Closed-loop Interaction with Probabilistic Models

Evdoxia Taka John Williamson Sebastian Stein
School of Computing Science University of Glasgow
e.taka.1@research.gla.ac.uk

The Problem

The representation and communication of uncertainty in probabilistic modelling are of particular importance for end-users to explore, comprehend and make judgements.

Interactive and animated representations seem to represent uncertainty more effectively than static displays [1], [2] by exploiting active perception via closed-loop control of displays. This could be achieved by the application of the concepts of pseudo-haptics [3].

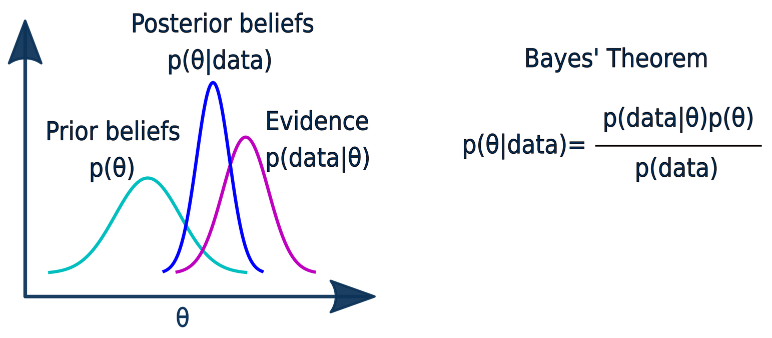
Research Focus

The research focus will be to explore the open research question of whether animated and interactive representations of uncertainty in probabilistic modelling help end-users acquire a better understanding of the uncertainty in comparison to static displays.

Uncertainty lies behind any prediction or any explanation of the generative processes of data that probabilistic modelling aspire to provide. A better comprehesion of uncertainty is crucial for the realization and consideration of its implications in our decisions.

Probabilistic Modelling

The problem will be viewed in the prism of probabilistic Bayesian modelling. Bayes' theorem is used to update our prior beliefs of a hypothesis as more data becomes available. We will exploit advances in:
- Probabilistic programming and efficient MCMC
- Web programming for building an interaction framework through the web browser.



Example

The following figure presents a vivid example of these concepts. A hierarchical regression probabilistic Bayesian model is applied to the reaction time of 18 subjects who were restricted to few hours of sleep. We will use the data provided by [4]. The end-user is able to interact with the posterior distributions of the model's parameters and explore the effect of the model's parameters' uncertainty on the estimated fitted lines to the data of each subject. In this way, end-users are able to explore different aspects of the model's uncertainty and view its effect.

