land use change in the future. To do this, I applied a methodology derived from the theory of Budyko, which given some of the future properties of climate and land use (whose contribution is epitomized in the ω parameter), is able to assess the future probability distribution of annual runoff.

Therefore, a first study, published in an article (Ruggiu and Viola, 2019), was based on the assessment of the ω parameter and on the linkage between water balance components and basin morphology and

vegetation characteristics. The result of this study is an empirical model for the definition of the ω parameter by basin morphology and vegetation parameters. Hypothesising different future scenarios of land use (deforestation, urbanization) it has been assessed the above-mentioned parameter ω. The same study showed that the vegetation type and soil water holding capacity are the most influential drivers of annual runoff, and so of water availability.

Subsequently, to assess the future climate evolution, climate models database from EUROCORDEX project have been analysed. These models showed that a reduction of the annual precipitation is to be expected for Sardinia, and also an increase in temperature, proportional to the future rate of anthropogenic CO_2 emissions.

The climate and land use results for the future showed that the mean annual runoff, namely water availability, will decrease. Another effect will be the reduction of the variability of the hydrological response of Sardinian watersheds. Climate change will be more influential compared to land use change in the alteration of regional annual runoff distribution in Sardinia. In order not to further reduce the regional water availability, it is necessary to adopt policies capable of reducing the CO_2 emissions and then stop the ongoing climate change, without neglecting the application of regional plans and programs capable of regulate the land use consumption.

Ruggiu D., Viola F., Linking climate, basin morphology and vegetation characteristics to Fu's Parameter in data poor conditions. *Water*, 2019; 11: 2333.

Construction solutions consisting of multi-layer packages coupled with insulating elements in sheep's wool

Chiara Salaris

Architect and PhD candidates in Civil Engineering and Architecture in Cagliari, focused on the environmental and energetic studies, passionate and experienced in urbanism design process and participation practice in Architecture. I received a bachelor's degree (B.Sc.) in Building Engineering and a master's degree with honors in Architecture in Cagliari with an experimental thesis in Architectural and Urban Composition entitled "Reciprocity: synergistic processes from informal actions...", which aimed to develop an operational methodology of urban regeneration. In the last year of my master's, I gained an internship in the Architecture and Engineering firm Ar-cò in Milan. I was involved in the project for the Poland Pavillon for Expo 2015, and in international cooperation projects for humanitarian emergency contexts. After graduated, I worked for two years as Research Assistant at the DICAAR in Cagliari taking part in several projects including the international "DE/BaTE. DEconstructiong/Building a Thinking Environment" and "Under Collective Construction" led by prof. Siddi. The past experiences have stimulated me to improve and consolidate my scientific knowledge on the environmental side. Therefore, I successfully applied for a Ph.D. position, and in April 2018 I started my doctoral research in technical/applied Physic supervised by prof. Andrea Frattolillo and prof. Giovanna Concu and funded under the National Operational Programme on Research and Innovation (PON RI) 2014-2020 (Directorial Decree no. 1377), issued by the Italian Ministry of

University and Research and co-funded by the European Social Fund (ESF). The research topic arises from the cultural model based on environmental sustainability that has developed in recent years, involving all sectors of human activities and including the construction sector (one of the most energy-consuming), aimed at the use of materials of natural origins and locally available, with low environmental impact. The project is particularly oriented to the scientific support of the partner company, therefore the main aim pursued is to verify the possibility of developing and activating local supply chains for circular construction from bio-regionalist products. These concerned raw or waste materials from the domestic territory, such as maritime pine and eucalyptus for the production of structural cross-laminated timber and sheep's wool for the production of thermal and acoustic insulation. The other three sub-objectives are respectively: "the thermal, acoustic and mechanical characterization, the improvement of industrial process efficiency and the innovation of the products". The innovative aspects are related to the mixed scientific-industrial approach and consist of the evaluation and standardization, through different phases of theoretical study, experimental application, and numerical tests. The research has an industrial partner and a scientific foreign partner. The former is a Sardinian company Brebey, produces thermal insulation products made from Sardinian sheep's wool, the latter is the Built Environment Research Institute Ulster University in Belfast. For many centuries in Sardinia, as in Northern Ireland, breeding has been considered an anthropological identity activity that over the ages has outlined an essential trialeptic relationship among environment-culture-economy. In NI the sheep's wool short supply chain and the use of it as insulating materials in the construction sector have been going on for several years. Between 2019 and 2020, I spent one year in a challenging and multicultural environment in the Ulster University supervised by prof. T. Hyde. This allowed me to provide in-depth knowledge of the theoretical and practical aspects that underlie the development of the local production chain. I learned different methodologies to complete the experimental thermal characterization of the sheep's wool batts, and I analyzed the local construction technics with traditional and innovative materials. I'm actually working to implement solutions construction for walls and floors consisting of multilayer packages, coupled with insulating elements in pure sheep's wool or mixed with other natural substances.

Urban surfaces parametrisation for air quality modelling

Luca Salvadori

Luca Salvadori was born in Nuoro, Sardinia, on June 1, 1991. He graduated in April 2014 for the bachelor's degree and in April 2017 for the master's degree in Environmental Engineering. His studies covered the analysis of environmental matters and ways to face it, and Environmental Fluid-Dynamics subjects. Since the beginning of his degree thesis, he started to get involved in urban morphological studies, with purposes such as applications in pollutant dispersion and microclimate analyses. Specifically, he devoted himself to the study of the best methods to derive the so-called morpho-metric parameters, namely the ones that schematically describe the buildings arrangement in a city.

In fact, the last are used for various purposes, such as the setting of a laboratory study, as those in wind tunnel when the purpose is to simulate the aerodynamic of a portion of a real city case study, the setting of aerodynamic simulation models, the modelling of the wind speed vertical profile in urban zones, and the forecast of major ventilation pathways in dependence of the wind direction.

Luca's thesis title is "*Urban surfaces parametrisation for air quality modelling*", and it involves a group of sub-themes as those above specified. In particular, two are the main interests when applying morpho-metric analyses. The first is the capability of deriving morpho-metric parameters (building heights, pairwise distances, frontal and planar areas) statistics, in order to use these for real case studies, both in laboratory experiments and in simulation model computations, and large part of

the work is inevitably dedicated to this kind of calculations and automatization. In (Badas et al., 2019) some specific issues are reported, with corresponding insights and ideas to deal with them: assuming that the objective is to schematically collect and describe the already mentioned features of urban texture for a specific area, the applied calculation method has implications on final results, and it leads to the importance of choosing the best one, depending on purposes.

On the other hand, it can be possible to investigate on possible simplifications, in order to quickly derive morpho-metric information even for those cities for which there may be a lack of required data (e.g. building heights representation is not always available), relying on other, more qualitative, information, as buildings date of construction or district urbanistic typology.

Badas M.G., *et al.*, Urban areas parameterisation for CFD simulation and cities air quality analysis. *International Journal of Environment and Pollution*, 2019; **66**: 5-18.

Field Architecture
Farms as landscape tool in Sardinia

Roberto Sanna

Architect. Ph.D. student in Civil Engineering and Architecture at DICAAR, University of Cagliari. His research deals with the design issues related to the transformations of rural landscapes and architectures in the low-density areas. Author of the project CURATORIAS, by which investigates the current state of the landscapes of Sardinia and their historical dynamics. Didactic assistant in the design courses and thesis laboratories of the school of architecture at the University of Cagliari where he develops his research joining local and international teams, conferences and workshops.

The research experience has been developing since 2015 by attending in academic research groups studying the transformations of rural landscapes. The need of an architectural approach to such issues have been in-depht at the University of Toulouse, France, during the Phd course by joining the historical analysis with the 'future' capacity of the project.

The thesis deals with the conflict between artificial and natural, geometrization and re-naturalization, infield and outfield. The aim of the research is to explore and understand the features of the low-density built environment in the island of Sardinia, that is the architecture of the farms. The heritage built outside the borders of the villages, starting from a condition of literally inexistence until the 19th century, has now become about 1/3 of the entire built heritage of the island. Such a large-mesh network of farms and rural devices widely controls the dif-

ferent and complex types of the island's landscapes. Farmsteads colonize the territory at different depths, from urbanity borders to wilderness, guaranteeing a widespread and extensive management of rural landscape transformations. Many rural artifacts, made of productive buildings linked to farming and breeding, have therefore a recent origin that overlap with the historical and minimal control systems of the countryside: pastoral enclosures, single-cell artifacts, isolated rural churches. Such devices replicate those settlement features that have designed over time the low-density structure of the Sardinian settlement, which, like other similar Mediterranean contexts, is based on the wise and constructive use of the residual space resulting from rural activities.

From this point of view the thesis *FIELD ARCHITECTURE – Farms as landscape tool in Sardinia* tries to understand how contemporary forms of agricultural production influence the continuous rewriting and transformation of the anthropic landscape. Understanding the internal dynamics of the rural exploitations, the relationship between abiotic devices and biotic dynamics can become a key interpretation for the "low density" architecture project that become so much necessary today for its strategic role regarding the climate regulation and the ethical production of rural goods.

Dessì A., *et al.*, Long-time rural landscapes: new models for sustainable and resilient project. In: Conte A., Guida A. ReUso2019. Matera. Patrimonio in divenire. Conoscere, Valorizzare. Abitare. Gangemi; 2020. 2455-2466.

Joint Inversion of Electromagnetic and Seismic data

Jeniffer Viegas

Jeniffer Viegas has completed the master in Civil Engineering with specialization in Geotechnical in 2016 at the Nova University of Lisbon with the thesis "Modeling of lateral sleeper-ballast interaction on rail track" and currently she's a PhD student at the University of Cagliari (Department of Civil, Environmental Engineering and Architecture) in a Cotulla agreement with Instituto Superior Técnico -Lisbon.

While studying in Lisbon, she has spent several months in Italy in Erasmus. She was a trainee at the Road Materials Laboratory (DICEA-Department of Civil, Construction, and Environmental Engineering - La Sapienza -Roma) performing tests on bituminous mixtures.

In the attempt to learn as much as possible, during 2015, she did a further internship at LNEC- National Laboratory for Civil Engineering (Lisbon), at the Hydraulics and Environment Department, contributing to a project for the application of a nonlinear and non-hydrostatic model of surface waves in rapidly changing bathymetry, the SWASH model.

During 2016-2017, Jeniffer was working in a micro-enterprise of civil engineering, involved in various activities (among others: Quantity surveyor of engineering works, store clerk, customer care, hiring subcontractors).

Her current activity in research falls on the field of the inversion problems. The study is concerned with the development of an inversion routine to joint invert Time Domain Electromagnetic (TDEM) and surface seismic wave data set in order to migrate information from one model to the other.

Often the data collected in the field are not the parameter one is looking for, usually, they are time arrivals, voltage, or magnetic fields components that are read in the receiver. But what is desired is the shear wave velocity or resistivity for example. That means that a process is necessary in order to obtain physical parameters from field data, this process is usually the inversion. The TDEM and seismic inversion are ill-posed problems, in the sense that one of the three following conditions is not met: i) the solution exists, ii) it is unique and iii) it is continuous with respect to the data. The second condition, the uniqueness, is the one who typically is not verified. If the problem has one solution than exist infinitely more solutions that fit the data at the same degree. To overcome that issue, prior information such as a reference model or borehole information is introduced through a regularization technique.

Jeniffer's research aims at integrating the data from the very initial phases, since the inversion stage (and not only during the interpretation) through regularization, connect the model spaces associated with the two data types and obtain two physical models (one for each type of data: SW and EM) mutually connected via the assumption that in the same location where one physical property is changing, also the other property is varying.

She has spent the last year in Lisbon where it was performed field tests (Seismic surface waves, Electromagnetic in time and frequency domain, and Electrical Resistivity Tomography) in Castanheira do Ribatejo to complement the information acquired from a geological and geotechnical investigation campaign at the Northern Lisbon Logistic Park (PLLN), located in Castanheira do Ribatejo – Lisbon. The purpose of the acquisitions is the geotechnical characterization of the site for the construction of industrial warehouses. The data collected in this survey will be used for applying the joint inversion routine.

PhD program in Earth and Environmental Sciences and Technologies

Coordinator: Prof. Giorgio Ghiglieri

http://dottorati.unica.it/stta/

The cultural core of the PhD training project is represented by a systemic, integrated, interdisciplinary and multi-level approach to the study of the territory as a physical-natural environment and the technologies necessary for its conservation/remediation.

The internationalization of the PhD is done through the involvement of the University of Barcelona and Girona (Spain), as well as through participation in international research programs and projects.

The main topics of the PhD course are the geological knowledge, the management of the physical and biotic environment, georesources, soil and subsoil, ecosystems and vegetal habitats, solid and liquid wastes, contaminated environmental matrices, secondary raw materials. It is worth to underline the connection existing between basic and applied disciplines, and between abiotic and biotic issues, in line with current trends in international research.

The knowledge of the territory and the protection and promotion of the environment are topics considered as a priority at international level, in particular by the European Union and for the Mediterranean area. For Sardinia, the conservation and valorization of the environment is a strategic aspect for the regional economy and for the development of sustainable tourism. The effects of such problems (coastal erosion, hydrogeological imbalances, desertification, pollution, coastal area salinisation, eutrophication of the basins, loss of biodiversity, contaminated sites, solid and liquid residues to be managed) result in heavy environmental, and thus socio-economic, imbalances. All these aspects emphasize a strong need for conservation/remediation of the territory, its proper use and rational exploitation of resources.

The PhD course, therefore, has a strong relation with the local territory, while pursuing also research topics of general and basic interest.

The PhD course offers courses, seminars and summer schools, participation to national and international conferences and training opportunities in Italian and foreign Research Centers. Participation to conferences and stages is considered as a priority for training and updating purposes. The achievement of autonomy in research, in particular the

capability of publishing on International journals, is considered as a primary objective.

Small Woodlots Outside Forests: multiscale and multi taxa assessment

Erika Bazzato

Urbanization and the accompanying changes of many spatial pattern and ecological processes is a challenge for ecology and an increasingly important issue in territorial planning strategies for species conservation. During the last centuries, human activities have fundamentally altered the biotic and abiotic properties of the natural resources, bringing about fundamental changes in patterns of biodiversity and ecosystem processes. In this altered and fragmented landscape context, we need to better understand the impacts of human activity on local diversity patterns, focusing not only on large habitat fragments but also on the smaller ones. Small fragments of natural remnants can have an important ecological value in ecosystem functioning and can play an important role in climate condition and climate mitigation. Small Woodlots Outside Forests (SWOFs; Italian National Forest Inventory; http://www.infc.it), a peculiar type of Trees Outside Forest with an area larger than 0.05 ha and less than 0.5 ha, can promote the biodiversity conservation and represent ecological corridors for numerous animal and plant species. In literature, only a few studies deal with the sampling strategies to assess tree attributes in the small woodlot but, surprisingly enough, no study has quantified response patterns for multiple taxa at SWOFs considering, for example, SWOFs located in different land-use matrices and evaluating whether biodiversity patterns differs between intact and modified landscapes. This knowledge is important as it could help improve biodiversity conservation efforts, particularly in modified landscapes. Aim of this project is to evaluate the taxonomic diversity and the influence of land use matrices on bio-

diversity patterns, in order to assess the role of Mediterranean Small Woodlots Outside Forests (SWOF) along a gradient of land-use intensification. The study is focused on cross-taxon congruence in species richness and composition among different taxonomic groups, such as vascular plants and arthropods which constitute more than 80% of all currently described species and contribute to important ecosystem processes.

Biographical sketch: Erika Bazzato graduated from University of Cagliari, Sardinia, Italy, with a master's degree in Natural Sciences with Honours, academic kiss and embrace, Honour mention, and dignity of printing for the thesis "Land fragmentation and beetles rich: an integrated approach to assessing the conservation state of the Metropolitan City of Cagliari" in Landscape ecology in 2017. She is currently in the last year of a three-year of the PhD program in Earth and Environmental Sciences and Technologies (EEST) at University of Cagliari, under the supervision of Prof. Michela Marignani. During the PhD, she spent several months working on a number of taxonomical and ecological projects at the Zoological research Museum Alexander Koenig (ZMK) in Bonn (Germany). The training and research period abroad to date have provided her with an excellent background in biology, systematics and ecology of beetles. Her academic interests are focused on community and landscape ecology, and biodiversity assessment, with a major attention to the effects of changes in biodiversity patterns. As a doctoral student her research project explores the patterns of diversity and composition of species assemblages of multiple taxonomic groups, to evaluate the impacts of anthropogenic environmental changes on plant–insect interactions. She has authored or co-authored since 2009 more than 70 new faunistic and taxonomic notes of great scientific value at a national level. Her PhD research activities resulted in several publications in International Journal and conference presentations.

Bazzato E., *et al.*, Multiple approach leads to multi-solutions – an index to plan functional urban areas. Submitted to Urban Ecosystems, submitted.

Distribution, floristic and ecological characterization of Sardinian Gymnospermae communities

Giacomo Calvia

Giacomo Calvia graduated in archaeology during the Academic Year 2004-2005, at the University of Sassari. Since then, he worked as a tourist guide, though increasing expertise about Sardinian flora and some specific areas, which resulted in several publications. Starting from October 2017, he is working as a PhD student in 'Earth and Environmental Sciences and Technologies', within the Center for the Conservation of Biodiversity (CCB), which is a structure of the Department of Life and Environmental Sciences of the University of Cagliari. His thesis is titled as follows: "*Distribution, floristic and ecological characterization of Sardinian Gymnospermae communities*". Gymnosperms, and more specifically conifers, represent an important part of plant communities worldwide. In the Mediterranean Basin, some of these species, such as *Taxus baccata*, are relict that grow at their extreme border and are facing drastic reduction as a consequence of climate changes. In Sardinia, where only a small percentage of the old forest coverage is currently preserved, after the deforestation that affected the island between the early 19th century and the second half of the 20th one, conifers are often residual stands if compared to their past distribution. In a recent past, several works were carried out about some of the conifers of Sardinia. Despite this, a number of gaps remained about the ecology and the floristic composition of species such as *Pinus pinaster*. This research has tried to fill, though partially, these gaps and has produced a first characterization of the conifer's woodlands of Sardinia.

The first phase of the study consisted in researching, identifying and mapping all the conifer's communities. In this phase, help was provided also by local people, forestry workers and environmental guides from many parts of the island. Moreover, the identification of conifer's distribution was mostly based on cartographic and bibliographic references. Secondarily, a number of field excursions was carried out in order to collect ecological and floristic data from each site, Information about each tree's species composition, canopy cover, occurrence and amount of renewal was collected. The main goal of the work was to define the distribution and phytosociological characterization of the three pine species' communities. After a first distributional and diachronic analysis about the recent recovery of natural pine stands of Sardinia, greater attention was payed in a phytosociological study liable to establishing the different pine wood types and their relations/differences with those from other Mediterranean regions. A study about the current and potential distribution of *Taxus baccata* has been carried out thanks to the cooperation with scholars from the University of Huelva. These analyses, performed on GIS, allowed to identify which surfaces the yew communities of Sardinia had potentially covered in the past, and which modification would they endure because of climate change. In addition, a characterization of the old growth yew woods habitat has been carried out within the 13 old yew stands out of a total 232 yew sites found across the entire island.

A first characterization of the ancient residual forests of Sardinia

Sergio Fantini

Sergio Fantini is a Geologist, he graduated in 1998 from the University of Cagliari and he is an employee of the Forestry Agency of Sardinia (Fo.Re.STAS) since 2000, where he mainly dealt with fire prevention, cartography and GIS. Since October 2017 he has been working as PhD student in 'Earth and Environmental Sciences and Technologies', in the Center for the Conservation of Biodiversity (CCB), which is a structure of the Department of Life and Environmental Sciences of the University of Cagliari. The title of his thesis is: "*History, distribution and ecological characterization of old-growth forests in Sardinia*". Old forests play a very important role globally. The most widely used definition of primary forest is the United Nations Food and Agriculture Organization's (FAO): "Naturally regenerated forest of native species, where there are no clearly visible indications of human activities and the ecological processes are not significantly disturbed". The biodiversity they contain, their ability to mitigate CO_2 emissions, the ability to modify the water cycle and climate globally and locally, make these fundamental ecosystems very important to study and preserve. It is well known that currently primary forests are in decline in the whole world. Also in Sardinia only a small percentage of the original forest heritage was saved from the deforestation that began in the early nineteenth century and continued until more than half of the twentieth century. Despite its great importance, there wasn't a complete knowledge of the consistency, structure, distribution, threats and types of ancient forests in our Island. This research has tried to fill, at least in part, these gaps and has produced a first characterization of the ancient residual forests of

Sardinia. The first phase of the study consisted in the research, identification and field mapping of the old-growth stands. The feedback provided by local experts from Public Forestry Agencies and research Departments of Universities through the compilation of a questionnaire was essential. 68 plots of 500 square meter each were surveyed throughout the Island. The identification of old-growth features was based on different amount of large-size and old trees, tree species composition, canopy heterogeneity, occurrence and amount of deadwood. The main goal of work was to determine the degree of old-growthness of each single plot, and for this reason several structural variables were surveyed. Because no one single proxy indicator can be a measure of old-growthness alone, a structural index SHI (Structural Heterogeneity Index) has been elaborated in order to summarize such variables in one single value. Finally, variations through environmental or human-related factors were analyzed. In the second part of the work the relationship between the presence of great longhorn beetles (saproxylic beetles that play an important role as an ecosystem engineer) and the structure of old growth holm oak, the most widespread and representative forest type present in Sardinia, were analyzed. Furthermore, the degree of protection of the old-growth stands from the legislative point of view and from wildfire hazard were considered. These analyses, performed on GIS environment, allowed to identify which surfaces of the old-growth stands are included in the regional protection network and, through the visibility analysis of the network of fire lookouts, was assessed the risk that a forest fire could burn them. In addition, the application of a parametric method allowed an assessment and the creation of a vulnerability map through the integration of visibility, oldgrowthness and wildfire hazard parameters of each old-growth stand.

Fantini S., *et al.*, Structural heterogeneity and old-growthness: A first regional-scale assessment in Sardinia. *Annals of Forest Research*, submitted.

Application of bioelectrochemical systems for cheese whey treatment

Marco Isipato

The dairy sector is the second largest agricultural sector in the European Union in terms of output value. This sector is characterized by the production of huge amounts of residues (i.e.: dairy wastewaters and cheese whey). Cheese whey (CW) is considered a main pollutant waste stream, not only for the high volume generated (around 130 million tonnes per year) but also for its high organic load. Currently, about 50% of the CW produced worldwide is discharged into the environment without any treatment. This improper managing results in dissolved oxygen depletion in surface water, toxicity for aquatic animals, groundwater contamination, impairment of soil characteristics, and even discharge of CW into the sewage systems may negatively affect the wastewater treatment plants. The high contents of lactose and minerals can cause issues for animals when CW is used as animal feed. Proper CW treatment is then mandatory, and traditional approaches have included so far physico-chemical and biological treatments, aimed only at organic load reduction. However, the sustainability and circular economy principles require a step forward in dairy residues management as compared to the mere treatment: the prevention of environmental impacts must be associated with the recovery of high added-value resources. Among the available technologies, bioelectrochemical systems (BES) have attracted the interest of scientists in recent years. BES are electrochemical cells in which a microbial biofilm grows on at least one electrode and catalyse the occurring chemical reaction. In Microbial Fuel Cells (MFC) and Microbial Electrolysis Cells (MEC), bacteria in the biofilm oxidise the organic matter contained in the

wastewater at the anode and release electrons into the external circuit of the cell. In the MFC the cathodic reaction is spontaneous and generates electricity, while in MEC an additional power is needed, to produce hydrogen gas. If a cathodic biofilm is present, bacteria are capable of uptake electrons from the electrode and transfer them to an inorganic acceptor like CO_2, to produce valuable organic acids. Moreover, another interesting application of BES is electro fermentation (EF), in which the applied current modifies the environmental conditions leading to gaseous and liquid high-value products. Until now, BES have been mainly studied for electricity and hydrogen gas production from raw cheese whey in a stand-alone process, but several aspects have limited the performance of this approach. These limitations could be overcome by using a multi-step valorization process. In this framework, *Application of bioelectrochemical systems for cheese whey treatment* project investigates the use of integrated BES and dark fermentation (DF) for the valorization of CW. A multidisciplinary approach was used, combining elements of environmental and chemical engineering, electrochemistry and biology, thanks to the collaboration between the Department of Civil, Environmental engineering and Architecture and the Department of Mechanical, Chemical and Material Engineering of the University of Cagliari. During the first period of the PhD, preliminary tests were performed to study how the composition of a fermented CW (in terms of volatile fatty acids) could influence biofilm growth and the effect of salt addition on performance and pH stability. To improve the knowledge on the topic, a collaboration with two foreign institutions was started. At the University of Bath, a study on the maximization of the electrode surface in a continuous flow MFC was carried out, with the aim of increasing the power output and the organic matter removal, using exhausted DF effluents (i.e. after the extraction of volatile fatty acids). Further studies on EF were performed at the National University of Ireland (Galway), using fermented CW, demonstrating the possibility of obtaining high-value soluble products, through CO_2 conversion to organic acids and lactic acid fermentation to propionic acid.

Asunis F., *et al.*, The dairy biorefinery: Integrating treatment processes for cheese whey valorisation, *Journal Environmental Management*, 2020; **276**: 111240.

Biological Study of Grape Populations in Sardinia by a Comparative Approach

Andrea Lallai

Andrea Lallai is a naturalist. Always interested about nature and botany which led him in 2016, to graduate from the University of Cagliari, with a thesis about the living collections of the Botanical Garden of Cagliari (Hortus Botanicus Kalaritanus). Since April 2018 he started a PhD in 'Earth and Environmental Sciences and Technologies', benefiting from a PON Ri scholarship. The thesis entitled 'Biological study of grape populations in Sardinia by a comparative morphocolorimetric and ecophysiological approach', concerns the study of the grapevine's biology and the characterization of the different cultivars, in particular those from Sardinia, with the aim of protecting and enhancing them. The Vitis vinifera L. ssp. vinifera (domestic vine) is considered one of the oldest fruit plants in the world and played a lasting role of primary importance for the ancient societies that developed around the Mediterranean Basin. The process of domestication would have taken place primarily in the near eastern area between the fourth and third millennium BC, and then gradually spread to the western Mediterranean Basin and Europe. Several studies have highlighted the existence of centers of secondary domestication of the grapevine in Spain, France and Italy. In the same way, Sardinia seems to have been an ideal place for the secondary domestication of the grape, thanks to its insularity and the presence of indigenous populations of wild grapes that have a high level of genetic variability. The work it has been developed with two different approaches: The morphocolorimetric analysis began with the sampling of cultivars in Sardinia, at the partner company's vineyards, Cantina Santadi, and at the CIEF in Valencia where he carried out the

research period abroad. The images of the seeds were acquired through flat board scanner considering both the ventral and the dorsal side of the seeds. The images were then processed through a software capable of identifying the characteristics of the seeds in an objective manner, minimizing data acquisition times and the possibility of mistakes. Specifically, ImageJ software was used, with the application of plugins specifically designed for seed analysis. In this way, for each sample, different dimensions related to shape, size, color, texture, etc. were obtained. All these data were then compared by means of statistical analysis that made it possible to distinguish and characterize the cultivars studied. The germination biology was studied carrying out experimental tests by subjecting the seeds to different environmental parameters (temperature, photoperiod, salinity and UV intensity). A variable temperature test has been defined and pre-treatments will be applied to interrupt the possible dormancy of the seeds. The tests were conducted on Petri dishes with 1% agar substrate to ensure biological sterility during all preparation, analysis and control procedures. the germination (protrusion of the radicle) and therefore the viability of the non-germinated seeds was evaluated by means of the cutting test and the consequent observation of the endosperm under the binocular microscope. Subsequently, having defined the optimal germination protocols for each cultivar, we proceeded to germinate the seeds in different salt concentrations. This aims to identify which cultivar have the greatest halo-tolerance characteristics. This doctoral thesis aims to make a contribution to improve the knowledge of the populations of Vitis vinifera L. in Sardinia in terms of estimation, a particularly important aspect, given the economic importance of the local wine industry.

Santo A., *et al.*, Salt tolerance of wild grapevine seeds during the germination phase, *Scientia Horticulturae* 2019; **255**: 115–120.

Treatment of mineral-metallurgical residues for the recovery of useful species and the reuse of process waste

Carla Mercante

My studies began with a bachelor's degree and a master's degree in natural sciences. During my dissertation internship, my research focused on coastal defence: the study of coastal dynamics through the analysis of the morphological evolution of the seabed. My career continued with the PhD course in Earth and Environmental Sciences and Technologies of the University of Cagliari, a.y. 2019/2020 - XXXIII cycle, for which I won a specifically themed scholarship financed with the resources of the CESA Project. The collaboration with the Geological Survey of Finland (GTK), Europe's leading competence centre for the assessment and sustainable use of geological resources, has enabled the implementation of a project aimed at the implementation of high-quality data that highlighted important mineralogical composition characteristics of the treated material.

The research carried out led to the writing of a doctoral dissertation entitled: *Treatment of mineral-metallurgical residues for the recovery of useful species and the reuse of process waste.* The study has also led to the participation in international events through the writing of scientific works such as the attendance at the 18th International Symposium on Environmental Issues and Waste Management in Energy and Mineral Production, Santiago de Chile with the work entitled *Environmental management and metal recovery: re- processing of mining waste at Montevecchio site (SW-Sardinia).* This work illustrates and discusses an innovative approach to the remediation of old mining areas, which is in-

spired by the principle of the circular economy and considers waste from old mining and ore processing activities as potential secondary raw materials. The research aims to apply the flotation technique to extract from solid mining residues fractions of useful but polluting species, obtaining the double result of downgrading the material below the CSC (Contamination Threshold Concentration) and extracting a concentrate of commercial characteristics. The materials of potential interest are those that constitute the landfills of the Pb and Zn minerals cultivation and treatment. The project has developed, with reference to a pilot basin, by integrating in the system the additional information necessary to evaluate the reproducibility of the residues present (reprocessing by flotation of Pb and Zn sulfide tailings).

The studies carried out so far have involved samples taken from Montevecchio Ponente and Levante on which batch flotation tests have been carried out for the reconstruction of a plant flowsheet that in one case develops in two sections, one for the recovery of zinc sulphide and the second for the separation of the oxidized fraction from the final sterile. Starting from feed concentrations of around 2% in Zinc, three products were obtained: a commercial concentrate of Zn sulphide with a 50% content; a final waste with concentrations in heavy metals, mainly Zn and Pb, lower than CSC for industrial sites; and an intermediate concentrate (non-marketable) whose residual Pb and Zn contents require inerting or disposal at a collection site.

Manca P.P., Massacci G., Mercante C. (2019) Environmental Management and Metal Recovery: Re-processing of Mining Waste at Montevecchio Site (SW Sardinia). In: Widzyk-Capehart E., Hekmat A., Singhal R. (eds) Proceedings of the 18th Symposium on Environmental Issues and Waste Management in Energy and Mineral Production. SWEMP 2018. Springer, Cham.

Modeling of Geogenic Radon Potential and Health Risk Assessments in Sardinia

Mirisina Mousavi Aghdam

Mirsina is a final year PhD. student at the University of Cagliari, and he is currently placed at Trinity college of Dublin as a Visiting PhD. student. He is researching on Geo-Environmental risk modeling. He started his PhD. in October 2017. He received his master's degree in civil-geotechnical engineering at the Khajeh Nasir University of Technology, Tehran, Iran. After graduation, he worked for two years as an executive director in a consultant company, which is active in monitoring and instrumentation of dams and tunnels. His current research focuses on analytical techniques and methodological approaches for the evaluation of natural radioactivity and radon release potentials in different geological contexts.

Radon is a radioactive natural gas. It is a colorless, odorless element and considered as the primary source of indoor air pollution. Radon atoms, along with decay products, can attach to dust and airborne particles, enters the lungs and decays, producing alpha and beta radiation that damages DNA and causes lung cancer. To help protect the public from the adverse health effects of radon and elevated levels of natural radioactivity, the European Commission has set Directives that require the member state countries to have action plans against radon problems. According to this, a PhD program was defined for which the main goal was to prepare a predictive map of geogenic radon potential for the territory of Sardinia and some parts of Ireland. Although the risk of radon in indoor spaces is a complicated function of geogenic and anthropogenic parameters (building material, living habits, etc.), the geogenic variables are the major controllers of indoor radon levels.

The geogenic potential is defined as a quantity of radon "delivered by the Earth," i.e., all the geologic factors that can influence the radon content at the ground level. Therefore, the production of a geogenic radon map would help to predict the indoor radon level for an individual dwelling, which can be residential, public building, or even a workplace.

An extensive study on bibliographic references, available data and recent peer-reviewed research works were carried out to find the best methodology for geogenic radon mapping in Sardinia. Using GIS-based techniques, a draft of a geogenic radon map was produced for the Sardinian region. The reliability and workability of the prediction map were evaluated. A set of laboratory and in-situ measurements were performed to examine the usability of the map. Different types of samples (soil, rock and water) were collected from different environments located in the Sardinian territory (e.g., workplaces, public buildings) and even inhabited areas (black shale of Villasalto district)) to estimate the natural radioelement concentrations (mostly ^{238}U, ^{226}Ra, ^{232}Th, ^{40}K) and the radon emanation and exhalation rate. The final goal of field and laboratory tests was to investigate the natural radiation potential of tested sites.

The last year of the PhD program was carried out at Trinity College of Dublin, where the primary purpose of the study was to evaluate in detail the radon potential of different geological structures. Data obtained from radiometric surveys, geochemical measurements and indoor radon concentrations were widely used for distinguishing between radon releases from different geo formations. Furthermore, a set of samples were collected from selected geo types and radon/thoron exhalation rates were estimated through laboratory experiments. As a result of the research work mentioned above, radon and thoron potential maps were developed. Besides, a detailed investigation of soil gas radon concentrations was considered in a radon priority area identified through the potential maps. The results of this study can help for decision making about the protection of the public against radiation risk in administrative and local levels. Furthermore, it can be used as a base for targeting the hot spots for additional testing of radon in Sardinia and Ireland and also for the management of future construction sites.

Archaeobotany of Phoenician and Punic Sardinia (7th-3rd c. BC)

Maria Mureddu

Maria Mureddu is an archaeologist specialising in archaeobotany. After studying archaeology in the University of Cagliari, she took an ulterior Master degree in Maritime archaeology in the University of Aix-Marseille (France). She participated to many fieldworks in Sardinia and in foreign countries (Spain, France, Greece). She collaborates with the Archaeological Superintendence (Soprintendenza ABAP per la città metropolitana di Cagliari e le province di Oristano e Sud Sardegna) and the Museum of Cabras-OR.

Her PhD project, with the title "*Domesticated and wild plant exploitation during the Phoenician and Punic period in Sardinia: the contribution of the waterlogged finds"*, is an interdisciplinary study involving human and biological disciplines. The research is held in the DiSVA – Department of Life and Environmental Sciences of the University of Cagliari, in collaboration with the Department of Letters, Languages and Cultural Heritage. Moreover, an important part of the project was developed in the Department of Archaeology and Ancient Societies of the University Paul Valéry – Montpellier 3 (France). The study focuses on the analysis of vegetal macroremains recovered in archaeological excavations held in Sardinia, and more specifically in waterlogged environments such as lagoons. As little is known at the moment concerning the relationship between man and plants in Sardinia during the period under investigation (7th-3rd c. BC), the aim is to fill this gap. In order to do so huge quantities of sediment were sampled during different archaeological excavations and sieved enabling the recovery of macroremains such as ancient seeds, fruits, leaves and other plant parts. The work in

the laboratory implied the analysis of several tens of thousands of items, between which more than 100 *taxa* were identified thanks to modern reference collections and plant atlases. Some preliminary results were presented at international conferences (the last one being Mureddu *et al.* 2019). The *taxa* recognised pertain both to domesticated and wild plants, giving information about ancient agriculture and trade, and on the human impact on the environment. Furthermore, morphometrical analysis were added to implement the study, and more specifically on the recovered seeds of *Vitis vinifera* and the endocarps of *Olea europaea*. This type of analysis is suitable for a good characterization of this plant elements and enables a comparison between ancient samples and modern ones without producing any damage to the archaeological materials. Thanks to this approach, new information about the state of domestication of this economic species at that period will be available, and hopefully it will be possible to speculate about the origin of modern cultivars, giving an important contribution at the same time to archaeology, botany and agronomy.

Mureddu M., *et al.*, Vegetal macro-remains from the Mistras Lagoon (Sardinia, Italy) as palaeoenvironmental indicators for the hinterland of Tharros, "40th Association for Environmental Archaeology Conference (Sheffield, 29th November-1st December 2019)", Abstract book, p. 65.

Emissions of particulate matter from tailings basins exposed to wind erosion

Francesco Pinna

Francesco was born in Iglesias on the 23rd of January 1992. In October 2017 he graduated with honours in Environmental and Land Engineering, at the University of Cagliari. From October 2018 he has been a PhD student at the Department of Civil and Environmental Engineering and Architecture (DICAAR) – University of Cagliari.

The title of his PhD thesis is "*Emissions of particulate matter from tailings basins exposed to wind erosion*".

