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Dear Members of the Recruitment Committee,

A central question in cognitive science is how humans and other animals acquire structured knowledge about their environment and use it to behave flexibly. My research addresses this problem by combining computational modelling, high-resolution neuroimaging, and non-invasive brain stimulation across species: an approach that sits at the intersection of decision science, cognitive neuroscience, and artificial intelligence. I am writing to apply for an Assistant Professor position in the new Department of Cognitive Science at Bocconi University. I am completing my DPhil in Experimental Psychology at the University of Oxford this month, April 2026, under the supervision of Prof. Matthew Rushworth and Prof. Laurence Hunt, and I would be available to start in September or October 2026.

The opportunity to contribute to building a department from scratch, one designed to unite computational modelling, cognitive neuroscience, and behavioural economics under a shared mission, is what motivates this application. Below, I describe my current research, future plans, and reasons for wanting to join Bocconi.

Current Research

During my doctorate, I combined computational modelling techniques in new ways and applied them to generate empirical findings across several interconnected lines of research.

A general framework for interpretable computational discovery. A persistent tension in cognitive science is the tradeoff between interpretability and expressiveness: theory-driven models are transparent but constrained, while artificial neural networks (ANNs) capture complex non-linear patterns but remain opaque. I developed a two-stage hybrid framework that addresses this tension. In the first stage, I embed a data-driven ANN within a theory-driven cognitive architecture, so that the ANN learns only the unknown computational component (e.g., how humans value information) while established principles (e.g., memory decay, softmax action selection) are handled by the structured module. In the second stage, I apply symbolic regression (a genetic programming technique) to distil the trained ANN into compact, interpretable mathematical equations. This approach recovers novel functional forms directly from behavioural data, validated through simulation-recovery studies. The framework is domain-general: it can be applied wherever a cognitive model has a component whose functional form is unknown, making it a tool for scientific discovery across perception, decision-making, memory, and beyond. This line of work connects directly to Bocconi's "AI Ready" strategic pillar, as it demonstrates how AI can augment human scientific understanding rather than merely predict behaviour.

Information sampling and value of information. How do humans decide when to stop gathering information and commit to a choice? This is a fundamental question for decision science, with implications ranging from medical diagnosis to financial investment. Applying my hybrid framework, I designed a novel information-sampling task and collected ultra-high field 7T fMRI data across four sessions per participant. The ANN-derived value of information outperformed all benchmark models for every participant. Symbolic regression then revealed that the learned value function takes an exponential form, integrating evidence from both attended and unattended options. Using 7T fMRI, I identified distinct roles for subcortical neuromodulatory nuclei (the ventral tegmental area encodes opposing signals for information value and selection value) as well as cortical regions: the anterior insula and anterior cingulate cortex guide information-sampling strategy. This work has been accepted and is currently in press in *Nature Neuroscience*.

Metacognition and causal neuroscience across species. In a second empirical line, I investigated the evolutionary origins of prospective metacognition—the ability to evaluate one's own future performance before committing to a course of action. As co-first author (with K. Miyamoto), I helped design a task in which macaque monkeys evaluate both environment-dependent and performance-dependent contingencies. Using fMRI in macaques, we identified two ventrolateral prefrontal areas (45a and 47/12o) with doubly dissociable roles, and then used transcranial ultrasound stimulation (TUS) to causally confirm this dissociation. Comparative connectivity analysis revealed that the combination of these two macaque areas matches the functional connectivity fingerprint of human anterior lateral prefrontal cortex, suggesting that this distinctively human region may have arisen through cortical expansion during primate evolution. This work is accepted at *Nature Human Behaviour*.

I also contributed to a study on hippocampal cognitive graphs (Pan, D'Ambrogio et al., under review), in which I helped conduct human TUS experiments targeting the hippocampus. TUS causally disrupted participants' ability to construct relational structures for flexible inference while leaving goal learning intact. Across these projects, I have developed hands-on expertise with TUS in both macaques and humans, a new technique directly relevant to the Bocconi Cognition Lab's non-invasive brain stimulation capabilities.

Generalization through structured representations. My third line of research asks how biological systems achieve rapid generalization when abstract task structure is preserved but specific content changes. Working with macaque behavioural data showing a six-fold acceleration in learning speed across sequential tasks, I developed computational models based on grid-hippocampal scaffolding (VectorHaSH) augmented with episodic memory. These models achieve 14- to 50-fold learning acceleration by separating abstract task structure from sensory-specific mappings, enabling immediate reuse of learned policies when encountering new stimuli. The models generate concrete, testable neural predictions—distinguishable through fMRI and causal interventions—about the roles of entorhinal cortex, hippocampus, and prefrontal cortex.