Data

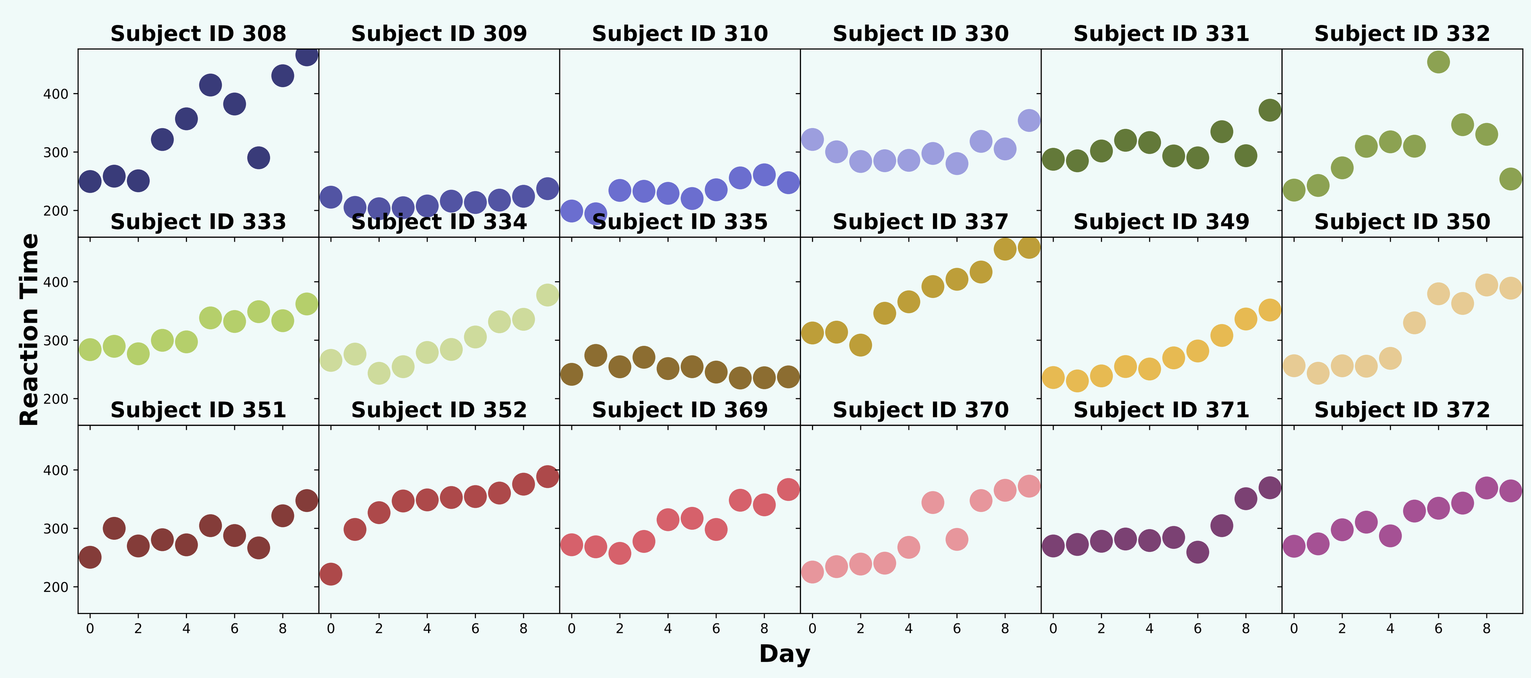


Fig 1. Reaction time to a visual stimulus for 18 subjects that have been restricted to 3 hours of sleep for 10 days. Data provided by [4].

Probabilistic Model

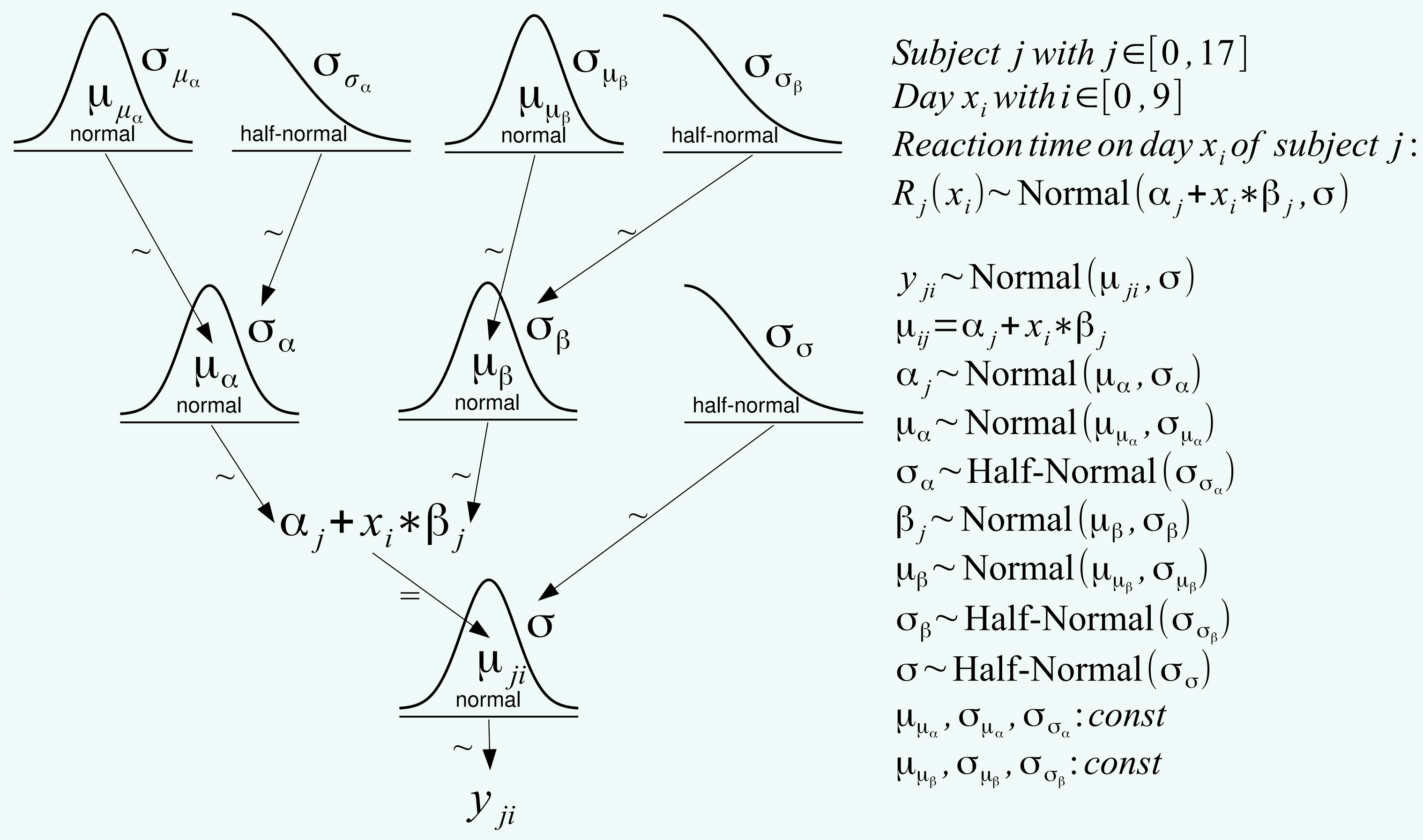


Fig 2. A hierarchical regression probabilistic Bayesian model was applied. The figure presents the Kruschke diagram of the model. First line: hyperpriors. Second line: priors. Third line: likelihood. Forth line: observations.