The research deals with the emission of Particulate Matter (PM) from the surfaces of tailings basins exposed to wind erosion (i.e.: *industrial wind erosion*) and aims at defining reliable Emission Factors (EF) to be used in the impact assessment studies (modelling/numerical analysis). The disposal of tailings represents, in fact, one of the most significant environmental problems related to the mineralurgical industry, due to the huge production of waste and the lack of economically viable reuse or recycling techniques. The main environmental risk related to the disposal of mineralurgical waste is the pollution of underground soil and water, caused by the percolation of the pollutants from the basin's bottom. Another major issue is related to drying processes at the basin's surface, which under specific meteorological conditions and depending on the disposal methods may favor wind erosion (industrial wind erosion) and the consequent emission of PM into the atmosphere.

In order to estimate the emission of PM from the surface of a tailings basin, it is necessary to define a site-specific Emission Factor (EF). To this end, an environmental wind tunnel was built at the DICAAR laboratory, based on a critical review of consistent scientific literature. The construction of the DICAAR wind tunnel enables to investigate the relationships between the emission of PM from different types of erodible surfaces and the main influencing variables (wind velocity and site-specific parameters).

The first experimental test with the environmental wind tunnel was performed on red mud samples from a major Bauxite Residue Disposal Area (BRDA) located in southwestern Sardinia (Italy), where anemometric measurements had been previously carried out to characterise the approaching wind profile. Wind speed measurements were preliminary performed in the tunnel to verify the accuracy of the simulated part-depth Atmospheric Boundary Layer (ABL) [1]. The red mud samples from the BRDA were prepared for the emission test through natural or oven-drying processes (reproduced in the DICAAR laboratories), in order to simulate the state of the mud at the top of the BRDA (field condition).

The emission tests inside the tunnel were performed by adjusting the wind speed to account for different intensity of the erosion/emission phenomenon. The PM concentration was detected downstream of the red mud samples with an aerosol monitoring system (DustTrak). The emission factor (EF) was then calculated, based on the measured values of PM concentration and wind velocity.

Dentoni V., *et al.*, Validation of a wind erosion model for tailings basins: wind tunnel design and atmospheric boundary layer simulation, *Int. J. Min. Reclamat. Env.*, 2019; **34**(8): 562-572.

PhD program in Economics and Business

Coordinator: Prof. Vittorio Pelligra

https://dottorati.unica.it/sea/

Today a PhD is gold. Having the chance to enroll in such an experience represents for any student a great opportunity to grow academically, professionally, and personally. For those who are curious, determinate, passionate about the qualitative and quantitative understanding of the economic systems, the behavior of its agents, individuals, firms and institutions, our PhD program offers a unique opportunity to learn how to use the analytic tools of economic and behavioral sciences, to go deeper into the functioning of the market, other social institutions and the firm and to develop a profound comprehension of how they are created, designed and managed. But the PhD program is also, perhaps, mainly, a trail towards critical thinking, autonomy as researches, and maturity as men and women who want to be able to in interpret with rigor and unbiasedness facts and figures of the economic realm and beyond.

The PhD is also a great opportunity to travel and to meet interesting people, to discuss our own ideas with other brilliant scholars and to try to give an original contribution to our understanding of the economic and social world.

Our *PhD Program in Economics and Business* (*Dottorato in Scienze Economiche e Aziendali*) is an initiative of the Department of Economics and Business (DSEA) of the University of Cagliari. The PhD program has agreements to provide co-tutorship and joint degrees with the Universitat Jaume I, in Castelló de la Plana (Spain) and with the International University Institute "Sophia" which, despite being and international institution, is based in Florence.

We offer our students three different tracks:

- *Economics*,
- *Business and Management*,
- *Quantitative Methods*.

Our students form a multicultural, inclusive and lively community of young scholars happy to learn, confront and open to new experiences. The older ones are always ready and willing to help the younger in their steps ahead toward the development of their ideas, researches and, finally, the defense of their thesis. At the end of the XXXIII cycle,

six of them will present their results to the reviewer and the to the panel that will examine them and, hopefully, will award the degree of *Philosophy Doctor*. I, personally, along with all the colleagues of the Faculty wish them a shining career and a great future.

Essays in monetary incentives and political selection

Andrea Caria
Curriculum: Economics

I am Andrea Caria, a PhD candidate in Economic and Business Sciences studying Political Economy. I am Born in 1991, and I am grown up in a small village in the middle of Sardinia. I graduated at the University of Cagliari, I got my bachelor's degree in economics and finance with a thesis on derivatives, and then I changed my educational path to focus on political economy. I enrolled in the course of Economic Sciences (now EFPP), and I became passionate about research. Once I graduated, I applied for my doctorate, and I won a PhD scholarship of P.O.R. Sardegna F.S.E. - Operational Programme of the Autonomous Region of Sardinia, European Social Fund 2014-2020). My research interests are in Applied Microeconomics and Political Economics, with a particular focus on policy evaluation and political selection. I am mostly up in empirical analysis but with specific attention to the underlying theory. I learned the very first econometric techniques during my master's degree, and then I improved my knowledge during my PhD courses. Finally, I had the opportunity to refine it during my visiting period in Amsterdam at the Tinbergen Institute, where I learned more about policy evaluation and applied microeconometrics. I have approached political economics thanks to my supervisor Fabio Cerina, who gave me the opportunity to work on it during my master's thesis. I took advantage of my visiting at Stockholm University to deepen my Political Economics knowledge, mainly thanks to the supervision of some of the fathers of this literature. In Stockholm, I had the chance to get to know the state of the art of my field both empirically and theoretically.
In my thesis, I analyze the effects of monetary incentives on political

selection and behaviour, and I also investigate how the electoral laws may affect these monetary incentive effects. Using various public online databases and digitalizing data sources only existing in paper format, I study politicians at different levels from the municipal assemblies to the national parliament. The most relevant part of my dissertation is the chapter titled "Political Selection and Monetary Incentives in Local Parliamentary Systems." Using a rich database on local politicians in Italian municipalities between 1985 and 1992, we implement a Regression Discontinuity analysis to evaluate the causal effect of a wage increase on the characteristics of these politicians. The politicians analyzed are councillors, mayors and executive committee at the 5000-population threshold. We focus our analysis only on municipalities with single-party governments in order to clean from the confounding treatment of the change of electoral rules from majority to proportional arising in the same threshold. This work is related to the strand of literature on the selection effect of monetary incentives in municipalities. We confirm positive results of pay on councillors but we consider the role of indirect election and the need form a coalition and extend the analysis to include councillors and members of the executive committee. We find that a 30% real wage increase for the mayor at the threshold leads to a 0.7 increase in the years of schooling for elected members of the local parliament. Conversely, the salary jump leads to a -0.9 years decrease for the mayor elected among the councillors by them. The heterogeneity analysis suggests that this result is driven by parties at the national level.

Strategic Management: An empirical analysis in the Italian public HES

Andrea Crienti
Curriculum: Business and Management

Andrea Crienti is a PhD. student in Economics and Business Sciences at the University of Cagliari. After graduating from the University of Cagliari, he collaborated with various accounting firms and carried out teaching tutor activity at the University of Cagliari. His research interests are Business Economics, Public Management, and Accounting.

During the PhD. course, I mainly carried out research activity, and, at the same time, I attended classes about research methodologies. Such activities, considered conjunctly, significantly contributed to developing competencies related to research. As part of the PhD. course, I conducted study and research activities at the Oslo Metropolitan University, Oslo (Norway). The experience at the Oslo Metropolitan University was precious since I had the opportunity to interact with different professors and researchers.

In particular, my dissertation *Strategic Management in the public sector: an empirical analysis in the Italian public higher education sector* focuses on strategic management in the Italian public sector and, in particular, in the higher education sector.

In the last twenty years, the Italian public higher education sector has been subjected to several laws that completely reshaped the environment in which higher education institutions (HEIs) operate. Such laws aimed to increase the quality, efficiency, and effectiveness of the higher education sector. Law 15/2009 and Law 240/2010 aimed to place an

HEI's performance as central in the debate, imposing relevant changes in the governance structure and the funding mechanisms while introducing a pervasive performance measurement system. Therefore, based on strategic management literature, HEIs needed to implement a strategic reorientation to achieve an alignment between their strategic stance and the new emerging environment. Maintaining the same strategic stance could indeed lead to a misalignment with the external environment and, consequently, a reduction in their performance. A survey helped to identify the strategic stance adopted by a single HEI before and after recent laws. The survey aims to understand whether the strategic stances of HEIs have changed because of the laws issued in recent years, and, if so, how. The responses from the survey, through the lens of the Miles and Snow's framework, were employed in an exploratory factor analysis to identify the strategic stances present within the public Italian higher education sector before and after recent laws. The analysis points out that, according to the literature of strategic management, Italian public HEIs carried out a process of strategic reorientation in response to recent laws. Such a process led several Italian public HEIs to adopt a more prudent risk-averse strategic stance interpreting the new environment as designed by the recent norms as riskier.

Overall, this work provides a contribution both to strategic management literature and a support for policymakers. In fact, in the higher education context, but more generally, in the public sphere, the results can help policymakers to better predict the reaction of public organizations in the event of the introduction of laws/reforms.

Storytelling and Science Fiction: a new strategy for third mission value

Laura Poletti
Curriculum: Business and Management

After graduating at University of Pisa, I have improved my knowledge and skills working in Italy and abroad as manager of innovational projects in the fields of technology transfer and communication. A master's degree in Business Management from the Business School of Bologna and an international master's degree in Communication Technologies, allowed me to upgrade my abilities and made me understand how learning could be seen as an important tool to boost competitiveness, the growth of a territory and innovation. Since 2013, I have been an employee of the Research and Territory Directorate of the University of Cagliari, and in particular I have managed projects about Third Mission and Technology Transfer at CREA UniCa, the University Service Center for innovation and entrepreneurship. Therefore I have been in touch with the academic world and researchers from different fields, and this experience helped me see how the power to communicate with the main characters of innovation and fully understand their language, was essential to seize the opportunity to be an important element in the innovation rise and knowledge-based economic growth.

It's from this that my research has started, and it was the chance to better understand how the third mission, now part of the knowledge society, needs a new strategic positioning to be perceived in the right way. It needs useful tools such as a cross-media plan with communication activities in the new media, a storytelling strategy and science fiction elements to increase the value of the Third Mission and the University's Technology Transfer.

The main goal of my theoretical model was to create a tool for the management and the communication of Third Mission and Technology Transfer that could reach the largest number of people. An approach that can bring out the best of each tool properties so everyone can understand the benefits that society can get from scientific research. Hence the need to start a real collaboration between researchers and creatives, between content and form, between what to say and how to say it, using different languages and tools.

The case study "The Shifters, the third mission" intends to communicate the University of Cagliari's Third Mission from a different point of view.

The Shifters intends to be a cross-media communication project, that involves the creation of a series of short fictional movies inspired and written starting from real research work within the University of Cagliari, to be released online for free.

Elaborating the idea, it does not tell only about the research but it tries to find the right media to convey the message, to make it effective, simple and even enjoyable. It makes an attempt to reach everyone, without any difference in tastes, interests or tendencies.

The project has its own website that contains several levels of information: in fact, it is built as an information pyramid. The most creative level is the episode, which shows the research but without revealing it completely. The featurettes, of the every researchers, uncover the Easter Eggs hidden in the story, after that every level is more elaborated and detailed: podcasts, blog, social networks (Facebook and Instagram), events, up to a high level of information such as scientific papers that can be downloaded and consulted by the most curious and interested user.

General Sentiment Decomposition: opinion mining based on raw NL text

Maurizio Romano
Curriculum: Quantitative Methods

Born in 1992, Maurizio Romano is a PhD. student in Economics and Business Sciences at the University of Cagliari. Graduated in Computer Science with a thesis related to the Semantic Web, he won received a research grant for the "Creation of algorithms for the analysis of data from the tourism sector". He is currently an Assistant Professor in the course "Statistical Learning Methods for Data Science" of the master's degree in Data Science, Business Analytics and Innovation. His research interests are Statistical Learning, Sentiment Analysis, and Big Data.

During his studies, he improved the English language speaking and problem-solving skills, theoretical and practical specific-domain knowledge, and his culture. In particular, international experiences such as Spain (Universitat Politècnica de Catalunya, Barcelona) and Germany (Jacobs University Bremen gGmbH, Bremen) provided a significant impact on his life, boosting his researches.

His PhD. thesis, «*General Sentiment Decomposition*», mainly focuses on the Sentiment Analysis of a considerable amount of Natural Language text corpora. In other words, he aims to analyze text produced by people who discuss a specific issue (post on Twitter.com, TripAdvisor.com, Booking.com, et similia, aka Word of Mouth), and to quantify how happy (or not) they are about a specific problem.

According to his last paper (Romano M., Mola F., Conversano C.; 2020), Word of Mouth political and marketing importance is growing day by day. These phenomena can be directly observed in everyday life, e.g.: the rise of influencers and social media managers. If more people talk about a specific product, then more people are encouraged to buy it and vice versa. This effect is amplified proportionally to how high the consideration or close the relationship between the potential customer and the reviewer is. Furthermore, considering the negative reporting bias, it is easy to understand how customer satisfaction is of absolute interest for a company or, e.g., for a politician.

After analyzing the impact of Word of Mouth on earnings and the related psychological aspects, he proposes, in his PhD. thesis, an algorithm to extract the sentiment from a Natural Language text corpus. The combined approach of Neural Networks, characterized by high predictive power but at the cost of harder interpretation, with more straightforward and informative models, allows not only to predict how much a sentence is positive (negative) but also to quantify a sentiment with a numeric value. The assessment of an objective quantity improves the interpretation of the results in many fields. For example, it is possible to identify specific critical sectors that require intervention to improve the offered services, to find the strengths of the company (useful for advertising campaigns), and, if time information is present, to analyze trends on macro/micro topics.

To support further decision-making, he applies this method to labeled (Booking.com, TripAdvisor.com) and unlabeled (Twitter.com) data, analyzing the sentiment of people who discuss a certain issue. In this way, he identifies the aspects that are perceived as critical by the people w.r.t. the "feedback" they publish on the web and quantify how happy (or not) they are about a specific problem. In particular, he put the focus on customer satisfaction of both Booking.com and TripAdvisor.com users, whilst for Twitter.com, the main topic is the climate change.

Romano M., Mola F., Conversano C., General Sentiment Decomposition: Climate Change topic & Twitter.com users. In: *10th iEMSs Conference 2020*, 14th –18th September 2020, Brussels, Belgium.

Economic agglomeration in Italy before and after the Great Recession

Alberto Tidu
Curriculum: Economics

I decided to enroll in a PhD after pursuing degrees in Business, Law and Politics and I chose to focus on Economic Geography after contemplating several interesting fields of research, related both to business and to economics. During my first year as a PhD student, I had the opportunity to learn how academic research works and to refresh concepts I had not seen in a while, through classes, exams and paper reading.
The second year included a period abroad where I was enrolled at the Birkbeck University in London, under the supervision of prof. Frederick Guy, attending classes in International Development, Macroeconomics, Finance, and Global Politics. During the three years as a PhD student, I have had the opportunity to attend many short courses that have proved very useful for strengthening my quantitative skills. I have also had the chance to present my ongoing research in several meetings and conferences, both in Italy and abroad.

Together with my supervisor, Stefano Usai, we decided to study economic agglomeration in Italy and how it changed during the Great Recession that took place after the 2008 financial collapse, producing a work titled "*Economic agglomeration in Italy before and after the Great Recession*". The first step of my research involved the study of a wide range of papers dealing with economic geography and location economics, in order to outline the first chapter of my dissertation, which consists in a literary review beginning with the works of Von Thunen and Marshall.

The second chapter is the most relevant part of the research and consists in the computation of Marcon and Puech's M index for different distance ranges (from 5 to 30 minutes) and for each industry (defined as per three-digit ATECO codes). M represents the degree of agglomeration for each economic sector in the country: the higher the result for an industry, the higher the tendence for its employees to locate close to each other, controlling for overall agglomeration and for the relevance of the industry in the whole economy. The same index is computed for 2007 and 2012 in order to allow for comparisons between the situation before and after the crisis set in.

The third and final chapter conceptually follows the previous one, but it verges towards a geographic approach: indices are now computed again by isolating subsections of the country and treating them as islands, in order to understand whether there is absolute homogeneity within or whether some parts are somehow disconnected from the rest and their industries follow different agglomeration patterns. The chapter goes on by describing the most peculiar and representative territorial situations that have emerged during the research, in order to outline how places with a different agglomeration structure have been impacted by the Crisis in ways that are possibly different from one another.

Big Data Insights Wanted: Dimensions, Effects, and Mechanism from a Pilot Project

Maryia Zaitsava
Curriculum: Business and Management

After dedicating 8 years to working internationally (Belarus, Russia, UK) in strategic innovation and technology products marketing, I have got joint MSc degree in Electronic Business Management in Middlesex University, UK and Mykolas Romeris University, Lithuania in 2017 and entered PhD. in Business and Economics programme in University of Cagliari.

My research focus is on how organizations approach and cope with Digital Transformation challenges and opportunities. Specifically, under the guidance of the supervisor prof. Maria Chiara DiGuardo and in cooperation with the Technology Innovation research group, I came up with the matrix explaining how Big Data dimensions participate in Big Data insights creation; explored the intriguing interaction between cognitive biases and Big Data in decision-making; delineated and explained proof-of-concept dynamics. I published in international peer-reviewed journals, co-authored international conference proceedings (Academy of Management Annual Meetings and Strategic Management Society) and several book chapters.

I was a Visiting Research Fellow in Liverpool John Moors University, Liverpool Business School in March - July 2019 where I was involved in the multinational large-scale pilot aimed at testing Big Data technology in leading transprtation companies in Europe and conducted the research on Big Data insights creation.

Specifically, the research "*Big Data Insights Wanted: Dimensions, Effects, and Mechanism From a Pilot Project"* aims at opening up the black box of Big Data by taking a close look at their characteristics and effects that influence the ability of Big Data to create different types of insights.

Big Data is the next milestone to advance innovation, performance, and competition. Existing research has shown that top-performing firms use data in their decision-making process five times more than low-performing firms. Notwithstanding the significance of Big Data, recent research has started putting in question the given usefulness of Big Data for firms. Researchers argue that having large volumes of data does not necessarily mean having interesting data, nor does it guarantee efficient decision-making, while converting data into meaningful insights is an effective use of Big Data.

Yet researchers have mostly focused on the role of Big Data analytics in the insights creation, neglecting the better understanding of the underlying mechanism of different insights creation at the level of Big Data. To take the challenge, the research disentangles Big Data dimensions and derives their related characteristics that work as sub-dimensions. Further, we conceptualized two effects of Big Data dimensions, namely, *Proliferation* and *Additive* effects. We built and validated a matrix that explains the mechanism of Big Data insights creation via the two effects. Specifically, we found that the degree of *Proliferation* effect influences the level of sophistication of insights, while *Additive* effect affects the level of usability of Big Data insights.

The study provides a bridge between technology innovation and information systems literature and allows a better understanding of the dynamics of insights creation by focusing on Big Data dimensions and their fine-grained distinct effects. It also contributes to the discussion on the usefulness of Big Data.

PhD program in Electronic and Computer Engineering

Coordinator: Prof. Alessandro Giua

https://www.alessandro-giua.it/DRIEI/

The *PhD Program in Electronic and Computer Engineering* (DRIEI: *Dottorato di Ricerca in Ingegneria Elettronica e Informatica*) of the University of Cagliari is offered by the Department of Electrical and Electronic Engineering (DIEE). It has been active since 1996 (XII cycle) and broadly covers the area of Information Engineering.

The PhD program is structured into two curricula.

- *Curriculum in Electronics and Telecommunications*, whose research topics span the disciplines of: Electrical and Electronic Measurements, Electrical Engineering, Electromagnetic Engineering, Electronics, Power Electronics and Electrical Drivers, Telecommunications.
- *Curriculum in Computer and Systems Engineering*, whose research topics include the disciplines of Automatic Control and Computer Engineering.

The program prepares for careers in high-technology environments, in Italy and abroad, including academia and international research centers, research management institutions, industrial research and development, consulting, and creation of technological start-ups.

The PhD program is internationalized and has formalized agreements with the School of Information Science of *Southwest Jiaotong University* (Chengdu, China) and the School of Electromechanical Engineering of *Xidian University* (Xi'an, China). In addition, theses in co-tutorship with other foreign universities are regularly activated.

Nine PhD students are enrolled at UNICA in the XXXIII cycle, which started in 2017 and ends in 2020. In addition, a student from Xidian University (Xi'an, China) is enrolled in the XXXIII cycle in co-tutorship.

The Covid-19 emergency during the last six months of the triennium has minimally affected the activities: all students were able to complete the required period of study abroad, visiting many prestigious academic groups and research centers. The quality and consistency of the scientific activity is testified by the 11 papers on international

journals and the 33 papers on international conferences the students of the XXXIII cycle have published as part of their doctoral activities.

Internet of things & remote sensing between Italy and France

Davide Aguiari
Curriculum: Electronics and Telecommunications

After concluding my computer science studies at the Alma Mater Studiorum University of Bologna, I decided to delay looking for employment for the moment, choosing instead to further investigate some research aspects at the University of Cagliari. Thanks to the collaboration with Professor of telecommunication systems Daniele Giusto at the Department of Electrical and Electronic Engineering (DIEE), I enrolled in the PhD course in Electronic Engineering and Computer Science to focus on Internet of Things and Networking. The University of Cagliari's international reputation allowed me to move to Paris at the Laboratoire d'Informatique de Paris 6, Sorbonne Université, where I had the honour to work as part of an international and dynamic team, starting a cotutelle for a year and a half. There I had the chance to work in partnership with professor Giovanni Pau, formerly associate professor at UCLA, developing and designing a small wearable air-quality sensor called "Canarin Nano", which is currently used by several patients at the Saint-Antoine Hospital in Paris. The doctors needed a system for monitoring the correlation between the pollutant exposure and the emerging chronic diseases; my previous knowledge in Internet of Things and networking, along with the experience gained at UniCA, helped me find the best options to put together several sensors for the PM10, PM2.5, PM1, TVOC, and CO2 sensing. Starting with a WiFi device, we progressively moved to a 4G device with an embedded GPS for samples tracking.

A similar device, for a static scenario, has been also designed and developed for a UNESCO site monitoring: the Biblioteca Joanina in Coimbra (Portugal). There I studied the correlation between the presence of residues of limestone dust and the status of furniture inside the library. Along with the sampling sensors, I added some thermal cameras to detect people/animals' moving patterns inside the library, helping the University of Coimbra to rearrange the touristic path inside the library museum in order to reduce the environmental impact. Recently, I have worked at the University of Bologna, developing a device for the monitoring of lithium batteries. We installed 30+ monitors inside different electric vehicles that are collecting thousands of battery's parameters every day. Later, these data will be analyzed for developing a prediction algorithm to prevents structural damages.

Finally, I worked with Professor Pau on new networking applications such as new ways to exchange data between mobile vehicles and other vehicles or the street infrastructures. Mobile autonomous systems deeply impact manufacturing, space exploration, rescue, defense, transportation, and everyday life, posing new challenges in networking, distributed systems and resource management. Our work aims to design a new generation of tools and mechanisms to enable fine-granularity computation, coordination and mobility management, e.g. a framework that dynamically offloads heavy tasks that can't be locally processed, to vehicles nearby. My activity research also allowed me to attend some prestigious conferences, such as the G7 Ministerial Meeting on Environment and to be part of the HORIZON2020 project "NRG-5 Enabling Smart Energy as a Service via 5G Mobile Network advances". My thesis will be the completion of the last three years and it will be titled "Edge Computing in IoT based sensor environment".

Aguiari D., *et al.*, Monitoring cultural heritage buildings via low-cost edge computing/sensing platforms: the Biblioteca Joanina de Coimbra case study; GOODTECHS; Bologna; 28-30 November 2018. *ACM International Conference Proceeding Series*, 2018: 415-421.

Intelligent Video Surveillance with a Human in the Loop

Rita Delussu
Curriculum: Computer and Systems Engineering

Rita Delussu was born in Cagliari. She received her Bachelor and Master degrees in Electronic Eng. at the University of Cagliari (Italy) in 2014 and 2017, respectively. Since October 2017 she is a PhD student at the Pattern Recognition Applications Lab, at the same University.

In her PhD she addresses Computer Vision techniques to support human operators in a real application scenario such as Law Enforcement Agencies (LEAs) in monitoring and investigation tasks. She focused on the tasks of person re-identification and crowd counting. Person re-identification consists of recognising images of a person of interest acquired from different (non-overlapping) cameras in order to reconstruct movements. It is a challenging task due to several issues such as different poses, illumination changes, low resolution cameras and several occlusions. Due to these issues, it is unfeasible use classic biometric techniques (e.g. face recognition) and it is necessary to use a different approach based on clothing appearance of the person of interest. Crowd counting task consists of counting people in an image or video. Also this task presents several and challenging issues such as perspective distortions, illumination variations, different scale, different and (often) complex background and occlusions.

During the PhD, she collaborated in the European Project (Horizon 2020) named LETSCROWD[1] developing a prototype for supporting LEAs operators. The prototype consisted of different tools that used

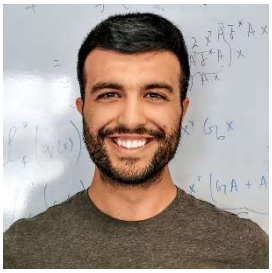
the human in the loop techniques. This collaboration allowed her to attend the meetings in which the prototype was examined by LEA operators in simulated scenarios. In particular, the prototype was tested in different scenarios in Belgium and in Germany. It was an amazing experience in professional and personal terms since it allowed her to improve professional skills and to get to know people that works not only in academic research and can provide useful and practical information about real world scenarios.

Due to the complexity of the person re-identification task, the human-in-the-loop approach was used. It consists of requiring the end user (e.g. LEA operator) a feedback on the system outcome. The input information of the system was an image of the person of interest and the output consists of a ranked list of images based on the similarity with the input image. In person re-identification, the required feedback was to indicate all images that show the person of interest among the top-k retrieved images to improve the results and limit the time required to analyse all videos. This approach allowed to achieve good results that were comparable and sometime better than those achieved by other approaches at the state of the art. In crowd counting task, to improve the estimation of the number of people in the videos, the use of synthetic data sets was proposed. The end-user should provide some information about the scene of interest in order to adapt the system at that scene without requiring the human effort to label images of the training set. In particular, a background image, the region of interest and the perspective map were required to the end user. By using the provided information, a synthetic data set can be generated. That data set was created by using a simple technique that consisted of overlaying person images on the background image. At the operational phase, therefore after the generation of synthetic data set and the training of a model, the system takes in input a video and the output consists of a number that estimates the number of people. The use of synthetic data set shows interesting results which can be comparable and in some cases better than the other approaches proposed at the state of the art.

Delussu R., Putzu L., Fumera G., Scene-specific Crowd Counting Using Synthetic Training Images. Pattern Recognition, under review.

Coordination of Multi-Agent Systems

Diego Deplano
Curriculum: Computer and Systems Engineering



I received the B.S. and M.S. degrees in Electronic Engineering "cum laude" from the University of Cagliari, Italy, respectively in 2015 and 2017. My PhD started right after at the University of Cagliari within the group of Automatica, under the supervision of Prof. Alessandro Giua and Prof. Mauro Franceschelli. The group is very active in theoretical and applied research through several international collaborations and participation in national and international projects. Over the 3 years of my doctoral studies, I had the chance to be part of this group, to work and collaborate with several skilled Professors, researchers and PhD colleagues, both at the University of Cagliari and abroad. In particular, I spent visiting periods at the CNRS (Centre National de la Recherche Scientifique) in Grenoble, France, under the supervision of Prof. Carlos Canudas-de-Wit and at the University of Toronto in Canada under the supervision of Prof. Luca Scardovi.

My research interests mainly focused on the coordination of multiagent systems, and the title of my PhD thesis is "*Coordination of multiagent systems: stability via nonlinear Perron-Frobenius theory and consensus for desynchronization and dynamic estimation*". In a general sense, the multiagent system (MAS) paradigm in control theory considers a system as a network of autonomous entities, called agents. The global behavior of such a complex system emerges from the local behavior of the agents and their pattern of interactions. The MAS approach has proved to be a suitable solution for coordination problems of distributed nature, where the information exchange, the control, and the processing are not centralized but rather distributed. The coordination problem of MASs consists in the distributed control of each agent in

order to achieve a desired global emergent behavior. A modern, intuitive yet illustrative example is the coordination of multiple unmanned aerial vehicles (UAVs), also called drones. UAVs are being utilized in environmental and natural disaster monitoring, border surveillance, search and rescue missions, transport, and other domains. Nowadays, the main point of interest is to design UAVs such that they are able to coordinate themselves autonomously, minimizing user intervention, in order to achieve a specific goal. From a theoretic point of view, coordination problems differ from each other by the intrinsic nature of each agent, the kind of communications and the goal to be achieved.

During my PhD, I worked on several different coordination problems, but in the following the focus is on the results presented in Deplano et al. (2020). In this work the behavior of the agents is described by the temporal evolution of some quantities of interest, which are usually denoted as the state of the system. The agents exchange information about their state with neighboring agents in the network. Once an agent has collected the state information from its neighbors, it changes its state according to a specific function called updating law. The focus of my research is on nonlinear updating law steering the agents to agree upon the same behavior, i.e., their state reach the same value which is the so-called consensus value.

Most of the actual literature addresses the consensus problem in MAS assuming that the updating law is linear and common to all the agents. This allows one to exploit several mathematical results mainly contained in the so-called Perron-Frobenius Theory to solve the problem. On the other hand, in Deplano et al. (2020), by exploiting generalization of the Perron-Frobenius Theory to the nonlinear case, a novel class MASs is identified and characterized, for which sufficient conditions solving the consensus problem are provided.

Deplano D., Franceschelli M., Giua A., A nonlinear Perron–Frobenius approach for stability and consensus of discrete-time multi-agent systems, *Automatica*, 2020; **188**: 109025.

The intriguing connections between Explainability and Adversarial ML

Marco Melis

PhD in Electronic and Computer Engineering

Marco Melis was born in Cagliari, Italy, and received from the University of Cagliari the Master of Science degree in Electronic Engineering in 2017, disputing the graduation thesis "Super-Sparse Learning in Similarity Spaces".

Machine Learning (ML) systems are nowadays being extensively adopted in many fields, like spam and malware detection, biometric recognition, computer vision, and few other human-safety critical applications, like autonomous-car driving and medical robots. Despite demonstrating to be competitive or superior compared with human performance in some tasks, many of these algorithms were not designed to cope with specialized attacks named Adversarial Examples. These are carefully-perturbed input samples that, when fed to the system during the training phase or the operating phase, can alter its expected behavior to achieve some malicious goal. The vulnerability of Machine Learning models to such wild patterns, along with the design of suitable countermeasures, have been investigated in the last decade by the research field of Adversarial Machine Learning, which has also been the main focus of our doctoral activity.

One of the main challenges of Adversarial ML is to properly test and measure the robustness of a system to these attacks. This process is commonly conducted by crafting a set of Adversarial Examples and measure the response of a trained model to these inputs, i.e., by simulating a test-time evasion attack. Unfortunately, the security evaluation

process turns out to be a costly operation in most cases and can also be unfeasible to perform if the ML algorithm is not derivable or unknown, i.e., black-box. Thus, to understand the vulnerabilities in these and all other cases, we started to study *the intriguing connections between Adversarial Machine Learning and Explainable Machine Learning*. This new and interesting research field tries to present in understandable terms to a human the decisions made by an artificial intelligence system.

Explaining ML-based systems generally involves presenting a set of numeric values of how significant or relevant each input value, or feature, is for the system decisions. For example, when applied to Android Malware detection, one of the applications we have mainly focused on during our doctorate, an explainability method will output the mobile application components, such as the permission to send SMS messages or unlock the screen, sorted by relevance.

By analyzing the set of relevance values, we discovered a strong correlation with the Adversarial Robustness of a specific system. In fact, depending on how the explanations are computed, by measuring their evenness, i.e., how uniform the values are, we can provide an indication of how resilient a system is to evasion attacks without performing a security evaluation process. Furthermore, this process can be extended to non-derivable and black-box systems by learning a separate differentiable approximation [1].

To conclude, we believe that the connections between Explainable and Adversarial Machine Learning studied during my doctorate will help designers and engineers understand more profoundly and more efficiently ML-based systems' security properties and build new and more robust defenses against to Adversarial attacks.

Part of the research work on the explainability methods for Android Malware detection systems has been carried out at the Technische Universität Braunschweig, Germany.

Melis M, *et al.*, Explaining black-box android malware detection, *26th European Signal Processing Conference (EUSIPCO)*, IEEE, 2018: 524-528.

Biometric technologies and adaptive systems

Giulia Orrù
Curriculum: Computer and Systems Engineering

Born in Cagliari in 1991, I received my M.Sc. degree in Telecommunication Engineering from the University of Cagliari in July 2017, defending a thesis entitled "*Adaptive biometric systems for face recognition*". During my PhD I continued to study the biometric technologies, starting from the person recognition through fingerprints, faces, EEG signal and palmvein, up to analyzing some related issues such as liveness detection, user-specific effect and more. My two periods abroad at the Universidad Autonoma de Madrid, led by Prof. Fierrez, and in the Biometrics Security and Privacy group of the Idiap Research Institute, led by Dr. Sebastian Marcel, have allowed me to deepen some of these topics.

In particular, my research work is mainly based on adaptive facial recognition systems. In recent decades, the interest in biometric technologies has grown rapidly due to the increasing public safety requirements and the rapid diffusion in important private and public sectors. The use of these technologies as authentication, even in mobile devices and Internet of Things applications, is also increasing. The performance of facial recognition systems is particularly influenced by variations such as lighting, pose and time variance. These variations cannot be captured during a single acquisition; therefore, they require multiple acquisitions (different facial expressions, different poses, different illuminations, etc. should be acquired) which are expensive, time-consuming and require a high level of collaboration from users.

"Adaptive biometric" systems, which adapt continuously the biometric templates to the variations of the input data, without the need of the human-in-the-loop, are born in response to this limitation. These systems are characterized by a high computational complexity due to the continuous insertion of new templates in the gallery. The initial goal of my work is to make it possible to use adaptive biometric systems in devices with limited computing power and limited storage space. To achieve this goal, I designed appropriate selection approaches in order to keep in memory only the most representative templates of the biometric trait.

Moreover, in the last five years, deep learning methods, in particular CNN, have attracted considerable attention in the field of face-based recognition, achieving impressive results. Despite the deep features power and compactness, it is not yet clear if they are able to follow all the intra-class variations that the face can present over time. During my PhD I assessed whether the compact and representative face representation obtained through face recognition systems based on deep learning still needed updating or is able to follow the evolution of the biometric trait over time. To simulate situations of long-term use in which the temporal variability of biometric data is high, I acquired a new dataset collected by using frames of some videos in YouTube related to Daily Photo Projects: people take a picture every day for a certain period of time, usually with the aim of showing how their appearance is changing. I then evaluated the performance of adaptive biometric systems on this dataset and others present at the state of the art, using representations of the face extracted through handcrafted methods, such as BSIF, and the most well-known and powerful neural networks for face recognition, such as FaceNet, ResNet50 and SeNet50.

I reported these and other experiments in my PhD thesis, entitled "*Template update algorithms and their application to face recognition systems in the deep learning era*".

Orrù G., Marcialis G. L., Roli F. A novel classification-selection approach for the self updating of template-based face recognition systems. *Pattern Recognition*, 2020; **100**: 107121.

Estimation of the Quality of Experience from facial expression and gaze direction

Simone Porcu
Curriculum: Electronics and Telecommunications

Simone Porcu was born in Cagliari (Italy) in April 1992. He obtained his MSc and BSc degree in Computer Science respectively in September 2017 and July 2015. Porcu's research interests are related to Multimedia Communication focused on Quality of Experience.

Quality of Experience (QoE) is defined as 'the degree of delight or annoyance of the user of an application or service.' Providing an optimal level of multimedia QoE is now considered a requirement by the major stakeholders involved in the production and provisioning of multimedia services. Usually, to evaluate the QoE provided by a given system configuration, subjective tests are conducted during which human participants are exposed to defined test stimuli and asked to judge the perceived quality experiences on standardised rating scales. This approach provides accurate results but has the disadvantages of being time-consuming and of requiring the availability of users that are willing to provide explicit feedback on multimedia services. Therefore, there is a strong demand for automated evaluation and forecasting procedures that can provide continuous and effortless QoE estimates. This may support the stakeholders in the provisioning of multimedia services with controlled high level of QoE.

For responding to the need for QoE estimation automatization, the recent studies in the literature investigated different fields. One successful approach is to apply the psychological field to the QoE. Accordingly, researchers investigate the physiological response to the test

stimuli and perceived quality of the multimedia content. In some tests, a correlation between the physiological measures (brain waves, electrocardiogram, etc.) and perceived quality level has been found. For this case, the hardware causes the main problem; in-fact, in a real context, it would be impossible to enjoy multimedia contents while wearing electrocardiogram sensors. For this reason, the PhD study has been focused on the investigation of a subjective, physiological, unobtrusive and automatic method to evaluate the QoE. Specifically, it focused on a physiological measure that does not require to wear sensors, i.e., the acquisition of facial expressions and gaze direction. The only hardware that is required is a webcam or a camera in general. This approach is already used to analyse people's emotions in Facial Emotion Recognition (FER) challenges. However, the PhD study has not considered human's emotions but has focused on the investigation of the correlation between facial expressions (by observing the activation and intensity of activation of each muscle of the face), gaze direction (to consider where the consumer is looking) and the perceived QoE. Part of this PhD study was carried out during a visiting period at the Quality and Usability Lab in Berlin, which is one of the most important laboratories focused on QoE in the world.

