Daniel Bennett

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PHD CANDIDATE AND RESEARCH ASSISTANT

Bristol University: Complex Systems Models of Cognition for HCI
(with Oussama Metatla & Anne Roudaut)

RESEARCH THEMES

Embodied Interaction
Computational Interaction
Complexity in HCI
Phenomenology
Eudaimonic UX

EDUCATION

University of Bristol
PhD Human Computer Interaction
(complete Sep. 2021)
MSc Computer Science
(Distinction)

University of Southampton
MA Philosophy *(Distinction)*
BA Philosophy *(2.1)*

EXPERTISE

Multifractal Analysis
Data Science
Signal Processing
Project & Team Management
User Study Design
Thematic Analysis
Prototyping

C, C++, C#, Python, SQL,
Neo4J, MAX/MSP, PureData
OpenFrameworks, Unity, Arduino

THEORY

4E Cognitive Science
Phenomenology
Complex Systems
Self Determination Theory
Positive Psychology

SELECTED PROJECTS

Multifractal Analysis of Interaction Behaviour

Cognitive Science, user experience, complex systems, dynamics
Multifractal Analysis of behaviour is a promising technique for inferring user behaviour and experience. Developed in cognitive science, the approach analyses complexity in human movement signals to understand the adaptive, embodied, dynamics underlying cognition and behaviour. My PhD thesis work evaluates multifractal analysis for application in interface design, to infer engagement, fatigue and coordination with technologies. I have conducted experiments and analyses to investigate multifractality in mouse, keyboard use, and eye-tracking data from microsurgery. This work shows that the feature can be used to infer task-engagement, locus-of-attention, fatigue, and level of expertise.

Understanding autonomy in HCI

Literature review, thematic analysis, wellbeing, theory
We conducted a thematic analysis of the full texts of 10 years of CHI papers dealing with issues of autonomy. We found a range of approaches, across a wide range of domains, and often complex scenarios, but only a small proportion of this work was significantly grounded in theories of autonomy, from either psychology or elsewhere. We also investigated opportunities to improve understanding via more nuanced application of the popular positive psychology framework Self Determination Theory.

Neurythmic - a neural drum machine

Prototype development, complex systems, dynamics, expert user studies
Central Pattern Generators (CPGs) are simulations of oscillating neural networks which control adaptive rhythmic behaviours in animals. They both generate rhythms and synchronise flexibly to input. I investigated CPGs for use in digital musical tools, including a neural drum machine Neurythmics. To understand the experience of interaction with such complex, dynamical musical interfaces, I recruited expert musicians, and ran structured tasks, comparing Neurythmic with their preferred instruments. I used the *explicitation interview* technique to elicit detailed reports of experience and implicit understanding, before analysing results with thematic analysis. I later developed a C++ library and toolkit to support development of interactive and creative applications with CPGs.

EXPERIENCE

Bristol University   June 2021 – Sep 2021
Research Assistant   University of Bristol

Design and development of an interactive online platform to allow members of the public to explore, understand and share crossmodal sensory effects, and connect them to mood and emotion. Design of a study around this platform.

University of East Finland   Dec 2020 – Feb 2021
Visiting Project   Joensuu Finland

Investigating multifractal signatures in eye gaze during training for microsurgery and forestry.

Bristol University   Feb 2018 – present
PhD Candidate, Lecturing, Thesis Supervision, Teaching Assistance   Bristol UK

Lecturing:
- *Theories of HCI* : Co-developed syllabus with Oussama Metatla. Developed and delivered lectures on The First Wave of HCI, Hedonic and Eudaimonic approaches to UX, Computational Interaction.
- *Programming in C* : Developed and delivered a series of additional lectures to support this module, 2018-2019 & 2019-2020.
- *Human Computer Interaction* : Guest lecture on Heuristics and Biases

Supervision:
- *MSc Computer Science* : Thesis supervision for 4 students 2018-2020.
- *Software Engineering* Supervised three undergraduate teams on NHS-specific projects (2020).
- *MSc Interaction Design* Supervised two project teams for this module, leading to two CHI Extended Abstract publications

Teaching assistance
- *Databases* , *Interaction Design* , *Interactive Devices* , *Introduction to Computer Science*

Admin and Organisation
- Organiser: Visiting Speaker Program, Bristol Interaction Group 2018-2020 including successful internal funding applications
- Organiser: HCI Reading Group: Bristol Interaction Group 2018-2019
- Co-organiser: Bristol Interaction Group Discussion Panels 2021 - developing panel discussion events on *Animal Computer Interaction* and *Theories of Affordances*

University Hospitals Bristol Healthcare Trust   Feb 2018 – present
Information Systems Consultant   Bristol UK
- Various short engagements: advisory and development work on projects to upgrade databases and information systems and develop ETL processes.

University Hospitals Bristol Healthcare Trust   Nov 2007 – Feb 2018
Information Systems Manager   Bristol UK

- Managed a team developing and maintaining BI processes for reporting to government and finance
- Provided support and training for a team of 15 healthcare information analysts
- Drove efforts to improve standards and modernize practices in the department. I worked to improve documentation practices and built up a unified set of best-practice guidelines.
- Technologies: Microsoft SQL Server, SSIS, SSRS, C#, PowerBI,

Freelance 2005 – present
Multimedia Developer, Performer, Curator Bristol UK

I have worked on various projects developing audio and game software, writing and performing music and narrative scenarios, and curating event programs.