End-User

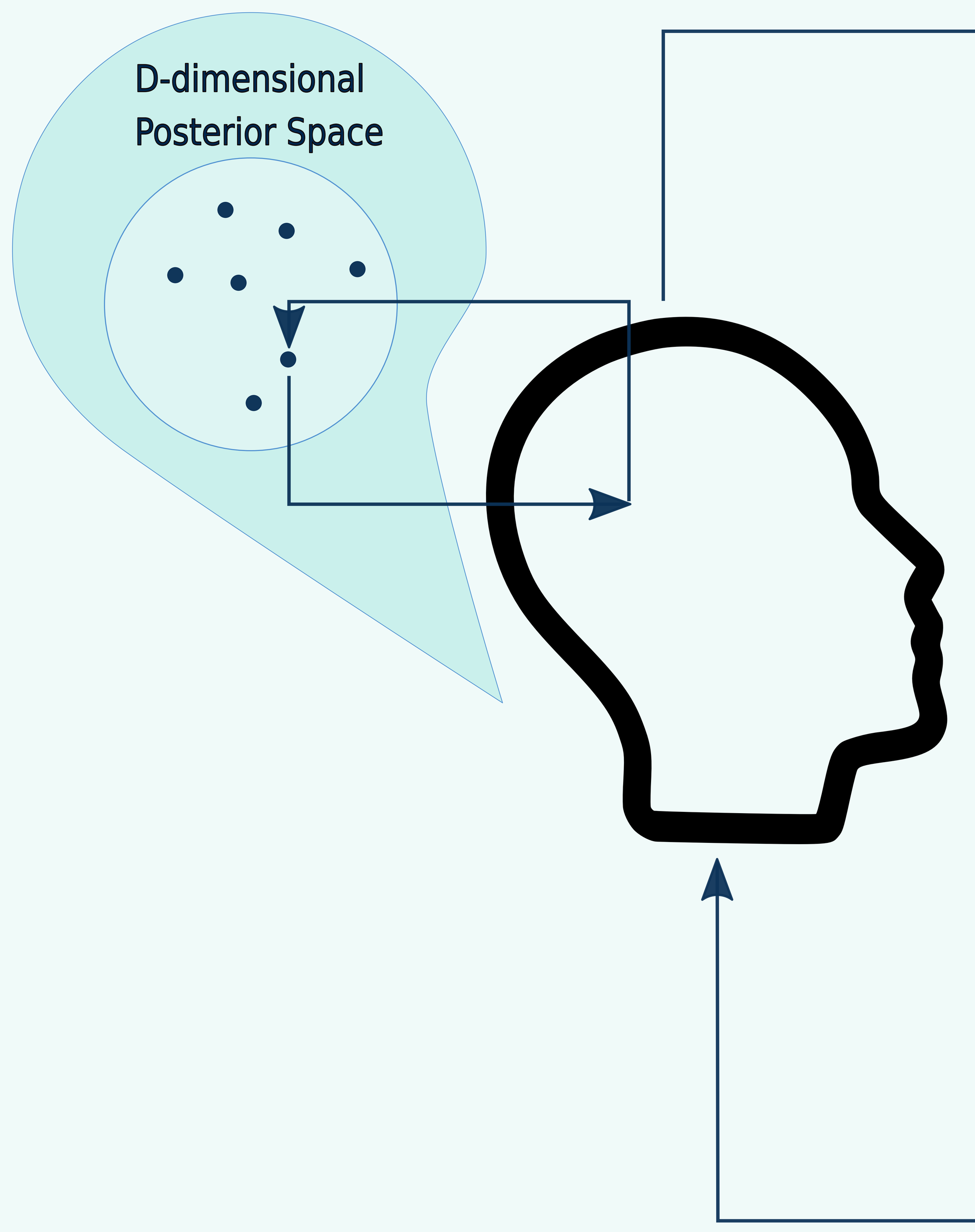


Fig 4. The end-user interacts with the posterior distributions and explores it by building a clearer picture of the high-dimensional posterior space.