As a result of the research studies conducted during the PhD period, a framework is defined for the *estimation of the QoE for video streaming services based on facial expressions and gaze direction*. This framework, based on a machine-learning algorithm, provides an estimate of the QoE automatically and unobtrusively by analyzing specific features extracted from the facial expression and gaze direction of the user. Therefore, the proposed framework is a valuable real-time tool for the monitoring of personal QoE during video streaming services without asking the user to provide feedback, with great advantages for service management. Moreover, the model outperforms the state-of-the-art models contributing to provide a dynamic and automatic way to perform the quality estimation task.

Porcu S., *et al.*, Estimation of the Quality of Experience during Video Streaming from Facial Expression and Gaze Direction, in *IEEE Transactions on Network and Service Management*, DOI: 10.1109/TNSM.2020.3018303

Explainable Artificial Intelligence for Cybersecurity

Michele Scalas
Curriculum: Computer and Systems Engineering

My PhD started in 2017, after graduating with honours in the M.Sc. degree in Telecommunications Engineering at the University of Cagliari. It has been carried out at the Pattern Recognition and Applications Lab (PraLab). Prof. Giorgio Giacinto has been my PhD supervisor, along with Prof. Konrad Rieck from the Technische Universität Braunschweig, where I was hosted for eight months as a visiting PhD student. My research field is Computer Security, which has many concrete applications in modern society. For example, during my PhD, I have been working on cybersecurity applied to healthcare, automotive, mobile phones, and digital forensics, both in the academic and industry context. The growing pervasiveness of ICT in society is indeed getting more and more evident. The European agency for cybersecurity (ENISA) prefigures a 2025 European scenario where operators in all sectors (e.g. energy, transport, finance) are providing connected services, and the quantity of data produced doubles every two years. Such a connected society implies serious cybersecurity threats. Consequently, the European Parliament has recently adopted the "EU Cybersecurity Act", which establishes an EU-wide certification scheme to ensure that critical infrastructures (e.g. 5G) and services meet cybersecurity standards. My research at PraLab has also been strictly tied to another crucial topic, that is *Machine Learning* (ML). It is part of *Artificial Intelligence* (AI), and it has emerged as the key technique that in the past few years brought breakthrough innovations in several fields. This phenomenon has been promoted by the growing ability to gather vast amounts of data (*Big Data*), which is the source of information for machine learning models. Specifically, such systems take as input sev-

eral examples of the entities to classify (e.g. photos) or events to predict (e.g. weather forecasts). These inputs are described in terms of their characteristics, called *features* (e.g. the colour in a photo, the wind in a location). Through specific algorithms, the models use such inputs to *learn* to make predictions. In this way, it is possible to use machine learning for autonomous driving, speech recognition, disease diagnosis, and many other use cases. In several of these applications, ML has allowed achieving unprecedented performance boosts. However, as its impact widens, the need to carefully evaluate ML systems emerges as well. In this sense, previous work in the scientific literature has shown that ML algorithms are vulnerable to the so-called *adversarial attacks*, i.e. carefully-perturbed inputs that can fool classifiers, causing, for example, a stop sign to be recognised by an autonomous car as a speed limit. This issue is often caused by the inability to understand what ML models learn due to their complexity. For this reason, the research topic of *explainability* (or *interpretability*) of machine learning is rising. This has been the topic of my PhD., whose thesis' title is *"Malware Analysis and Detection with Explainable Machine Learning"*, intending to explain ML models so to deploy secure ML-based systems. As an example, the primary domain I have been working on is malware detection for Android devices. Suppose you want to detect the presence in your mobile phone of ransomware attacks, which are malicious applications that block or encrypt devices to force victims to pay a ransom. Designers of ransomware detectors explore different ways to develop effective systems, with the aim to *(a)* minimise the number of false negatives, i.e. malicious applications that get classified as legitimate ones, *(b)* detect previously-unseen attacks, since attackers spread new ones on a daily basis, or *(c)* avoid the models to learn spurious patterns, i.e. characteristics that are not relevant for proper detection. Employing explainability could lead to improve these aspects, thus making malware detection more accurate, resilient, and trustworthy.

Scalas, M., *et al.*, On the effectiveness of system API-related information for Android ransomware detection, *Computers & Security*, 2019; **86**: 168–182.

Integrated Electronics for Molecular Biosensing

Stefano Sonedda
Curriculum: Electronics and Telecommunications

Stefano Sonedda was born in Cagliari in 1993. He received his B.Sc. in Electrical and Electronic Engineering and his M.Sc. in Electronic Engineering at the University of Cagliari in 2015 and 2017, respectively. His research work focuses on integrated electronics for biological applications such as a DNA sensor, the control of a neural prosthesis and a platform to use bacteria as chemical sensors. Research in this field gives the opportunity to learn and use many different tools, both software (for integrated circuit and board design) and hardware (electronic instrumentation and lab equipment). Moreover, many universities in the world are researching on bioelectronics topics: the chance to work on bacteria sensing at University of California, Berkeley has been a really formative experience, that showed how research is conducted in such a different reality.

This thesis, *Integrated electronics for molecular biosensing*, focuses on different approaches to sense the presence and activity of a specific analyte by using integrated electronic platforms. The aim of the first platform is to detect the enzyme telomerase. Telomerase causes the elongation of telomeres, which are part of the chromosomes, and determines the lifespan of cells. Telomerase expression is a marker of malignity in tumoral cells and its evaluation can be exploited for early diagnosis of many types of cancer cells. To detect the telomerase enzyme, a CMOS (complementary metal-oxide semiconductor) biosensor based on CMFET (Charge-Modulated Field Effect Transistor) able to measure kinetics of DNA replication and telomerase reaction was developed. The sensor can be functionalized by immobilizing single

strands of DNA that contain the telomeric sequence, used as probes. If telomerase is present, the probes will be elongated by the enzyme and the charge on the sensing area will change, which reflects in a variation of the output current or voltage. The chip includes three different readout schemes (voltage, current- and time-based), each of which has different measuring ranges and operating conditions. The measured data is then digitized, stored, and can be sent off-chip through SPI (Serial Peripheral Interface) protocol. A total of 1024 biosensors have been integrated in a single chip with a size of 10x10 mm^2. Each sensor can be independently addressed and functionalized by an electrochemical procedure using an integrated potentiostat, thus requiring no external equipment. Although the sensors have been tailored and optimized to perform telomerase detection, the sensing areas can be functionalized to be used with different analytes. This feature turns the chip into a complete bioassay platform.

The second part of this work rises from the idea that bacteria, like *Escherichia coli*, can detect analytes in solution even at extremely low concentrations and change their movement through a process called chemotaxis, to move towards chemical gradients in the solution. *E. coli* moves by rotating its flagella either clockwise (for random tumbles) or counterclockwise (for straight runs, when it senses a chemical it is attracted to). Therefore, observing bacteria flagellar rotation can give enough information on the presence of a specific analyte in the solution. To electronically detect bacteria movement, an active surface covered in electrodes has been designed. By measuring the impedance between each pair of electrodes through an integrated LIA (lock-in amplifier), it is possible to know how a single bacterium is moving. By that, the presence or absence of the analyte can be deduced, thus effectively turning bacteria into chemical sensors.

Sonedda S., Napoli C. and Barbaro M., A CMOS Lab-on-a-Chip for Fully Automated Telomerase Activity Detection, *2019 IEEE Biomedical Circuits and Systems Conference (BioCAS)*, Nara, Japan, 2019, pp. 1-4.

Supervisory Control and Analysis of Discrete Event Systems

Dan You
Curriculum: Computer and Systems Engineering

I received the B.S. and M.S. degrees from the School of Information and Electronic Engineering, Zhejiang Gongshang University, China, in 2014 and 2017, respectively. I am currently pursuing the PhD degree in the Department of Electrical and Electronic Engineering of the University of Cagliari, under the supervision of Prof. Carla Seatzu and Prof. Shouguang Wang. During my doctoral studies, I had the chance to spend visiting periods in Zhejiang Gongshang University, China, under the supervision of Prof. Shouguang Wang and in New Jersey Institute of Technology, USA, under the supervision of Prof. Mengchu Zhou.

My research interests mainly focused on the supervisory control and analysis of discrete event systems. The title of my PhD thesis is "*Supervisory Control and Analysis of Partially-observed Discrete Event Systems*". Discrete event systems (DES) are a class of dynamical systems whose states are discrete and state evolution driven by the occurrence of asynchronous events. There are a variety of examples in the real world, ranging from flexible manufacturing systems and intelligent transportation systems to communication systems and distributed software systems. They are either inherently state-discrete and event-driven or modeled in a discrete-abstraction level for the study of problems concerning with their "high-level" logical behavior. In the framework of DES, a lot of problems may be addressed in an elegant manner, related to issues like the safety, information security, and performance of systems in the real world. We notice that, in practical scenarios, due to facts such as limited sensor technique, sensor failure, unstable network

and even the intrusion of malicious agents, it might occur that some events are unobservable, multiple events are indistinguishable in observations, and observations of some events are nondeterministic. Taking into account various practical scenarios, we then focused on DES with partial and/or unreliable observations.

One of my research topics during PhD is the verification of fault-predictability in partially-observed DES. In a DES framework, faults typically correspond to undesirable events. Fault prediction consists in providing an approach to predict the occurrence of a fault based on the partial observation of the system evolution. Fault prediction allows the system operator to be more proactive than passive when facing potential faults. Indeed, once the occurrence of a fault is predicted, timely reactions can be provided for the impending fault, such as limiting the possible future evolution of the system or even halting it. That way, disastrous consequences caused by faults may be avoided, which is of great importance especially for safety-critical systems. Actually, it is fundamental to preliminarily investigate if the occurrence of faults in a DES can be predicted, which is called the *fault-predictability* of DES. In our work, we study the verification of fault-predictability in the formalism of labeled Petri nets, which may capture both bounded and unbounded DES with unobservable and indistinguishable events. Specifically, we propose a verification approach based on the construction of a Predictor Net and a Predictor Graph. In particular, a necessary and sufficient condition for fault-predictability is derived by characterizing the structure of the Predictor Graph. Furthermore, two rules are proposed to reduce the size of a given Petri net, which allow one to analyze the fault-predictability of the original net by verifying the fault-predictability of the reduced net.

You D., Wang S. G., Seatzu C., Verification of fault-predictability in labeled Petri nets using predictor graphs, *IEEE Trans. Autom. Control*, 2019, 64(10): 4353-4360

State Estimation in Discrete Event Systems Under Attack

Qi Zhang
Curriculum: Computer and Systems Engineering

I am a PhD student in cotutorship between Xidian University and the University of Cagliari. In 2016, my PhD started at the Xidian University within the group of System Control and Automation, under the supervision of prof. Zhiwu Li. In 2017, I was also admitted as a PhD student to the University of Cagliari within the group of Automatica, under the supervision of prof. Alessandro Giua. The two groups at Xidian and UNICA have been collaborating for over 8 years and many PhD students and other researchers have visited Cagliari during this period.

Over the three years of my PhD, I spent one year (2018) at UNICA under the supervision of prof. Alessandro Giua and had the opportunity to also collaborate with prof. Carla Seatzu. The rest of my PhD period was spent at the Xidian University in Xi'an, China, under the supervision of prof. Zhiwu Li.

My research interests focus on the cyber security of discrete event systems, and the title of my PhD thesis is "state estimation in discrete event systems under attack".

A *discrete event system* (DES) is a discrete-state, event-driven system, whose state evolution depends on the occurrence of asynchronous discrete events over time. The state space of a DES is described by a discrete set, and the state transitions, which occur and can be observed only at discrete points of time, are associated with events. Many real-life systems can be described at a high level of abstraction using this

formalism, in particular in the domains of manufacturing systems, computer networks, telecommunication systems and smart cities.

During my PhD, I used different models of discrete event system, including *automata* and *Petri nets*, to solve the problem of cyber attacks, but in the following the focus is on the results presented in Zhang et al. (2020).

Cyber-physical systems (CPS) arise from the interaction of physical processes, computational resources and communication capabilities. Examples of CPS include transportation systems, medical monitoring, power generation and distribution systems, process control systems, advanced communication systems. With the extensive applications of CPS, there are higher risks for the systems to suffer attacks from malicious agents.

In this paper, we consider a plant modeled as a DES, whose evolution is observed by an operator. The occurrence of a subset of events, called *observable events*, can be detected by sensors while all other events, called *silent events*, produce no observation. We assume that there exists an *attacker* that has a full knowledge of the plant, and the attacker may corrupt the sensor readings. The operator observes the system evolution in order to verify if a state in a given set of critical states is reached. The attacker corrupts the observation with the aim of preventing the operator to establish when a critical state is reached. The attacker is required to be stealthy, i.e., the operator should not be able to detect that the plant is under attack.

We show how to construct a supremal stealthy attack substructure that describes which type of attacks may succeed. This general methodology can be used by an attacker to choose which observations should be corrupted to reach its goal, but also by an operator to understand what the system's vulnerabilities are and correct them.

Zhang Q., *et al.*, Cyber attacks with bounded sensor reading edits for partially-observed discrete event systems, ArXiv, 2020: 1906.10207.

PhD program in History, Cultural Heritage and International Studies

Coordinator: Prof. Cecilia Tasca
Deputy coordinators: Prof. Olivetta Schena, Prof. Christian Rossi

https://corsi.unica.it/dottoratosbcsi/

The international PhD in History, Cultural Heritage and International Studies of the University of Cagliari, in agreement with the Federal University of Goiás (Brasil), aims to train highly qualified scholars within the studies of History, considered in its multiple facets and meant as a process of knowledge of the past which provides useful insights into the current world, into the spatial and territorial conditions and the dynamics regulating its social functioning also from an international perspective. In the framework of its primary interests and educational process, the PhD combines history *sensu lato* and considered in its widely acknowledged time periods (ancient, medieval, modern, ecc.) and cultural heritage in its broader sense (archaeological, artistic, cinematic, musical), with a focus on Sardinian history and cultural heritage, aiming at the development of the territory and the enhancement of international relations.

In the framework of this general organisation, the PhD is subdivided into three curricula (International and Area Studies. History. Spaces. Society; Euro Mediterranean Historical Studies from the ancient times to the contemporary era; Archaeological and Artistic Heritage, Film and Music Studies), which encourage the candidates to nurture, within the History guidelines, specific and original research directions with a multidisciplinary and comparative approach. Teaching is thus structured in several educational stages offering a basic research methodology in humanities, with a focus on the historical and historiographical approach, through a synchronic perspective which enables to observe the events in the context which has actually produced them and where they have occurred, and a diachronic perspective which favours the connections between different eras and geo-cultural areas, also from an interdisciplinary perspective.

The educational path represents an opportunity for growth and maturation within an inspiring academic environment which provides the PhD candidates with a valuable wealth of knowledge and skills regarding the management and promotion of historical and cultural heritage, financial resources in the field of research and European and extra European planning, development of European and extra European projects, mainly focused on the field of Cultural heritage, History and International relations, management of cultural-historical heritage, communication and scientific dissemination.

Guido Piamonte archive collection: From archival treatment to scientific enhancement

Paola Cossu

Paola Cossu (Sassari, 1987) obtained the II Level Degree in Piano in 2012 at the "L. Canepa" of Sassari and the Master's Degree in Musicology and Musical Heritage in 2015 at the Ca' Foscari University of Venice with a thesis entitled *Le maschere di Malipiero: l'uomo, le circostanze storiche, i momenti meno noti* (supervisor, Adriana Guarnieri), currently attends the PhD in History, Cultural and International Studies of the University of Cagliari (tutor, Paolo Dal Molin). The work of my doctoral research has as its object the Guido Piamonte Collection preserved in the archives of the Ugo and Olga Levi Foundation in Venice. The collection consists of three series: "Library", "Miscellaneous" and "Newspaper clipping". This latter gathers more than six thousand articles written by Piamonte between the 1930s and 1980s. My research started from the archival field to then move to the historical-musicological one and it is divided into three sections: the first part focuses on the archival research, the second on the figure of Piamonte and, more specifically to music criticism, and finally the last section examines the relationship between the critic and the surrounding cultural environment. In addition to the research work, I was able to participate in various seminars, in some of them only as an auditor, in others as a speaker. Research work on this archive allowed me to significantly improve my skills in archival science related with music studies. The first year of my PhD mainly concerned the collection of bibliography and work on the archive collection. I started with a summary census and an initial assessment of the conservation status of the documents. The next work phase was inevitably the conditioning operation and the consequent preservation of the documents themselves. I also started the documentation description

phase. Facing an unusual series, I had to find the appropriate descriptive standards. In the debate on the conservation of the personal archives of the 20thcentury, the problem of dealing with periodicals has sometimes been taken into consideration, although not much specific bibliography has ever been produced on the subject. The case of the Piamonte archive collection, however, is even more different and complex. It is true that, since we are dealing with a personal archive, part of the description of the documentary units is facilitated by their obvious links with the producing subject; but unfortunately, since the articles are often found in the form of clippings, and it is not always possible to go back to the periodical in question or to the chronological details of the document itself, description thus becomes even more difficult. Since there are no descriptive standards for this specific documentation, I proceeded to create a form that was as comprehensive as possible. Parallel to the archival treatment, I visited various archives and libraries, including the Fondazione Giorgio Cini in Venice, the Historical Archives of the Teatro La Fenice in Venice and Padua University Historical Archives, seeking for other sources on Piamonte's journalism and his relationship with the surrounding cultural world. After these work phases, I went on to study the figure of the critic in comparison with the typological images available from contemporary Italian music critics. Venetian by birth, a man of culture, but also of science, music critic, teacher and librarian at the Conservatory of Bolzano first and then Parma, Piamonte's papers show him to be a multifaceted journalist with numerous interests. His university studies, in particular those with Luigi Stefanini, a philosopher close to spiritualism, proved to be fundamental in the formation of his aesthetic ideal. Near to idealism and reticent towards the twentieth-century musical avantgardes, Piamonte was a critic who mainly worked in the journalistic field. His language, never teeming with technicalities, always puts the public at the centre of attention; Piamonte has always placed emphasis on the Italian cultural crisis. Finally, I dealt with the peculiarities of Piamonte's musical criticism: his proximity to Gian Francesco Malipiero whose courses he had attended as an auditing student, and the attention to the dynamics of the Venetian musical institutions, when Venice, thanks to the International Festival of Contemporary Music, was at the centre of the contemporary musical debate.

The cultural identity of Sardinian landscape: a postcolonial perspective of the rural settlements in Roman Sardinia

Dario D'Orlando

Born in Nuoro, he accomplished his formation in 2015 taking the degree in Archaeology and Art History in the University of Cagliari where he took a post-master degree in 2017 with a research entitled 'La bassa valle del fiume Posada. Censimento archeologico per uno studio delle dinamiche insediative'. His interest about the Landscape of Roman Sardinia is the root of its doctoral research.

Sardinia was appointed by Rome as the second *Provincia* at the end of the III century BC. Its important role as a productive centre for the so-called *annonariafrumentaria* has never been practically verified as well as many other aspects like its rural settlements' distribution, or the production of other commodities and breeding by-products. From this perspective the period I spent in Greece thanks to the Italian Archaeological School at Athens was a real turning point. The daily contact and comparison with many researchers of entire Europe allow me to define an entirely different way to approach those issues in a more modern and contemporary manner. The importance of digital aspects as the centrality of the GIS tools and the nowadays fundamental digital revolution are central focusing points of almost all the most interesting archaeological works to which we have to compare our efforts.

The aims of my research '*Archeologia e Culturadellearee interne dellaProvincia Sardinia: l'archeologia come indicatoreculturale, economico e*

insediativodurante la fase di occupazioneromana in Sardegna' took me to to analyse and verify the aspects of the Roman presence in two different areas:one in the southern part of Sardinia (between Cagliari and the centre of the island) and the other in the north-eastern portion of the coast. The latter was connoted with a general weaker presence of Punic Age witnesses, which is a valid observation point to focus on the direct relation between Romans and the inhabitants of Sardinia. To undergo with the inquire, it was fundamental to verify the settlement patterns and their diachronic change using different tools than the ones used to analyse the historical period of the Island. I used mainly software and procedures of other research areas as protohistoric and medieval works like visibility, spatial and path analyses in Geographical Information Systems. A central element was the landscape archaeology approach due to a strong geographical, topographical and geomorphological interest mainly in its relation with the positioning of the sites during pre-roman, roman and post-classical phases. Another aspect was the fundamental use of a great number of different cartographic documentation from historic to modern military and administrative maps. Along those key-points, there was the use of digital tools and technological approaches, mainly thanks to UAV flights. That allow the creation of photogrammetry reconstructions and 3D-models opening the way to a future more widespread use of remote sensing tools as LiDar scanners and undisruptive archaeology surveys.

Every cultural aspect derived from classical and digital approaches analysed during the research has been collected in order to weave a complex database. The aim was to evaluate if, how and when new cultural aspects arrive on the Island and which of them take a different 'roman' glaze. The whole amount of data has been analysed in a multivariate process under the lens of a postcolonial perspective that finally fulfils the target of creating a history of the Roman rural settlements in the Island. From this point of view the aim is to verify how the cultural identity of Sardinian peasants mutate during the Roman phase and evaluate if the landscape reflects those changes.

Ambassadors of Valencia and Sardinia: two kingdoms in the royal court

Miquel Fuertes Broseta

The author has a degree in History from the University of Valencia in 2015. He has a Master's degree in History and Society in the Western Mediterranean (XV-XIX centuries) in 2016 and a Master's degree in High School teacher in 2017, both in the University of Valencia.We will bediscussing about the PhD thesis titled *Two kingdoms at the Habsburg court. Trustees and ambassadors of the kingdoms of Valencia and Sardinia (17th century).* The theme and chronology are part of the history of Spanish Sardinia and the Spanish Monarchy. This has conditioned the path of the investigation. The consulted archives were primarily Sardinian and Spanish; therefore, the research periods have been divided between Sardinia and Spain. The dispersion of the sources has forced to make several trips and periods in different cities such as Madrid, Barcelona, Valencia or Toledo. The stays have been especially long in Valencia, where there is a co-supervision agreement with the University of Valencia, and in Barcelona,since there is where important documents for the history of Sardinia are kept and where I was accepted to develop the stay by the Area of Modern History of the Department of History and Archeology of the University of Barcelona. These trips have allowed, in addition to developing the research, to meet other researchers and other methodologies and investigations in progress.

The research project for the PhD thesis raises a topic that's been traditionally understudied: the contact between the kingdoms and cities that formed the Spanish Monarchy with their permanently

absent king, through agents and representatives. These agents or territorial intermediaries in the opinion of Antonio Álvarez-Ossorio were one of the bases on which the practice of government of the Habsburg monarchy was constituted, which is corroborated with the frequency with which they acted.

For Valencia and Sardinia, two kingdoms of the Crown of Aragon in the Hispanic Monarchy, the role of the envoys was fundamental to always keep the communication channels open between the sovereign and his kingdoms, even more important in Sardinia for being one of the "*regnesservits de mar y queestánmoltapartats y lluny de samagestat*".It should be considered that unlike our times when communications between distant spaces are immediate, in the seventeenth century news and messages could take weeks or months to arrive from Madrid -the king's place of residence- to Sardinia, so the resource to have delegates to manage affairs and negotiate *in situ* became common. On the one hand, the king had two viceroys in Valencia and Sardinia who exercised the government in his name, assisted by other officials delegated of the monarch. On the other hand, the kingdoms, such as Sardinia and Valencia, had representatives before the king to send their supplications, protests and complaints, and ultimately to maintain an open negotiation channel. The delegation of powers and representation in an individual allowed them to speak on behalf of a kingdom or city, so that although today it would be unthinkable in the Middle and Early Modern Ages, they were considered ambassadors even if they did not represent a sovereign or free republic, but a community of vassals.

Among the tasks of these territorial representatives was, in the Sardinian case, the request for the decree of the new laws emanating from the Parliaments that every ten years brought together the three *Braços* of the kingdom. Furthermore, both in Valencia and Sardinia, these delegates acted to obtain graces and privileges and to ensure that the sovereign complied with the laws of the kingdoms. It was, therefore, a mechanism for political dialogue of the first magnitude, which was used very frequently, and which allowed kingdoms and cities to be brought closer to the presence of a distant and permanently absent king.

Dynamics and management of Abkhazian and South Ossetian conflicts

Federico Mariano Giuntini

Federico Mariano Giuntini, historian of international relations. Degree in Political Science from the University of Cagliari, with a thesis on Sino-Soviet relations, supervised by Prof.Annamaria Baldussi. Master's Degree in Governance and Global System from the University of Cagliari, with a thesis on the geopolitics of Ukrainian regional plurality, supervised by Prof.Gianluca Borzoni. Since 2017, PhD candidate at the University of Cagliari with a research project on regional cleavages in the post-Soviet space and, specifically, on the dynamics and management of ethno-political conflicts in Abkhazia and South Ossetia, under the supervision of Prof.Gianluca Borzoni.

During his research path, the PhD candidate investigated the geopolitical dynamics in post-Soviet space and, particularly, the main regional cleavages in South Caucasus and Black Sea areas (fomented by strongly mono-ethnic approaches often pursued in the new state-building processes, like the Georgian and Ukrainian ones) and their relationship with the evolution, on the one hand, of involved countries' international orientations (primarily Tbilisi's and Kiev's) and, on the other, of Russian foreign policy and strategies (with a focus on Moscow's soft power presented at the eighth conference of Italian Society of International History). In order to deepen the Russian perspective and to access to new sources, the PhD candidate spent three different quarterly research period in the Russian Federation, as a guest of the Moscow State Institute of International Relations (MGIMO).

The main object of the PhD project has been the ethno-political conflicts in Abkhazia and South Ossetia and their relationship with the processes of Georgian state building and Russian repositioning in the post-Cold War international system (significantly affected by events such as 2003 Rose Revolution and 2008 August War).A systematic analysis of primary sources concerning the different sides of these conflicts has been carried out. In the course of the research path, the strong resurgence of national questions across the USSR during its last decade was explored, deepening the relationship of antagonism and mutual stimulation between Georgian national revival and Abkhazian and Ossetian ones, which led to Georgian declaration of sovereignty from the URSS and to Abkhazian and South Ossetian declarations of sovereignty from Georgia (1990), to the outbreak of South Ossetian war, to Georgian and South Ossetian declarations of independence (1991) and to the outbreak of Abkhazian war (1992).

Therefore, dynamics of conflicts management were investigated, examining the negotiations culminating in ceasefires in South Ossetia (1992) and Abkhazia (1993-1994), the role of the international mediators (Russian Federation, Conference on Security and Co-operation in Europe, United Nations) and the differences in the developments of these two South Caucasian conflicts. Great attention was paid to the difficult attempts to identify a political settlement: if in the CSCE-led management of South Ossetian conflict it was practically unachievable due to the already declared independence, in the UN-led management of Abkhazian conflict it remained theoretically attainable during the 1990s, but a comprehensive agreement with Georgia was never reached and, finally, Abkhazia formally declared its independence in 1999. The international significance of Abkhazian and South Ossetian crisis became evident with 2003 Rose Revolution in Georgia and, above all, with 2008 August War, an unprecedented moment of tension in post-Cold War relations between Russia and the West.

Nissardi's*dactyliotheca*: Gem impressions

Miriam Napolitano

Miriam Napolitano is a PhD candidate in Classical Archaeology (Doctorate of History, Cultural Heritage and International Studies) with a PhD scholarship of P.O.R. Sardegna F.S.E. - Operational Programme of the Autonomous Region of Sardinia, European Social Fund 2014-2020). Her research activity is focused on studying Filippo Nissardi's gem impressions, extraordinary devices that are useful for the knowledge of the main Greek and Roman iconographic series and for understanding the reception of ancient art in the Neoclassical Age. The PhD candidate acquired familiarity with these artefacts at the Specialization School in Archaeological Heritage, where she investigated the collection of engraved Roman and post-antique gems of the National Archaeological Museum of Cagliari (in 2016).Her research concerns the Roman material culture, especially the engraved gems and the pottery discovered in Sardinia. She is a member of the archaeological équipe of Isthmos Project of the University of Cagliari since 2013, before as a student and after as a Head of laboratory, responsible for the registration and cataloguing of all exhibits found during the excavation.

Among Sardinian scholars who lived between the 19th and 20th centuries, Filippo Nissardi (Cagliari, 1852-1922) emerges as a significant figure, whose work is finely reconstructed in this thesis, thanks to the written testimonies preserved in the Central Archives of the State. While working for the Royal Museum of Antiquities of Cagliari, he became an expert connoisseur of antiquities, compiling

catalogues and evaluations of important collections at the service of the Archaeological Museum of Cagliari. The dactyliotheca in itself was a very important methodological and didactic tool for the amateur, the scholar and, in our case, the archaeologist. Unlike prints or drawings, the three-dimensional support given by impressions - taken from the glyptic masterpieces of the ancient and modern world - provides direct observation of pieces that could be appreciated as invaluable media for direct knowledge of ancient art. This PhD thesis, titled "*Nissardi'sdactyliotheca: Gem impression in the collection of Filippo Nissardi*" presents the study of 1409 red sulphur impressions of gems and cameos, which are considered remarkable for their quality and state of preservation. Impressions of intaglios and cameos include Egyptian, Etruscan, Graeco-Roman, Renaissance and 18th century gems, organized in series based on thematic criteria: the most important gods of the Egyptian and Graeco-Roman Pantheon, mythological subjects, philosophers, poets and orators of classical antiquity, portraits and busts of the main figures in Greek and Roman history, masks, genre scenes, vases and animals. Almost all of the chosen subjects revolve around classical art and provide meticulous knowledge of the Greco-Roman world. The casts were probably made in Rome between the middle of the 18th and the beginning of the 19th century, a time of particular interest and of spread of the commercial production of impressions. Christian Dehn emerges as an early prominent figure in the manufacture of gem casts, followed by Daniel Lippert, James Tassie and Tommaso Cades. During the PhD candidate's research abroad, based in Oxford University's Beazley Archive, she consulted these precious collections of casts, in order to determine the affinities and variations between the catalogues of Neoclassical impression.

For a tradition of tourism in geographical terms. Hypotheses and representations for the management of a complex system

Rachele Piras

The scientific disciplinary sector in which all the research activity is included is M-GGR / 01 - Geography. Among the most relevant training experiences we mention: Didactic tutor for the landscape and environment reading laboratory in 2016 at the Department of Letters, Languages and Cultural Heritage, University of Cagliari; seminar lessons within the courses of Human Geography, Regional Geography, Landscape and Environmental Geography, Geography of Cultural Heritage from September 2017 until today. Since 2020, expert in Human Geography and Regional Geography. Author of about twenty publications including articles in A-grade magazine and book chapters, participation in conferences and seminars as a speaker starting from 2016.

The research carried out as part of the PhD program, which began in April 2018, highlights the theme that links the territory and the geographical discipline to the entire tourism sector in a cross-cutting manner. Within this specific sector, which is understood as a multi-sectoral container, the state of the art of tourism is investigated in terms of geography, the importance of matter in understanding the tourism phenomenon, as varied as it is complex. The fundamental premise of this research is to create an innovative study on the sector that moves towards two directions, one theoretical and one practical. Greater

importance will be devoted to this last aspect, of a geographically applicative nature, thanks to the collaboration with the Sardinian company Nabui. Specifically, an applicative geographic research work was carried out in the territory of Nughedu Santa Vittoria. This training experience is then accompanied by specific work in the field of tourism conducted within the Department of Geography and Environment of the University of Geneva structured according to the smart working mode and in presence. The final objective, therefore, supported by the work conducted with the Nabui company and consolidated with the experience within the Department of Geography and Environment, of the University of Geneva, is to collect a series of data with important practical and managerial implications. for the tourism and innovative supply chain in Sardinia and, specifically, to create with the proposed research a segmentation not only of the existing tourism offer sector, but also of the market demand characterized by increasingly demanding and complex niches and micro-niches.

Quality processes and assessment of the performances in the practices of crowdsourcing applied to the cultural heritage

Mattia Sanna Montanelli

Mattia Sanna Montanelli is an archaeologist specialized at the University of Cagliari (curr. Late Antiquity) with research interests in public-participatory archaeology and educational design. The issues related to public participation and involvement are increasingly present in the debate on cultural heritage, especially with regard to its enhancement. In this framework, also in Italy, kinds of experiences of 'citizen science' and 'participative research' begin to be known with the name of *crowdsourcing* (portmanteau coined from a combination of the words *crowd* + *outsourcing*). The effectiveness of this method, able to outsource portions of a scientific research to a large number of people (typically via the Internet), is certified on a global scale by generalist platforms such as *Wikipedia*, or sectorial ones like *MicroPasts*. Despite this, at the moment, the scientific debate does not seem able to respond qualitatively (and not only quantitatively) to the growing "needs of past" expressed by communities, whose satisfaction does not always appear to be sufficiently guaranteed. From these observations, the main purpose of this research project (entitled "*Quality processes and assessment of the performances in the practices of crowdsourcing applied to the cultural heritage"*) is to determine codes of conduct and operational protocols that can be shared by the "heritage community", i.e. "people who value specific aspects of cultural heritage which they wish, within the framework of public action, to sustain and transmit to future

generations" (according to the definition of the European 'Convention on the Value of Cultural Heritage for Society', 2005). This project, funded under the so-called "*Innovative Doctorates with industrial characterization*" (PON RI 20142020), is based on an agreement between three subjects: the University of Cagliari, a qualified European research center (i.e., the '*Instituto de Cultura y Tecnología'* of the University Carlos III of Madrid and an 'industrial' partner (i.e. the Italian company 'ConsorzioCamù'). The innovative elements of the research, emerging in a framework of constructive collaboration and exchange of expertise, lie in the identification of simplified paths for the convergence between public and private interest. This approach has been pursued mainly through the analysis of institutional and administrative processes concerning the cultural heritage sector. Following a systematic bibliographic review on the theme of crowdsourcing, it has been provided the census of multi-scale experiences (regional, national, international) in different levels of management (public, private, amateur). Subsequently, especially within the activities carried out at the ICyT de Madrid, it was possible to analyze the compatibility between crowdsourcing and different systems of rules in force, to estimate the effectiveness of different types of means ("analogical", digital or mixed) and to synthesize a spectrum of uses of the concept of 'quality' in crowdsourcing applied to cultural heritage. A particular focus has been reserved to the relationship between 'citizen science' and governance, starting from the advanced experiences of the U.S. government. Equally, much attention was given to the European political support to the cultural heritage sector, both by analyzing the policy tools of the 'Smart Specialization Strategy' (aimed at encouraging territorial entrepreneurial discovery paths) and by reviewing the EU protocols on 'Responsible Research and Innovation' (RRI), able to offer one of the most advanced frameworks in the field of inclusive research. In the same way, great attention has been dedicated to the new perspectives coming from the studies on the heritage interpretative planning carried out in the EU (e.g. DELPHI Erasmus + project), useful also to give a for measuring the performance of participants in crowdsourcing processes. The survey has allowed to identify a general model of the workflow of crowdsourcing. The research points to converge the acquired data in a *vademecum*, useful to run quality models in the use of crowdsourcing in cultural sector and to obtain a positive involvement of the heritage communities.

New paths of archival communication: The University of Cagliari students' database and the demo-anthropological sound archive Luisa Orrù

Valeria Zedda

After graduating in Literature from the University of Cagliari with a thesis in Archivistics entitled *"La compagnia barracellare di Meana Sardo"*, she graduated in History and Society with a thesis in Archivistics entitled *"Le tesi di laurea della Regia Università degli studi di Cagliari dall'Unità d'Italia al 1900"*. At the end of her studies, she completed a period of internship at the Historical Archives of the University of Cagliari during which she filed the theses discussed between 1901 and 1950.

The research is aimed at the creation of the University of Cagliari students' database and the enhancement of the Luisa Orrù demo-anthropological sound archive. Both are hosted on the site of the Historical Archive of the University of Cagliari, created within the DH.unica.it project, the Centre for Digital Humanities of the University of Cagliari.

The idea of creating a database summarising the university careers of the students who attended the University of Cagliari was born firstly as a result of the numerous requests for information on the subject; secondly as a result of the difficulties encountered by the user and the archivist in extrapolating data.

First of all, it was necessary to study the historical and regulatory context, then the database was set up on an Excel file. The fields in the table can be divided into anagraphic and career-related parts.

The sources that have been consulted for the retrieval of data are many, most of them are kept in the historical archives of the university, in the University Library of Cagliari, and finally in the student secretariats. The import phase of the Excel file into Drupal, the software that hosts the database, has recently been completed.

The user can carry out the search by entering the student's first and last name or by means of the filters that allow to select the information by academic year of enrolment, by faculty, course and academic year of degree; moreover, people can also be filtered by gender and origin; the result of the search will be the student's form.

In the page of Archivistica.dh.unica.it, a space is also dedicated to the valorisation of the Luisa Orrù demo-anthropological sound archive, an aggregate archive of the historical archive. The fund is not currently in order and requires the transfer of the documentary units from analogical to digital support, therefore it is a work that takes a long time and for which a period of training was necessary at the sound archives of the Maison méditerranéenne des sciences de l'homme (MMSH), a centre for research and specialized didactics on the Mediterranean world based in Aix en Provence. Here the attention has been turned to the study of the work phases necessary to achieve its enhancement in the portal, which will allow the user not only to read the archival descriptions of the documentary units but also to be able to listen, with respect for privacy, to the sound documents that constitute it.

