Real-world human locomotion as a platform for cumulative and societally impactful computational cognitive science

Gustav Markkula[1,2], Aravinda Srinivasan[1], Yi-Shin Lin[1], Yueyang Wang[1], Jac Billington[2], Matteo Leonetti[3]

[1] Institute for Transport Studies, University of Leeds, [2] School of Psychology, University of Leeds, [3] Department of Informatics, King's College London

Background

- Recurring calls for **cumulative theory-building** in psychological/cognitive sciences
- One suggested approach: model **real-world human behaviour** → requires **integration of theory**
- Most applied human behaviour modelling is **ad hoc engineering models** or **black box machine-learning**

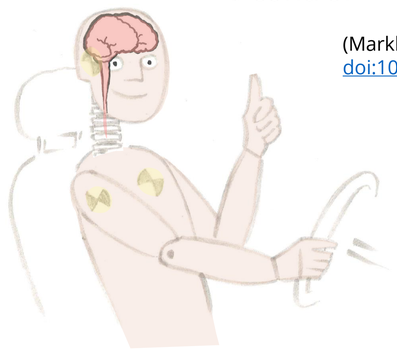
→ Here: **Integration of computational cognitive theory to model human driving/walking**

Routine and near-crash driver behaviour

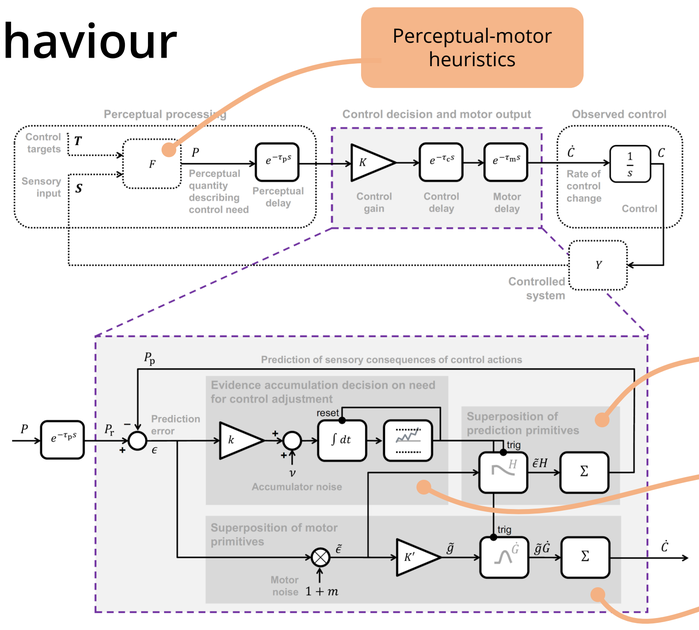
Closed-loop ⟷ Open-loop

Short delays ⟷ Long, random delays

Well-adjusted control ⟷ Under- and overreactions

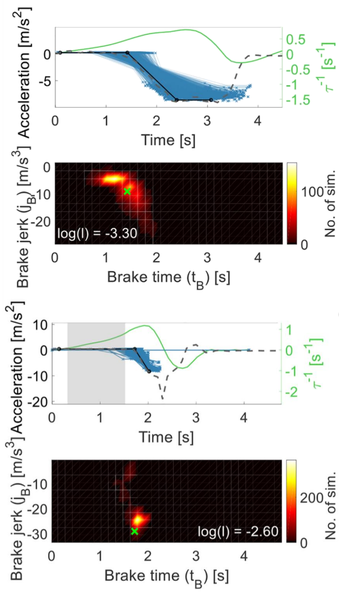


(Markkula, 2014, HFES Annual Meeting)
doi:10.1177/1541931214581185



(Markkula et al., 2018, Biological Cybernetics)
doi:10.1007/s00422-017-0743-9

Modelling braking in real near-crashes and crashes



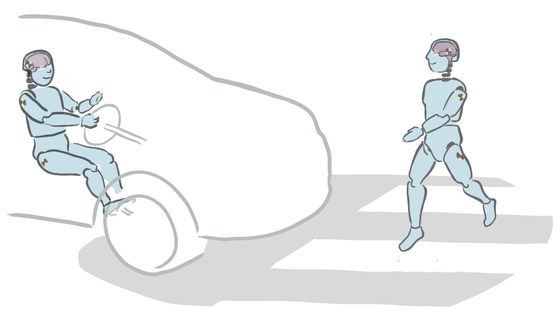
(Svärd et al., 2021, Accident Analysis & Prevention)
doi:10.1016/j.aap.2021.106433

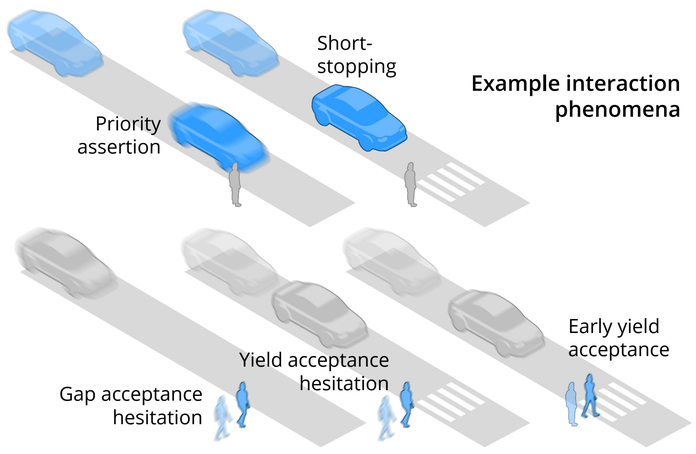
Sensory predictions (corollary discharge)