- Contributor (music, sound design) to Mark Fisher and Julian Barton's art installation *On Vanishing Land* . Commissioned by the Turner Prize-nominated Otolith Group and exhibited in London, Beirut, Bristol. Reviewed in international arts magazines including Frieze. Recording published by Hyperdub records.
- Contributor (scenario, software development, sound design) to a game *Sonalethe* which is currently seeking 2nd round funding based on a substantive demo.
- Composer/performer for DEMONSTRATE theatre company's touring production *Hazmat & Me* .
- Composer of music published by internationally respected publishers Touch and Hyperdub
- Musical performances using self-developed software at venues and festivals around Europe
- Co-curator of musical event and event series for venues including Bristol's Arnolfini Gallery and Southampton's John Hansard Gallery

PUBLICATIONS

[C1] Emergent Interaction: Complexity, Dynamics, and Enaction in HCI CHI 2021 Workshops & Symposia

Daniel Bennett, Alan Dix, Parisa Eslambolchilar, Feng Feng, Tom Froese, Vassilis Kostakos, Sebastien Lerique, Niels van Berkel HTTPS://DOI.ORG/10.31234/OSF.IO/ZD82B

I led the organisation of this workshop and the development of the workshop paper. There is a long tradition of work in Human Computer Interaction which emphasises the way behaviour arises from ongoing adaptation, and the dynamically varying relationships between human(s), technology(s), and their context(s). Recent work has framed this well established approach in a new way - arguing that interaction is well modelled as a complex dynamical system. This workshop investigates the opportunities and challenges raised by this approach, drawing on recent work from enactivist cognitive science, social science, philosophy and control theory.

[C2] Complex Systems Models of Cognition for HCI BCS HCI 2020 Doctoral Symposium
Daniel Bennett HTTP://DOI.ORG/10.14236/EWIC/HCI20DC.4

An overview of my thesis work investigating complex dynamical systems models of human behaviour, and specifically "interaction dominant" models of cognition, for HCI research. Building on adaptive models of human behaviour to develop low cost, unobtrusive measures of skill learning, task-engagement, and executive function during interaction with technology.

[C3] Difficult Duets Society for Electro- Acoustic Music in the United States Conference, 2020
Farwell, N. J., Jordan, F. M., Liveley, G., Habgood-Coote, J. T., Bennett, P., Bennett, D., Kanno, M., Mertin, U., Wiltshire, H. & Hayes, S.,

This paper describes an investigation into the challenges posed to the expressive agency of virtuoso musical performers when they perform with technology. The investigation centres on the composition, work-shopping and performance of a piece of music involving written scores and adaptive, generative computer systems which pose challenges to the performers. The work grew out of an interdisciplinary collaboration between academics from music, anthropology, philosophy, classics, and computer science.

[C4] Small-'p' philosophy in HCI

Daniel Bennett, Oussama Metatla, Anne Roudaut

Cognitive Science's engagement with philosophy has often resulted in defensive gatekeeping, with research programs dismissed on a priori grounds which are divorced from empirical practice. We suggest HCI can avoid this, by learning from recent more constructive, practice-engaged work in which philosophers collaborate with cognitive scientists?

[C5] Neurythmic: A Rhythm Creation Tool Based on Central Pattern Generators   NIME 2018

Dan Bennett, Anne Roudaut, Peter Bennett

Neurythmic is an interactive musical instrument which uses the rhythmic properties of biological neural oscillators to generate appealing, generative and adaptive rhythms. The system is based on Central Pattern Generator networks. These are dynamical neural networks, which are often deployed in robotics, and which model those neural structures responsible for adaptive rhythmic behaviours including heartbeat, gut peristalsis and gait.

[C6] Disruptabottle: Encouraging Hydration with an Overflowing Bottle   CHI 2020 Extended Abstracts

Adam Beddoe, Ro Burgess, Lucian Carp, James Foster, Adam Fox, Leechay Moran, Daniel Bennett, Peter Bennett

Nudge theory is now a familiar idea in HCI to encourage healthy behaviours without undermining autonomy: but what happens when a 'nudge' becomes a 'shove'?! Drink enough water, or this water bottle will overflow and spill. Disruptabottle aggressively nudges you to drink while drawing attention to drinking habits and motivating conscious decision making.

[C7] PauseBoard: A Force-Feedback Keyboard for Unintrusively Encouraging Regular Typing Breaks

Lewis Bell, Jay Lees, Will Smith, Charlie Harding, Ben Lee, Daniel Bennett

A computer keyboard designed to unintrusively encourage users to take regular breaks. The force required to activate each key is increased towards the end of a set work period, by the use of motorised linear potentiometers.