In conclusion, we can say that during these three years of intense work we have tried to create new archival tools for the historical archive site that could accompany the traditional ones, so that with their simplicity of use, more users can approach the archive, so that the preserved documentary heritage, owned by the community, can be accessible to everyone.

PhD program in Industrial Engineering

Coordinator: Prof. Francesco Aymerich

https://dottorati.unica.it/ingegneriaindustriale/

The PhD programme in Industrial Engineering aims at providing doctoral-level education in key engineering areas of industrial relevance, with specific reference to the domains of Electrical, Mechanical and Chemical Engineering. The main objective of the PhD programme is that of training highly qualified researchers and professionals, capable of carrying out, working both independently and within a team, original and innovative research, and of promoting advancements in methodologies for analysis, processes and enabling technologies for real engineering applications.

During the three years of the programme, the PhD students are offered the opportunity of improving and acquiring, by a multidisciplinary approach, knowledge, skills and competencies required to meet the challenges and opportunities of the current industrial progress in the international context.

The doctoral candidates follow a path that includes the attendance to advanced courses and lectures organised explicitly by the PhD programme, the participation in workshops and summer/winter schools, the dissemination of the results of their research through presentations at national and international conferences and publications on scientific journals. The candidates are also required to spend research periods abroad to enhance and widen their scientific knowledge and cultural background in an international environment.

The research work performed for their theses and presented in this book by the PhD students of the XXXIII cycle represents an excellent example of the interdisciplinary research conducted within the PhD programme. The research activities have been carried out in cooperation with industries or well-known foreign institutions and provide new insights on specific themes in a wide range of industrial areas, including ergonomics and biomechanics, planning and control of smart- and micro-grids, characterisation of food properties.

Methods and tools for the evaluation of sitting postural

Federico Arippa

Federico Arippa is a Biomedical Engineer and PhD student in Industrial Engineering at the University of Cagliari. His experience in research begins in 2010, when he joined the Biomechanics and Industrial Ergonomics Laboratory at Cagliari University in the context of his bachelor thesis. During this 6-month period he was involved in a sports biomechanics project on elite footballers' balance abilities, in collaboration with Cagliari Calcio Football Club. Then, he moved to Politecnico of Milan for his Master's studies, having the opportunity to collaborate with the Luigi Divieti Movement Analysis Laboratory. His M.Sc. thesis was focused on the application of quantitative techniques for human movement analysis in people with Parkinson's Disease. On October 2017 he started his PhD course, having the opportunity to work on several projects in the industrial, clinic and sports ergonomics fields. During his period abroad (July 2019-May 2020) he worked at the Laboratory of Ergonomics at University of California Berkeley: here he worked on gaming ergonomics and exoskeleton use in industry. The main focus of his research is the study of prolonged sitting posture. With the rapid growth of modern technology, sitting has become the most common posture in workplaces worldwide. However, to keep a seating posture for long periods of time has been associated with numerous cardiometabolic and musculoskeletal disorders, so with his study *"Methods and tools for the evaluation of prolonged sitting posture and applications in the ergonomic field"* he aims to characterize sitting postural strategies over prolonged periods within two main sedentary workers categories: bus drivers and office workers. To this aim, pres-

sure sensitive mats have been used to continuously collect body-seat contact pressure distribution. Raw pressure data were then post-processed to calculate the position of the center of pressure (COP, the point of application of the resultant of all contact forces) Postural sway, (the small oscillations of the body that express the action of nervous and muscular systems to keep the body balanced) is commonly used to characterize the performance of the postural control system in upright posture; postural sway parameters include sway path (the total distance travelled by the COP within a certain time frame, sway area (the ellipse's area containing 95% of the path points), sway velocity (COP velocity during the trial) and COP maximum displacements in antero-posterior (AP) and mid-lateral (ML) directions. An innovative tool that he uses to characterize sitting posture is the amount of in chair movements (ICM) or "fidgeting" performed during the sitting time, as it has been demonstrated that individuals tend to develop unique patterns of seated movements and move more when perceived discomfort increases. In particular the number of ICM is identified as the number of times in which the sway ellipse's centroid overpasses a predefined threshold. Application of this method may include the ergonomic design of workstations, development of smart applications and sensorized seats using an integrated model based on quantitative data that allows to evaluate the in real time workers' comfort state.

PhD course at University of Cagliari allowed me to develop important skills in several fields ranging from research- including scientific writing and thesis/articles revisions and teaching- to the industrial applications. Working in a well-established laboratory, strongly supported by my supervisor, helped by collaborative colleagues and having the chance to participate in international Conferences is essential for PhD student's growth and gives the adequate preparation to compete in the international market world.

Arippa F., Leban B., Pau M., Postural Strategies of Bus Drivers During a Regular Work Shift in Urban Area: A Pilot Study, *Proceedings of the Human Factors and Ergonomics Society*, 2019; 63(1): 967-971.

Development of Innovative Techniques for Food Products Characterization

Fabio Fanari

I was born in Oristano, Italy, on August 19, 1991. I received my bachelor's degree in chemical engineering and master's degree in chemical engineering and biotechnological processes from the University of Cagliari, in 2014 and 2017, respectively. My research work mainly concerns food process engineering and food characterization with a particular emphasis on doughs. The thesis title is "*Durum Wheat Dough Characterization by means of Mechanical, Spectroscopic and Thermal Measurements, and their Relationship with Microstructure*". I started my PhD. project learning and performing some food rheology. Rheology is a branch of physics that deals with deformation and flow of materials. Rheological measurements, especially in the field of food characterization, can give useful insights on the process tuning and the final product. However, these measurements are difficult to interpret and present high response times that make them difficult to use, for example, in the implementation of an "online" process monitoring and control system. For this reason, my PhD. work aims to consider alternative characterization techniques and apply them to food analysis. Regarding this, Broadband Dielectric Spectroscopy and Infrared Spectroscopy have been taken into account. Dielectric Spectroscopy is a non-invasive technique, able to discriminate between the free and the various coexisting bound water states in the material, and it relates the different mobility to the structural and textural changes. In particular, this aspect was studied in depth during my experience abroad at Karlsruhe Institute of Technology (KIT) in Germany, which lasted 10 months. I was hosted by Prof. Manfred Wilhelm at the division of Technical Chemistry and Polymer Chemistry. There I performed measurements

using a special combined device able to measure rheological and dielectric parameters at the same time. Dielectric spectroscopy turned out to be a powerful technique for food characterization. For example, in the bread dough characterization, it was found that this methodology is able to show how the amount of the ingredients influences the quantity of bound water and also how the flour characteristics can influence the dough microstructure. At KIT I also had the opportunity to perform several IR spectroscopy measurements. Also IR spectroscopy showed up as a good tool for food characterization. By this practice, it is possible to obtain information about the presence of some specific conformational groups and the quantity of free and bound water in the food. The study of the food microstructure is very important, especially in comparison with rheological properties, because food structure is responsible for the mechanical properties of the material. In this regard, also Thermogravimetric Analysis (TGA) has been taken into account. This investigation provides information about physical phenomena, such as phase transitions, absorption, adsorption and desorption, as well as chemical phenomena including chemisorption and thermal decomposition. Through the study of these phenomena, it is possible to identify and characterize some kinds of bonds that are established in the food and that are responsible of its mechanical and chemical characteristics. An example of the comparison between this technique and the rheological measurements in bread dough characterization is reported in one of the papers linked to my PhD. project (Fanari et al., 2020).

Fanari F., *et al.*, Thermal properties of semolina doughs with the different relative amounts of ingredients. *Sustainability*, 2020; 12(6): 2235.

On the robust control and optimization strategies for islanded inverter-based microgrids

Milad Gholami

Milad Gholami was born in Ghazvin, Iran. He received the BS and MS degrees in Electronic and Mechatronics Engineering from, Qazvin Islamic Azad University, Iran, in 2010 and 2013, respectively. He has been working since October 2017 for a PhD degree in industrial Engineering at the Department of Electrical and Electronics Engineering in Cagliari. He spent visiting period at Technical University Berlin (TUB), Berlin, Germany. His research interests include microgrid control, renewable distributed generation and multi-agent systems. His PhD program was structured in three years. In the first year, he attended several courses held at the University of Cagliari. As a PhD student, under his supervisor and co-supervisor, he tried to learn computer software such as Latex, MATLAB, and so on that helped complete his doctoral dissertation. In the second year, he also tried to take part in some international courses to increase his knowledge of achieving a better PhD thesis. In this regard, he participated in two short ten-day courses held in Germany and France. In these two courses, he learned a lot of things that helped him to do his doctoral dissertation better. During this period, He published several papers with the help of his supervisor and colleagues, which led him attend some conferences to present his papers. At the end of his second year of doctorate, he was invited by TUB to develop his scientific research for a one-year course. This period provided the opportunity to strengthen the research collaboration between him and some of the researchers in the group of the TUB work-

ing on related subjects. The focus of his research is the study *on the robust control and optimization strategies for islanded inverter-based microgrids*. Since the performance of most conventional power systems leads to a significant increase in greenhouse gas emissions, renewable energy sources have been replacing them. To facilitate the integration of a sizeable number of renewable distributed generation (DG) units, the concept of microgrids has become increasingly popular. A microgrid is a small-scale power system, generally consisting of local generations, local loads and energy storage systems. Appropriate microgrid control is of particular importance for stable and economically efficient operation. In this regard, Milad Gholami was trying to design distributed secondary layer controllers for restoring DG's voltages and frequencies to the desired values. During his PhD program, he proposed three distributed sliding-mode-based control strategies. In the first approach, the proposed distributed secondary controller regulates the DG's voltages and frequencies to the desired values in finite-time by exploiting delay-free communications among DGs. While the second approach which is more realist than the first one, provided an exponentially converging voltage and frequency restoration rate by accounting also the presence of time-varying delays in the communications links. The performance of the proposed schemes is analysed by means of Lyapunov tools and verified by means of numerical simulations taken in different operative scenarios. The obtained results of these approaches were published as a book chapter. He was trying to extend the second one by developing an optimization algorithm to find the optimal control gains and estimates the allowable upper bound for communication delays. During his period of visiting abroad, he was trying to design a certainty model predictive control (MPC) approach for the operation of islanded MG with very high share of renewable energy sources. To this aim, he modelled the conversion losses of storage units by quadratic functions to reduce the error in storage units state of charge prediction.

A. Pilloni, *et al.*, On the Robust Distributed Secondary Control of Islanded Inverter-Based Microgrids, *Springer: Variable-Structure Systems and Sliding-Mode Control. Studies in Systems, Decision and Control*, vol 271, 2020, pp. 309-357.

Innovative techniques for the posture assessment in older workers

Micaela Porta

I am a biomedical engineer and I started my experience in research in 2013, when I joined the Biomechanics and Industrial Ergonomics Laboratory of Cagliari to develop my B.Sc. thesis which was focused on the use of quantitative techniques for movement analysis in people with multiple sclerosis. Then I moved to the University of Bologna for my M.Sc. keeping working on biomechanics. Finally, I came back in Cagliari in 2017 to join the PhD. course in Industrial Engineering.

When you decide to start a PhD. program you are not actually aware of what expects you. You only know that you are about to spend three years of your life doing research about something new that you really like, but what you don't know is how great will be your personal other than academic growth. During my experience I had the chance to carry out industrial research among an Italian company. This was a very useful experience to understand how to apply the academic knowledge in an industrial context. Beside I had the opportunity to spend 8 months in an internationally recognized occupational ergonomics laboratory, where I have been in contact with a high-level research team and, not less important, I worked in a multicultural environment. This allowed me to know new cultures and uses that brought me to look at things with a different perspective. The PhD. is also a moment to learn to share your knowledge with totally different people: peers during conferences; students in class; or professionals, opening different opportunity for your future.

In these three years I carried out a research titled *"Assessment of risk factors related to the development of musculoskeletal disorders in older workers"*. This is a crucial topic as most of the developed countries are experiencing the ageing of the society, due to different retirement policies which share a common feature, that is, people have to work longer. Working longer means to cope with the natural ageing process, which implies a decline of the physical capabilities and a higher likelihood to develop chronic and degenerative disorders, including musculoskeletal disorders (MSD) which represent a major health issue in workplaces and are known to cause productivity loss, absenteeism, and disability with a considerable economic burden. Several risk factors have been strongly implicated in the aetiology of work-related musculoskeletal disorders (WMSDs), including manual material handlings and prolonged non-neutral postures. To effectively control WMSDs and provide individual specific interventions, there is the need to quantify physical exposures: what task a worker does, how long, and how frequently this happens. The interest quantifying the exposure to physical risk factors is not new as several methods have been developed in the last decades with this aim, starting from self-report questionnaires to observational and direct measurement methods. To obtain valid and reliable estimate of exposure easily comparable the latter have become more popular, also due to the advancement of technology and a parallel reduction in cost of wearable inertial sensors units (IMUs). Such devices provide quantitative data about common parameters in assessing exposure to non-neutral posture their duration and frequency to evaluate cumulative exposure proportional to chronic damage. To enhance the applicability of quantitative assessment in real work condition, this research propose a single IMU and an activity tracker to evaluate trunk posture and to monitor the intensity of physical activity, with the possibility to monitor large number of workers, identifying risk of low back injury, managing high risk jobs, and improving return-to-work strategies.

Multicriteria methodologies for the appraisal of smart grid projects when flexibility competes with grid expansion

Matteo Troncia

Matteo Troncia pursued his PhD degree in industrial engineering within the Power System group of the Department of Electrical and Electronic Engineering (DIEE) of the University of Cagliari. He received the MSc. degree (cum laude) in Electrical Engineering in 2017 from University of Cagliari. In 2014, he has been a student intern at the Department of Energy Management and Power System Operation (e^2n) at the University of Kassel. The doctoral activity on the power system and smart grids has been focused on improving the practices related to network planning and operation. Efforts have been made on the appraisal of smart grid initiatives, market mechanisms for ancillary services, the analysis of regulation, the introduction of Blockchain technology, and load profiling. Among others, the involvement in the International Smart Grids Action Network (ISGAN) has been of utmost relevance. The collaboration with Ricerca sul Sistema Energetico (RSE S.p.a) has been aimed at supporting regulatory bodies and companies for the assessment of smart grid initiatives. One of the main achievements is the article: Celli G., et al. Multi-Criteria Analysis for decision making applied to active distribution network planning. EPSR, 2018, 164: 103-111. The activities at the Institute for Research in Technology (IIT) of the Comillas Pontifical University (Madrid) have been focused on energy economics and regulation.

The contribution of the PhD Thesis *Multicristeria methodologies for the appraisal of smart grid projects when flexibility competes with grid expansion*

is twofold: improve the accuracy of power system studies through updated typical load profiles and provide decision-making support for strategical power system planning. Recent political drivers require distributors to regularly submit a transparent development plan in which have to be specified the innovative smart grid assets and services which will enable system flexibility by maximising the exploitation of the existing infrastructure. Flexibility services (e.g. generator dispatch, demand-side management, system reconfiguration) have to compete with traditional network reinforcement; hence, reliable appraisal approaches are of utmost interest. In this context, power system studies are fundamental for assessing the impacts of different assets and services. The accuracy of planning and operation depends on the reliability of the representation of the electricity demand. Typical load profiles (TLPs) for low voltage costumers have been obtained from a large dataset of real consumption data, an original two-stage clustering methodology is proposed. The methodology seeks for the best final partition considering the k-means and linkage Ward's clustering techniques and a range of clusters. The new TLPs improve the representation of power exchange at network interfaces and feeder voltage profiles. Moreover, the Energy Management System operation for microgrids is enhanced. Along with a reliable representation of the demand, the active management of distribution networks which combines traditional network reinforcements with flexibility calls for multi-objective planning approaches able to generate a set of Pareto optimal alternatives. However, identify the best planning option of a large set is tremendously difficult. To outclass this shortcoming, an automatized methodology for project selection is proposed. The methodology is based on the Analytic Hierarchical Process (AHP) and combines the Cost-Benefit Analysis (CBA) and the Multi-Criteria Analysis (MCA) transposing the international guidelines on smart grid initiatives appraisal. Moreover, the issues of defining criteria weights are addressed proposing an optimization method based on Regret Theory. The proposed methodology allows the appraisal of monetary and no-monetary impacts considering multiple conflicting criteria. In conclusion, the research activities conducted have been aimed at supporting system operators and regulatory bodies by providing tools for smart grid project appraisal and at improving the accuracy of power system studies considering novel context requirements.

PhD program in Innovation Sciences and Technologies

Coordinator: Prof. Roberto Orrù

https://sites.unica.it/internationalphdist/

The International PhD in Innovation Sciences and Technologies has started its activity during the academic year 2013/14, by taking advantage of the positive experience of the International PhD in Environmental Science and Engineering (2001/02 – Cycle XVII to 2012/13 – Cycle XXVIII), first one of this type at the University of Cagliari, as well as the PhD in Biomedical Engineering (2010/11 – Cycle XXVI to 2012/13 – Cycle XXVIII), which are no longer active.

The program of the International PhD in Innovation Sciences and Technologies takes into account most of the topics related to the latter ones, while introducing new lines of investigation.

In particular, three curricula are involved in the framework of this PhD program:

- *Regenerative medicine and biomedical applications,*
- *Methods and systems for environmental protection,*
- *Methodologies and processes for the transformation and use of materials.*

The PhD Committee, coordinated by professor Roberto Orrù, is constituted in alphabetical order by the following assistant, associate and full professors as well as experts in their field: Silvia Ajossa, Matthias Angermeyer, Doris Barcellona, Giacomo Cao, Mauro Giovanni Carta, Giovanni Caocci, Alessandro Concas, Antonio Crisafulli, Guido Crisponi, Francesco Delogu, Sandro DeMuro, Marina V. Duljasova, Fabian I. Ezema, Gavino Faa, Vassilios Fanos, Stefano Guerriero, Giorgio La Nasaù, Roberta Mostafa, Maalmi Licheri, Valerio Mais, Gian Benedetto Melis, Ana Isabel Miranda, Marco Monticone, Valeria Marina Nurchi, Germano Orrù, Anna Maria Paoletti, Palmina Petruzzo, Giorgio Pia, Luca Pilia, Massimo Pisu, Giovanni Maria Sechi, and Annalisa Vacca.

The enrolled students are supposed, apart from the other requirements established by the current rules issued by the University of Cagliari, to have published or accepted for publication at least two papers in reputable scientific journals, along with their co-authorship as first name, by the time of the presentation of their third year activity.

Fabrication and characterization of barium titanate based ceramics materials

Blessing Ezealigo
Curriculum: Methodologies and processes for the transformation and use of materials

I obtained a Master's degree in condensed matter physics from the University of Nigeria, where I worked on Electrochemical studies of copper (I) iodide, copper thiocyanate, and cobalt sulfide thin films. In the same University, I also participated in a funded research on mixed halide organolead perovskites for solar cell applications.

It has been an exciting research period these past 3 years of the PhD. program. Research in the field of energy storage and conversion interests me the most, and my PhD. work focuses on the same area. In my previous graduate study (M.Sc.) I worked on energy storage materials, supercapacitors to be precise. I employed a simple and low-cost thin-film preparation method to obtain nanomaterials that were analyzed for their energy storage capacity.

My PhD. curriculum involves methods and processes for the transformation and use of materials. During my PhD. I was privileged to use advanced technologies such as the self-propagation high-temperature synthesis (SHS) to prepare ceramic powders and the spark plasma sintering (SPS) equipment to densify the obtained powders. These systems were entirely new to me but became very interesting as I adopted them in my research on energy storage materials. The incorporation of both systems in my work afforded me novel results. My PhD. research is aimed at the implementation of two fast processing (i.e. SHS-SPS) routes for the preparation of barium titanate based ceramic materials for energy storage application as ceramic capacitors. My period abroad

was at the Universite de Bordeaux, France, where I work in two laboratories (Institut de Chimie de la Matière Condensée de Bordeaux (ICMCB) and Laboratoire de l'Intégration du Matériau au Système (IMS)).

The SHS method of powder preparation is a relatively low-cost technique, when the reactants are ignited, a combustion wave at high temperature converts the reactant to products within seconds. In my work, I used the SHS method of powder preparation to obtain for the first time two doped compositions of barium titanate which are barium zirconate titanate (BZT) and barium strontium titanate (BST). These powders were then densified using the spark plasma sintering equipment, which can obtain nearly fully dense ceramic products within minutes. The dense products were analyzed for their composition, energy storage capacity, and electromechanical properties. The latter two analyses were performed during my period in France, where I was trained to use the equipment independently and I gained wholesome experiences and skills.

The key results I obtained was that for a particular composition of ceramics products ($BaZr_xTi_{(1-x)}O_3$), varying the temperature at which the powders were densified could facilitate the dielectric response manipulation of the ceramic capacitor.

I have gained a wealth of knowledge and skills during my PhD. and I look forward to continuing research in the field of energy storage and conversion, and also mentor/coach younger students and researchers.

Ezealigo B.N, et al., Annealing effects on the structural and optical properties of undoped and Zr-doped Ba titanate prepared by self-propagating high-temperature synthesis, *Ceramics International*, 2020; **46**: 17307-17314.

Evaluation of cerebral oxygenation in patients with metabolic diseases

Virginia Pinna
Curriculum: Regenerative medicine and biomedical applications

My passion for cardiovascular and exercise physiology is what led me to start my PhD in Innovation Sciences and Technologies at Sport Physiology Lab, under the supervision of Prof. Antonio Crisafulli. I combined my interests in both clinical and research area by pursuing a PhD that focused on the effect of sympathetic activation on cerebrovascular regulation and cerebral oxygenation in metabolic disease patients, such as Type 2 Diabetes Mellitus (DM2).

Previously, I have worked as a resident doctor in Sport Medicine, on several research projects regarding cardiovascular adjustments in response to exercise in healthy subjects and patients suffering from metabolic and chronic diseases (i.e. DM2, metabolic syndrome, coronary artery disease). In order to improve my research skills and to explore the vibrant international scientific community, throughout my PhD education, I did a trainee-ship at Research Institute for Sport and Exercise Sciences, John Moore University, in Liverpool under the supervision of Prof. Dick Thijssen. Over a period of 5 months I worked on a project about vascular and hemodynamic response to sympathetic stimulation in healthy and cardiovascular disease patients. Continuing the collaboration with Prof. Thijssen, I spent 7 months at the Physiology Department of Radboudumc in Nijmegen, where I worked on a study regarding the evaluation of cerebral blood flow during daily life activities. This successful and stimulating experience turned out in a long term collaboration between my Department and the physiology Department of Radboudumc, as from June 2019 an agreement for the joint supervision of my PhD thesis was signed.

Recently, using the method of the post-exercise muscle ischemia (PEMI), our group found that patients suffering from metabolic syndrome show an abnormal hemodynamics during sympathetic activation, with reduced cerebral blood flow. Since metabolic syndrome is often the harbinger of DM2, we wondered whether cerebral blood flow was impaired in patients with DM2 during exercise and whether this phenomenon may reduce cerebral oxygenation (COX). We further hypothesised that contemporary mental task (MT) and metaboreflex (a reflex activated during exercise) activation would reduce COX in these patients.

Starting from these considerations, we set a study to verify whether patients suffering from DM2 showed an abnormal COX during contemporary metaboreflex and MT. COX was evaluated using near infrared spectroscopy with sensors applied to the forehead. Hemodynamics were assessed by impedance cardiography.

We found that when MT was superimposed on the PEMI-induced metaboreflex, patients with DM2 could not increase COX to the same extent reached by the CTL group (101.13±1.08% vs. 104.23±2.51%, $p<0.05$). Moreover, patients with DM2 had higher mean blood pressure and systemic vascular resistance and lower cardiac output levels compared to the CTL group throughout experiments. It was concluded that patients with DM2 had reduced capacity to enhance COX when a MT superimposed the metaboreflex, and that patients had a dys-regulated hemodynamics during the metaboreflex, with exaggerated blood pressure response and vasoconstriction. This may have practical implication for the poor predisposition to exercise of these patients.

Moreover, this suggests that practical and cheap methods able to detect tissue oxygenation should be developed in order to monitor COX in these patients.

Pinna V., *et al.*, AJP-Heart and Circulatory Physiology. *Under review*

Innovative treatments in psychiatry: genetic screening in Bipolar Disorder

Martina Piras
Curriculum: Regenerative Medicine and Biomedical Applications

My name is Martina Piras and I'm a PhD student, at the last year of the course in Innovation Sciences and Technologies (XXXIII). My history at the university began 10 years ago, with the degree course in Tecniche della Riabilitazione Psichiatrica, concluded with honors in 2013. After my graduation, I worked as a Psychiatric Rehabilitation Therapist in different Mental Health Care settings, maintaining a strong interest in research. My specific interest was to bring innovative approaches to psychiatric rehabilitation and social inclusion. In 2015 I decided to start the Master Degree in Scienze Riabilitative delle Professioni Sanitarie, studies that led me to expand my knowledge in health management, growing my interest in scientific research. At the end of my master's degree, completed in 2017 with honors I started my PhD, in the course of Innovation Sciences and Technologies, with field of study in Regenerative medicine and Biomedical Applications, because I think it will allow me to reach an important meeting point between innovative and biotechnological approaches to mental health, which I strongly desire.

My years of research are mainly carried out in the Centro di Psichiatria di Consultazione e Psicosomatica (AOU CA), under the supervision of Professor Mauro Giovanni Carta. During my PhD I had the opportunity to work and collaborate on several research studies, focusing mainly on my thesis entitled "*Validation of a genetic screening tool for bipolar disorder*", being psychiatry my specific field of interest. Bipolar Disorder is a mental disorder that causes unusual shifts in mood with important consequences in many areas of the individual's life. These

moods range from periods of extremely "up" (manic episodes) to very sad, "down" (depressive episodes). Bipolar Disorder is one of the most serious mental illnesses and moreover, the problem of the delay of the first diagnosis increases the impact of the disorder. This is the reason why we decided to focus our research on the study of a genetic screening tool for bipolar disorder. The screener, accompanied by screening tools paper&pencil used in psychiatric clinic, has the objective of improving early diagnosis and differential diagnosis with the aim of obtaining more accurate treatments since the onset of the disorder, and thus a better prognosis. The project provides for an evaluation of the genetic mutations involved in Bipolar Disorder, analyzing a saliva sample, on a cohort of healthy subjects and subjects with mood disorders, using low-cost standard methodologies such as real-time PCR. To carry out my study, I collaborated with prof. Germano Orrù of the Laboratorio di Genetica Molecolare (AOU CA), who analyzed the saliva samples. I spent the second year of my PhD in Paris, at the Universitè Paris Descartes – Laboratoire de Psychopatologie et Processus de Santè: here I carried out the study on the genetics of Bipolar Disorder, administering interviews and collecting saliva samples from Sardinian immigrant volunteers. I'm currently working on the draft of my PhD thesis and on a systematic review, in order to have an overview of the innovative treatments for Bipolar Disorder. In my thesis I'll analyze the data collected from me and other students in Italy, France, Brazil and Argentina, a total of 260 cases, with the aim of understanding the implication of the genetic mutation identified in correlation with Bipolar Disorder.

An important research work done during my PhD is:

Carta M.G., *et al.*, Megacities, migration and an evolutionary approach to bipolar disorder: a study of Sardinian immigrants in Latin America, *Braz J Psychiatry*, 2020; **42**(1): 63-67.

Study of Metabolomic Networks of Autistic children and Schizophrenia

Hema Sekhar Reddy Rajula
Curriculum: Regenerative medicine and biomedical applications

I graduated with a Master of Science in Bioinformatics from the University of Saarland, Germany in 2017. I am currently a third-year student of Innovation Sciences and Technologies doctorate at the University of Cagliari (XXXIII cycle). My interest in bioinformatics and metabolomics is what led me to start my PhD at the Department of Surgical Sciences, under the supervision of Prof. Vassilios Fanos. I applied my bioinformatics skills in the research area by pursuing a PhD that focused on the metabolomic network analysis of young autistic children and different genotypes of schizophrenia susceptibility gene NOS1AP.

In the framework of EU Horizon 2020 project CAPICE (GA # 721567, H2020-MSCA) I visited the R & D department at Johnson & Johnson (Solna, Sweden - 3 months) and CITO (Arnhem, the Netherlands – 3 months) focusing on data standardization, preparing the variable data catalogue for various cohorts, which used for secondary analysis. Mental ill-health and neurological conditions have touched nearly everyone on the planet. The brains of people with mental disorders are different in many ways from those of people living without the condition. The differences are likely due to multiple genetic variants and metabolites affecting the brain. Advances in bioinformatics utilizing a big data and network analysis approach may provide opportunities for novel insights with respect to the causes of mental illness. In my doctorate thesis (entitled *Study of Metabolomic Networks of Autistic children and Schizophrenia Susceptibility gene*), bioinformatics and network analysis have been applied to study the metabolomics data of the young

autistic children and different genotypes of schizophrenia susceptibility gene NOS1AP.

Firstly, a multivariate statistical model was built for schizophrenia metabolomics data. Network analysis was applied to the list of schizophrenia significant metabolites that are identified from the multivariate model. Metabolic networks were mapped in conjunction with KEGG and PubChem CID identifiers. We found that metabolomic network analysis of the serum metabolome influence of schizophrenia gene NOS1AP is involved in a set of complex metabolic alterations, including amino acids, organic compounds, fatty acids, and cholic acids. The serum metabolome suggests to have the required sensitivity and specificity to gain insight into the schizophrenia susceptibility gene and aid a network-based medicine approach.

The findings of autistic children's metabolome open up new perspectives for a better understanding of the correlation between the clinical phenotype of autistic children and their urine metabolome. The severity of autism core symptoms and problematic behaviors may be associated with specific metabolic perturbations, most of them induced by an overgrowth of Clostridia spp., changes in gut mycobiome, and by alteration of mitochondrial functions. Metabolomics enables the early screening of children at risk for autism, improves the accuracy of diagnosis, and identifies novel candidate biomarkers of symptoms severity.

Mental health and innovation

Giorgia Testa
Curriculum: Regenerative medicine and biomedical applications

I am Giorgia Testa and I'm attending the XXXIII PhD cycle in Innovation Sciences and Technologies with a focus on regenerative medicine and biomedical applications, my tutor is Professor Mauro Giovanni Carta. My university education began in 2010 with enrolment in the three-year degree course in Tecniche della riabilitazione psichiatrica. I finished my studies, obtaining the title of Doctor in psychiatric rehabilitation technique, in 2013. In 2015 I decided to be enrolled in the master's degree Course in Scienze riabilitative delle professioni sanitarie, a path concluded with full marks in 2017. During my studies and in my work, I have always shown interest in the field of research in mental health, and, in particular, I was very interested in finding a synthesis between an approach centered on the user and his needs and the possibility of using the most advanced technologies to improve the quality of care. Therefore, in the same year of the achievement of the master's degree I started my career as a doctoral student at the PhD course in Innovation Sciences and Technologies. This kind of course seems to me to provide concrete support in the field of mental health through the use of innovative technological tools.

My research activity takes place at the centre of Psychiatry and Psychosomatic Consultation directed by Professor Mauro Giovanni Carta. My activity is focused, as mentioned before, in the field of mental health and the pivotal project of my research activity is entitled: Heart Rate Variability (HRV) in biofeedback training: assessment of treatment effectiveness in fibromyalgia: pilot study. The main objective of the study is to verify the feasibility of an HVR biofeedback training protocol in patients with fibromyalgia, and to produce a preliminary

measurement of the possible improvement induced by the technique in relation to quality of life, quality of sleep, perception of pain, depressive symptomatology, anxious symptomatology. This measure will be useful to estimate the expected improvement in future case-control studies. The survey sample is composed of N 50 female persons with FM recruited at the at the pain therapy Centre of San Giovanni di Dio Hospital by the AOU of Cagliari. The experimental group underwent 10 Biofeedback Training sessions, once a week using the program Software EmWave. Each session lasted 45 minutes. The overall duration of the treatment is 10 weeks. The parameter used is heart rate variability. The group has maintained the standard therapies in progress. The control group continued only the standard therapies in progress.

My thesis, as mentioned before, will focus on the previously mentioned work. Its title will be Heart Rate Variability (HRV) in biofeedback training: assessment of treatment effectiveness in fibromyalgia: pilot study.

An important research work done during my PhD is:

Carta M.G., *et al.*, The impact of fibromyalgia syndrome and the role of comorbidity with mood and post-traumatic stress disorder in worsening the quality of life. *International Journal of Social Psychiatry,* 2018; **64**(7): 647-655.

Long-term cryo- and lyo-preservation of human stem cells: modelling and process optimization

Gabriele Traversari
Curriculum: Regenerative medicine and biomedical applications

Gabriele Traversari graduated in Biomedical Engineering (2014) and got his master's degree in chemical engineering and Biotechnological Processes (2017) at University of Cagliari. He is currently a third-year student of Innovation Sciences and Technologies doctorate at University of Cagliari (XXXIII cycle).

During the doctorate, his research has been focused on the analysis of multiphase systems for bio-medical applications as well as materials science.

In the framework of EU project DRYNET (GA # 734434, H2020-MSCA-RISE-2015) he visited the laboratories at NIAS Tsukuba (Ibaraki, JAPAN - 3 months) and CBS Edmonton (Alberta, CANADA – 2 months) focusing on the processes of long-term preservation for biological material, i.e. Cryo- and Dry-preservation, both of considerable importance in the field of regenerative medicine and tissue engineering that are part of BioEngineering in general: the first is the main process for the conservation of biological samples at cryogenic temperatures (-196°C) by means of liquid nitrogen, while the second, imitating the anhydrobiosis that some species of insects and plants undergo to protect themselves from unfavourable environmental conditions, could become a valid alternative, with much lower costs.

In the doctorate thesis (entitled *Experimental and modelling analysis of multiphase systems*) the physicochemical and biological phenomena involved in the above processes - i.e. phase formation and disappearance (crystal and glass from/to liquid), water osmosis and solute permeation through cell-membrane (cryo- and lyo-protectant agent), cytotoxicity and final cell viability - were first analyzed experimentally and then mathematically modelled, on the basis of the application of prime principles of conservation and thermodynamic phase-diagrams. The numerical solution of these mathematical models is used both as a tool for the rational explanation of the dynamics of events during the entire process, and for the determination of protocols and optimal operating conditions able to improve the final result and efficiency.

In the PhD thesis the attention was also paid to materials science, and in particular to the mixing and reaction kinetics of ball-milling processes.

Casula E., *et al.*, Modelling the osmotic behaviour of human mesenchymal stem cells, *Biochem. Eng. J.*, 2019; **151**: 107296.

PhD program in Legal Science

Coordinator: Prof. Gianmario Demuro
Vicecoordinator: Prof. Silvia Corso

https://dottorati.unica.it/scienzegiuridiche/

The PhD in Legal Science aims to develop a high critical awareness of the complexity of the legal phenomenon in all its multiple aspects, in constant comparison with the European and international regulatory context.

The joint training had a greater importance during the XXXIII cycle, in which all doctoral students has been called to compare their respective experiences.

The Doctorate has promoted the publication of the work of doctoral students showing the achievement of scientifically relevant results in the Department's editorial series or in scientific journals, as well as the participation of doctoral students as speakers at seminars and conferences on the topics covered by their research.

At the end of the XXXIII PhD course, PhD students in Legal Sciences acquired a methodological toolbox suitable for carrying out scientific research and a critical autonomy that will allow them to achieve results with originality in the field of legal research.

The PhD programme is part of the Doctoral Project of "Advanced Training in Legal Sciences", which includes the Doctorates of Venice Ca' Foscari, Foggia, Siena, Second University of Naples, LUISS Guido Carli Rome, Cagliari, Catania, Florence, Pamplona and Salamanca (Spain). In 2020 the Doctorate concluded a doctoral cooperation agreement with the Université Sorbonne Paris Nord that will allow for doctoral candidates to acquire the double title of PhD valid in each of the countries participating in the agreement.

«*Oggetto*» of the Contract between Legal History and Comparative Law

Gian Mario Aresu

Born in 1993, in 2015 I obtained (in 3 years and 9 months instead of 5 years) the Master's Degree in Law with honours (110/110 *cum laude*; I was declared among the best graduates in the University of Cagliari for a.y. 2014-2015). In the same year *cultore di materia* in Roman law and trainee lawyer (lawyer since 2019).

My research (with the supervision of Prof. Riccardo Fercia) focuses on the *«Oggetto» of the Contract between Legal History and Comparative Law*. In the academic year 2018-2019, as a Visiting Postgraduate Researcher, I spent six months at the University of Surrey S*chool of Law* (invited by Prof. Francesco Giglio), with a study programme on the *Object of the contract in comparative perspective*. Then, in the academic year 2019-2020, I had a *séjour de recherche* which lasted more than three months at the *Université Paris V René Descartes* (*Université de Paris* since January 1st, 2020) *Institut d'histoire du droit* (invited by Prof. David Kremer). My study commences from the contemporary Italian law: starting with Article 1325 of the Civil Code, which provides the «Indication of the Requirements» of a contract: «The contract requirements are: 1) the agreement of the parties; 2) the cause; 3) the *oggetto*; 4) the form, when it appears that, without it, the contract is void». What is the *oggetto* of the contract? Legal scholars have predominantly two ideas: the *oggetto* of the contract would be the item of the reality (physical entity) to which the contract refers; or it would be the performance (ideal entity). Indeed, in the Italian law, an obligation arises from the contract: this element consists of the performance, i.e. what the debtor has to do in favour of the creditor (e.g., in a purchase, to pay the price).