Visualization

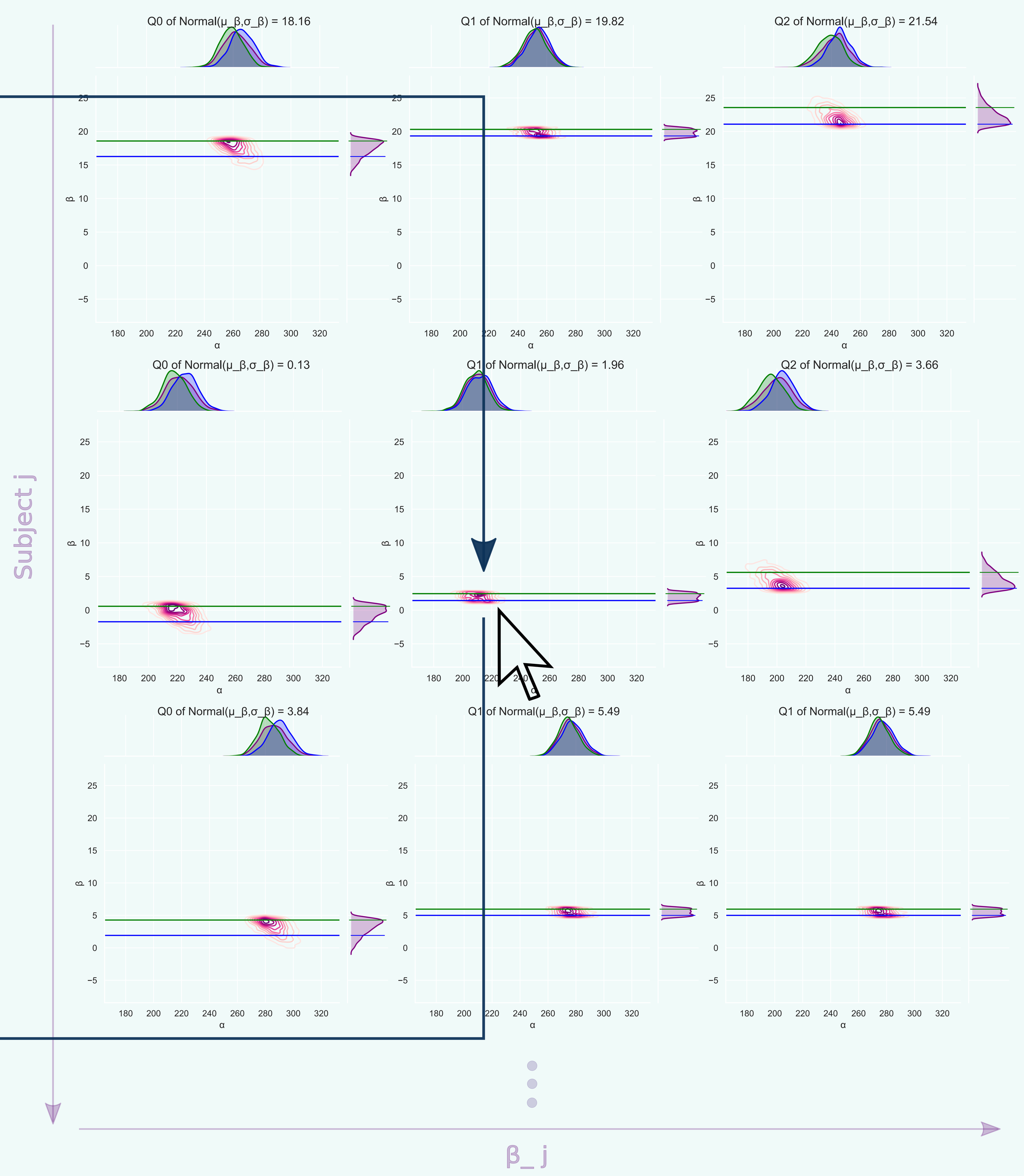


Fig 3. This figure presents the joint and marginal distributions of the α and β parameters for 3 different values of the μ_β parameter for each subject. The user can interact with the posteriors and explore the model by selecting specific values of the parameters.

References
[1] Pierre Dragicevic et al. 2019. Increasing the Transparency of Research Papers with Explorable Multiverse Analyses. CHI 2019.
[2] Alex Kale et al. 2018. Hypothetical Outcome Plots Help Untrained Observers Judge Trends in Ambiguous Data. IEEE transactions on visualization and computer graphics (2018).
[3] Andreas Pusch et al., Pseudo-haptics: from the theoretical foundations to practical system design guidelines, ICMI 2011.
[4] Belenky et al. Patterns of performance degradation and restoration during sleep restriction and subsequent recovery: a sleep dose-response study. J Sleep Res 2003;12:1-12.

Acknowledgement: Closed-Loop Data Science for Complex, Computationally- and Data-Intensive Analytics, EPSRC Project: EP/R018634/1