[C8] Towards a Resistive Computer Music   UWE Philosophy of Sound Conference, 2015
Daniel Bennett

I develop proposals for computer music practice drawn from the work of composer Helmut Lachenmann and his comments on the physical impoverishment of electronic music. Drawing on Bataille's account of base materialism, I argue that the impoverished resonances and hidden labour in the material conditions of electronic sound production, point to possibilities for critical and materialist approaches to computer music.

PUBLICATIONS IN DEVELOPMENT / UNDER REVIEW

Multifractality in Eye Gaze Correlates with Skill in the Control of Complex Machinery

Daniel Bennett, Jani Koskinen, Roman Bednarik, Oussama Metatla, Anne Roudaut

There is growing interest in the use of eye-gaze analysis to develop metrics of skill and expertise. However, extant approaches generally rely on linear measures, and can be invalidated by the evolution of skilled behaviour over time. They also tend to rely upon the mapping of gaze to scene - a step which can be resource intensive and error prone. We investigate an approach to quantifying skill during the operation of complex machinery based on multifractal complexity in eye-movement, grounded in recent research on the role played by complex, non-linear interactions between motor and visual pathways in tasks involving hand-eye coordination. Our approach does not rely on the mapping of gaze to scene, nor upon features of behaviour which may be invalidated by gross behavioural changes. We capture eye-movement signals under real world working conditions, during an authentic forestry-training task and subject them to multifractal analysis. Our results demonstrate significant differences in non-linear multifractality between expert and novice eye-gaze signals. We discuss the value of this approach for skill learning and monitoring applications, and make methodological contributions to support the future application of similar approaches.

Multifractal Mice: Measuring Task Engagement & Readiness-to-Hand via Hand Movement

`https://doi.org/10.31234/osf.io/tq53k`

Daniel Bennett, Oussama Metatla, Anne Roudaut

We investigate a new, unobtrusive, method for inferring task-engagement and "readiness-to-hand" during inter-action. "Readiness-to-hand" is an influential theory in HCI, which suggests that during more-or-less skilful and fluid tool use, certain features of behaviour and experience will co-vary. We conduct three experiments (N=28, N=44, N=30) to demonstrate the relationship between these features of readiness-to-hand and multifractality - a measure of systemic complexity and coordination originally developed in fluid dynamics. Our paper represents the first evaluation of multifractal measures of behaviour for use in HCI and also contributes a new technique for tuning multifractal analysis algorithms

Understandings of Human Autonomy in HCI

Daniel Bennett, Elisa Mekler, Oussama Metatla, Anne Roudaut

A review paper investigating the empirical and theoretical resources HCI researchers use to understand human autonomy, and how technology can supporting and undermine it. We review 10 years of papers dealing with issues of human autonomy at the CHI conference and find a relative lack of theoretical and empirical grounding and consistency. We discuss the potential to address this by combining further engagement with frameworks already influential in HCI, (e.g. Self Determination Theory) with a broader conceptual account of human autonomy.

CPGlib⁓ : A Library for Developing Creative Rhythmic Systems with Neural Oscillators

Daniel Bennett, Oussama Metatla, Anne Roudaut, Peter Bennett

A paper describing the libraries for creative applications of Central Pattern Generators (CPGs) that grew out of my work on Neurythmic (above). We describe a library for C++ and the visual programming language MAX/MSP which makes the use of CPGs accessible to musicians, creative coders and interface designers, and describe example applications implemented with the library

INVITED TALKS

[T1] Centre for Interdisciplinary Studies in Rhythm, Time and Motion   University of Oslo
Central Pattern Generator Networks for Musical Interaction   Feb 2021

[T2] Institute for Empirical Aesthetics   Max Planck Institute, Frankfurt
Complex, Non-linear Approaches to Rhythm and Interaction   Jan 2021

[T3] Human-Centred Computing Research Group   University of Cardiff
Multifractality and Adaptation in Human Computer Interaction   Dec 2020

[T4] Centre for Interdisciplinary Studies in Rhythm, Time and Motion   University of Oslo
Multifractality and Adaptation in Human Computer Interaction   Nov 2020

[T5] Computational Neuroscience Research Group   University of Bristol
Multifractal Patterns in Ready-to-hand Tool Use   July 2019

OTHER ACTIVITIES & TRAINING

Journal Reviews
International Journal of Human Computer Studies,
Adaptive Behaviour   2em **Conference Reviews**
CHI (10 papers 2019-2022),
CSCW (2021),
Halfway to the Future (2019),
Audio Mostly (2019),
NordiCHI (2019-20),
CHI 2020 Student Games Competition.

Training: Blended Teaching   University of Bristol
Training on creating and carrying out remote teaching during the Coronavirus pandemic   Sep 2020

Training: Computational Interaction Summer School 2018   University of Cambridge
   ACM SIG CHI Summer school on Computational Interaction: Applying computational techniques to understand
   and improve interaction: Unsupervised Learning, Bayesian information gain, interface optimisation, probabilistic
techniques for text input   August 2018

Training: Project Management for Researchers   University of Bristol
                                                                            June 2018

Training: Start to Teach   University of Bristol
                                                                       September 2018

REFERENCES

Dr. Oussama Metatla
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EPSRC Early Career Fellow

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