Evidence accumulation

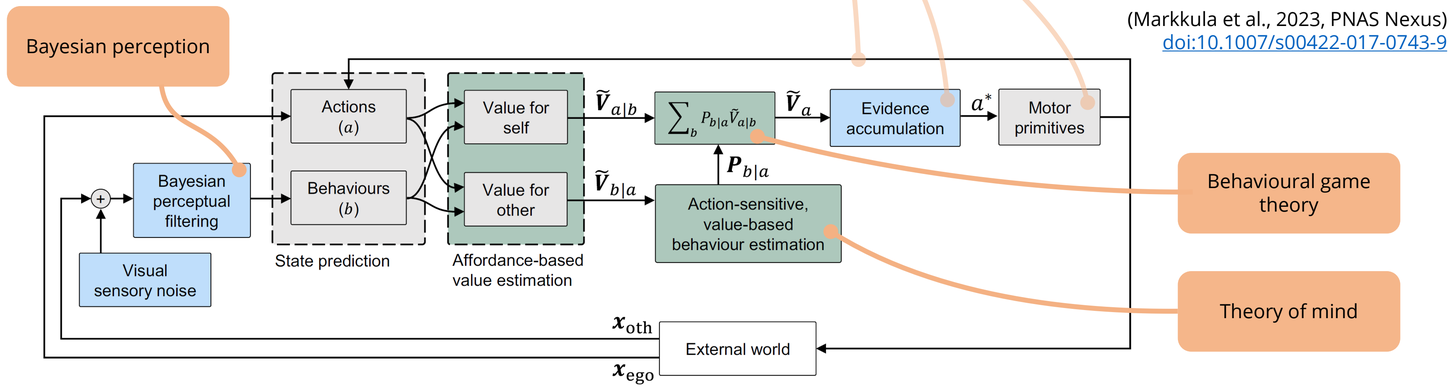
Motor primitives

Driver-pedestrian interaction



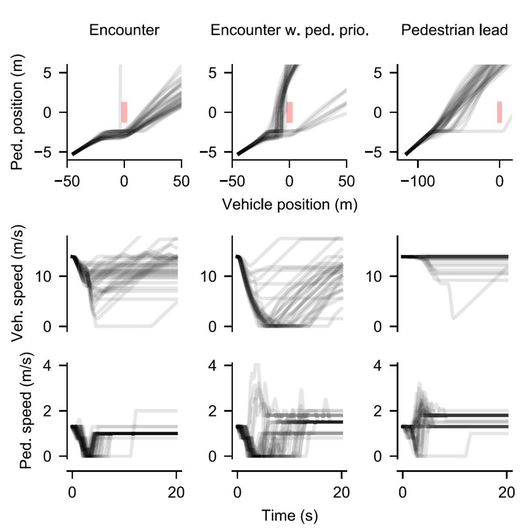


Example interaction phenomena

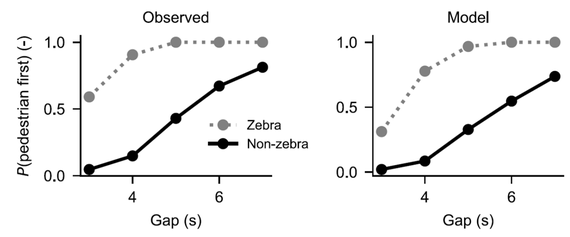


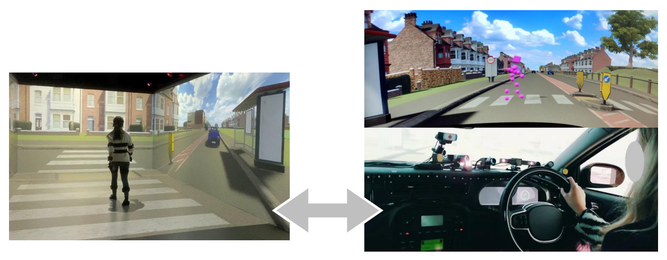
(Markkula et al., 2023, PNAS Nexus)
doi:10.1007/s00422-017-0743-9

Two-agent model simulations



Predicting outcomes in two-participant simulator study





(Kalantari et al., 2023, Accident Analysis & Prevention)
doi:10.1016/j.aap.2023.107050

Outlook

- Real-world locomotion is a **microcosm of human cognition** → good platform for **integrating models**
- In general many **benefits** of developing **applied human behaviour models based on fundamental theory**

Applied researchers get models that can be:
- Explained and understood
- Used to guide interventions
- Extended as fundamental science progresses

Fundamental researchers get:
- Cumulative theory-building
- Real-world impact of their models
- Ideas/steer on research directions

Engineering and Physical Sciences Research Council

UNIVERSITY OF LEEDS

KING'S College LONDON

SCAN ME