Decision-making under sources of uncertainty: strategic interaction, temporal delay, risk, ambiguity and indecisiveness

Every day, we make decisions under uncertainty—whether we're playing games of chance, investing in a new business, choosing a pension plan, or simply deciding whether to buy a coffee mug. Sometimes we know the odds, sometimes we don't. We might be unsure about future events, about what others will do, or even about our own preferences. These different types of uncertainty—risk, ambiguity, indecision, strategic uncertainty—might seem unrelated, but they often share deep connections.

Our research project explores how people make decisions under various forms of uncertainty. We take an interdisciplinary approach, combining mathematical theory, behavioral psychology, game theory, and experimental methods. Our goal is to build models that are not only logically rigorous but also reflect how people actually make decisions in real-life situations—models that bridge the gap between rational theory and observed behavior.

One major focus is decision-making under **risk**, where the probabilities of outcomes are known. Most experimental studies use binary gambles—lotteries with two possible payoffs. These are simple, intuitive for participants, and often sufficient to identify model parameters. However, many decision theories that differ conceptually end up making the same predictions on this restricted domain. They all reduce to what is known as a **biseparable preference model**, which acts as a kind of common denominator. Because of this, it is difficult to distinguish between competing theories using only binary gambles. Our work investigates when and how such models can be extended to richer domains with more than two outcomes, and how different theories diverge in these broader contexts.

We also study **ambiguity**, which refers to situations where probabilities are unknown. People encounter it in many areas of life—such as investing, politics, or health. We analyze how individuals value uncertain prospects, how they form expectations, and how their aversion to uncertainty manifests. We are particularly interested in the characterization of biseparable preferences and their extensions to ambiguous settings. By characterization, we mean identifying a set of simple behavioral postulates that, taken together, are equivalent to a given abstract model of decision-making. This includes models of **reference-dependent preferences**, in which the decision-maker evaluates outcomes in terms of gains or losses relative to a fixed reference point—such as current wealth, expected value, or another salient benchmark. Finally, we aim to characterize a **measure of uncertainty aversion** as the **difference between the buying price and the short-selling price** of an act within several well-known preference models.

A special focus of our research is the relationship between **time and uncertainty**. Is it better to take a smaller reward now or wait for a larger one later? It is commonly believed that people are impatient because they prefer immediate gratification. We show, however, that an important factor is fear of termination—not only the fear of death, but also the concern that a plan may be cancelled or that another party may fail to deliver on a promise. We incorporate this into our models, such as the **Discounted Incremental Utility (DIU)**, which better reflect actual decision-making behavior. We combine this model with **Range Utility Theory (**Baucells, Lewandowski & Kontek, 2024), which adds sensitivity to the decision context. This integrated approach allows us to explain empirically observed effects such as the common ratio and common delay effects, magnitude effects in discounting, preference reversals in both risk and time domains, and various temporal patterns of impatience. What are often viewed as anomalies in classical theories emerge in our framework as natural consequences of more psychologically realistic assumptions.

In the context of **strategic uncertainty**, we study situations where the decisions of others are not fully predictable—such as in voting or negotiations. For instance, in Borda voting systems, where jurors assign points to candidates, we introduce the concept of the **nearest Nash Equilibrium**—an equilibrium reached through the shortest sequence of unilateral profitable deviations starting from truthful voting. We are also interested in the **stability of juror consensus** within such equilibria.

To test and refine our theories, we use a mix of methods: formal modeling (using axiomatic approaches, functional equations, and noncooperative game theory), numerical simulations, standard surveys, and interactive experiments—including mobile app-based tools that capture decisions in real-time.

Ultimately, our goal is to better understand how people make decisions when outcomes are unclear, information is incomplete, and the future is unpredictable. Whether in economics, policy, or everyday life, uncertainty is the norm—not the exception. By uncovering the patterns and principles behind our choices, we hope to contribute tools that improve individual and collective decision-making in an increasingly complex world.