Why is it important to study this topic? Because a correct individuation of this element is fundamental in contract law. In fact, if the *oggetto* of the contract is missing or presents particular defects, the contract is void (Article 1418 of the Italian Civil Code): therefore, the one analysed in my research is an issue with practical consequences.
To answer my question «What is the *oggetto* of the contract?» it has been useful to start from Roman law proceeding through the various phases of Legal History. Roman scholars did not explicitly refer to the *oggetto* of the contract, nevertheless in the development of the European legal culture (Roman tradition) some academics started mentioning *substantialia*, i.e. the essential elements of the contract: without them, there is not a contract. E.g., a contract of purchase (in Latin *emptio venditio*) exists only if it has two elements: 1. a physical item (e.g. a house); 2. the price. With a long and deep evolution, and in particular by virtue of Pothier's works, *substantialia* have become the *objet* of the contract of the French *Code Civil* promulgated in 1804. For this reason and for the reform of the Code completed in 2016, it has been valuable for me to spend a period in France, being it the first civil law State to have a modern codification (I extensively consider this evolution in my thesis).

In my opinion, in order to respond to my question, it has also been very useful to conduct my research for a semester in the United Kingdom, whose common law, in several fields, does not follow the tradition of Roman law. This, in fact, has allowed me to look at the topic I studied without historical stratifications and preconceptions. Despite the fact that the English law does not recognise a doctrine of the *oggetto* of the contract, in doing my research I have started appreciating the fact that it conveys the idea of the element that the Italian and the French call by this name.

In conclusion, I have investigated a topic of Italian contract law on which – according to several scholars – deeper analysis and studies were needed: to do so, it has been profitable to apply the historical (Roman law, Legal History etc.) and comparative (English law, French law etc.) methods, taking advantage of long periods abroad.

Contracting party and third party in the legal transaction

Felice Cabiddu

After graduating in law, he continued his study experience by doing an internship at the Avvocatura di Stato di Cagliari and then pursuing a doctorate in legal sciences. During this period, he deepened his knowledge of various sectors of private law, including succession law, family law and contract law. In order to study the topics covered by the doctoral thesis, he carried out a research period abroad at the Institut de recherche en droit des affaires et du patrimoine (IRDAP) of the Université de Bordeaux. During his stay in France he had the opportunity to study the similarities and differences between the Italian and French legal experience about contracts.

The thesis, entitled "Contracting party and third party in the legal transaction", focuses on the position of the subjects who are involved in various ways in the contract. Starting from the established insufficiency of the dichotomy between the contracting party and the third party - traditionally considered capable of exhausting all the possible declinations of the relationship between the legal entity and the contract - the work proceeds by reconstructing the cases on the level of subjective participation, most significantly revealing the heterogeneity between the legal positions that should nominally be similar and the affinity between the legal positions which, always by name, should be heterogeneous. In particular, the events related to the use of contractual representation, the contract in favor of a third party, the various economic transactions characterized by the contractual connection (related agreements), as well as, on the family law side, the

hypothesis purchases made by a single spouse under the community of property state.

The leitmotif of the entire work is the attempt to highlight a sort of descriptive relativity characterizing qualifications and concepts such as those of contracting party and third party. Thus, within the various cases taken into consideration, the examination involves the problems that arise to the interpreter when it is necessary to establish which tools and which remedies are up to whoever is, involving the single contract, in a position characterized by proximity both to the position of those who are usually invested with the quality of a party, and to that of those who are usually invested with the quality of a third party. These issues cannot be resolved by resorting to rigid formal qualifications, nor by developing general identification criteria through which to establish who a third party is and who it is a party once and for all. If anything, it will be a question of reconstructing in detail the structure of interests as a result of before and after the position of the legal transaction, to establish for what purposes, and which interests justify the attribution to the holder of shares designed to guarantee its protection, possibly to the detriment of other interests in any case relevant in the context of the legal case taken into consideration.

The reform of Common European Asylum system (CEAS) between the principle of solidarity (art. 80 TFUE) and the revival of nationalism in Europe

Rossella Carta

I graduated in Law, summa cum laude from the University of Cagliari in 2015. After my graduation I had the chance to spend period of research at the Centre for Migration law at the Faculty of Law of Radbaud University (Nijmegen). In 2017 I've been selected for the Advanced Graduate Seminars in Parliament studies and research Silvano Tosi, a postgraduate school of the University of Florence, directly funded by the Italian Chamber of Deputies and the Italian Senate of the Republic.

I'm currently a PhD student in Legal Science under the guidance of professor Roberto Cherchi. My interest lies broadly in the area of European migration and asylum law. During my doctoral studies, I had the opportunity to spend a three months period of research at the International Center for Migration Policy Development (ICMPD) in Vienna. Under the supervisor of Martin Wagner, senior policy advisor on asylum at ICMPD, I've studied the phenomenon of secondary movements of migrants, one of the most important issue in European asylum Law.

Indeed, the main subject of my thesis is the reform of the European asylum system. Moving from the EU asylum law, the study analysed the concrete reform possibilities and try to evidence the different im-

plementation of this system in the Member States. It started examined the Italian system from the art. 10 of Italian Constitution and the national asylum law, and compare the Italian law with other Member States.

In particular, the research analyses the concrete reform possibilities of the current "Dublin system", that establishes the criteria for determining which member State is responsible for examining the asylum applications, in light of the resistance shown by certain EU Member States; as well as the EU principle of solidarity (art. 80 TFUE) among States could be applied in the actual European context, characterised by nationalist policies, and by the lack of State's will to cede further shares of their sovereignty on migration matter. The open question is if it's possible to develop a future CEAS' vision and to manage a new form of solidarity and burden sharing between member States. Therefore the study is focused on the concrete possibilities to change the CEAS (Common European Asylum System) rethinking a new hierarchy of criteria that take on the top the "genuine links" that connect applicants and states, and even gives applicants an element of choice as to their destination, in front of the phenomenon of secondary movements. Secondary movements are a huge problem that shows the lack of a real common European asylum system. The onward migration is undesirable phenomenon for Member States as it is expression of inefficient in the asylum procedures, but even for asylum seekers which frequently undertake a dangerous journey for arriving in another European country. Then, for addressing, limiting or preventing secondary movements it's necessary a real policy change and an effective harmonisation of the asylum procedures in the European member State.

Reorganization of corporate companies in a state of crisis

Emilia Fois

I graduated in law with a dissertation on comparative corporate law, for which I did a research in Madrid, and then I started my PhD in legal sciences. The PhD course in Legal Sciences at University of Cagliari, during which I attended several interdisciplinary classes, provided me with methodological tools for my individual research on commercial law, and in particular company law. The main area of my research is the analysis of the management instruments that the company's administrators can use in case of definitive or potential insolvency of the company. On these topics I developed my thesis: *"capital operations and extraordinary operations as tools for the recovery of going concern value of companies in a state of crisis"*.

Thanks to the Legal Science PhD program I had the opportunity to continue my research abroad, at the University of Hamburg, for four months, where I studied the main aspects of the German bankruptcy system, European legislation, and the differences between the countries in which the bankruptcy procedure is geared towards the satisfaction of creditors and those in which the goal is, on the other hand, the protection of shareholders. State of crisis and state of insolvency are different. The crisis does not determine the end of the company, but it is one of the moments in its life and it can be overcome through reorganization. Protecting the going concern value is a principle of our legal system, and it's implemented through tools to prevent the risk of crisis or in order to manage it. Keeping the company in business is the main interest, more than the right of creditors to be satisfied and more than the right of shareholders to obtain liquidation. So one of the issues

on which I focused my attention is the transition from a system that gives value to the different interests of shareholders and creditors according to the phases of the life of the company - the first during the physiological phase, the second only in the pathological situation - to a system that has as its main objective throughout the life of the company: the maintenance of the going concern value, to which other interests are subordinated. Business continuity was previously only a criterion for drawing up a budget, but it is now the management reference point. The need to provide for warning tools and adequate structures to prevent the crisis has repercussions on managerial responsibility. Companies must measure the risk of a crisis and take the necessary measures to prevent it, so that we can talk about a statute for companies in crisis.

A very recent Italian legislative reform, still in progress, has the insolvency system as its main topic. In particular it enhances the recovery and restructuring plans, rather than the liquidation of the company, which becomes a last resort, as well as eliminating the stigma of bankruptcy. The Italian reform adopts requests heard at European level and also emerged in a recent directive. The need to move to the "rescue culture" is felt in other European states and the principles of refresh start and crisis risk prevention are adopted by the most recent European legislation.

My research then goes into the detail of extraordinary and capital operations, which may be useful for recapitalizing the company or saving a business unit. Capital operations do represent for me one of the most interesting subjects. With regard to the recapitalization, in addition to the classic operations of capital increase or reduction, there are different possibilities to achieve the same result: company contributions, shareholder loans, capital payments, and so on. Some instruments that were once controversial are now justified by the need for a speedy corporate recapitalization aimed at averting the crisis. The reorganization can also be implemented through operations that modify the organizational structure of the companies, allowing the company to be saved from a state of crisis and avoiding its liquidation, such as mergers, corporate split, spin-off.

Data protection and multilevel constitutionalism

Francesco Parodo

I graduated in law from the Università degli Studi di Cagliari in 2013, and I received from the same University the degree of specialisation in legal professions in 2015. After passing the State exam to become a lawyer in 2016, I won the PhD in Legal Sciences in 2017, which truly had been a great experience for me. During these last three years I had the opportunity to deepen the knowledge of Constitutional law, my field of studies, and to learn from all the law department professors. In fact, the doctoral programme includes insights involving every law branch, and three weeks of study, workshops and lessons at the Università Ca' Foscari (Venezia). In light of this, I can say it helped me to pass the national exam to become a judge in 2018, which was my biggest dream. Moreover, I would like to underline that the PhD programme allowed me to spend a very useful six months research period at the Univesidad de Sevilla.

My final thesis deals with data protection law and the process of European integration. This work aims to answer to the questions: can national States still defend the right to the protection of personal data in the new digital-globalisation era? And which role will the European Union play in the safeguard of this right? The subject of this thesis is thus the relationship between the member States and the European Union in the protection of personal data.

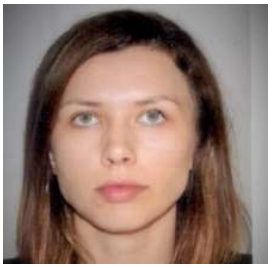
The first chapter concerns multilevel constitutionalism and the relevance of the development of public policies about data protection. In

addition, it investigates the existence of this right in the Italian Constitution and its autonomy from the different right to privacy. The second chapter deals with the creation of a common idea of data protection within the EU, its frame and its contents. It focuses also on GDPR's capacity to become a global standard for the defence of personal data. The last chapter concerns the mechanisms to preserve the shared concept of data protection in all the member States. In particular, it examines the importance of national supervisory authorities and judges in the implementation of this right.

In my opinion, the right to the protection of personal data offers a favoured perspective to analyse the process of European integration, revealing, from a constitutional point of view, the strengthening of the bonding between the national and the European legal orders.

Mediation in post-Soviet States

Roksolana Vasyliuk



My course of study, characterized by the specialist degree in law (obtained in Ukraine) and the three-year degree in Legal Sciences Services (obtained in Italy) and my current activity, as a PhD student at the University of Cagliari, allowed me to deepen the legal norm in the international / cross-border context with the implementation of knowledge of foreign languages.

The double qualification, foreign and Italian, was a prerequisite to be able to analyse the legal norm from a different perspective and to compare it in the foreign and "markets" of foreign law with the Italian one. The revival of mediation, as well as the method of dispute resolution, has attracted my attention focusing on a subject that has often challenged the problems and effectiveness of civil law and common law systems in the development of the European and international internal market. The structures and environment, the practical (the nuances of the language of the norm used) and legal context of mediation, as well as the results of mediation have yet to be explored from a global and comparative perspective. At the same time, many critical or undefined issues remain on the mediation process. Post-Soviet countries (Ukraine, Belarus, Georgia, Russian Federation) have been my primary interest in identifying strengths and weaknesses of the regulatory regime for national and cross-border mediation and have become a starting point for further research.

I used a benchmarking methodology within a system called "Regulatory Robustness Rating System" ("Regulatory Robustness Rating - RRR", Kluwer Law International, 2017). The RRR system is elaborated

in a detailed and explanatory manner by N. Alexander and is aimed at providing potential legal advisors and other actors in cross-border/international mediation processes with a quicker knowledge of the main features of the regulatory environment in which mediation will take place, stressing the importance of accessibility and predictability of the Mediation Law. At the meeting of EU Member States and former Soviet states the title was born: Mediation in the context and regulatory regimes in post-Soviet States. During the experience period abroad, I was able to enhance the objectives and aims: to collect, catalogue research material, document resources and highlight promoters and protagonists of mediation (judges, lawyers, mediators, university professors).

For my period of study abroad I preferred different countries: for the Western European part, Spain, and for the post-Soviet part, Georgia, in each of which I spent 3 months. Both countries have an accessible culture and a cosmopolitan society: each one of them has enriched me thanks to the multifaceted opportunities and language, to an active and vibrant reality in which malleability towards other study methods has been pregnant also at work level.

PhD program in Life, Environmental and Drug Sciences

Coordinator: Prof. Simona Distinto

https://corsi.unica.it/sciviamfa/

The PhD program in Life, Environmental and Drug Sciences involves 25 qualified professors with multidisciplinary expertise. It is organized in 3 curricula:

- *Biomedical*, where the students acquire competences in biochemistry, genetics and microbiology;
- *Human and Animal Biology and Ecology*, where the students acquire competences in anthropology, ecology and zoology;
- *Drug Sciences*, where the students acquire competences in organic and medicinal chemistry, pharmacology, and pharmaceutical technology.

The PhD board activated international conventions with an Asian University (Taipei Medical University) and a European University (University of Porto), which will allow doctoral students to acquire a double international degree.
Ten students are now enrolled in the XXXIII cycle 9 of which received a scholarship: 4 financed by the MUR funds for postgraduate scholarships and the budget of UNICA; 2 by Sardinia Region with POR FSE program, in scientific fields consistent with the strategic lines of the National Research Plan (NRP) and regional Smart Specialization. Finally, 3 students have been granted for innovative PhD programmes with an industrial characterization, related to disciplinary and topic areas in line with the development tracks indicated by the National Strategy of Intelligent Specialization 2014-2020 (PON R & I scholarships), for which components of the PhD board presented a specific project.
XXXIII cycle students are all highly motivated. They are going to complete their course with an enriched CV, which includes several publications, school and conferences participation, abroad experience, training in companies involved in the projects, prizes for conferences. Some have been involved in summer schools and events organization.

Phytocomplexes loading in phospholipid vesicles tailored for skin delivery

Mohamad Allaw
Curriculum: Drug Sciences

Mohamad Allaw was born in Lebanon in 1992. He was granted a diploma high school in 2010. He graduated from the University of Cagliari in 2017 with a master's degree in Pharmacy. In 2018 he joined the XXXIII Cycle of PhD program in Life, Environment and Drug Sciences at the University of Cagliari with a scholarship funded by PON under the supervision of Professor Maria Manconi. The project was focused on the *development of innovative nano-formulations carrying phytocomplexes for the treatment of skin diseases.*

In 2019, he spent three months at the University of Teheran (Iran) to enrich his knowledge on both the most effective and environmentally-friendly methodologies for the extraction of phytochemicals from plants and agri-food residues and the methods used for their characterization. According to his PhD project, he spent six months working at the facilities of a SME, Icnoderm S.R.L, thus improving his skills and learning about the production of nanoformulations at industrial level. In 2020, he spent two months at the University of Murcia in Spain, aiming at evaluating the biological activities of the plant-derived nanoformulations by means of in vitro and in vivo studies.

As reported above, his PhD-PON project is based on the development of phospholipid vesicles loading phyotochemicals obtained from Sardinian plants or agrifood waste and specifically tailored for the treatment of skin diseases connected with inflammatory and oxidative processes. After a deep bibliography research, three types of plants from

Sardinian flora have been selected: the leaves of Olea europaea, the aerial parts of Hypericum scruglii (a native species from Sardinia) and the berries of Pistacia lentiscus. The Sardinian folk medicine and data reported in the literature corroborate the beneficial properties of the selected plants mainly because of their high content in bioactive molecules with antioxidant and anti-inflammatory properties. Extracts were obtained by maceration in a water-ethanol blend and their main components were identified and quantified. Then, they were incorporated into phospholipid vesicles aiming at improving their bioavailability in the skin layers, their internalization in the most representative skin cells, thus prolonging their residence time at the action site. For each extract, different formulations were developed, starting from conventional liposomes (phospholipids in water) and modifying them by adding co-solvents, or surfactants, or polymers, aiming at maximizing the extract loading and the stability of dispersions over time. The main physico-chemical (size, zeta, entrapment efficiency and viscosity) and technological properties (stability, release rate and skin penetration) were evaluated. The biocompatibility of nanovesicles along with their ability to protect the cells against oxidative stress induced by using hydrogen peroxide and their wound healing activity using an in vitro cell model, were evaluated.

Overall results disclosed that glycerosomes modified with glucidex and gelatin were the most promising vesicles capable of promoting the beneficial properties of Hypericum scruglii extract, while Olea europaea extract containing transfersomes modified with collagen were the most effective in speed-up the healing of the wound in vitro and transfglycerosomes loaded Pistacia lentiscus extract were the most promising for the treatment of skin diseases. The results confirmed the fruitful delivery of the extracts in the ad hoc formulated phospholipid vesicles and their promising ability as skin care products.

Allaw M., *et al.*, Advanced Strategy to Exploit Wine-Making Waste by Manufacturing Antioxidant and Prebiotic Fi Bre-Enriched Vesicles for Intestinal Health, *Colloids and Surfaces B: Biointerfaces*, 2020; **193**: 111146.

Vesicles loading natural extracts for the treatment of nasopharyngeal diseases

Eleonora Casula
Curriculum: Drug Sciences

Scientific research is a world in continuous evolution, made up of exchanges of ideas, history, cultures, people, allowing the interaction between purely scientific and humanistic subjects. Because of my historical-archaeological background, my research experience well represents the encounter between distant subjects. When I started my PhD, I had to deal with a completely different world, which enriched me culturally and personally, and took me to Basque Country (Spain) and to work at Sakura Italia. There is a thin thread that connects traditional medicine and ethnopharmacology with new pharmacological research, and that thread is to design innovative and effective health promoting formulations loading extracts of plants used since ancient times to treat different diseases. Bioactives extracted from plants are gaining an increasing importance as valid alternative or adjuvant to synthetic drugs, due to their higher biocompatibility and less side effects. My work fits into this context, and the results will be collected in my thesis *"Innovative phospholipid vesicles loading Zingiber officinalis and Cardiospermum halicacabum for the treatment of rhynopharingeal diseases"*. These beneficial plants are used since ancient time for their therapeutic properties, antibacterial and anti-inflammatory action for the treatment of different diseases. Their biological efficacy is ascribed to several identified bioactive compounds. Historical evidence attest that *Z. officinalis* was already used 4000 years ago in India for the treatment of respiratory disease by inhalation; *C. halicacabum* was a main component of Chinese, Indian medicine and Ayurveda, used as natural cortisone and for the treatment of rhinopharyngitis. Considering the historical and scientific evidence, I have designed

modified phospholipid vesicles loading the extracts of *Z. officinalis* and *C. halicacabum* specifically tailored for nasal administration as spray. The formulation of nanocarriers as nasal spray permits an easy and non-invasive application and can improve the local efficacy of delivered molecules. Regarding these aspects, the study on *C. halicacabum* is of great interest. Formulations were prepared by mixing the extract with phospholipid (S75) and surfactants (PEG400), then hydrated alternatively with water to obtain PEVs or a dispersion of sodium hyaluronate in water to obtain hyalurosomes [1]. A commercial gelatin or the biopolymer chondroitin sulfate were added to PEVs and hyalurosomes to obtain different formulations. The morphology of the vesicles was observed by cryogenic electron microscopy (CryoTEM). The main physicochemical properties of the vesicles (mean diameter, polydispersity index and zeta potential) and the technological properties (entrapment efficiency, storage stability and plume angle) were measured. The vesicles were small and sized between ~96 and 178 nm, and negatively charged (between -7 and -55 mV). The entrapment efficiency was between 47 and 99% and the stability of the formulations was about 7 months at 4°C degrees, especially for hyalurosomes. Experiments on human keratinocytes (HaCaT) were performed to evaluate the cytotoxicity and the antioxidant activity. The results suggest that biocompatibility and efficacy against oxidative stress-induced damage are >90%. Furthermore, the spray efficacy was evaluated by laser diffraction with the Malvern Spraytec® to predict the deposition of the bioactives in the nasal area. The feasibility of the formulations as nasal delivery systems was demonstrated, thus suggesting their potential use for the treatment of nasopharyngeal disorders associated with oxidative stress.

Manca M.L., *et al.*, From waste to health: sustainable exploitation of grape pomace seed extract to manufacture antioxidant, regenerative and prebiotic nanovesicles within circular economy, *Sci. Rep.*, 2020; **10**(1): 14184.

New antitumour agents with potential polypharmacological activities

Serenella Deplano
Curriculum: Drug Sciences

I received my bachelor's degree in Toxicology in 2015, and in 2017 obtained a master's degree in Cellular and Molecular Biology at the University of Cagliari. I joined the XXXIII PhD Cycle with a scholarship funded by PON R&I, under the supervision of Prof. Elias Maccioni.

Tumours are multifactorial diseases generally characterized by both inflammation and hypoxic environment. Commonly, their chemotherapy is based on the association of drugs towards diverse targets. A promising therapeutic approach might be the identification of agents capable to interfere with more than one pathway involved in tumour growth. Within these pathways, enzymes that play a key role are human Carbonic Anhydrase (hCA), Cyclooxygenase (COX) and Kinases.

- **hCA** are metal enzymes involved in functions like pH regulation and CO_2 homeostasis. In particular, hCA IX-XII are associated with hypoxic tumours leading to a pH imbalance in extracellular environment;
- **COX** isozymes are involved in homeostasis and inflammation. Notably, the expression of isoforms COX-2 is induced by inflammation and, not surprisingly, are overexpressed in several cancers. Furthermore, their activity is might promote angiogenesis, tissue invasion, metastasis, and resistance to apoptosis;

- **Kinases** are enzymes involved in the regulation of cell division. Their dis-regulation in tumour cells promotes and strengthens their uncontrolled growth.

To design polypharmacological inhibitors, a common structural denominator has been identified, indicating the primary sulphonamide moiety as a promising group for the inhibition of these enzymes.

On these bases, we designed a structural model that might satisfy the common requisites for inhibition. The benzensulfonamide moiety is highly beneficial for the inhibition of both COX-2 and hCAs; this fragment binds, through a double bond, a dihydrothiazole or tetrahydrothiazole core, that can be variously substituted to modulate activity and selectivity toward both enzymes' families. Moreover, to further expand the activity spectrum toward kinases, an opportunely substituted isatine ring was introduced on tetrahydrothiazole nucleus. Accordingly, we have synthesised different series of potential multitarget inhibitors.

Within the PON R&I scholarship, I spent 9 months at LDS (Siena), supervised by Prof. Maurizio Botta and synthetized a small library of substituted pyrazolo[3,4-*d*]pyrimidine, to evaluate their activity toward mutated Kinases involved in cancer.

During this last year, I will be hosted for 6 months at the University of Porto, under the supervision of Prof. Fernanda Borges.

Deplano S., *et al.*, Tuning the Dual Inhibition of Carbonic Anhydrase and Cyclooxygenase by Dihydrothiazole Benzensulfonamides, *ACS Med. Chem. Lett.* 2018; **9**: 1045-1050.

Chemical composition and biological activities of *Washingtonia filifera* seeds

Sonia Floris
Curriculum: Biomedical

I graduated in Biology in 2015 and in 2017 I attained a master's degree in Cellular and Molecular Biology, at the University of Cagliari. During my master, I spent a period at the University of Salamanca (Spain) working on analysis, characterization and evaluation of the biological activity of phenolic compounds. I joined the XXXIII Cycle of PhD program in Life, Environmental and Drug Sciences, Biomedical Curriculum, at the University of Cagliari in 2017. I am currently working on a project focused on *Chemical Composition and Biological Activities of Washingtonia filifera seeds*. During my PhD I spent a period at Department of Pharmacognosy and Herbal Medicines at Wroclaw Medical University (Poland) where I have studied the chemical composition of *Washingtonia filifera* (*W. filifera*) seed extracts. I spent a further period at the Department of Medical Cell Biology at Uppsala University (Sweden) where I have investigated the biological activity of *W. filifera* seed extract, in particular if this extract inhibits Islet Amyloid Polypeptide (IAPP) fibril aggregation that is observed in most individuals with type-2 diabetes.

The plant kingdom is a renewable, low cost and largely unexplored source of biologically active molecules. Many palms are of particular importance in the field of nutrition and some of which may also have pharmacological interest. The biological properties of the extracts or compounds of seeds might increase utilization of this part of the fruit. Bearing this in mind and taking into account that the chemical composition and the biological properties of *W. filifera* seeds is not well

known, the focus of my research was to determine its phytochemical composition and the inhibitory activity of the extracts against target enzymes. As for phytochemicals, previous authors studied the antioxidant activities of aerial part of *W. filifera* and reported the presence of flavonoids. These molecules can act simultaneously as antioxidants and inhibitors of target enzymes involved in disease like Alzheimer's disease (AD) and diabetes. The phenomenon of oxidative stress is known to play an important role in both AD and diabetes due to the neurodegeneration and diabetic complications. AD is a neurodegenerative disease and cholinesterase inhibitors are in the first line of pharmacotherapy. The phenomena related to AD are mainly initiated and enhanced by oxidative stress. An important enzyme that has been reported to proliferate during oxidative stress is xanthine oxidase (XO). Compounds that can inhibit XO may reduce both the circulating levels of uric acid and the production of reactive oxygen species (ROS). Another contribution in ROS production derives from disease such as diabetes mellitus. A therapeutic approach to treat diabetes is to decrease postprandial hyperglycemia. This can be achieved by the inhibition of carbohydrate hydrolyzing enzymes like α-amylase and α-glucosidase.

Therefore, in order to research bioactive molecules with potential beneficial effects we evaluated the phenolic composition, the total polyphenol and flavonoid contents, as well as the antioxidant properties and their effect on cholinesterase, XO, α-amylase and α-glucosidase. Analyses of pulp extracts showed a low phenol and flavonoid content and no significant inhibitory effect on the enzymes under study. The seed extracts revealed as a good source of phenolic compounds with significant antioxidant activity. Moreover, *W. filifera* seeds displayed butyrylcholinesterase, XO, α-amylase and α-glucosidase inhibition properties, which is of interest, considering that they are an inedible part of the fruit and are usually discarded. Therefore, *W. filifera* seeds can emerge as a promising natural source of bioactive compounds for AD and diabetes mellitus disease.

Floris S., *et al.*, Phytochemical composition and the cholinesterase and xanthine oxidase inhibitory properties of seed extracts from the *Washingtonia filifera* palm fruit, *RSC Advances*, 2019; **9**: 21278-87.

A community pharmacy protocol intervention for promoting adherence

Enrico Keber
Curriculum: Drug Sciences

I have a master's degree in Pharmacy (2011) from the University of Trieste and a second level joint master's degree in Clinical Pharmacy from the Universities of Cagliari and Milan (2013). Since 2013 I have been working with the Italian Society of Clinical Pharmacy (SIFAC), carrying out clinical research, teaching and tutoring university courses, preparing training content for community pharmacies, and writing scientific articles. My field of investigation is drug-epidemiological research and pharmaceutical care. In 2016 I have spent a research period at the Virgen de las Nieves Hospital of Granada (ES) in the area of pharmaceutical care. My PhD project has been developed in collaboration with the Italian Society of Clinical Pharmacy. The focus of investigation is *adherence to treatment and disease control in patients with asthma*.

Failure to adherence to drug therapy is one of the most relevant problems in clinical practice, especially in the treatment of chronic diseases. When treating asthma, it is estimated that more than 50% of patients do not take the prescribed medications correctly. A great part of this population follows the treatment wrongly or suspends it because it is not perceived as necessary. The positive effects of education and training on the correct use of inhaler devices in chronic inhalation therapy are certain, but more than a quarter of the patients do not receive such instructions. Many international studies have highlighted the pivotal role of pharmacists and community pharmacy for adherence promotion and patient guidance in respiratory chronic disease management, and therefore also in asthma. The aim of my PhD project is to develop

a community pharmacy protocol intervention for promoting adherence to inhalation therapy in asthmatic patients.

The first thing I have made was selecting a tool that could asses the grade of adherence to inhalation therapy and could be easily used in the community pharmacy setting. There are several approaches to assess the level of adherence. The TAI Test (Test of Adherence to Inhalers), is the only tailored tool to evaluate the adherence to inhalers in patients with asthma. I have decided to select this tool for the project. The questionnaire has been originally developed in Spain. To date, the Italian version of the TAI Test questionnaire had not been validated yet. Therefore, as first step I developed a process to evaluate the psychometric properties of the Italian version of the TAI. The validation process I conducted, assessed more than 80 patients in two different rounds: at baseline and after two months. At each visit patients were administered the Italian version of TAI. The results of our study confirm that the Italian version of the TAI is a valid and reliable tool to identify and monitor non-adherence.

Once the tool was validated, I have developed the second part of the project: evaluate the effectiveness on adherence and clinical parameters of an educational intervention administered by clinical pharmacists (CPs) to asthmatics on chronic inhalation therapy. A prospective comparative study involving 34 Italian community pharmacies across Italy (11 control, 23 intervention) has been developed. Subjects were evaluated for adherence to inhaled therapy, asthma control, and lung function at baseline and after 2 months through the TAI. The educational intervention at baseline was based on TAI results and administered by specifically trained pharmacists. 242 consecutive subjects (167 intervention, 75 control) were enrolled. The results, which are about to be published, confirm that a targeted educational intervention by CP is effective in improving adherence to therapy and can lead to significant improvements in disease control.

Baiardini I., *et al.*, Validation of the Italian version of the Test of Adherence to Inhalers (TAI), *J Investig Allergol Clin Immunol.,* 2020; 0.

Fish stock assessment models and their applications

Andrea Pierucci
Curriculum: Animal and
Human Biology, and Ecology

I'm a PhD student at University of Cagliari. I obtained a bachelor's degree in Marine Environmental Sciences in 2012, with an experimental thesis *"Evaluation and quantification of sillover effect in the Marine Protected Areas (MPA)"* at the University of Genoa with the collaboration of the University of Cadiz (Spain). After, I got a master degree in Marine Sciences, in 2014 with an experimental thesis *"Bionomic characterization of the benthic communities in the MPA of Tremiti islands and the quantification of the abundance and the distribution of Caulerpa racemosa var. cylindracea (Forsskål) J.Agardh 1873"* at the University of Genoa in collaboration of the University of Ancona and the University of Ravenna. I also worked in 2015-16 with the Registro Italiano Navale (RINA Services S.p.A.) focusing on the sustainable fishery certifications: Marine Stewardship Council and Friend of The Sea. In March 2017 I participated in the Antarctic Circumnavigation Expedition (ACE), a historic multidisciplinary international Southern Ocean voyage organized through the Swiss Polar Institute at the École Polytechnique Fédérale de Lausanne, Switzerland, and the ACE working on visual census and spatial distributions of macro plastic and microfibers in oceanic surface waters[1].

My main researches are focused on fish stock assessment and spatial modelling, two fundamental tools in sustainable management of fisheries. Although, the Mediterranean Sea is one of the most ancient and deeply studied basin, overfishing remains a remarkable issue, always object of continuous investigations. For this reason, we are called to find the correct way to manage these resources, not only for an ecolog-

ical point of view, but also because those represent the most important natural source of healthy proteins available nowadays.

With my thesis *"Stock assessment of Mullus barbatus (Linneo, 1758) and Aristeus antennatus (Risso, 1816) with catch at age models in Sardinian waters (GSA 11)"* I aim to provide a status quo (health status of the two stock now), reference points (indicators for a sustainable fishing) and short term forecast (projections of stock trends with different fishing pressures) for two of the most relevant fish stocks in Mediterranean Sea and Sardinian waters.

My studies have always been driven by fascination, and this led me to undertake as many extracurricular experiences as I could, mainly in the fields of marine biology and ecology, visual census methods, ecology of alien species and ecolables (Marine Stewardship Council and Friend of the Sea). I lived these experiences in many countries always with my constant extraordinary passion for these subjects. From the begging of my PhD I worked hard to reinforce my knowledge in statistics (lm, glm, glmm, gam etc), modelling and coding (R, LaTeX). I spent 8 months in Canada at the University of British Columbia working with one of the most important quantitative modelling group composed by Dr. Tom Carruthers, Prof. Villy Christensen, Prof. Murdoch McAllister, and Prof. Carl Walters. During my experience abroad, I obtained important knowledge in fish stock assessment modelling, fish biology and ecology, aquaculture and fishery science. I also have had the great pleasure to work with Prof. Daniel Pauly, Rashid Sumaila and Amanda Vincent. This was definitively one of the most formative work experiences I ever done.

Now, I'm happy and grateful for having the opportunity to apply these knowledges obtained abroad, in Italy and in Sardinian context.

Suaria G., et al. (2020). Microfibers in oceanic surface waters: A global characterization. *Science Advances*, 2020; **6**(23): eaay8493.

Lipid nanocarriers as a strategy to improve 8-MOP skin delivery

Giulia Pitzanti
Curriculum: Drug Sciences

Giulia graduated in Pharmacy at the University of Cagliari with an experimental thesis entitled "The influence of microneedle rollers on the percutaneous penetration of Nile Red nanosuspensions". After her degree, she spent three months at the University of Hertfordshire where she worked on the development of bioadhesive nanoparticles for drug delivery to the bladder. In October 2017 she joined the PhD Program in Life, Environmental and Drug Sciences (Drug Sciences Curriculum) at the University of Cagliari, under the supervision of Prof. Chiara Sinico. She joined the University of Coimbra and Queen's University Belfast as a visiting PhD student to improve her research skills in Pharmaceutical Technology. Her main expertises are solid lipid nanoparticles (SLNs), PEVs, nanocrystals, microneedles and 3D printing. Her PhD thesis consists in the *development of innovative drug delivery systems to improve skin drug delivery*. Particular interest is addressed to the development of nanocarriers for improving 8-Methoxypsoralen (8-MOP) skin drug delivery.

8-Methoxypsoralen (8-MOP), is an organic molecule commonly employed in the photochemotherapy of various skin disorders characterized by hyperproliferative conditions or by lack of skin pigmentation (i.e. psoriasis, eczema and vitiligo). 8-MOP is pharmacologically inactive but when exposed to ultraviolet radiation is converted to its active metabolite to produce a beneficial reaction affecting the diseased tissue, thus alleviating the symptoms of the skin disorder. In PUVA therapy, 8-MOP is administered orally or applied topically before exposing the skin to UVA light from special lamps. The oral administration of 8-MOP is associated with a wide range of side effects. In order to mini-

mize systemic adverse effects, in some dermatological treatments PUVA is performed with topical psoralen administration. However, the nowadays available 8-MOP topical formulations are unable to achieve good skin drug permeability as well as drug penetration to deeper skin layers requiring high doses and exposure time to UVA radiation that in turns lead to increased risk of serious adverse effects such as carcinogenesis. New formulations based on lipid nanocarriers could be a promising opportunity to answer to these issues. During the last three decades there has been a large interest in nanocarriers (drug carrier systems having sizes < 1000 nm) as effective approach to delivery active molecules through the different administration routes, and among them lipid nanocarriers such as liposomes have been the most studied to improve skin drug delivery. However, since conventional liposomes are often unable to efficiently carry drugs across the intact skin, an intensive research has been devoted to the development of new classes of lipid vesicles by adding new additives in the classic composition of liposomes. Our research group has been studying for years the so-called Penetration Enhancer-containing Vesicles (PEVs), liposomes with a penetration enhancer (chemical compound that enhance skin permeability) in their composition. Given the promising results obtained with these new delivery systems, in this work 8-MOP loaded PEVs were prepared with different concentrations of the penetration enhancer Transcutol® with the aim to improve 8-MOP skin delivery. We found out that PEVs size (~135 nm) and encapsulation efficiency (~65%) were not affected by Transcutol® concentration. Transdermal delivery study showed that 8-MOP mainly accumulated into the stratum corneum and interestingly after PEVs application, the drug recovered in this layer was almost double of that delivered by conventional liposomes. Finally, biocompatibility studies demonstrated that the incubation of human keratinocytes for 24 h with 8-methoxypsoralen loaded PEVs did not significantly reduce cell viability. In conclusion, PEVs could be promising 8-MOP carriers in topical PUVA therapy.

Sinico C., *et al.*, Nanoliposomes@Transcutol for *in vitro* skin delivery of 8-methoxypsoralen, *Journal of Nanoscience and Nanotechnology*, to be published.

