IDP on implementing efficient data-analysis tools for the study of human decisions and decision confidence

Background:
Imagine you are choosing between two similar products—say, two laptops with slightly different specs. You might quickly pick one and feel very sure about your choice, or you might hesitate, second-guessing which is truly better. This "gut feeling" about your decision is called confidence, and it plays a key role in how we make value-based choices (like shopping, investing, or even selecting a meal).

Researchers study these decisions using computational models—mathematical frameworks that predict not just what people choose, but how confident they feel and how long they take to decide. However, testing these models requires powerful software to estimate hidden cognitive parameters from real behavior.

The Project's Focus (Software Development):
While the science of confidence is fascinating, testing these models requires efficient software—especially when estimating parameters from real-world behavior. Current tools can be slow or unreliable, creating bottlenecks in research.

This project tackles that problem by developing and optimizing scientific software (in R) for fitting confidence and decision-time models. Key tasks include:

- Implementing faster, more robust optimization methods.
- Comparing classic statistical approaches with modern Bayesian (MCMC) techniques.
- Ensuring the software is user-friendly and reliable for real research.

What You Will Do:

- Work with computational models used in psychology/neuroscience.
- Improve existing tools or build new ones for parameter estimation.
- Benchmark performance (speed/accuracy) of different methods.
- Compile your tools in a well-documented and user-friendly software package.
- Summarize your results in a paper-style report.

Why It Matters:
Better tools mean better science—whether studying shopping habits, financial decisions, or even health behaviors. You will gain hands-on experience in scientific programming while contributing to open-source tools used in innovative science.

Ideal for students who have always wanted to **dip their toes into psychology**—while building serious coding skills!

Your skill set:

- Strong programming experience in C, C++, or R
- Familiarity with numerical optimization (e.g., gradient descent) and basic knowledge of statistics/probability (e.g. parameter estimation, distributions)
- **No prior psychology background needed!** - Just curiosity about decision-making or cognitive science
- Self-motivated & collaborative: Reliable, independent work ethic with strong interdisciplinary teamwork skills
- Of advantage, but not required:
  - Experience with psychology/behavioral data (e.g., reaction times, choice tasks)
  - Basic high-performance computing (e.g., parallelization, efficient code)
  - Knowledge of version control (Git) & open-source workflows

Possible start date:

The project can start anytime. Ideally, the project should be completed within 6 months. Regular meetings ensure close alignment with the project goal while keeping room for the student's independence and creativity.

Lectures:

Participation in (one of) the following lectures would nicely complement the IDP:

- Empirical Research in Management and Economics (WI000258VO)
- Applied statistics in R - Seminar & Exercise (MGT001438)
- Process Tracing: Methods and Applications (MGT001337S)
- Introduction to Bayesian Data Analysis (MGT001381)
- Judgment and Decision Making (MGT001363S)

Recommended Resources:

- Rcpp for integrating C++ into R: https://www.rcpp.org/
- The pmwg sampler for flexible MCMC sampling in R: https://github.com/university-of-newcastle-research/pmwg
- Psychological background:
  Hellmann, S., Zehetleitner, M., & Rausch, M. (2023). Simultaneous modeling of choice, confidence, and response time in visual perception. Psychological review, 130(6), 1521–1543. https://doi.org/10.1037/rev0000411

Contact: If interested, please send your CV, grade report, and a brief statement of your motivation via email. All applications and questions should be directed to:
sebastian.hellmann@tum.de