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# GAURAV MALHOTRA

## PROFILE INFO

I am a postdoctoral Research Fellow at University of Bristol, interested in human vision and decision-making. My work lies at the intersection of psychology, neuroscience and artificial intelligence. It combines computational models with behavioural experiments to understand how our environment and biology shape our cognition.

## EDUCATION

**PhD** (Dorothy Hodgkin Scholar)**University of Edinburgh**

Psychology

2004 – 2009

Thesis: *Dynamics of syntactic priming***MSc** (Distinction)**University of Edinburgh**

Informatics

2002 – 2003

**BEng** (First class)**Thapar University, India**

Computer Science

1996 – 2000

## WORK HISTORY

**University of Bristol**

United Kingdom

2018 — now

**Research Fellow**

Senior researcher and co-lead on large ERC grant testing the ability of AI models to capture human cognition.

**University of Bristol**

United Kingdom

2012 — 2018

**Senior Research Associate**

Senior postdoc and mentor on EPSRC grant bringing together psychologists, mathematicians and economists to research decision-making in an unstable world.

**Aix-Marseille Uni**

France

2009 — 2011

**Postdoctoral Researcher**

Integrated behavioural and neuroscience research to propose a new model for how people generate temporal expectations.

**Hughes Software**

India

2000 — 2002

**Software Engineer**

Designed, implemented and tested software for telecom systems that enabled analog voice networks (AT&T) to interface with digital networks (Voice over IP).

## FUNDING & AWARDS

**EPSRC Impact Acceleration Award** (Co-I) | 2014 — 2015

*Strategic award to apply research to challenges in society. Worked with industrial partner to improve recommendation system based on Bayesian sampling methods.*

**EBI Health Research Grant** (named postdoc) | 2015 — 2016

*Worked with consultants in Bristol Royal Infirmary to examine how adaptive nudges can be used to improve decisions made by doctors in the Intensive Care Units.*

















**EPSRC Platform Grant** (named postdoc) | 2015 — 2020
















*Joint project with engineering, investigating how insights from perceptual decision-making can be used to improve image and video de-noising algorithms.*

**Dorothy Hodgkin Postgraduate Award** | 2005 — 2009

*Highly competitive RCUK and industrial studentship for talented international students*

## PUBLICATIONS

- submitted   Obstacles to inferring mechanistic similarity using representation similarity analysis.  
Dujmović, Bowers, Adolfi & **Malhotra\*** **bioRxiv (pre-print)**  
*in which we show that RSA can be a misleading method of measuring whether two cognitive system systems encode the world in the same way.*
- in press   Human shape representations are not an emergent property of learning to classify objects.  
**Malhotra**, Dujmović, Hummel & Bowers **Journal of Experimental Psychology: General**  
*we show that humans are sensitive to relations between object features — a property that does **not** emerge when CNNs learn to classify objects.*
- in press  Reinforcement learning under uncertainty: expected versus unexpected uncertainty and state versus reward uncertainty.  
Ez-zizi, Farrell, Leslie, **Malhotra** & Ludwig **Computational Brain & Behavior**  
*where we explore how people update their beliefs when their perceptual system is noisy and the environment is stochastic and unstable.*
- 2023   Deep Problems with Neural Network Models of Human Vision.  
Bowers, **Malhotra**, Dujmović, Montero, Tsvetkov, Biscione, Puebla, Adolfi, Hummel, Heaton, Evans, Mitchell & Blything **Behavioral & Brain Sciences**  
*where we identify gaps between Deep Neural Networks and human vision and argue for controlled experiments for correctly comparing the two.*
- 2023    The role of capacity constraints in Convolutional Neural Networks for learning random versus natural data.  
Tsvetkov, **Malhotra**, Evans & Bowers **Neural Networks**  
*we show that CNNs exhibit a super-human capacity to learn visual inputs, which can be partially remedied by introducing internal noise in activations.*
- 2022  Lost in latent space: Examining failures of disentangled models at combinatorial generalisation.  
Montero, Bowers, Ludwig, Ponte-Costa & **Malhotra\*** **NeurIPS†**  
*in which we show that latent representations of generative models are unlikely to be compositional and fail at combinatorial generalisation.*
- 2022   Feature blindness: a challenge for understanding and modelling visual object recognition.  
**Malhotra**, Dujmović & Bowers **PLOS Computational Biology**  
*we find that humans ignore highly predictive non-shape features in novel objects, a behaviour that contrasts with Deep Neural Networks and demonstrates the inflexibility of human shape-bias.*
- 2021    Biological convolutions improve DNN generalisation.  
Evans, **Malhotra** & Bowers **Neural Networks**  
*in which we show that adding a layer of Gabor and centre-surround filters to CNNs helps them generalise to out-of-distribution stimuli.*