Effect of stress on Roman rats, a genetic model of depression

Francesco Sanna
Curriculum: Drug Sciences

I obtained a master's degree in biology and Human Evolution from the University of Rome Tor Vergata in 2014 with a thesis on the palaeodiet of a late eneolithic community. After obtaining a Master in Criminology in 2016, I entered a traineeship in Neuroscience (October 2016 to April 2017) at the Department of Neuroscience, University of Turin, under the supervision of Professor Maurizio Giustetto. In August-September 2017 I was a fellow in Dr. Fabrizio Sanna's laboratory at the Department of Biomedical Sciences, University of Cagliari, participating in a project aimed at investigating the neural plasticity processes in the CNS induced by sexual experience in rats.

My doctoral thesis (entitled: "*Behavioral and neurochemical characterization of the Central Nervous System of Roman High- (RHA) and Low-Avoidance (RLA) rats: effect of acute stress and neonatal handling*.") is aimed at characterizing the neurobiological basis of two major psychiatric disorders, namely, depression and schizophrenia. Depression (i.e., Major depressive disorder) is a common and debilitating chronic psychiatric condition associated with functional impairments and a variety of socio-economic difficulties; accordingly, it is the leading cause of disability worldwide in terms of total years lost due to disability. The schizophrenias are a group of chronic mental disorders, often severely disabling and representing a major challenge for health systems and social assistance.

The research program of my thesis is based on the use of the psychogenetically selected Roman High-(RHA) and Low-Avoidance (RLA) rats, which are well established as a valid genetic model for the investigation of the neurobiology of depression and schizophrenia and the development of novel and more efficacious treatments.

The studies of the neurobiology of depression focus largely on the association between stress and depression, with the hope that an understanding of the biological pathways that link stress to depression would inform on the pathophysiology of the disorder. Thus, the experiments conducted in Cagliari were aimed at comparing the effects of acute stress on the function of brain neurotrophic factors. Different forms of stress can induce depressive symptoms, both in humans and in experimental animals, by modifying the synthesis and expression of different brain neurotrophic factors such as the Brain Derived Neurotrophic Factor (BDNF), which modulate the growth and differentiation of neural networks, are necessary for the survival of adult neurons and glia, and play a key modulatory role of synaptic plasticity. The results obtained indicate that, in basal conditions, the levels of BDNF in the hippocampus (HC) is lower in RLAs vs. RHAs. Moreover, acute stress induces a decrease in BDNF expression in the ventral HC of both lines and an increased expression in the dorsal HC in RLA, but not RHA rats. These findings support the view that differences in BDNF signalling and neuroplastic mechanisms between RLAs and RHAs are involved in the susceptibility of RLAs and resistance of RHAs to stress-induced depression.

The experiments carried out during my stage in the Autonomous University of Barcelona, where I spent nine months as required by my PhD course, were aimed at characterizing RHA rats as a genetically based model of schizophrenia-related behaviors following exposure to neonatal handling. Collectively, these studies add experimental support to the validity of the Roman rats as a model to investigate the neurobiology of depression.

Serra M.P., *et al.*, Effect of Acute Stress on the Expression of BDNF, trkB, and PSA-NCAM in the Hippocampus of the Roman Rats: A Genetic Model of Vulnerability/Resistance to Stress-Induced Depression, *Int. J. Mol. Sci.*, 2018; **19**(12): 3745.

Proteomics and molecular studies of genes and enzymes of heme pathway

Stefania Solinas
Curriculum: Biomedical

I earned the bachelor's degree in Applied Bioecology in 2010 at the University of Cagliari, where I did an internship in Organic Chemistry addressing the interest in the synthesis of new organic molecules. Afterwards, in 2014, I obtained a master's degree in Cellular and Molecular Biology, at the same university, where I carried out research in Molecular Anthropology focused on NOS2 gene related to Malaria in Sardinia. I spent a semester internship at the Institut für Molekulare Virologie at Universität Ulm in 2012, focused HIV-1 studies. I joined the XXXIII cycle PhD program in Life, Environmental and Drug Science in 2017. My project is focused on *Proteomics and Molecular studies of genes and enzymes involved in heme biosynthesis*. Defects in one of the enzymes of the heme pathway can lead to the expression of inactive enzymes and consequently to the manifestation of metabolic disorders called Porphyrias. Porphyrias are a group of rare diseases, generally hereditary with late incidence and variable expression, characterized by the excessive accumulation in the liver and the urinary excretion of several porphyrin intermediates. These intermediates represent important biomarkers in clinical diagnostics for the discrimination of the so-called acute and non-acute porphyrias, which show different genotypic and phenotypic characters depending on the enzymatic defect. Enzyme deficiencies are generally linked to single nucleotide polymorphisms (SNPs) involving the coding genes thus compromising their regular gene expression. Molecular analyses were carried out on DNA extracted from saliva samples applying commercial kits and specific protocols. Purified DNA was utilized in molecular analysis by PCR experiments, using specific primers designed on each region delimiting

the genes coding for enzymes involved in the heme biosynthesis. The amplified fragments were analyzed by electrophoresis on agarose gel, purified and then sequenced to verify the presence of new mutations. I conducted molecular experiments focusing on four of the eight genes involved in Porphyria: Coproporphyrinogen Oxidase, Ferrochelatase, Hydroxymethylbilane synthase and Protoporphyrinogen Oxidase. The alignment of the gene sequences reported in the chromatograms compared with those of the database, showed the presence of numerous heterozygosis in the intronic regions flanking the coding ones, affected by alternative splicing phenomena, a frameshift mutation which involves a slippage in DNA reading and various SNPs in the exonic regions which in this case do not involve any amino acid replacement . Currently, I am working on proteomic analysis to characterize the salivary proteome of patients affected by porphyria since they often show severe damage to the oral mucosa. Salivary proteome of healthy subjects will be also analyzed and compared to salivary proteome of patients to identify potential salivary biomarkers of this disease. Saliva samples from donors, immediately after collection, were treated with trifluoroacetic acid so that we could analyze the acid soluble fraction of saliva using a top-down approach based on mass spectrometry. During my PhD, I spent a period at the Porphyria Investigation Center to Hospital Universitario 12 de Octubre, (Madrid) where I have investigated both the molecular and biochemical aspects of porphyrias. In particular, in studies related to the quantification of porphyrin precursors and total porphyrins present in blood, urine and feces. Moreover, I conducted molecular and genetic studies for the detection of asymptomatic carriers of the most frequent porphyrias in Spain.

Long term effects of sport on body composition in the elderly

Silvia Stagi
Curriculum: Animal and
Human Biology, and Ecology

Silvia Stagi graduated with honours in Natural Science at the University of Cagliari in February 2017. Her Master's degree focused on science communication, with a thesis entitled 'University Presses and open access science. Opportunities in the area of museum and natural science'. She studied for 12 months (Erasmus project) in the University of the Basque Country (Bilbao, Spain).

The project of the PhD research was carried out in the laboratory of body composition and anthropometry, within the research group of Professor Elisabetta Marini. During the PhD period, three months were spent at the University of the Basque Country (UPV/EHU – Bilbao), working on the study on body image perception, in collaboration with Professor Esther Rebato and her team. Other five months were spent at the Institut Nacional d'Educació Física de Catalunya (Universitat de Catalunya – Barcelona), with Professor Alfredo Irurtia Amigó and his research group, with the aim of validating a new body composition approach.

Physical exercise substantially contributes to maintaining the individual's physical and psychological well-being at all stages of life, even in the old age. However, the long-term effects of sport in older individuals, who regularly practice physical exercise, have not yet been adequately analysed. Moreover, the study on the effects of physical exercise in different body districts, on morphological and functional symmetry and of different sports disciplines is almost absent in the literature.

The main objective of the PhD thesis titled '*Long-term effects of sport on segmental body composition: a study in adult and elderly subjects*', was to study the impact of physical exercise on the physiological and psychological well-being during aging. This study was conducted through the analysis of the body composition, evaluated by mean of bioelectrical impendance vector analysis (BIVA) and psychological state assessment techniques. At this purpose, a first phase of the research was dedicated to test BIVA in the assessment of body hydration and fat mass percentage, through the comparison with techniques defined as 'gold standard', and to define a new procedure to evaluate segmental body composition.

The long-term effects of continuous physical exercise were analysed in different disciplines (Tai Chi Chuan, Tennis and Running), selected among those most practised in late age. In the active subjects and in a sample of age-matched inactive controls, the total and segmental body composition (different body districts: arm, leg and trunk), the morphological and functional symmetry between right and left limb, muscle strength, the degree of depression and body image perception were tested.

The results of the research showed that the practise of regular exercise in middle-aged and older adults mitigates the effects of the aging process, helping to maintain skeletal muscle mass and reducing the level of fat, especially at the trunk level. Active subjects were more symmetrical in the body composition of the limbs, more satisfied with their body image and showed a lower risk of developing depression when compared to control individuals. Part of the results of the thesis concerning the sample of Tai Chi Chuan practitioners was published. The article showed the practise of this discipline helped maintain low-fat mass levels in all body districts. Also, Tai Chi Chuan practitioners have in general a better nutritional status than their peers from the control sample. Other articles that investigate the ageing process and sport and address methodological issues have been published, or are in progress, as a result of the collaboration with several research groups from different countries, such as Portugal, Spain, and Brazil.

Stagi S., *et al.*, Lower Percentage of Fat Mass among Tai Chi Chuan Practitioners, *Int. J. Environ. Res. Public Health.*, 2020; **17**(4): 1232.

PhD program in Mathematics and Computer Science

Coordinator: Prof. Michele Marchesi
Vicecoordinator: Dott. Roberto Tonelli

https://dottorati.unica.it/matematicaeinformatica

The XXXIII cycle of the Doctorate of Mathematics and Computer Science saw the participation of eight doctoral students, five in a traditional doctoral course and three winners of PON-RI MIUR grants for industrial research doctorates in computer science. The latter carried out their research work in three locations, at University of Cagliari, at a foreign research institute and at a software company, respecting a research schedule agreed between the various locations and approved by MIUR. Two PON-RI PhD. students started their activities six months misaligned with the others and will end their third year in April 2021. Among the five PhD. students who completed the traditional path, two belonged to the mathematics curriculum, one to the big data curriculum and two to the computer science curriculum. In these three years, the doctoral students have carried out teaching support tutoring activities in various university courses and carried out the research path both in Cagliari and at foreign institutions, including: Universitat Politècnica de Catalunya, Barcelona (Spain), King's College London , London (UK), Kingston University, London (UK), IME-USP (Instituto de Matemática e Estatística da Universidade de São Paulo), São Paulo (Brazil), CIRM Luminy (France), INRIA - Lille (France), New York University, Eurecat - Technology Center of Catalonia, Barcelona (Spain), University of Technology, Sydney (Australia), PwC Luxembourg (Luxembourg), Aston University, Birmingham (UK). Some doctoral students have carried out support activities for the organization of the first and second edition of the Scientific School on Blockchain and Distributed Ledger Technologies, organized by the Department of Mathematics and Computer Science in collaboration with Sardegna Ricerche and CRS4. The third year of activity was characterized and influenced by the Covid-19 epidemic which in some cases slowed down the regular research activity and changed the way of interaction between doctoral students, tutors and research groups. Six of the eight doctoral students have requested an extension to two months to complete the planned activities. Their research produced several publications on international conferences and journals, including: Ann. Glob. Geom., J. Geom. Phys., Comm. On Pure and Appl. Math., J. of Mathematical Analysis and Applications, Electronic J. of Differential Equations, Complex Variables and Elliptic Equations, Lecture Notes in Computer Science, ACM Int. Conference Proceeding Series, IEEE Int. Workshop on Blockchain Oriented Software Engineering, Comm. in

Computer and Information Science, ACM Trans. on Graphics, Computers and Graphics, Robotics and Autonomous Systems.

Quantizations of Kähler metrics on blow-ups

Francesco Cannas Aghedu

Francesco Cannas Aghedu is going to complete his PhD in the field of Kähler geometry, under the supervision of Prof. Andrea Loi. He earned his B.Sc. and M.Sc. in Mathematics at the University of Cagliari. He was also mathematics tutor for some scientific undergraduate courses. He also authored the paper *On the balanced condition for the Eguchi-Hanson metric* (J. Geom. Phys., (2019) 137:35-39) and, joint with Andrea Loi, authored the paper quoted at the end of the contribution. During his doctorate he spent three months at King's College London (UK) to study with Prof. Simon Salamon. In addition, he spent two months in the Laboratory of Geometry and Dynamical Systems of the Polytechnic University of Catalonia (Barcelona) under the supervision of Prof. Eva Miranda. Finally, he spent three months in the Department of Mathematics and Statistics at University of São Paulo (Brazil) to collaborate with Prof. Roberto Mossa.

The main theme of his PhD Thesis, *Quantizations of Kähler metrics on blow-ups*, is the study of quantizations of Kähler manifolds. In particular geometric quantization and Berezin quantization of the blow-up of C^n at the origin endowed with suitable Kähler metrics. The modern theory of quantization was developed in the second half of the twentieth century and the term quantization mainly refers to a construction for passing from a classical mechanics system to the "corresponding" quantum system, which has the classical system as its limit. It is known however, that not all quantum systems have a classical counterpart and moreover, several quantum systems may reduce to the same classical theory. From the mathematical point of view, there are also obsta-

cles of different kinds, namely no general theorem of existence of quantization which satisfies the physical interpretation. As a result, nowadays we are faced the existence of many different quantization theories, ranging from geometric quantization, deformation quantization, Berezin quantization, asymptotic quantization or stochastic quantization, to mention just a few. None of the existing approaches completely solve the quantization problem; on the other hand, on the mathematics side all these have evolved into rich theories of their own right, and with results of great depth and beauty. Francesco focused his research on the study of quantizations of Kähler manifolds. A Kähler manifold is a manifold with three mutually compatible structures: a complex structure, a Riemannian structure, and a symplectic structure. The concept was first introduced by Erich Kähler in 1933. The Complex Euclidean space endowed with the flat form, and the Complex projective space endowed with the Fubini-Study form are classic examples of Kähler manifold. In complex geometry the blowing-up operation consists of replacing a point in a space by the space of all complex lines through that point. It is a local operation and in the case of the blow-up of C^n at the origin, we may think of it as obtained from C^n by replacing the origin 0 by the space of all lines in C^n through 0. This complex manifold endowed with suitable metrics has the structure of Kähler manifold. Additionally, Aghedu and Loi prove that the blow-up of C^2 at the origin endowed with the Burns–Simanca metric admits a regular (geometric) quantization. They use this fact to prove that all coefficients in the Tian-Yau-Catlin-Zelditch expansion for the Burns–Simanca metric vanish and that a dense subset of the blow-up of C^2 at the origin admits a Berezin quantization. They also prove that the generalized Simanca metric on the blow-up of C^n at the origin does not admit a regular quantization for any integer $n \geq 3$.

Cannas Aghedu F., Loi A., The Simanca metric admits a regular quantization, *Ann. Glob. Anal. Geom.*, 2019; **56**(3): 583-59.

Dirichlet problems for several nonlocal operators

Silvia Frassu

Silvia Frassu earned her bachelor and master's degree in mathematics at University of Cagliari, where she also attended her PhD. course in Mathematics and Computer Science under the supervision of Prof. Antonio Iannizzotto. Her research is devoted to the study of existence and multiplicity results for solutions of elliptic differential equations with fractional order and pseudo-differential inclusions driven by nonlocal operators, by applying variational and topological methods. This is the main topic of her PhD. thesis *Dirichlet problems for several nonlocal operators via variational and topological methods*, and of her papers published. During the three years, she has spent three months at University of Aveiro (Portugal) to collaborate with Prof. Vasile Staicu and Prof. Eugenio Rocha, two weeks in The Graduate Center of CUNY (New York) under the supervision of Prof. Marcello Lucia, and two weeks at Centro de Ciencias de Benasque Pedro Pascual (Spain) to take part in the workshop "VII Partial differential equations, optimal design and numerics".

Recently, great attention has been focused on the study of fractional and nonlocal operators of elliptic type, both for pure mathematical research and in view of concrete real-word applications, such as, among others, game theory, optimization, crystal dislocation and population dynamics. The main reason is that nonlocal operators are the infinitesimal generators of Lévy-type stochastic processes, which extend the concept of Brownian motion, where the infinitesimal generator is the Laplace operator. The most common example of nonlocal operator is

the well-known fractional Laplacian, a linear operator, denoted in the literature by $(-\Delta)^s$ with $s \in (0,1)$.

She focuses on the study of nonlinear Dirichlet problems driven by (linear and nonlinear) nonlocal operators in a smooth domain. The topological and variational approaches not only provide existence of one or several solutions, but allow to achieve relevant knowledge about the behavior and properties of the solutions, which is extremely valuable in the absence of an explicit resolutive strategy (as is usual for nonlinear equations). As a specific example of property of a solution that she looks for is the sign of the solution, that is, to be able to determine whether it is positive, or negative, or nodal (i.e., sign changing). Among others, in collaboration with A. Iannizzotto, she deals with a pseudo-differential equation involving the fractional Laplacian and a reaction term subject to either subcritical or critical growth conditions, depending on a positive parameter, under Dirichlet type conditions in a smooth domain. In the critical case, the main difficulty lies in the fact that the energy functional, associated to the problem, does not satisfy the (usual in variational methods) Palais-Smale compactness condition. As particular case, they consider a pure power reaction combining a sublinear (concave) term and a critical (convex) term and prove that the problem admits at least two positive solutions for small values of the parameter. Elliptic equations with critical powers of the unknown are the subject of a vast literature, including pioneering works of Brezis-Nirenberg and Ambrosetti-Brezis-Cerami. In the fractional framework, an analogous result was obtained by Barrios et al. The novelty of the approach, followed by Frassu-Iannizzotto, is that it is purely variational, mainly based on an abstract critical point theorem of Bonanno.

Frassu S., Iannizzotto A., Existence and multiplicity of positive solutions for the fractional Laplacian under subcritical or critical growth, *Complex Var. Elliptic*, 2020.

Using recommender systems to support decision-making in eCoaching platforms

Walid Iguider

Walid Iguider completed a Bachelor's degree in Mathematics and Computer Science at Mohammed V University of Rabat (Morocco) and a Master's degree in Software Quality at Sidi Mohamed Ben Abdellah University of Fez (Morocco), then he attended his PhD. course in Mathematics and Computer Science at the University of Cagliari advised by Prof. Salvatore Mario Carta and Dr. Ludovico Boratto. His research focuses on using Recommender Systems and Algorithmic Fairness to support decision-making in eCoaching platforms.

He was a visiting researcher at the Data Science and Big Data Analytics research group at Eurecat – Technology Centre of Catalonia (Barcelona, Spain). During his stay at Eurecat he was studying and implementing Learning to Rank and Algorithmic Fairness Algorithms.

He is also collaborating with Abinsula srl, which is a company that offers tailor made systems design, development and integration services in the Automotive, Precision Farming and e-Health domains.

During his collaboration with Abinsula and the company of its group focused on health platforms, Everywhere Sport, he designs and builds tailored software systems to help personal trainers support and guide people towards a healthy and active lifestyle.

Since coaches usually have to deal with several users at the same time, with no direct human contact, means that it is hard for them to quickly

spot who, among the people they follow, needs a timelier support. For that reason, he builds automated approaches that model users according to their workout performance, then rank them in ascending order of workout quality, thus suggesting first those with the worst performances.

The choice of introducing a recommender system between the end of a workout and the support offered by the coach is not only motivated by the large number of users that a coach follows, but also by the complexity of workout results (a workout is usually composed by different activities, such as running, walking, and resting, and each activity is in turn made up of several statistics, like the speed and covered distance), which need to be contextualized with the characteristics of the users (e.g., gender, age, and workout objective). The main goal of these approaches is to provide coaches with an initial filtering of the workout results, to facilitate their work.

Sensitive attributes of the users, such as the gender, are used by the ranking algorithms. Hence, there might be the risk for the users who belong to a certain gender to receive a disparate treatment, i.e., to receive a less timely support, because of an attribute that should not affect their ranking position. Indeed, relevance estimation by itself does not guarantee fairness of exposure. Hence, it is important that users receive a fair exposure, i.e., that their ranking positions are not affected by their gender.

In order to deal with this issue, he provides metrics to assess fairness of exposure and algorithms to re-rank the unfair lists.

Formal models for secure smart contracts

Stefano Lande

Stefano Lande is a PhD student in Mathematics and Computer Science, under the supervision of prof. Massimo Bartoletti. His research interests span from computer security to programming languages. More specifically, these topics join in his research of blockchain technologies. He earned a BSc and a MSc (both with honours) in Computer Science at the University of Cagliari. From 2015 to 2017, he worked as research assistant, where he started working on programming languages. Then, he transitioned to blockchain technologies during the master's degree and PhD program. During the PhD, he spent three months at the Mobility Reading Group of the Imperial College London, UK. Under the supervision of dr. Nobuko Yoshida, he has broadened his knowledge in programming languages research. Then, he furthered these topics at the Aston University, Birmingham UK., supervised by dr. Alceste Scalas.

Stefano's current research revolves around smart contracts, which are agreements between two or more parties, that can be automatically enforced without a trusted intermediary. Fallen into oblivion for several years, the idea of smart contract has been resurrected with the recent surge of distributed ledger technologies, led by Ethereum and Hyperledger. In such incarnations, smart contracts are rendered as computer programs executed by the nodes of a peer-to-peer network. These nodes collectively maintain the history of all transactions in a public, append-only data structure, called blockchain. A crucial feature of smart contracts is that their correct execution does not rely on a trusted authority: rather, the nodes which process transactions are assumed to be mutually untrusted. The absence of a trusted intermedi-

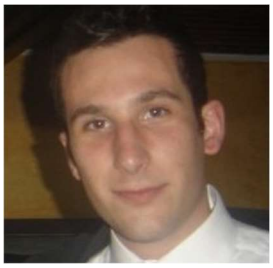
ary, combined with the possibility of transferring money given by blockchain-based cryptocurrencies, creates a fertile ground for the development of smart contracts. For instance, smart contracts may be lotteries, gambling games, contingent payments, and other types of financial contracts. Since smart contracts handle the ownership of valuable assets, attackers may be tempted to exploit vulnerabilities in their implementation to steal or tamper with these assets; consequently, it is particularly important to focus on security and correctness. For instance, a series of vulnerabilities in Ethereum contracts have been exploited, causing money losses in the order of hundreds of millions of dollars.

Stefano's thesis *Formal models for secure smart contracts* is focused on smart contracts on Bitcoin. Despite the wide variety of use cases witnessed by many works on Bitcoin smart contracts, no tool support has been provided yet to facilitate the development of Bitcoin contracts. Today, this task requires to devise complex protocols which, besides using the standard cryptographic primitives, can read and append transactions on the Bitcoin blockchain. Creating a new protocol requires a significant effort to establish its correctness and security: this is an error-prone task, usually performed manually. Stefano contributed to BitML, a high-level language for smart contracts, featuring a verification technique for relevant security properties. In his work, he developed a toolchain for writing and verifying BitML contracts, and for deploying them on Bitcoin.

Atzei N., *et al.*, Developing secure Bitcoin contracts with BitML. In *Proceedings of the 2019 27th ACM Joint Meeting on European Software Engineering Conference and Symposium on the Foundations of Software Engineering* (pp. 1124-1128).

QuadMixer: Layout Preserving Blending of Quadrilateral Meshes

Stefano Nuvoli



Stefano Nuvoli earned his B.Sc. and M.Sc. in Computer Science at the University of Cagliari, where he also attended his PhD. course in Math and Computer Science. His research focuses on Computer Graphics, specifically on Geometry Processing for Remeshing and Digital Fabrication processes. During his first year, he mainly worked on a project of Digital Fabrication with subtractive techniques, with the goal of finding a segmentation method that allows the production of 3D shapes with 4-axis milling machines. During the second and third years, he has spent a total of 11 months in Sydney, Australia, holding the position of Visiting Scholar at the University of Technology Sydney (UTS) under the supervision of Prof. Nico Pietroni. Here he started his projects on Remeshing processes for quadrangulation of blended surfaces.

The main contribution of his PhD. thesis *Retopology for blending quad-dominant meshes* is *QuadMixer* [Nuvoli et al. 2019], a novel interactive technique to compose quad mesh components preserving the majority of the original layouts. *QuadMixer* mimics all the conventional boolean operations for quadrilateral meshes, taking inspiration from the classical operations defined on triangles. The technique has been presented in an interactive tool to show its usability and robustness.

Previous solutions require a parametrization-based re-meshing [Bommes et al. 2009; Jakob et al. 2015; Myles et al. 2014; Pietroni et al. 2016] of the entire surface, resulting in a new meshing where the original connectivity is lost. *QuadMixer* blends two different connectivities

with a pure quad meshing, preserving all the quads in the patches which are not involved in the blending. Given two watertight pure quad meshes, a robust boolean operation is performed on the triangulated meshes. The surface to be preserved is identified by finding the quad layout patches which are not modified by the boolean operation. A tracing algorithm subdivides the surface near the intersections in new patches. The new patches are carefully quadrangulated, solving an optimization problem with boundary constraints. The re-meshed surface is stitched back to the untouched parts of the original models. The resulting mesh preserves the designed edge flow that, by construction, is captured and incorporated to the new quads.

Nuvoli S., *et al.*, QuadMixer: Layout Preserving Blending of Quadrilateral Meshes, *ACM Trans. Graph.*, 2019; **38**(6): 180:1-180:13.

Tools to Improve the Ethereum Blockchain' Usability

Giuseppe Antonio Pierro

Antonio Pierro graduated in Physics cum laude at University of Bari and after completion of the MA in Physics, received a PhD in Physics working on the "Compact Muon Solenoid" experiment at CERN (Genève, Switzerland), where he was in charge of developing a data management system to extract raw data from multiple sensors and converting them into understandable information.

Currently, my research is in the field of Blockchain technology, with a specific focus on the Ethereum Blockchain. Ethereum Blockchain has been created in 2015 with a cryptocurrency, called "Ether", which has quickly become the second-largest cryptocurrency by market capitalization, right after Bitcoin. A Blockchain is a digital public record of transactions. The name comes from its structure, in which individual records, called "blocks", are linked together in a single list, called "chain". One of the most common uses of the Blockchains is for digital payments without a third party, such as a bank or a notary.

While Blockchain is widely known for its use in cryptocurrencies such as Bitcoin, the technology has several other uses in different areas such as Healthcare, Insurance, Transportation and Energy. Indeed, the Ethereum Blockchain enables "smart contracts", i.e. computer programs which are executed when certain conditions are met. This provides an automated escrow system for transactions between two parties.

My research project has been conducted at the Department of Computer Science, University of Cagliari, in collaboration with the Agile Research Group under the supervision of Prof. Roberto Tonelli and Prof. Michele Marchesi. As part of a PON 2017 the research project has also been developed in collaboration with INRIA together with the RMOD research team under the supervision of Dr Stephane Ducasse. For what concerns my research abroad, the experience at INRIA allowed me to discuss my research plan with experts in software development and to deepen some aspects of my work, such as advanced concepts in Object-Oriented Programming.

The main research question guiding my PhD thesis, A User-Centered Perspective for the Blockchain Development, is "Can this new technology be fully *exploited* by expert and non-expert users?". The question concerns the usability of the Blockchain by different kinds of users, having different interests and/or expertise. The hypothesis that I am currently investigating is that, despite being used for more than 5 years, the Ethereum Blockchain technology could be further spread to both experts and non-experts by providing user-centered tools. Examples of user-centered tools for non-experts are more reliable Oracles than existing ones. In the field of computer science, Oracles are software systems which analyse data to make some predictions on future behaviours of the network. The concept of Oracle is strictly related to the smart contracts because Oracles are usually employed to verify facts and trigger the smart contract to be automatically executed. Part of my research has been dedicated to the design of a user-centered Gas Oracle. Gas Oracle assumes indeed a very specific meaning related to the activity of forecasting Gas prices. The Gas price is the fee the users need to pay to execute a transaction in the Blockchain and therefore it has significant economic implications. A user-centered Oracle should provide the users with the fairest prices, based not only on how much the users are willing to pay, but also on how much they are willing to wait to have their transaction executed, thus meeting their interests and requirements.

Pierro G.A., Rocha H., The Influence Factors on Ethereum Transaction Fees. IEEE/ACM 2nd WETSEB; Montreal, Canada, 27 maggio, 2019. New York: IEEE Press. ISBN: 978-1-7281-0869-8, 2019. 32-39.

Motion Planning in Static Environments

Raza Saeed

Raza Saeed graduated from the University of Salahaddin and he starts his academic carrier at Sulaimani University, Sulaimani, Iraq since 1995. He is currently in the final year of his PhD. at the University of Cagliari, Cagliari- Italy (from 2017), and he is a visiting researcher at the Faculty of Science, Engineering and Computing at Kingston University, London, UK (from May 2019). His research interests include Path Planning Algorithms, Artificial Intelligent, and Mobile Robot.

In robotics, the motivation of path planning is to find a path for a mobile robot to move from a starting point to a goal point in a given robot working environment based on certain optimization criteria, such as the walking distance, the energy consumption, and so on. It is expected that the robot reaches the final destination point safely through the shortest walking path within the minimum computational time. In this research work, a novel path planning method is developed for solving the path planning problem of a mobile robot. The developed method is used to find the shortest path for a mobile robot through a sequence of way-points that the robot has to traverse from the starting point to the goal point without colliding with any obstacles. The simulation results show that the developed method can successfully find the shortest path and generates a safe path for a single mobile robot to navigate in a complicated environment within a relatively short time.

Additionally, the developed method is extended further for solving multiple-goal planning problems instead of a single goal point location. The developed method can generate the shortest collision-free path that connecting a given set of goal points scattered randomly in a

robot working environment, efficiently. Moreover, this method takes a relatively short computational time to solve multi-goal path planning problems which makes it easy to implement in real-time navigation. Moreover, instead of a single robot, the developed method is also extended successfully to solve the multi-goal path planning problem for multiple mobile robot systems. While each robot has to find its path independently without collision with either static obstacles or other robots in the system. The simulation results demonstrate the effectiveness of the developed method for solving the multi-goal path planning problem for multi-robot systems. Furthermore, this study investigates another novel methodology for simulating crowd movement in a large and complex virtual environment, where the crowd consists of multiple groups. The intention of each group is different for visiting the number of goal points with different sequences of visits. The proposed methodology uses the multi-group microscopic model for generating real-time trajectories for each individual in each group. Based on the proposed methodology, each individual can adjust constantly their position and optimize their paths toward the desired goal points and avoid obstacles and other agents when they move closer. Additionally, this methodology takes into account the safety space and collisions among multiple agents, where each agent has a safe space. Furthermore, the safety zone around obstacles is also considered to avoid the possibility of overlapping the trajectories traced by agents with obstacle boundaries. The simulation results have shown that the proposed methodology is capable of describing the agent behavior in the virtual environment realistically.

Finally, simulations and experiments are performed on a real mobile robot to demonstrate the effectiveness of the developed method for solving path planning problems. The results obtained from the experimental tests show that the developed method can construct the shortest collision-free path and direct the real physical robot to the final destination goal point.

Automatic detection of frauds on crypto-currency

Sergio Serusi

Sergio Serusi is a PhD student in Computer Science, under the supervision of Prof. Massimo Bartoletti. His research interests span from computer security join together in his research of blockchain technologies. Blockchain technology is the main research topic he has focused on. In particular, he studied the various uses of blockchain technology: from social good to frauds. He earned a BSc and a MSc (both with honours) in Computer Science at the University of Cagliari. Then, he transitioned to blockchain technologies during the master's degree and PhD program. During the PhD, he spent six months at PWC Luxembourg as blockchain expert and one year with Abissi (Sestu, CA), a cybersecurity company.

Concerning frauds on crypto-currency, Sergio et al. investigate data mining techniques to automatically detect and quantify Bitcoin Ponzi schemes. In the absence of publicly available datasets, the first step was to retrieve from the web a collection of Bitcoin addresses related to Ponzi schemes. To this purpose they manually search the main discussion forums on Bitcoin (e.g., Reddit and bitcointalk.org) for advertisements of "high-yield" investment programs, that inevitably hide Ponzi schemes. Then, they visit the websites through which Ponzi schemes are operated (possibly recovering old snapshots through Internet Archive), hunting for their Bitcoin addresses. They expand the collection through a semi-automatic visit of the websites that are linked to Bitcoin addresses on blockchain.info/tags. Following this methodology, they

collect 32 Bitcoin addresses which gather deposits from investors of Ponzi schemes.

Overall, Ponzi schemes have received deposits for ~10 millions USD. Sergio et all. then devise a set of features that can be useful to characterise Ponzi schemes. These features range from simple statistics on the transactions to/from the frauds (e.g., overall transferred value, ratio between incoming and outgoing transactions, etc.) to more complex ones, like measures of inequality of the transferred values (e.g., Gini coefficients), and measures of the activity of the scheme (e.g., lifetime, average delay between incoming and outgoing transactions, maximum number of daily transactions, etc.). They extract from the Bitcoin blockchain the transactions of the frauds in their collection, and they compute a dataset of features, which they make publicly available. They complete the dataset with the features of 6400 randomly-chosen addresses. They use this dataset to experiment with various supervised learning algorithms, in order to automatically detect Ponzi schemes. They formalise the detection model as a binary classification problem, where the task is to distinguish between 'Ponzi' and 'non-Ponzi' class instances.

A number of experiments across different settings resulted in a detection model with good performance, which is finally applied, with promising results, to an independent set of data. The supervised method Random Forest proved to be the most effective and most versatile one. In that dataset, containing the features of 6432 addresses (proportion of one fraud to 200 not fraud), Random Forest has obtained a Recall of 96.9% for Ponzi schemes, and it has classified correctly 31 Ponzi schemes out of 32.

Bartoletti M., Pes B., Serusi S., Data mining for detecting Bitcoin Ponzi schemes, 2018 Crypto Valley Conference on Blockchain Technology (CVCBT), 2018/6/20; 75-84.

PhD program in Molecular and Translational Medicine

Coordinator: Prof. Sebastiano Banni

https://people.unica.it/molecularmedicine/

The Molecular and Translational Medicine graduate program at UNICA aims to provide students with a high-level research experience, complemented by a range of stimulating academic and training activities. Excellent mentorship is the cornerstone of the PhD. training. The overall goal is to empower students with the essential skills to pursue a distinguished career in biological and/or medical sciences, either in research institutions or in the biotech industry.

Molecular and Translational Medicine PhD program welcomes students from a variety of educational backgrounds.

Working in a truly multidisciplinary environment, students carry out their research in one of more than 20 Faculty research laboratories headed by well-established Italian and international scientists, further favored by the recent agreement with the Universitè Laval, Quebec City, Canada.

The two curricula encompass a broad spectrum of interests and research objectives with a common denominator, the translational approach to research.

- Molecular Oncology and Pathology: PhD Students in the molecular oncology and pathology curriculum investigate genetic/epigenetic alterations and molecular epidemiology of solid and ematologic cancers, cancer biomarkers of diagnostic and prognostic value, genes involved in the pathogenesis of rare genetic diseases, molecular mechanisms of neurodegeneration, molecular interactions of pathogens with the host.

- Nutritional and Metabolic Sciences: PhD Students in the nutritional and metabolic sciences curriculum investigate, at the molecular level, the nutritional and metabolic impact of nutrients in physiological and pathophysiological conditions where the nutritional and / or metabolic component is particularly relevant.

However, as you may evince from the PhD students' contribution of the 33rd cycle, the research conducted within the PhD program is much broader reflecting a great dynamism and continuous evolution of the scientific interaction between students and tutors.

Developmental neurotoxicity testing of chemical mixtures in zebrafish embryos

Alessandro Atzei

During my three-year PhD. in Molecular and Translational Medicine at the University of Cagliari, I had the pleasure to perform my research under the supervision of Prof. Alberto Angioni at the Department of Life and Environmental Sciences (DiSVA) and to enrich my PhD. experience spending my last year at the Dutch National Institute for Public Health and the Environment (RIVM) at the Center for Health Protection supervised by Dr. Leo van der Ven, Dr. Harm Heusinkveld and Dr. Ellen Hessel. I am from San Gavino M.le (US) where I studied at the high school "G. Marconi". Then, I graduated in Pharmacy at the University of Cagliari. I decided to apply for a PhD. position in Molecular and Translational Medicine driven by the desire to contribute to the preservation of human health. My PhD. has been a multitude of human and professional experiences that surpassed my expectations. It was a great opportunity to live abroad, to be fully in touch with a new culture where I could learn another language and to be faced up with a different working reality. The aim of my PhD. research project was to investigate the likely human health risk relating our daily exposure to environmental mixtures of chemical compounds. The first part of the research was conducted at the University of Cagliari where, in order to obtain a reliable overview of the environmental pollution, a preliminary analytical screening of common food contaminants (i.e. pesticides), was carried out. To do that, the most recurrent alimentary matrices were submitted to liquid and gas chromatography methods coupled with mass spectrometry techniques. Successively, at the RIVM, I focused my attention on the hypothesis that prenatal exposure

to environmental pollutants may increase the incidence of neurodevelopmental disorders such as autism spectrum disorder and attention deficit-hyperactivity disorders. To test my hypothesis, I used the zebrafish (*Danio rerio)* embryo as study object due to its high level of conservation of processes involved in development of the brain, the presence of most human-relevant neurotransmitter pathways and the development of a blood-brain-barrier. Moreover, it displays remarkable practical advantages, including being transparent during development, which allows for direct observation of developmental delay and malformations. Also, within 5 days post fertilization (dpf) the zebrafish embryo is not considered as an animal experiment according to European legislation. The locomotor activity is a sensitive endpoint for developmental neurotoxicity (DNT) assessment because it depends on the integrity of brain function and nervous system development. Therefore, in order to obtain experimental support for the study hypothesis, the locomotor activity of 5 dpf zebrafish embryos following chronic exposure to three pharmaceuticals of concern, carbamazepine (CBZ), fluoxetine (FLX) and venlafaxine (VNX) as well as their main metabolites, carbamazepine 10,11 epoxide, norfluoxetine and desvenlafaxine was tested. Next, to reproduce the real-life scenario of exposure, the target compounds were tested in binary mixtures of CBZ-FLX, CBZ-VNX and FLX-VNX. The resulting cumulative effect of the mixtures was assessed applying the dose-addition model as suggested by the European Food Safety Authority. Taken together, the results from these experiments confirm that low doses of environmental contaminants may contribute to the increasing incidence of neurodevelopmental disorders by forming active mixtures. Interested in more detailed results? You can read all about it next year in my publication!