Visual cognition and economic choice. How do basic perceptual processes shape economic decisions? This question motivated a line of work I developed during my visiting position at the University of Pennsylvania's Wharton School. In a first-authored study (under review at *Nature Communications*), I showed that visual salience alters risky choice largely independently of gaze: when potential gains in a monetary gamble are made more visually salient, people are more likely to accept the gamble, yet over 80% of this effect operates through a gaze-independent pathway. To formalise these mechanisms, I developed an image-computable attentional Visual Accumulator Model (aVAM) that links raw visual pixels to choices and reaction times via a convolutional neural network. In a separate first-authored study (*Psychology & Marketing*, 2022), I used computational modelling, eye-tracking, and pupillometry to show that celebrity endorsement in advertisements shapes consumer decisions by altering both the starting point and the rate of evidence accumulation. Beyond these projects, I have contributed to large-scale cross-cultural behavioural economics: I conducted the statistical analysis for a 21-country study testing the robustness of mental accounting (*Journal of Consumer Research*, second round of review), and contributed to a 61-country investigation of temporal discounting (*Nature Human Behaviour*, 2022). Together, this work demonstrates that the perceptual and computational principles I study in the laboratory have direct implications for understanding consumer behaviour and economic choice.

Future Research Plans

Building on my doctoral work, I envision three research directions that would benefit from and contribute to the intellectual environment at Bocconi.

1. The computational architecture of efficient decision-making. My fMRI work identified where information value and selection value are encoded, but a key open question is how these computations unfold in time. Does the brain compute the value of information before or after evaluating the available options? How do these signals evolve as evidence accumulates within a single trial? I plan to address these questions by combining my information-sampling paradigm with EEG, using the Cognition Lab's capabilities to track the temporal dynamics of information valuation with millisecond resolution. The hybrid modelling framework would generate trial-by-trial regressors for EEG analysis, linking computational variables to neural time courses. Scaling the paradigm to large behavioural samples through BELSS would further enable investigation of individual differences in information-seeking strategies and their relationship to economic and clinical outcomes.

2. Memory systems and adaptive behaviour in economic contexts. The computational models of generalization I described above generate specific neural predictions that remain untested in humans. Entorhinal cortex should maintain invariant representations of abstract task dimensions, testable through fMRI representational similarity analysis, while disrupting hippocampal or entorhinal function should impair rapid generalization while leaving asymptotic performance intact. At Bocconi, I would test these predictions using the Cognition Lab's brain stimulation capabilities. This programme connects naturally to research on cognitive economics and the role of memory in shaping beliefs and decisions.

3. AI as a discovery tool for cognitive science. The hybrid approach I developed—embedding neural networks within cognitive architectures, then distilling interpretable equations—is a first step toward AI-driven discovery in cognitive science. A natural extension is to replace genetic-programming-based symbolic regression with large language models as programme generators, following recent advances in LLM-guided programme synthesis for scientific discovery. LLMs can search a far richer space of candidate functions, potentially uncovering computational principles that genetic programming cannot reach. I plan to develop this approach and apply it across a broader cognitive space: perceptual decision-making, social cognition, and multi-agent economic games. This connects to Bocconi's collaborative AI initiatives and the ELLIS unit in Milan, and positions cognitive science not just as a consumer of AI tools but as a domain where AI methods drive fundamental theoretical progress.

Motivation for Joining Bocconi

Three considerations make Bocconi's new department an ideal environment for my research.

First, **intellectual fit**. My work inherently bridges computational modelling, decision-making, cognitive neuroscience, and memory systems—four of the seven research areas the department seeks to cover. I do not merely collaborate across these fields; my research questions require synthesising them. The opportunity to work alongside researchers in computational neuroscience, cognitive economics, consumer psychology, and visual perception would create precisely the kind of interdisciplinary environment in which my methods and questions thrive. I am particularly drawn to the potential for collaboration on topics such as how memory distortions shape financial decisions, how consumers search for and integrate information, and how computational principles generalize across perceptual and economic domains.

Second, **personal connection**. I was trained in Italy—my B.Sc. and M.Sc. are from the University of Padua—before pursuing doctoral work at Oxford and a visiting position at the University of Pennsylvania's Wharton School. This international trajectory has given me a network of collaborators spanning Europe and the United States, which I would bring to Bocconi. The prospect of contributing to building a world-class cognitive science department in Italy is deeply motivating.

Third, **teaching**. I am prepared to contribute to Bocconi's curricular expansion in cognitive science. I could teach the mandatory undergraduate "Cognition and Behaviour" course, drawing on my breadth across decision-making, memory, and computational modelling. I could develop a new course on *Computational Methods for Cognitive Science*, covering the modelling techniques (reinforcement learning, Bayesian inference, neural networks, symbolic regression) that are increasingly essential to the field. At the graduate level, I could teach *Decision Neuroscience*, integrating behavioural economics with cognitive neuroscience. My teaching approach emphasises interactive, data-driven learning—students analyse real datasets and run simulated experiments—consistent with Bocconi's goal of 30% dialogic teaching.

Building a cognitive science department from scratch is an extraordinarily rare opportunity. I believe my research profile—combining computational modelling, causal neuroscience, and decision science—together with my commitment to interdisciplinary teaching, make me well suited to contribute to this vision. I would welcome the opportunity to discuss how my work could fit within the department, and I am happy to provide any additional materials.

Sincerely,

Simone D'Ambrogio