- 2021  The role of disentanglement in generalisation. **ICLR†**  
 Montero, Malhotra, Ludwig, Ponte-Costa & Bowers  
*we show that disentangled latent representations do not necessarily lead to better combinatorial generalisation in Variational Auto-Encoders.*
- 2020   What do adversarial images tell us about human vision? **eLife**  
 Dujmović, Malhotra & Bowers  
*we show that human response to adversarial images is qualitatively different from CNNs, which classify these images with high confidence.*
- 2020   Hiding a plane behind a pixel: shape-bias in CNNs and the benefit of building in biological constraints. **Vision Research**  
Malhotra, Evans & Bowers  
*we show that CNNs can learn highly idiosyncratic features in images. This behaviour can be ameliorated by attaching an input layer of V1-like filters.*
- 2019   Mechanistic models must link the field and the lab. **Behavioral & Brain Sciences**  
 Houston & Malhotra  
*we critique a theory of animal foraging behaviour and argue that realistic theories must build in various sources of environmental uncertainties.*
- 2018   Optimal gut size of small birds and its dependence on environmental and physiological parameters. **Journal of Theoretical Biology**  
 Ez-Zizi, McNamara, Malhotra & Houston  
*we show that birds have an optimal gut-size which is determined by a trade-off between energetic gains and cost of digestion and foraging.*
- 2018  Time varying decision boundaries: Insights from optimality analysis **Psychonomic Bulletin & Review**  
Malhotra, Leslie, Ludwig & Bogacz  
*where we use dynamic programming to show that, in many real-world situations, optimal decision thresholds can collapse with time.*
- 2017   Overcoming indecision by changing the decision criterion **Journal of Experimental Psychology: General**  
Malhotra, Leslie, Ludwig & Bogacz  
*we show that people frequently decrease their decision thresholds during perceptual decision-making but deviate from optimal decision boundaries.*
- 2016  Increasing compliance with low tidal volume ventilation in the ICU with two nudge-based interventions **BMJ Open**  
 Bourdeaux, Thomas, Gould, Malhotra, Jarvstad & Gilchrist  
*in which we investigated the impact of two nudge-based cognitive interventions on behaviour of doctors in Intensive-Care Units.*
- 2008   On the persistence of structural priming: Mechanisms of decay and influence of word-forms. **CogSci**  
Malhotra, Pickering, Branigan, Bednar  
*where we showed that the dynamics of short-term memory can explain syntactic decisions made by interlocutors during language production.*

\* Senior Author

† *NeurIPS* (Advances in Neural Information Processing) and *ICLR* (International Conference on Learning Representations) are highly prestigious, peer-reviewed conferences dedicated to Artificial Intelligence and Machine Learning research.

## SKILLS & EXPERTISE

### Scientific Computing

I'm a highly skilled mathematician with an in-depth knowledge of **linear algebra, calculus** and **statistics**. I'm also a proficient programmer with extensive experience in **Python, Matlab, C, C++** and **Java**.

### Experiments & Data Analysis

I'm an expert at designing, conducting, and analysing human perception experiments. I'm a skilled user of **PsychoPy** & **PsychToolbox** for designing experiments and **R** and **Stan** for simulation and analysis.

### Machine Learning

I have a strong background in machine learning methods, including **Bayesian statistics, regression models, reinforcement learning** and **kernel methods**. I am an accomplished user of **PyTorch** with extensive experience in building and testing **CNNs, VAEs, Transformers** and **Deep RL** systems.

### Written and Verbal Communication Skills

I have delivered numerous invited lectures and talks at international conferences and authored a large number of journal articles, reports and theses. I'm a fluent speaker of **English, Hindi, and French**.

## TEACHING & SUPERVISION

2022 – present

**Teaching Associate** | 3<sup>rd</sup> Year | Psychology | University of Bristol

- Units taught: **Cognitive Neuroscience**
- Prepared course material and delivered lectures on using Artificial Intelligence to understand human cognitive processing

2019 – present

**Supervisor** | MSc, PhD | Psychology | University of Bristol

- Co-supervised 3 PhD students on projects examining Deep Learning models of human vision and decision-making
- Co-supervised 1 MSc Research student on project related to models of human decision-making

2012 – 2017

**Mentor** | PhD | Psychology | University of Bristol

- Mentored 4 PhD students in perceptual decision-making and vision
- Supported learning about research design, modelling, data collection, data analysis techniques and report writing

2012 – 2013

**Tutor** | 1<sup>st</sup> Year | School of Mathematics | University of Bristol

- Units taught: **Linear Algebra, Probability, Statistics, LaTeX**
- Delivered tutorials, marked reports and provided mentorship

2010 – 2011

**Teaching Assistant** | 1<sup>st</sup> Year | Informatics | Aix-Marseille University

- Units taught: Programming in **C, C++**
- Delivered tutorials, helped in designing course and marking reports

2004 – 2006

**Teaching Associate** | Masters | Informatics | University of Edinburgh

- Units taught: **Neural Computation, Logic, Java**
- Developed materials, delivered tutorials and marked reports