A study of agranulocytosis induced by deferiprone in β-thalassemic patients

Antonina Balsamo

I come from Turin where I hold a master's degree in medical biotechnology and a postgraduate scholarship in Clinical Pathology.

I did my PhD attending the Clinical Metabolomics Unit, Department of Biomedical Sciences. The main goal of metabolomics is to detect and quantify a great number of small molecules in biological samples. The Clinical Metabolomics Unit, carrying out metabolomics analyses in collaboration with different clinical groups, is trying to better understand the role of metabolic changes in biofluid and tissues to identify new biomarkers of disease, the response to the therapy. Title of my study, performed in collaboration with Department of Medical Science and Public Health, Clinical and Molecular Medicine Unit, University of Cagliari c/o Regional Hospital for Microcythemias, is: "*A study of granulocytes damage induced by deferiprone in β-thalassemic patients through a metabolomics approach*"**.** β-Thalassemia is one of the most prevalent forms of congenital blood disorders, characterised by a reduced or absent ability to produce haemoglobin. The mainstay of treatment consists of transfusion. Repeated transfusions result in an excessive accumulation of iron in the body, removal of which is achieved through iron chelating agents. Deferiprone is the first orally bioavailable iron chelator approved for clinical use in 1997. Considering its potential toxicity, the use of Deferiprone is allowed in Europe only for the treatment of thalassemia major, when Deferoxamine, the first choice iron chelator, therapy is contraindicated or unappropriated. The main Deferiprone adverse effect is the development of agranulocytosis (in 1–2% of patients), which can

induce the death of the Patient. The mechanisms behind this unpredictable negative effect remain largely unresolved. The oxidative stress, which plays a crucial role in the pathophysiology of β-thalassemia, can induce cytotoxicity, and its possible role in the agranulocytosis is suggested. Moreover, possible changes in cellular metabolism may be present. My project aimed to analyse and compare the metabolomics profiles in polymorphonuclear leukocytes, from thalassemic patients enrolled in the study. Identify molecular markers able to predict the onset of agranulocytosis might reduce the incidence of this event, minimizing its complications and shedding some light on the physiopathological mechanisms of this effect.

Can probiotics protect the human gut against oxysterols?

Emanuela Casula

I started my university studies in 2012 obtaining, first a bachelor's degree in Biotechnologies in 2015, and then a master's degree in nutrition and food sciences in 2017. In the same year, I started my PhD research activity, in the research group of the Experimental Pathology Unit (Dept. of Biomedical Sciences) at the University of Cagliari, working mainly on cell cultures and molecular biology techniques, in order to investigate the interaction between human intestinal cells and food compounds, in particular cholesterol oxidation products (oxysterols) and probiotics. Part of the trials were also carried out with the collaboration of the Laboratory of Applied Hygiene (Dept. of Medical Science and Public Health), where I had previously worked during my bachelor's degree internship, to set up appropriate experimental procedures to cultivate the bacterial strains.

During the three years of my PhD, I had the opportunity to spend nine months at the University of Roehampton in London, where I could increase my competence in the pathology and microbiology field, working on batch culture systems in order to study how human gut microbiota reacts against external substances, as 'potentially dangerous' oxysterols and 'potentially protective' probiotics. In particular, the aim of my thesis research project '*Ability of probiotic Lactobacillus strains to mitigate permeability alterations induced by oxysterols on human intestinal epithelium*', was to evaluate the capacity of probiotic strains of *Lactobacillus*, present in commercial products, to protect the intestinal environment against potential damage induced by dietary components,

with a focus on oxysterols. Oxysterols have been proven to cause oxidative stress and inflammation, which impact intestinal integrity, determining the loss of epithelial barrier function, a crucial factor in the initiation and progression of pathological intestinal disorders such as inflammatory bowel diseases (IBD) and cancer. Several studies reported that probiotics, in particular *Lactobacillus* species, exert anti-oxidant and anti-inflammatory effects and they can improve the positive role of the residential gut bacterial population, called microbiota. The first objective of my research project was to test the effect of the bacterial extracts (the intracellular content of the tested strains) in a human intestinal cell models, using Caco-2 cells. Cells were pre-treated with a mixture of oxysterols representative, in the composition and in the concentration, of what could be present in foods. The protective action of the bacterial extracts was evaluated as ability to counteract the disruption of epithelial integrity, indicated by an altered permeability, measured as variation of transepithelial electrical resistance (TEER). The tested bacterial extracts were able to protect the Caco-2 monolayers, mimicking the epithelial barrier, against oxysterols-induced damage. As epithelial permeability alteration is likely to occur in relation to tight junction modulation, we investigated some of the tight junction proteins, Junctional adhesion molecule A (JAM), Occludin and Zonulin (ZO-1), through electrophoresis and Western Blotting. Cell signalling pathways involved in the modulation of tight junction proteins, as those related to MAPKs, were also studied. Data collected so far highlighted the capacity of the tested *Lactobacillus* strains to protect Caco-2 cells monolayers against oxysterols-induced barrier dysfunction, through the inhibition of the tight junction proteins alteration due, at least in part, to the ability to modulate MAPKs pathways.

Ongoing studies are focused on the interaction between oxysterols and/or the tested strains of probiotics and human microbiota. I'm investigating, in particular, if oxysterols and/or probiotics may affect microbiota composition and metabolites production, thus exerting a further modulatory effect in the intestinal homeostasis.

Role of hepatic microenvironment in NAFLD progression

Simona Onali

My research experience started during the last year of Medical school, when I joined the Liver Unit of Cagliari University Hospital, under supervision of Prof. Luchino Chessa. After graduating from Medical school, I specialized in Internal Medicine at the University of Cagliari. In the course of my post-graduate training, I spent one year as honorary fellow at the Sheila Sherlock Liver Centre (Royal Free Hospital, London, UK), working on the complications of cirrhosis and liver cancer. In 2017 I was granted a PhD in Molecular and Translational Medicine at the University of Cagliari, joining the Oncology and Molecular Pathology Unit directed by Prof. Amedeo Columbano. My project entitled "*Role of hepatic microenvironment in NAFLD progression*", supervised by prof. Andrea Perra, aims at investigating the behaviour of hepatic stellate cells across the different stages of non-alcoholic fatty liver disease (NAFLD), one of the leading cause of cirrhosis and liver cancer worldwide. Hepatic stellate cells are well-known drivers of liver fibrogenesis thus represent a key component of the hepatic microenvironment. Two different experimental approaches are used to better understand the molecular mechanisms underlying their pro-fibrogenic activated phenotype. The first consists in the use of a new 3-dimensional culture model, developed in the laboratory directed by Prof. Massimo Pinzani at the Institute for Liver and Digestive Health, University College London, which I attended for one year during my PhD course.

This innovative culture system, based on decellularized human healthy and diseased liver extracellular matrix scaffolds, allows to better characterize hepatic stellate cell phenotype/behaviour according to

the different changes in the hepatic microenvironment. Secondly, further analysis is performed by using an *in vivo* experimental model of NAFLD that recapitulates all different stages of the human disease.

Impact of a Mediterranean diet on the Gut Microbiota of obese patients

Silvia Pisanu

Obesity, a chronic disease that has reached a pandemic dimension, can be defined as abnormal or excessive fat accumulation, associated with major health risks. The gut microbiota (GM), the community of microorganisms colonizing the gastrointestinal tract, is needed for the proper development of infants and the maintenance of homeostasis and health throughout life. In fact, compositional changes of GM have been linked to metabolic disorders, including obesity, and functional gastrointestinal disorders. It has been observed that an alteration of the intestinal microbiota is among the risk factors associated with obesity; on the other hand, it is known that the composition of the microbiota is influenced by lifestyles, and that the diet is among the most important modifiable factor affecting the composition of the gut bacteria. My primary research topic relates to the interface between diet, GM and host health in human models, with a focus on obesity. During the research period spent abroad, at the International Agency for Research on Cancer (Lyon, France), I was involved on a project aimed at identifying lifestyle factors associated with a better intestinal microbial profile, in order to evaluate the possible role of these factors in the prevention of colorectal cancer. I also participated in a validation study aimed to explore the stability and accuracy of the fecal immunochemical test (FIT) tubes, currently used for the screening of colon-rectal cancer, for the analysis of the GM.

The aim of my PhD thesis, entitled "*Gut microbiota alterations associated with obesity and evaluation of the impact of a weight-loss intervention based on a hypocaloric balanced diet*", was to characterize the GM of a cohort of overweight/obese patients in Sardinia (Italy) and to explore the potential role of a three months-nutritional intervention in modulating the GM composition. The GM was analyzed by using the "Next Generation Sequencing" technology, which enables to examine the entire genomic content of the microbial community, including those organisms that are uncultivable. Regarding the GM characterization in obese and overweight Sardinian individuals, an increase in Firmicutes members and a depletion in Bacteroidetes members was observed. Alterations in the contents of these two dominant bacterial phyla could be associated with a higher presence of enzymes involved in carbohydrate degradation and fermentation and therefore to a greater caloric production. In addition, an increase in Enterobacteriaceae taxa, Gram-negative bacteria known for holding pro-inflammatory properties, was also documented. After the baseline characterization, patients followed a weight-loss intervention, based on a balanced Mediterranean diet (MD) with a moderate caloric restriction. Noteworthy, the MD showed to be effective not only in reducing body weight and waist circumference but also in modifying numerous microbial profiles. In fact, an increase in the abundance of several Bacteroidetes taxa and a depletion of many Firmicutes taxa were observed. In particular, the changes in GM composition after the intervention suggested a decrease in Short Chain Fatty Acids (SCFAs)-producing bacteria, which had shown a high content at baseline, compared with normal-weight controls. SCFAs are produced by GM from dietary carbohydrates and proteins that reach the colon, and it has been suggested that they may promote obesity via increased energy availability. Taken together, findings from the present work allow the identification of novel taxa associated with obesity, with potential therapeutic relevance, and highlight the potential benefit of a moderately restrictive nutritional approach based on the Mediterranean model in counteracting the gut dysbiosis, commonly observed in obese and overweight patients.

Pisanu S., *et al.*, Impact of a Moderately Hypocaloric Mediterranean Diet on the Gut Microbiota Composition of Italian Obese Patients, *Nutrients*, 2020; **12**(9): E2707.

Lactate cross-talk between cancer cells and macrophages

Marina Serra

My interest in liver diseases, in particular liver tumors, started during my master's degree in medical, Sanitary and Veterinary Biotechnologies obtained at the University of Sassari. During this period, I spent several months at the University of Greifswald (Greifswald - Germany), working on the signaling pathways involved in hepatocarcinogenesis. Later on, I decided to apply for a PhD position at the Molecular and Translational Medicine program under the supervision of Prof. Amedeo Columbano, whose research group is internationally known in the field of hepatocellular carcinoma (HCC). My PhD research interest is focused on the study of the metabolic alterations that occur in cancer cells during tumorigenesis. Recently, metabolic reprogramming has been identified as one of the main features of cancer cells (Hallmarks of Cancer), as it is required to enhance cell proliferation as well as cell survival. My current research is aimed at identifying the metabolic alterations that take place during HCC development. In this context, the so-called Warburg effect plays a critical role as it defines a mechanism by which tumor cells increase glucose uptake even in presence of high levels of oxygen. This results in the production of a large amount of lactate which promotes the emergence of an immune-permissive micro-environment[1].

Based on these premises, we are investigating the *lactate cross-talk between cancer cells and immune cell, such as macrophages, in a hepatocellular carcinoma background*, through two different approaches. On the one hand, we are trying to inhibit tumorigenesis by deleting the gene responsible for lactate production in cancer cells. On the other hand, con-

sidering the role of microenvironment and of the immune system in cancer development and progression, in the second approach, we are studying the effect of the deletion of the transporter responsible for lactate uptake by immune cells, in particular macrophages.

PhD program in Neuroscience

Coordinator: Prof. Paola Fadda

https://people.unica.it/dottoratoneuroscienze/

The PhD International program in Neuroscience is settled at UNICA Departments of Biomedical Sciences, Medical Science and Public Health, which actively collaborate with Italian as well as foreign Universities, research centers and private companies/industries. PhD Faculty board includes both basic and clinical researchers from UNICA and foreign Universities within the international PhD agreement. Some faculty board members belong to the CNR Institute of Neuroscience. Because of the discrete skills of PhD faculty board members, the research covers multiple neuroscience topics, including neuroanatomy, neurophysiology, neurobiology, neuropathology and neurodegenerative mechanisms, neuropsychopharmacology, behavioral neuroscience, diagnostic biomarkers, and the testing of novel compounds active in the CNS.

The Neuroscience PhD program offers a highly qualified scientific education based on practical training within productive and internationally renowned research groups, in order to provide the required skills to work in the scientific research field.

Semiautomatic analysis of sleep microstructure parameters

Rosamaria Lecca

Education: I graduated in 2012 in Medicine and Surgery and specialized in 2017 in Neurology at University of Cagliari. During the years of training as a neurologist I developed my interest in Sleep Medicine and I acquired experience in the analysis of Electroencephalography (EEG) and Polysomnographic (PSG) exams. During specialization I also spent six months as Honorary Researcher at the Sleep Neurology Centre at Queen Square Hospital in London where I developed my specialization thesis.

PhD research activity: In 2017 I started my PhD program in Neuroscience, my PhD scholarship is financed within the project "PON-RI 2014-2020 Dottorati innovativi a caratterizzazione industriale", a particular PhD program involving the collaboration with a company and with a foreign university.

At University of Cagliari I carry out my research work at the Interdepartmental Sleep research Centre under the supervision of Prof. Monica Puligheddu. I participated to different studies particularly on Restless Leg Syndrome, Circadian Rhythm Disorders and Sleep Disorders associated to Neurodegenerative diseases such as Parkinson and Dementia. I also took part as a sub investigator in an IIB-phase for a drug experimentation.

My special field of research is the analysis of the Cyclic Alternating Pattern (CAP), which is a periodic EEG activity that is present in sleep.

CAP analysis provides information about the sleep microstructure, and is a marker of sleep instability, it's widely used for research purpose, and its analysis is a very time-consuming process.

The title of my Thesis is "*Semiautomatic analysis of sleep microstructure parameters: arousal, Cyclic Alternating Pattern and REM sleep atonia*" and is focused on the creation and use of a software for the analysis of particular parameters of a polysomnography.

The industrial partner of my scholarship is a company based in Mogliano Veneto (TV): Micromed®, an Italian company for the development and manufacturing of hardware and software for Neurophysiology diagnosis, such as EEG and PSG. I spent six months with them working side by side with the research & development engineers for the creation of the software for the analysis of CAP. I individuated al the criteria and parameters that the software had to satisfy, and I supervised the project and validated step by step all the results obtained. The software now allows the semiautomatic analysis of CAP in a with their software Brain Quick and calculates all the parameters for the report and for research use. I used the software in a study aimed to assess differences of CAP in a population of patients with epilepsy and disorder of arousal.

As a part of the project I also spent six months at Clermont Ferrand University (Universitè of Clermont-Auvergne) in France. I worked at the Sleep Centre and at the laboratory of Neuropsycopharmacology of Subcortical Dopaminergic System under the supervision of Prof. Maria Livia Fantini. During those months I participated to the clinical and research activity of the group and finalized the second part of my thesis project: the automatic analysis of muscular activity during sleep.

I analyzed with a semiautomatic software the activity of muscles during all sleep phases in three population of patients affected with Parkinson's disease, Multiple System Atrophy and healthy controls. My results showed that this analysis can help to discriminate the MSA patients from Parkinson's, which can be a helpful neurophysiologic parameter for such a difficult differential diagnosis.

Promising drugs to treat alcoholism

Irene Lorrai

November 2017 to present. Ph. D. Student in Neuroscience at University of Cagliari.
November 2017-April 2019. Ph. D. visiting student at the Department of Immunology and Microbiology, The Scripps Research Institute, California, USA.
February 2014-November 2017. Intern and later Research Fellow, at the Laboratory of Behavioral Pharmacology, Institute of Neuroscience, section of Cagliari, of the National Research Council (CNR).
June 2013. Board Certified Pharmacist
February 2013. Graduation in Pharmaceutical Chemistry and Technologies at University of Cagliari.

My experience in carrying out research began in 2014 at the Laboratory of Behavioral Pharmacology, Institute of Neuroscience, section of Cagliari, of the National Research Council (CNR). I was involved in preclinical research studies aimed at understanding and examining the neurobiological bases and mechanisms that characterize alcohol use disorder (AUD), a worldwide chronic disease. For this purpose, I employed a well-characterized animal model of AUD called Sardinian alcohol-Preferring (sP) rat. These rats have been selectively bred for high alcohol preference and consumption; when posed in the condition to choose between a bottle containing water or another one containing an alcoholic solution [10% (v/v)], they voluntary drink large amounts of alcohol, meeting most of the fundamental criteria for an animal model of AUD. In 2017, I started my PhD program in Neuroscience that allowed me to perform a relevant part of my studies and research in California at the Scripps Research Institute (TSRI). I really enjoyed my

overseas experience because it lets me meet brilliant scientists from all over the world and contributed a lot to the enhancement of my professional skills. One of the studies I took part during my stay at Scripps Research regarded the role of an ATP-channel known as PANX-1 on AUD. We demonstrated that the administration of Probenecid, an approved drug clinically used to treat gout, reduced alcohol self-administration in alcohol-dependent and non-dependent rats and decreased excessive alcohol drinking in a binge-like drinking model in mice. These results are of relevance as they confirm the alcohol ATP-mediated action and support the *"drug repositioning or repurposing"* strategy, according to which an already approved drug can be employed for new therapeutic purposes.

Currently, I have been working on my Ph. D. thesis entitled *"In vivo characterization of the anti-addictive properties of COR659 in rodents"*. COR659 is the most interesting outcome of a project of medicinal chemistry intended at synthetizing and testing novel positive allosteric modulators (PAMs) of the $GABA_B$ receptor. GABAergic neuro-transmission has a crucial role in AUD, and preclinical studies demonstrated that PAMs like for example, GS39783, CGP7930 etc., are able to reduce voluntary alcohol drinking in mice and rats, producing – as a results of their lack of intrinsic activity- fewer side effects compared to the "traditional" agonists of the $GABA_B$ receptor. The aim of my Ph. D. project is then to evaluate and characterize the anti-alcohol, and more widely, anti-addictive properties of COR659 in rodents. Our latest results showed that COR659 effectively reduces the reinforcing and motivational properties of alcohol in sP rats, suggesting a potential use of COR659 for treating AUD. Also, we recently demonstrated that COR659 suppresses locomotor hyperactivity induced by cocaine, amphetamine, nicotine, and morphine in mice (an animal model of the human euphorigenic effects of drugs of abuse). Together, these data suggest that, at least at preclinical level, COR659 displays a broad anti-addictive profile.

Tunstall B.J., *et al.*, Probenecid Reduces Alcohol Drinking in Rodents. Is Pannexin1 a Novel Therapeutic Target for Alcohol Use Disorder? *Alcohol Alcohol*, 2019; 54: 497-502.

Investigating the Cannabis Gateway Hypothesis

Paolo Masia

2014 Bachelor's Degree in Biological Sciences at the University of Sassari; 2017 Master's Degree in Neuroscience at the University of Trieste/SISSA; PhD candidate at the University of Cagliari, and 2018-2019 PhD visiting student at the NIDA/NIH of Baltimore (USA), 8 months. Awarded with two Erasmus scholarships: University of Toledo (Spain), 12 months; University of Pablo De Olavide, Sevilla (Spain), 6 months. Fluent in English (C1) and Spanish (C1) with academic certifications.

I joined Professor Paola Fadda's research group on October 2017. We investigated the effects of cannabis use, in the context of the 'Gateway Hypothesis', which postulates that the consumption of a drug (such as cannabis) during adolescence increases the likelihood to consume other illicit drugs (such as cocaine) at a later point in life. Coherently with my thesis project, I have also spent 8 months as a visiting PhD student at the National Istitute On Drug Abuse (NIDA/NIH), Baltimore, USA, under the supervision of Dr. Gianluigi Tanda.

We treated chronically both adolescent and adult male rats with WIN (a synthetic cannabinoid), and we then challenged them with cocaine after a period of abstinence. We found that adolescent, but not adult WIN-pre-treated rats showed a significant increase in the amplitude of dopamine release in the Nucleus Accumbens (NAcc), and in the motor-activating effects of cocaine compared to vehicle-pre-treated ani-

mals. Furthermore, we found that cocaine-induced behavioral cross-sensitization of WIN-pre-treated rats correlates with a variety of molecular modifications at the level of both pre-frontal cortex and NAcc. Thus, our results suggest that cannabinoid consumption in rat adolescence is able to reprogram the behavioral, molecular, and epigenetic response to cocaine.

Scherma M., *et al.*, Cannabinoid exposure in rat adolescence reprograms the initial behavioral, molecular, and epigenetic response to cocaine, *PNAS*, 2020; **117**: 9991–10002.

Functional Brain Networks: intra and inter-subject variability

Sara Maria Pani

2017 Master's Degree in Medicine e Surgery and Medical Licence, University of Cagliari; 2018-2019 Visiting Ph.D. Student Brain, Mind and Society Research Hub, Monash University (VIC, Australia); 2020 Neurology Tutor, School of Medicine and Surgery, University of Cagliari.

From October 2017 enrolled in the PhD program in Neuroscience at the University of Cagliari, under supervision of Monica Puligheddu and Matteo Fraschini. Thesis title "*Functional brain networks: intra and inter-subject variability in healthy individuals and patients with neurological and neuropsychiatric diseases*". The common thread of the project I'm carrying out concerns how brain networks vary across individuals in both healthy and clinical conditions. In the first study conducted (Pani et al., 2020) we aimed to investigate how the variability due to subject, session and task affects electroencephalogram (EEG) power, connectivity and network features estimated using source-reconstructed EEG time-series. The results show a remarkable ability to identify subject-specific EEG traits within a given task, together with striking independence from the session. This then suggests that power and connectivity EEG features may be adequate to detect stable individual properties within predefined and controlled tasks. These results may have important implications for both bio-engineering and clinical applications, and about these last it would be of relevance to investigate how connectivity and network similarity across tasks and sessions varies in the presence of diseases.

Winner of one of the 2018 GlobusDoc mobility grant for extra-EU training activities, I spent 10 months of the second year (October 2018 - August 2019), at the Brain Mind and Society Research Hub (ex BMH) of the Monash University (VIC, Australia), under supervision of prof. Alex Fornito. It was an exceptional opportunity to acquire new technical skills and to live in a challenging and multiethnic working environment, which has given me a lot both at professional and human level. I worked on fMRI (functional magnetic resonance imaging), and I applied partial least square analysis on an healthy cohort to evaluate how different specific aspects of psychosis-like experiences related to functional connectivity. We found an association between the functional connectivity of the circuit linking dorsal caudate and regions of left dorsolateral- and medial- prefrontal cortex, and general psychosis-like experiences severity, with a spatial correspondence with circuits changes suggested as risk phenotype for psychotic diseases.

The last work I'm working on has the aim of investigate whether it is possible by using 19 channels sleep scalp EEG to highlight local sleep alterations in the brain of patients affected by non-rem parasomnias and sleep-related hypermotor epilepsy. We focused on sleep stage N2 and N3, of nights without clinical episodes, and we are carrying out analysis on the periodic and aperiodic component of the EEG power spectra, connectivity and network. Our purpose is to evaluate if some of the features extracted may be useful to distinguish the two pathologies providing sleep experts an important tool to make the differential diagnosis easier.

Pani S.M., *et al.*, 2020. Subject, session and task effects on power, connectivity and network centrality: A source-based EEG study, *Biomed. Signal Process. Control*, 2020; **59**: 101891.

Cerebellar transcranial magnetic stimulation in movement disorders

Angela Maria Sanna

I graduated in Biological Science in 1997 and I have worked for almost 15 years in preclinical neuroscience. I graduated at University of Cagliari in Medicine in 2011 and I specialized in Neurophysiopathology in 2017. During specialization I learnt the principal neurophysiological techniques applied to disorders of central and peripheral nervous system. I published 22 papers indexed on Pubmed and my H-index score is 13.

I'm now conducting my PhD in Neuroscience at University of Cagliari, under the supervision of my tutor, Professor M. Puligheddu, focusing on the therapeutic effect and mechanisms of action of transcranial magnetic stimulation (TMS) in movement disorders. I also collaborate with University of Sassari, studying the effects of TMS in substance use disorders.

The main project of my PhD (*Therapeutic use of cerebellar transcranial theta burst magnetic stimulation in movement disorders. Mechanisms of action and biomarkers of efficacy*) has been focused on the effect of TMS in different movement disorders targeting cerebellum which is functionally and anatomically linked to the other areas of the motor system. Due to its peculiar role in motor learning and control it represents an interesting target for neuromodulation techniques. My research has shown that the inhibition of cerebellum activity by TMS is able to reduce levodopa-induced diskinesia (LID) in patients affected by Parkinson's Disease, that this effect is mediated by a reduction in serum

BDNF levels and is influenced by a polymorphism of the BDNF gene. I also studied the effects of cerebellar stimulation by TMS in Multiple System atrophy (MSA), an atypical parkinsonism, and a hereditary spino-cerebellar ataxia, SCA-38. My results indicate that a cerebellar excitatory stimulation is able to ameliorate ataxia and other motor symptoms. Ongoing research will explore mechanisms of action of TMS by the characterization of serum BDNF levels and the analysis of brain connectivity by quantitative electroencephalography.

Sanna A.M., *et al.*, Cerebellar continuous theta burst stimulation reduces levodopa-induced dyskinesias and decreases serum BDNF levels, *Neurosci. Lett.*, 2020; 716: 134643.

Effects of gene by environment interaction on the mesolimbic system

Valeria Serra

I obtained a BA in Biological Sciences and a MA in Neuropsicobiology at the University of Cagliari. I am currently attending the 3rd year of the Neuroscience PhD program at the University of Cagliari under the supervision of Miriam Melis.

My PhD research project aims at revealing the effects of early life adversity on social behavior and abuse of drugs with a focus on the effects on mesocorticolimbic system during peri-adolescence, a critical window of vulnerability. Indeed, the interaction between environmental (e.g., early stress exposure, drug use) and genetic factors during this period can alter neuronal development (i.e., neuronal differentiation, dendritic arborization, dopaminergic projections) and may result in psychiatric disorders (e.g., schizophrenia, ADHD, autism, conduct disorder). The dopamine system plays an important role in rewarding effects of drugs and in behavioral addictions (e.g., food, shopping, gambling, sexual behavior). The mesocorticolimbic dopamine system originates in the ventral tegmental area (VTA) where dopamine cells projecting to subcortical limbic regions (i.e., nucleus accumbens, amygdala,) and to cortical areas (i.e., medial prefrontal cortex). This pathway is also implicated in neurobiological mechanisms of other psychiatric disorders such as schizophrenia, depression and conduct disorder.

I am, therefore, involved in the study of synaptic changes in the mesolimbic system in a mouse model of gene by environment interaction, which shows an aggressive behavior at pre-adolescence and a vulnerability towards the psychostimulant effects of cocaine.

Besides my specific PhD project, I have also been involved in the study of the effects of prenatal cannabis exposure on the progeny.

To achieve these goals, I performed the following experiments:

1) behavioral observations of maternal behavior, spontaneous locomotor activity, pre-pulse inhibition, risk-taking behavior, anxiety-like behavior, resident intruder and social interaction tests not only to study physiological mechanisms underlying the development of neuropsychiatric disorders, but also the effects of different drugs that alter or restore behavior;
2) electrophysiological recordings by means of ex vivo patch clamp technique in acute brain slices to study electrical activity and synaptic properties and plasticity of dopaminergic neurons in the VTA and pyramidal neurons in the prefrontal cortex (PFC).

Coherently with my research project, I was planning to spend six months in France at the laboratory of Professor O. Manzoni (INMED, Institut de neurobiologie de la méditerranée, Marseilee, France), but it has been postponed due to the Covid-19 health emergency.

Frau R., *et al.*, Prenatal THC exposure produces a hyperdopaminergic phenotype rescued by pregnenolone, *Nature Neurosc*, 2019; **22**: 1975-1985.

The overlap between Neuropsychiatry & Rheumatological/inflammatory disorders

Marcello Giuseppe Tanca

Marcello G. Tanca has been trained at the University of Cagliari -Department of Biomedical Sciences - under the supervision of Alessandro Zuddas and Antonella Gagliano, working at the Child & Adolescent Neuropsychiatry Unit.

The first year of the PhD Program has been devoted to training on specific clinical and therapeutical approaches to Neuropsychiatric Disorders such as the Tourette's Disorder, including the participation to an international multicenter registrative clinical trial evaluating the long-term efficacy and safety of Deu-tetrabenazine (a vesicular monoamine transporter 2 inhibitor) in children and adolescents with Tourette Syndrome.

The following two years have been devoted to a specific research program on developmental neuropsychiatric disorders with neuroinflammation as main pathogenic factor, the so called Pediatric Acute-Onset Neuropsychiatric Syndrome (PANS). PANS is a clinically heterogeneous disorder described the first time in 2012 as result of evolution of the clinical and biological construct Paediatric Autoimmune Neuropsychiatric Disorders Associated with Streptococcal infections (PANDAS), which originally identified a subset of patients with Obsessive-Compulsive Disorder (OCD) and Tics for whom the onset of symptoms appeared related to a Group A β-hemolytic Streptococcus (GABHS) infection.

The current conceptualization of PANS defines a group of pediatric autoimmune-mediated inflammatory brain diseases that may be triggered by different environmental agents (e.g. stress, substances, virus or bacteria), in subjects with a brain susceptibility to autoimmunity. In fact, neuroinflammation has been postulated to have a pathogenic role in many psychiatric illness (e.g. Major Depressive, Bipolar, Schizophrenia, Obsessive-Compulsive Disorders.

Main lines of research have been focused on exploration and description of three aspects:

1. The associations between the different PANS features using the Artificial Neural Networks (ANN) approach to exploit putative simultaneous connections among the full spectrum of clinical variables and different domains of impairment;
2. The clinical and polysomnographic features in children diagnosed with PANS with no medications nor nutracetincs for at least 4 weeks before enrollment to establish sleep a possible major criterium for diagnosis;
3. The serum metabolomics profile of children with PANS through the Nuclear Magnetic Resonance Spectroscopy (NMR) technique. The Metabolomics results in 34 PANS patients (25 controls) suggested that the abnormal tryptophan metabolism might play a role in the pathophysiology of PANS (clinical presentation encompasses tic, obsessive, psychotic and anxiety symptoms). Oxidative stress seems to play a crucial role in PANS.

In 2020 he has been a Visiting Researcher at the Stanford University School of Medicine - Department of Pediatrics – in California, under the supervision of Jennifer D. Frankovich (PANS program director), being involved in clinical and research aspects of PANS. He also attended the ECNP Workshop on Clinical Research Methods in 2018, and a training period with Enzo Grossi (State University of Milan) for using Artificial Neural Networks (ANN) analysis.

Gagliano A., *et al.*, Pediatric Acute-Onset Neuropsychiatric Syndrome: A Data Mining Approach to a Very Specific Constellation of Clinical Variables, *J. Child. Adolesc. Psychopharmacol.*, 2020; **10**: 1-17.

ADHD and ASD environmental risk factors and polygenetic risk scores

Susan Velásquez González

Susan Velásquez González is a psychologist carrying out her last year of PhD studies in Neuroscience at the University of Cagliari. She obtained her master's degree in Clinical and health psychology at the University of Pisa and carried out part of her studies at the University of Málaga in Spain.

During her PhD program she has been involved in different research programs on environmental risk factor for neurodevelopmental disorder mainly Attention Deficit/Hyperactivity Disorder (ADHD) and Autism Spectrum Disorder (ASD).

One part of her research was developed at the University of Cagliari, and carried out at the Unit of Child and Adolescent Neuropsychiatry at "A.Cao" Paediatric Hospital and "G.Brotzu" Hospital Trust, Cagliari. A case control study was used to assess exposure to environmental risk factors in ADHD and ASD population. A questionnaire about prenatal and postnatal risk factor was developed to explore the environmental factors and some scales were applied to parent of children to measure psychiatric disorders and parenting. A total sample of 97 children and adolescents between the ages of 6-18 year were recruited: 21 ASD, 42 ADHD and 34 control, with a total of 97 questionnaires and 310 scales collected for the analysis. Statistical analysis was carried out to measure the exposure of both clinical groups to the environmental factors compared to the control group. Environmental factors as cesarean delivery, formula feeding vs breastfeeding, high

sugar consumption, family adverse situations, psychological aggression, bullying and inconsistent discipline were associated with an increased risk of ADHD.

The other part of the research is currently carried out at the University of Groningen in the Netherlands, at the Child and Psychiatric Unit, University Medical Center Groningen. The aim of the study is to investigate the interplay between ADHD environmental risk factors and polygenetic risk scores using the Avon Longitudinal Study of Parents and Children (ALSPAC), a prospective birth cohort study. ALSPAC sample consists in 15,454 pregnancies of women recruited from Bristol, England, during 1990–1992. Children born from these pregnancies and their families have been observed for more than 25 years, data was collected through questionnaires and clinical assessment visits and provides information about environmental and genetic factors. ADHD traits were measured by mother-reported symptom scores using the Development and Well-Being Assessment (DAWBA) interview at age 8. DAWBA score was able for 8156 children and genotype for 8941. ADHD polygenetic risk scores were derived from the latest Genome-wide association (GWAS) study from the Psychiatric Genomics Consortium (PGC). Statistical analysis for ADHD traits showed a partially mediation effect in some of the environmental risk factors and polygenetic risk scores in ADHD traits.

Boi J., *et al.*, Caesarian Delivery as a risk factors for Autism: a review and integration of findings, *Journal of Ultrasounds in Obstretics & Gynecology*, under review.

PhD program in Philosophy, Epistemology and Cultural History

Coordinator: Prof. Gabriella Baptist (Coordinator in 2019/2020)

https://dottorati.unica.it/fesc/

The doctoral course in Philosophy, Epistemology and Cultural History is organized in three curricula:

- *Philosophy*,
- *Logic and Epistemology*,
- *Cultural History*,

and it is characterized by its interdisciplinary profile, by the search for an integration and coordination between specialized languages and cultural constellations, historical legacy and contemporary discussions. Great attention is always given to the international contacts and collaborations, which have led over the years to numerous projects of thesis in co-tutorship with prestigious universities in Germany, Spain, France, as well as to the conferral of the title: *Doctor Europaeus* to some of its alumni.

In the 33rd cycle, the 'classical' philosophical discussion of theoretical and hermeneutical questions has found interesting integrations through innovative pathways in the applied research, which has been proposed together with local and national companies in the framework of ministerial projects (PON), demonstrating so the persistent interest of a high formation in the humanistic fields. All candidates could integrate their scientific training through research visits abroad, despite the inconvenience caused by the recent health emergency.

Building effective tutorials for immersive virtual reality environments

Giada Corrias
Curriculum: Logic and Epistemology

Graduated in 2014 in the master's degree course in "Developmental and dynamic-relational Psychology", in 2018 she obtained a PON-RI PhD Scholarship (Research and Industrial Innovation - XXXIII cycle) with which she started the research project called *"Study of perception-action cycles in immersive virtual reality environments"*.

This project investigates the perception-action cycle in the context of the Human Computation Interface. This sector has received new attention in recent years, mainly due to the greater availability of virtual reality (VR) devices, that led to the need to design the software and environments used through these new devices in a way that is increasingly centred on the experience and on the particular physical, cognitive and psychological characteristics of the final user (Norman, 2002).

The human-centred design approach requires close collaboration between technicians, software engineers and psychologists. From an industrial point of view the realization of new experiences requires an understanding of the mechanisms that lead to the definition of the affordance of an object or a virtual experience, aspects that strongly influence the final quality of objects and experiences in terms of perception and cognition. The presence of objects or interface elements that cannot be used leads to a lack of clarity that results in an increase in user frustration, which determines the abandonment of the experience (Schell, 2008) and a negative impact on terms of suspension of disbelief and immersion, elements that accelerate and facilitate the transfer of knowledge (Griffiths and Guile, 1999; Jarvis and de Freitas, 2009).

Based on the abovementioned theoretical considerations, we developed a series of experiments to test the effectiveness of different kind of immersive VR environments intended for the training/teaching of procedures, and for the analysis of users' characteristics that can influence their effectiveness. The collaborative work between UNICA and INFORA, a company actively engaged in the research and analysis of the opportunities offered by the latest technologies and their applications, has led to the development of the technical aspects (such as the choice of the device, the configuration of the setting and the implementation and subsequent correction of the software used) that are the basis of the construction of Virtual Kitchen (VK), a modular 3D "virtual laboratory" in which subject's activities and behaviours can be observed, recorded and measured in order to test the interaction of different categories of variables and their effects on procedural learning, presence and immersion. A research stay at Lawrence Technological University in Detroit (USA), an institution characterized by a strong collaboration between Psychology, Computer Science and Design, allowed to better define some procedural characteristics of the experimental protocol such as the choice of tools for psychological and behavioural analysis, the sequence of proposed tasks, the definition of the instructions (tutorials) and questionnaires about the VR experience. The experimental protocol was prepared and tested for both Italian and American users, in order to verify the possible intervention of cross-cultural variables.

The main scope was to verify what form of instructions (tutorials) during VR training are most effective in terms of performance and quality of learning (times and errors during the test), and lead to a better understanding of the environment and its interactions. Preliminary results indicate that a visual and punctual approach, typical of tutorials widely used for education and professional training, is more effective and engaging than tutorials used in more traditional tutoring approaches.

Conceptual models for bibliographic description

Marco Demurtas
Curriculum: Cultural History

After graduating in Philosophy from the University of Cagliari, a period during which he took advantage of an Erasmus study stay at the Université de Neuchâtel, Marco Demurtas obtained his doctorate in Philosophy, Epistemology and Cultural History at the University of Cagliari. His research project, entitled "Conceptual models for bibliographic description. Informatic application for ancient book", is focused on the study of new bibliographic standards that are particularly relevant to the description of the ancient book. Specifically, the interest of the PhD student is focused on the design and development of an innovative bibliographic information management system specifically designed for the ancient book heritage and based on the study of conceptual models and communication languages and data exchange. The evolution of interchange and data management formats in the context of the so-called semantic web has led to a shift from compact data structures with a high level of complexity (records) to highly granular and open solutions based on Linked Data technology. On the basis of this background, the research topic will focus on the theoretical and applicative aspects related to the description of the ancient book in a computerised context. The prospective is to implement an open architecture compatible with the Linked Data setting, so as to allow the exchange and reuse of the data between information systems produced by different bibliographic agencies. This technique makes it possible to publish structured data on the web using specific vocabularies that can connect to each other. In this way it is not only possible to create a path of semantic communication between men and machines, but also to establish a bridge that acts as a data exchange structure for different

digital platforms, allowing the various library institutions to share their bibliographic data. At the application level, the structural revision of the database "Le biblioteche degli ordini regolari in Italia alla fine del secolo XVI" produced by the research group RICI (Ricerca Sull'Inchiesta della Congregazione dell'Indice) and currently hosted and managed by the Vatican Library will be used as a case study. The database was designed by Professor Giovanna Granata, which is a member of the RICI group and also the Phd student's supervisor. The database contains the lists of titles of books owned by the religious of Italian convents and monasteries (contained in the Vatican Latin Codes 11266-11326), acquired by the Holy Congregation of the Index librorum prohibitorum after the publication of the Index by Pope Clement VIII in 1596, in a period up to 1603. With its importance in the world of cultural libraries, the RICI database is the perfect candidate for this update, also because, being active for twenty years now, the database still belongs to the old generation systems, so it is fully qualified for adaptation to the new communication systems and an alignment with the new bibliographic standards. Together with the already mentioned open system due to the Linked Data, one of the most important updates is the introduction of a multifaceted search that will help the user in the filtering of bibliographic elements. An option that no bibliographic institution now seems to give up. After having theorized and effectively put into practice the work of re-engineering of the database (in collaboration with the company ATCULT), the Phd student will spend a period of eight months at the CED (Centro Elaborazione Dati) of the Apostolic Library to review the entire research project and carry out performance checks on the new product, to install finally the product that will update the database. It is therefore a testing ground for identifying descriptive needs, assessing the shortcomings of traditional systems, developing a new data structuring model and testing its applicability according to the study of old editions and the development of advanced functionalities for the publication, exchange and reuse of data on the web.

Relations between Consciousness and 'Self' in Idealism and Phenomenology

Marco D. Dozzi
Curriculum: Philosophy

My philosophical research is primarily on phenomenological and ontological understandings of self-consciousness from antiquity to the present. I am especially interested in this topic in the context of late 18th/early 19th century 'German Idealism' as well as in 20th century German and French phenomenology. In the former context, I have published articles in Fichte-Studien and Schelling-Studien, one of which earned an essay prize (the 'Fichte Prize for Young Researchers,' awarded by the International Fichte Society: Dozzi M. The Problem of the Unconscious in Fichte's Later Jena *Wissenschaftslehre*. Fichte-Studien, 2020; 48: 434-55). In the latter context, I am currently completing a doctoral thesis entitled *(Self-)Consciousness, Reflection, and the Ego in Sartre's Early Philosophy*.

I'm from the U.S.A., and have a dual-major bachelor's degree in Philosophy and Religious Studies from Allegheny College (Meadville, Pennsylvania), a Master's degree in Philosophy from SUNY Buffalo (New York), and a Master's degree in Religious Studies from the University of Pittsburgh (Pennsylvania). Since beginning the PhD in 2017, I have carried out numerous periods of research abroad and frequently with additional grants. These study periods/grants include: 2017-18, University of Freiburg, Germany (DAAD Research Grant); 2018-19, McGill University, Montreal (Globusdoc), research at La Sapienza, Rome; 2019-20, The Husserl Archives of the École Normale Supérieure in Paris (Placedoc).

One of my goals in studying 'self-consciousness' is exposing the ambiguities of this notion, although to the greater end of explaining the various ways in which it correctly characterizes several kinds of consciousness. What has appealed to me about Sartre's work in particular is the manner in which he exposed this ambiguity and elaborated a novel and compelling perspective regarding both how it may be and how it should be understood. In his essay entitled *The Transcendence of the Ego*, Sartre maintains that consciousness is 'impersonal,' in the sense that we cannot say that consciousness belongs to a self (or 'ego'), let alone that consciousness *is* a self. When we think of 'ourselves' *as* selves (as 'our-selves'), Sartre maintains, we are actually thinking of an 'object' of consciousness, not a 'subject.' That is, this self, or ego, exists *for* the consciousness which thinks of it: it is not to be identified with it. Sartre adds that most of the time, however, we are not thinking of a self at all, and in those moments (of 'unreflective consciousness') there essentially *is* no self; at least, in any kind of 'experiential' sense. In such consciousness, 'our' awareness is wholly engaged in something other than a self, or *itself*, and there is thus no 'self' or 'ego' to be found. In his later, more famous (and far longer) work, *Being and Nothingness*, Sartre maintains the essence of these principles but 'softens' his view somewhat. Beginning with this work, Sartre maintains that consciousness is 'self-like' in the limited sense that we are always conscious of ourselves as *free agents*, and that we are always aware of choices we make as well as a certain kind of continuity of them across time. Nonetheless, there is always a 'gap' in this 'self-presence' – even on the unreflective level – and for this reason we still cannot rightfully claim to *be* selves.

My dissertation explores many subtleties in Sartre's position(s) which appear to have not been recognized, some of which perhaps even by Sartre himself. It is not, however, merely exegetical: I argue that the fundamental aspects of Sartre's views are correct, but that there are additional senses both in which consciousness is 'self-like' and that there is something like a 'self' present to consciousness in certain forms of unreflective consciousness (something Sartre actually concedes in an incomplete way). The matter is not as simple as saying that consciousness is or is not a 'self' because the notion is multi-faceted, and as Sartre recognizes, some of these senses of 'self' can rightfully be ascribed to consciousness while others cannot.

Situated and timing-based approach to consciousness in learning processes

Fabrizia Giulia Garavaglia
Curriculum: Logic and Epistemology

My main research experience is focused on the field of philosophy of mind, epistemology and philosophy of science. I graduated at Università degli Studi di Milano and I am enrolled in the PhD Program in Philosophy, Epistemology and Cultural History at Università degli Studi di Cagliari.

I work on the optimisation of the notion of consciousness in two different kinds of learning, neural and cognitive, and their multimodal characterisation. I explore research in neural field and philosophy of mind, with the aim to link neural and cognitive learning and try to improve their processing. More in detail, I explore a situated and timing-based approach to consciousness by focusing on the process of individual learning, starting from two polarities. On the one side, the role played by intentionality and intersubjectivity in individual action. On the other hand, the role played by motor conditioning. I distinguish between different types of learning (voluntary and recursive) and I try to explore if an interaction between neurophysiological and philosophical approaches could contribute to a different interpretation of some data, in order to have a broader notion of consciousness that could be associated with these learning processes. I'm investigating timing processes involved in this kind of mental activity and I propose a timing-based model to shed light on the complex relationship between neural subjective activity and phenomenological experience of action, on one hand, and intersubjective reality, on the other hand.

As a student in the Doctoral Program in Cagliari, I could develop my project through many activities, courses and seminars, and constantly working with my supervisor, Prof. Marco Giunti, and many other professors and colleagues in a stimulating and multidisciplinary research reality. I had the chance to be involved in the organization of different departmental activities and conferences. During the first year of PhD I also had the opportunity to organize a two-days conference about the topic of my project, where different professors presented their contributions.

During PhD I had the chance to spend several months abroad, where I could further my work with professors, researchers and PhD colleagues from many different research realities. During my stay at the University of Exeter, I focused on the second part of my project, working, with my on-site supervisor Prof. Giovanna Colombetti, in the *Egenis Research Group*, and I gave a presentation on the extended mind debate as a part of *Body and Mind* Module.

The aim of the months spent in Lisbon was to go deep in neural mechanism involved in timing and explore new theoretical frameworks that some cognitive scientists are developing in this field. There I worked with the supervision of Prof. David Yates, in an interdisciplinary interaction that involved three main structures: the PhD Programme of *Mind and Brain,* Neuroscience Department and Cognitive Science Department of Lisbon University; the *LanCog Group*, Philosophy Department of Lisbon University; and the *Lisbon Mind and Reasoning Group*, Philosophy Department of Nova University Lisbon. I also had the chance to present my work in a conference with a very stimulating audience.

The Problem of «Absolute Chance» in Peirce and Meillassoux

Giovanni Maria Mulargia
Curriculum: Philosophy

In 2013 I graduated in History at the University of Bologna with a thesis entitled *Truth and Subjectivity in Alain Badiou's Political Thought*. In 2016 I obtained my master's degree in Philosophy at the University of Padua with a thesis entitled *Ethics and Complexity: The Problem of the Political Subject in the Perspective of Social Systems Theory*. I have done two Erasmus research stays, both in Paris: I spent the 2014-15 academic year at the Université Paris 1 Panthéon-Sorbonne as well as five months in 2018 -19 at the École des Hautes en Sciences Sociales. The general theme of my research is the relationship between contingency and the processes of subjectivation in a theoretical and political perspective. Currently, my investigation is focused on contingency in its epistemological and ontological dimensions. I am mainly interested in classical American pragmatism and French post-structuralism. The title of my PhD. project is *The Problem of «Absolute Chance» in Peirce and Meillassoux*. The expression «absolute chance» may at first glance appear paradoxical: it is not by accident that chance has often been conceived in a negative sense in the history of thought, frequently being reduced to the ignorance of a deeper necessity which is incomprehensible to the human intellect or rendered illusory by the invention of probability calculus. In contrast to these attempts of "domestication", some philosophers have endeavored to provide a positive and non-statistical understanding of chance. In my research, I particularly focus on two authors who, although coming from very distant traditions, both defend a conception of chance as having objective reality. Charles S. Peirce is mainly known as the founder of pragmatism and contemporary semiotics, but he is also the inventor of

the phrase «absolute chance» and of a doctrine called «tychism» which portrays chance as a fundamental and constitutive factor of the universe. Quentin Meillassoux is the major exponent of a recent trend in Continental philosophy called 'speculative realism' and supports the controversial view that contingency is necessary, i.e. every entity (including physical laws) is subject to absolute chance. My hypothesis is that, beyond the differences that separate these authors, it is possible to establish a fruitful comparison between them starting from their common conceptualization of chance as an 'ultimate' category – that is as a general attribute of every reality, which Peirce calls «Firstness» and Meillassoux «hyper-Chaos». This reconfiguration is not achieved without some problems and the goal of my thesis is to map and articulate several of the many critical issues. One of the most stimulating aspects of the notion of absolute chance is that attempting to dissolve its contradictory aspect forces us to invent new ways of thinking beyond the classic dichotomies of order/disorder and necessity/contingency. From this point of view, several difficult questions arise concerning how we can claim to know absolute chance: first of all, how do we know that chance as a category is truly absolute and therefore independent of our thinking? That is, how do we know that it is not merely relative to our way of knowing reality, and is rather the fundamental mode of being itself? Do we need a specific faculty of the mind to grasp it? Are there other categories which determine the nature of reality beyond chance? How does chance relate to other categories? Only the formulation of these questions and a rigorous attempt to answer them can provide us with an original approach to those classical problems of philosophy in which chance plays a fundamental role as an ontological category. To expand upon my research, I intend to explore three main issues in further detail: the question of the emergence of order from a state of disorder, the problem of the contingency of the laws of nature as well as the problem of the possibility of knowing them, and the question of the possible (in)existence of God.

What remains of man. The immanent phenomenology of Michel Henry

Marina Pisano
Curriculum: Philosophy

After graduating in Philosophy at the University of Cagliari, I did a PhD in Philosophical Disciplines at the same University, I received a scholarship at the Italian Institute for Historical Studies in Naples, and I had the opportunity to do a second PhD in Philosophy, Epistemology and Cultural History. During the three years of my PhD I had the opportunity to develop my research in the most important academic places for the researchers who study the thought of Michel Henry: the *Université Paul Valery 3* in Montpellier, where the philosopher taught for almost forty years, until the end of his career; the *Archives et bibliothèque du Fonds Michel Henry* in Louvain-La-Neuve, where the thinker's unpublished manuscripts and his personal library are preserved; and the *McGill University* in Montreal, where it is possible to interact with leading specialists in Henryan phenomenology. I held some seminars on the central themes of my academic interests and, in addition to having worked on some scientific articles, I have curated the edition of a text of unpublished writings by Giovanni Gentile that will be published in the series *Inediti e Rari* by the publishing house Le Lettere.

My research, *What remains of man. The immanent phenomenology of Michel Henry*, aims to frame the peculiar ontological status of man within the phenomenological reflection of the French thinker. The interest in this object of study derives from two essential reasons: the first concerns the eminent role that man plays in the phenomenological cosmos investigated by Henry. The purpose to which Henryan philosophy, in fact, dedicates the almost totality of its conceptual and

argumentative forces is to show the existence of a foundation that is no longer understood as transcendent with respect to what it founds, but is instead a foundation of immanent nature: the *life*. The latter can be intuited, however, only when it allows itself to be glimpsed in the *living*, and it is for this reason that man - as a living being, who not only exists, but even questions his own existence - becomes the conceptual place in which to recognize the trace of the essence of manifestation. The second reason that has conducted to place the concept of man at the center of the research is that preserves a hermeneutical character more properly critical and problematic. Note, in fact, that man does not simply distinguish himself by being that "entity" that has a privileged relationship with the foundation, since, more surprisingly, man is also the one who stands in opposition to life, and «*dit non à la vie*» (*Entretiens*, 2005: 72), rebutting with a "no" to the appeal coming from his own origin. To this phenomenon of riotous denial, the thinker assigns the name of *nihilism*, what could also be defined in terms of a hallucination that prevents man from consciously observing his relationship with the essence. The problem, then, becomes that of understanding if the human capacity to deny the foundation also implies the existence of a difference between man and his origin: a *remainder*, therefore, that makes the living not completely reducible to life.

Henry discusses this problem by establishing a very precise argumentative scheme, according to which the "no" articulated by the living towards life can be pronounced, but only because, *ab origine*, it is life that allows the living to answer with a "no" to the appeal that comes from it. Through the reiteration of this typically elenchic argumentative path, the main aim of Henry's philosophy is then made manifest: the one aimed at consuming any "remainder" that can be constituted independently of the immanent essence. However, it is possible to trace, along the course of Henry's production, rare but, precisely for this reason, precious unexpected deviations from the direction imprinted by his philosophy. The task of the research is exactly that of illuminating the philosopher's argumentative oscillations to show the deepest speculative inquietudes that inhabit his thought.

PhD program in Physics

Coordinator: Prof. Paolo Ruggerone
Vicecoordinator: Prof. Umberto D'Alesio

https://dottorati.unica.it/fisica/

The PhD in Physics at the University of Cagliari is the only PhD course in Sardinia, making thus its presence of particular importance for the Region. It plays a two-fold role in providing a high-level training and in acting as a further hub for scientific collaborations with the national research institutes (INFN, INAF, CNR). PhD students are strongly involved in large collaborations and experiments as well as in projects funded by international agencies (ERC, IMI, NIH are few examples). The XXXIII Ciclo's fellows have brought their expertise and enthusiasm in research lines related to high-energy, experimental and theoretical condensed-matter physics, computational biophysics, and dark matter studies. Two foreign PhD students out of seven are non-Italian, and a further thesis has been activated as a cotutelle PhD with the University Paris Diderot (Paris 7). In order to offer a broad educational spectrum, two lines of training have to converge. First, PhD students should be exposed to all aspects of research. Active participations to conferences, workshops, summer schools, collaboration meetings and project drafting indicate that our PhD students are well versed in interacting with senior researchers and in fostering collaborations. The quality of their research has been recognized also at international level, as for example by HPC Europe 3 prize attributed to a student of ours. Second, PhD students should be involved in teaching-related activities. They have been committed to tutoring undergraduate students at different levels (Laurea Triennale, Laurea Magistrale) and with different backgrounds. Surely, the pandemic emergency occurred during the last year of the XXXIII Ciclo with its restrictions have affected the normal route of the PhD course, especially by reducing the face-to-face interactions at all levels. To reduce these limitations, several instruments have been successfully adopted, such as the possibility to attend lectures and seminars online.

Heavy-ion physics with the LHCb detector

Samuel Belin

Originally from Dijon, France, I took interest in physics during preparation school. My curiosity pushed me to continue my studies at the university of Lyon instead of an engineering school to further learn about fundamental physics. During my master's degree I did two internships with the ALICE group of Lyon. For my PhD, I applied for the program for foreign students of the university of Cagliari and joined the LHCb group.

The LHCb collaboration is one of the 4 main experiments of the Large Hadron Collider (LHC) located at CERN, Geneva. Those experiments record high energy collision of protons or nuclei to unfold the mysteries of the universe, whether by detecting new particles, measuring the matter/anti-matter asymmetry or characterize new states of matter.

My work in the LHCb group focused on heavy-ion physics by studying Lead-Lead collisions recorded by LHCb.

Heavy-ion physics aims to understand the Quantum Chromodynamic (QCD) matter. Existing experimental results in collisions of ultra-relativistic heavy nuclei are consistent with the formation of a deconfined state of hot parsonic matter, referred to as Quark-Gluon Plasma (QGP). A better understanding of the QGP would help us better understand the strong interaction as well as the formation of our universe. As the time of life of this state is very short, its characterization is difficult and requires a lot of different probes. For my thesis, I was exploring a new

possible probe; the photoproduction of the J/ψ vector meson. The J/ψ, a bound state of c and $\bar{c}$ quarks, can be produced by the interaction of the strong electromagnetic field created by the Lead nucleus going to almost the speed of light, with the constituents of the other Lead nucleus. It is believed that the particle produced in this way could be affected by both the structure of the Lead nucleus and of the possible presence of the QGP by enhancing or reducing its production rate.

This analysis was challenging as it was the first-ever done using Lead-Lead collision, as the LHCb detector was not originally designed to record this type of event. Thus, I had to develop new analysis methods to estimate the performance of the detector in such environment. Indeed, this kind of collision can produce a thousand times more particle than in typical proton-proton collision making the recording of the information more challenging for the detector.

This PhD offered me a lot of opportunities, in particular by staying several months at the CERN laboratory where I helped prepare and monitor the Lead-Lead 2018 data taking. It was a very rewarding experience to be in contact with excellent scientists from all over the world and to be at the closest of the biggest machine mankind ever built.

I was also lucky to participate in several international conferences in Italy, France, and China where I could meet the top scientist in the world in this subject.

In relation to the PhD program, I also attended two PhD schools that helped me a lot strengthen my general knowledge in particle physics.

Aaij R., *et al.*, First Observation of Excited Ω^-_b States, *Phys. Rev. Lett.*, 2020; 124: 082002.

Multiscale approach to thermoelectricity in PEDOT organic polymers

Antonio Cappai

Antonio Cappai received his Laurea Magistrale in Fisica (2017) at the Università degli Studi di Cagliari, where is currently pursuing his PhD under supervision of prof. Claudio Melis. His research focuses in particular on the polymerization mechanism and thermal and electrical transport of PolyEthyleneDiOxyThiophene (PEDOT). He studied during the mandatory 6-month abroad period at the Laboratory for Chemistry of Novel Materials at Mons (Feb.-Jun/2019 under prof. Jerome Cornil supervision) and at the ICMAB in Barcellona (Feb.-April/2020) under the supervision of prof. Riccardo Rurali.

Increasing awareness of the risks related to the traditional techniques of producing electrical power has recently stimulated a huge interest on the research on power generators driven by thermoelectricity based on organic and conducting polymers, considered a very promising approach to convert waste heat directly into electrical energy and thus increasing the overall conversion efficiency. Even if many inorganic alloys have been already considered as the most efficient constituents for TE devices, the use of organic materials, especially intrinsically conducting polymers (CP), is currently encouraged because of their unique mechanical properties, as flexibility and low specific weight, low toxicity, biocompatibility and high relative abundance. Despite a low conversion efficiency, great efforts are ongoing in order to make thermoelectric based organic generators able to power small devices for biomedical applications and many efforts have been taken in order to optimize CP conversion efficiency by properly tailoring their electrical and thermal conductivity. One of the main issues is at the mo-

ment to clearly address the role of the polymerization conditions on the resulting CP morphological and transport properties.

In this perspective, classical and ab initio simulations can be usefully exploited in order to obtain crucial information of the polymerization process, hardly obtainable from the experiments. To this aim, a novel computational approach based on a combination of classical molecular dynamics and ab initio Density Functional theory (DFT) calculations was developed to generate realistic polymer samples and estimate their corresponding transport properties by simulating the polymerization process using formation energies of reaction estimated by means of DFT free energies calculations.

Focusing on PEDOT, it was possible to demonstrate that different choices of specific reactants used to trigger the polymerization reaction, dramatically influence the resulting polymer morphology by affecting the chain length distributions, average molecular weight and spatial arrangement of the chains as confirmed by means of simulated X-Ray Diffraction patterns. Successively, by standard Molecular Dynamics techniques, it was possible to demonstrate the impact of morphology on the corresponding heat transport properties. In particular it was observed the emergence of clear anisotropy in heat transport linked to the increase of average chain length and degree of crystallinity, proving the paramount importance of the reactants used during the polymerization process. Finally, a novel computational approach based on the formalism of Marcus theory was developed in order to calculate hole mobilities and provide meaningful estimates for electrical conductivities. Also in this case, the morphology proved to be fundamental in determining the hole transport properties, with a non-trivial behavior observed in the increase of mobility as function of average chain length.

Cappai A., *et al.*, Interplay between synthetic conditions and micromorphology in poly(3,4-ethylenedioxythiophene): tosylate (PEDOT:Tos): an atomistic investigation, *Phys Chem Chem Phys.* 2019; **21**(16): 8580-8586.

Study of the Quark Gluon Plasma using low-mass dimuons with ALICE

Alex Chauvin

After obtaining a master in subatomic and astroparticle physics in Grenoble (France), I have continued my formation in Munich at the TUM as a technical student working on dielectrons production in the ALICE collaboration. During this period, I have participated to the analysis in high-multiplicity event and on open-heavy flavours production. On top of this analysis I made a service task for the collaboration on the development of the High-Level Trigger leading to various publications.

During my PhD I could focus on the dilepton study of the Quark Gluon Plasma (QGP) with the ALICE collaboration in Cagliari and pass part of this period at the Institut de Physique des 2 infinis de Lyon (Ip2i Lyon). During my PhD I could learn the processes to go through to obtain the publication of my results within A Large Ion Collider Experiment (ALICE) collaboration. As this experiment involves a large community and so a precise control on the results being published, the procedure requires a special effort either on the consistency and the conduct of the analysis. This analysis has been supported with the period spent abroad, in my case either at different conferences, at CERN (where the experiment is taking place) and at the Ip2i. First at CERN I was involved more technically into the experiment by becoming an expert of a detector (the Muon Chamber) giving me the opportunity to be on-call for several weeks during data taking. My presence to conferences gave me the chance to keep in touch with the latest analysis ongoing in my field. For what concerns the time spent in Lyon, I could

have focus on different data sets for the analysis and be in contact with other students from the same collaboration performing similar analysis and tools leading to profitable exchanges.

The main part of the work furnished during this time was devoted to the analysis of Low-Mass dimuons with ALICE at the Large Hadron Collider (LHC). The ALICE detector has been especially designed for the study of the QGP giving the possibility of the study of this exotic state of matter where gluons and quarks can propagate freely not being bounded together by the strong force described by Quantum Chromo-Dynamics (QCD), part of the Standard Model of particles. Benefiting from the collisions of the LHC, ALICE can record Pb-Pb collisions where the creation of QGP is expected, and p-p collisions, where the requirements to create this medium are not expected to be satisfied, are used as a reference. Low-mass dimuons in ALICE allows especially the measure of two main mesons (particles made out of a quark and an anti-quark): the omega (with light flavour quarks) and the phi (with strange quarks content). The mechanism to describe the creation of the strange quarks diverging from the one of light flavours in pp collisions, the observation of an increase of strangeness (with respect to light flavours) content in Pb-Pb with respect to p-p collisions is a signature of the presence of QGP. Nevertheless, recent results have shown an increase of strangeness production in collisions systems where the signature was not predicted.

My analysis focused on the omega and phi mesons production in p-p collisions. As other collisions have been performed at this energy this particular sample is also used as a reference. Using the large statistic obtained in 2017 the analysis could be extended to multi-differential studies of the phi and omega production. The results of this analysis could have been added to results obtain in different p-p collisions systems to study the phi production as a function of centre-of-mass energies. For what concerns the analysis as a function of multiplicity, being related to the energy density of the system, gives the opportunity to control the presence of QGP-like behavior in p-p collisions.

Acharya S., *et al.*, Evidence of Spin-Orbital Angular Momentum Interactions in Relativistic Heavy-Ion Collisions, *Phys. Rev. Lett.*, 2020; **125**(1): 012301.

Study of bacterial efflux pumps with molecular dynamics simulations

Chiara Fais

Chiara Fais started her PhD at the University of Cagliari in 2017. She joined the Computational Biophysics research group headed by Prof. Paolo Ruggerone, under the co-supervision of Dr. Attilio V. Vargiu. She took part in collaborations involving research groups from several universities, such as King's College London, the University of Birmingham and Queen Mary University of London, where Chiara spent part of her PhD as visiting student. Her contributions to these works are based on computational methods, like molecular dynamics simulations and prediction of protein structures.

Her thesis, *Computational studies on pharmaceutical targets in human diseases*, focuses on the investigation of bacterial protein systems named efflux pumps. These are complex machineries located in the cell wall of bacteria and able to expel a broad range of compounds, including many antibiotics. For this reason, efflux pumps play a key role for the occurrence of multidrug resistance (the ability of bacteria to survive in presence of various drugs) and have become an important pharmaceutical target. In order to combat their action, several strategies have been designed. Among them is the development of efflux pumps inhibitors (EPIs), small compounds that can affect the functioning of the pump and prevent the expulsion of antibiotics. Research in this field has led to the identification of several EPIs, however none of them is currently usable due to toxic effects. Possible routes are thus the design of novel EPIs, or the modification of the molecular structure of the available ones. In both cases, a deep knowledge of the mode of action of the known EPIs is crucial. Several questions are however open.

During her PhD, Chiara contributed to an investigation on the mode of action of an EPI (PAβN), known to be effective against the efflux pump AcrB from *Escherichia coli* (a pathogen typically found in intestines). This study was performed in collaboration with groups from the University of Birmingham and King's College London. Chiara performed molecular dynamics simulations of the AcrB efflux pump in presence of PAβN and of an antibiotic (ciprofloxacin). According to previous studies, ciprofloxacin and PAβN can bind to the same region within AcrB. Simulations performed in this work revealed that this binding is possible for both compounds at the same time. Moreover, the simulations revealed that binding of the EPI induces a significant rigidification of AcrB, and this effect is further amplified when both the EPI and the antibiotic are bound to the same region of the transporter. These results suggest that the EPI may alter the efflux of antibiotics by interfering with key movements of the pump. Importantly, synergy between EPIs and antibiotics has not been reported previously in the literature. The protocol used in this study may be applied to other EPIs and other EPI/antibiotic combinations.

Ahdash Z., *et al.*, Perturbed structural dynamics underlie inhibition and altered efflux of the multidrug pump AcrB, *Nature Comm.*, in press.

Ab initio study of thermoelectric layered materials

Roberta Farris

In 2015 I graduated in Physics, then I decided to deepen my knowledge in the physics of matter during the master's degree. Afterwards, in 2017 I started a PhD in Physics at the University of Cagliari under the supervision of Prof. Vincenzo Fiorentini and Prof. Alessio Filippetti. During this time, I did an internship at the Institute of Condensed Matter and Nanosciences (IMCN), Université Catholique de Louvain (Belgium) for 7 months in the Prof. Gian-Marco Rignanese research group.

My research is mainly focused on the theoretical and computational study of novel materials for energy production. In particular, during my thesis I mostly worked on thermoelectricity, namely the direct conversion of temperature differences to electric voltage and vice versa.

Thermoelectric materials could play a significant role in sustainable energy production and various technological applications. Indeed, temperature gradients and heat flow are omnipresent in natural and human-made settings and offer the opportunity to harvest energy from the environment.

This research crucially depends on identifying materials with higher thermoelectric efficiency than those currently available. This is challenging because factors that come into play are often conflicting. For example, a thermoelectric material should allow efficient transport of electric charge, but hinder heat conduction - but in most materials, electrical and thermal conductivity go hand in hand.

In my work I analyzed materials with standard methods for material science and I identified promising compounds with interesting properties, as for instance, the Zintl phase of Mg_3Sb_2, paying particular attention to thermal conductivity, that plays a key role in this field. In fact, this feature allowed me to focus on a broad class of materials possessing the desirable low thermal conductivity: layered materials. My thesis, entitled A*b initio studies of thermoelectric layered materials,* builds on this idea.

As in other contexts, theoretical investigations can contribute to reduce or optimize time-consuming and expensive experimental work which with to compare the results. For example, high-throughput calculations and materials database search and analysis are useful tools for the discovery of novel thermoelectric materials. During my abroad experience, at the Catholic University of Louvain-la-Neuve, I got familiar with just this method. My use of this approach discovered several interesting candidate materials, among which the compound LaSO, with a large thermoelectric efficiency due to its electronic structure.

Fiorentini V., *et al.*, High thermoelectric figure of merit and thermopower in layered perovskite oxides, *Phys. Rev. Mater.*, 2019; **3**(2): 022401

The unexpected physics potential of the liquid argon detectors

Michela Lai

I am a third-year PhD student, performing a joint-PhD between the University of Cagliari and the Universitè Paris Diderot (PARIS VII). I was born in Cagliari in 1992; I entered the Faculty of Physics in Cagliari in 2011, where I got my Bachelor in 2014 with a thesis on general relativity. I went on with theoretical physics during the Master course, in Cagliari, where I focused on high energy particle physics. I entered the PhD in Cagliari in 2017, joining the DarkSide research group, headed by my local supervisor Walter M. Bonivento. In the second year, my work continued in Paris, with the supervisor of the host University, Davide Franco, who leads the local Neutrino Group. After seven months abroad, I came back in Cagliari, where I also joined the DEAP collaboration.

My research aim is to fully exploit the physics potential of a specific class of detectors designed for the search of Weakly Interacting Massive Particles (WIMPs), one of the most likely candidate for the missing mass in our Universe, called "dark matter", measured to constitute about the 23 % of the whole universe mass-energy. The specific class of detectors I work with exploit as target the liquid Argon: when the incident particle, a WIMP hopefully, will eventually scatter on the argon nucleus, it will excite it into an unstable molecular dimer, i.e., an excimer. After some millionth of seconds, the dimer breaks up, releasing heat (which is not detected), “scintillation” photons and ionized electrons. Experiments from DarkSide collaboration, which I joined from the first year, collect and study both the released photons and the electrons. Then, during my third year I also joined the DEAP-3600 col-

laboration, whose detectors look at the scintillation photons only. My PhD. project, "*Physics of the Standard Model and Beyond Standard Model in a dark matter detector filled with Argon*" aims to fully exploit the technology developed for WIMP search in liquid Argon based experiments, both looking at the neutrino physics and to the dark matter search.

For the neutrino physics, I have focused on the neutrino signal from an eventual Supernova, wondering if DarkSide detectors can see this. Specifically, I have tested the sensitivity of the future detectors DarkSide-20k and ARGO, respectively working with 50 ton and 400 tons of ultrapure Argon, to this kind of supernova. The emitted neutrinos would allow for knowledge on the star's mass and structure and eventually confirm the theoretical physics process assumed for the collapse. With these dark matter detectors we will be able to clearly record the neutrino signal from any supernova exploding in our Galaxy!

On the dark matter search, I got interested to MIMPs, where the M stands for "Multiple": opposite to WIMPs, MIMPs would eventually perform much more than one scattering in the detector, all along an effectively straight line; this is a consequence of their very high mass, thousands of millions of times greater than argon atoms. To perform this analysis, I joined the DEAP-3600 collaboration, whose running detector has 3.3 tons of liquid Argon, more than enough to be sensitive to MIMPs. I have come through all the analysis steps, learning every day by the work itself and the working team. As first contribution I built a C++ Monte-Carlo simulation to see how the MIMPs would be slowed down after the scattering with earth and atmosphere atoms. This simulation has fully reproduced the detail of DEAP-3600. Then, I have determined the best parameters to discriminate potential dark matter signal against the (known and fully understood) background, mainly due to natural radioactivity in the detector. After one year and a half, I can now say that the analysis is ready to be applied to 3 years of data taking. We are ready to "unblind" the full dataset, so to unpack the box and -who can say?- claim a dark matter discovery!

Agnes P., et al., Low-Mass Dark Matter Search with the DarkSide-50 Experiment, *Phys Rev Lett.*, 2018; **121**(8): 081307.

Carbon nitride compounds for photonic and photocatalytic applications

Stefania Porcu

Born in Nuoro in 1988, I graduated in Chemistry in 2011 after an internship at the "Institut de Chimie Moléculaire et des Matériaux d'Orsay" (University of Paris XI) and in Chemical Science at the University of Cagliari in 2017 under the supervision of Professor Francesco Secci. In 2017 I started the PhD in Physics at the University of Cagliari working in the materials science and optical spectroscopy research group under the supervision of Professor Pier Carlo Ricci. In 2019 I worked at the College of Engineering (University of Notre Dame, Indiana - USA) for three months supervised by Professor Svetlana Neretina and afterwards, for four months at the Institute of Electrochemistry (University of Ulm - Germany) in the Professor Radim Beranek research group. My PhD research project focuses on *Carbon nitride materials for photonic and photocatalytic applications*. Energy crisis, due to both population growth and industrial development, has been a big challenge in recent decades. In fact, the availability of the fossil fuel resources is continuously decreasing, while the CO_2 emissions and the greenhouse effect are becoming a global issue. Looking at recent reports the global primary fuel is still the oil, followed by coal and natural gas in 2015. In this framework, the research of new materials with high potential in the energy and the environmental issues is mandatory. Since 2014 an increasing attention has been devoted to graphitic carbon nitride. It was indicated as a very promising material for photovoltaic applications, a very efficient phosphor for smart lighting applications, and a suitable photocatalyst for hydrogen generation, water splitting, and pollutants degradation. Structural and optical properties of a phenyl modified carbon nitride were studied using a multi-technique ap-

proach and a first prototype of white LED emission, by assembling a commercial blue LED and the phenyl modified graphitic carbon nitride as a phosphor, was developed. Eco-sustainable solutions for the neutralization of air and water pollutants have increasingly gravitated toward the use of heterogeneous photocatalysts. Semiconductor-based photocatalysis is a promising pathway for the degradation of environmental pollutants and, among all the various semiconductors used, titanium dioxide has proved itself to be the foremost material for environmental remediation due to its highly desirable photocatalytic properties. However, it poorly exploits the visible part of the electromagnetic spectrum due to the relatively large bandgap of its anatase phase. In this regard a phenyl-carbon nitride/TiO_2 hybrid system was studied and validated as an efficient catalyst for pollutants degradation under white LED irradiation. Part of the results have been included in an International Patent of the University of Cagliari that focuses on the realization of an indoor antipollution, antibacterial, antiviral photocatalytic paint activated by LED light. Currently, I'm studying the efficiency of this paint on the air purification, performing the test for the NOx degradation with respect to the UNI-11247.

Porcu S., *et al.*, High efficient visible light Phenyl modified Carbon Nitride/TiO_2 photocatalyst for environmental applications, *Appl. Surf. Sci.*, 2020; **531**: 147394.

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