Applying Ontologies to Behavioural Science: The Human Behaviour-Change Project

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11th International Conference on Biomedical Ontologies

www.ucl.ac.uk/behaviour-change

Changing human behaviour lies at the heart of …

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- The causes and solutions of gobal problems e.g.
  - Environmental degradation & climate change
  - Ill-health, disability and avoidable deaths
  - Pandemic viruses
  - Etc etc

To solve these problems, policy makers & practitioners need answers to this question …

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When it comes to behaviour change interventions:

What works,
compared with what,
for what behaviours,
how well, for how long,
with whom, in what setting,
and why?

Interventions to change behaviour

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- Social & behavioural sciences have produced a rich source of theories and methods for intervention design and evaluation
- Considerable investment in interventions aimed at individuals, communities and populations
  - Trials: estimated 100's behaviour change interventions per day
- Most have modest and variable effects
  - *e.g. Cochrane database, National Institute for Health & Care Excellence (NICE)*

We are limited in…

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1. The advance of behavioural science
   - understanding of human behaviour and how to change it

2. The application of behavioural science to solve real-world problems

Why not faster progress?

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- For interventions
  - Vague and/or inconsistent reporting
  - Labels and definitions may be unclear
  - Different terms for the same things; same terms for different things
- For theories/models,
  - As above
  - A plethora of overlapping theories/models

- This leads to slow accumulation of knowledge

Part of solution

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1. Better reporting of all aspects of interventions, their mechanisms of action and their contexts
2. Improve methods to
    1. organise and synthesise large amounts of complex evidence at scale and rapidly, using automation
    2. make inferences from that evidence to generate new understanding

Better reporting: science needs …

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- Language that is understood by all, with the same terms used for the same things
- Without this, we are limited in our ability to
  - replicate,
  - implement effective interventions,
  - evaluate and
  - improve interventions

Reporting guidelines/ tools helpful

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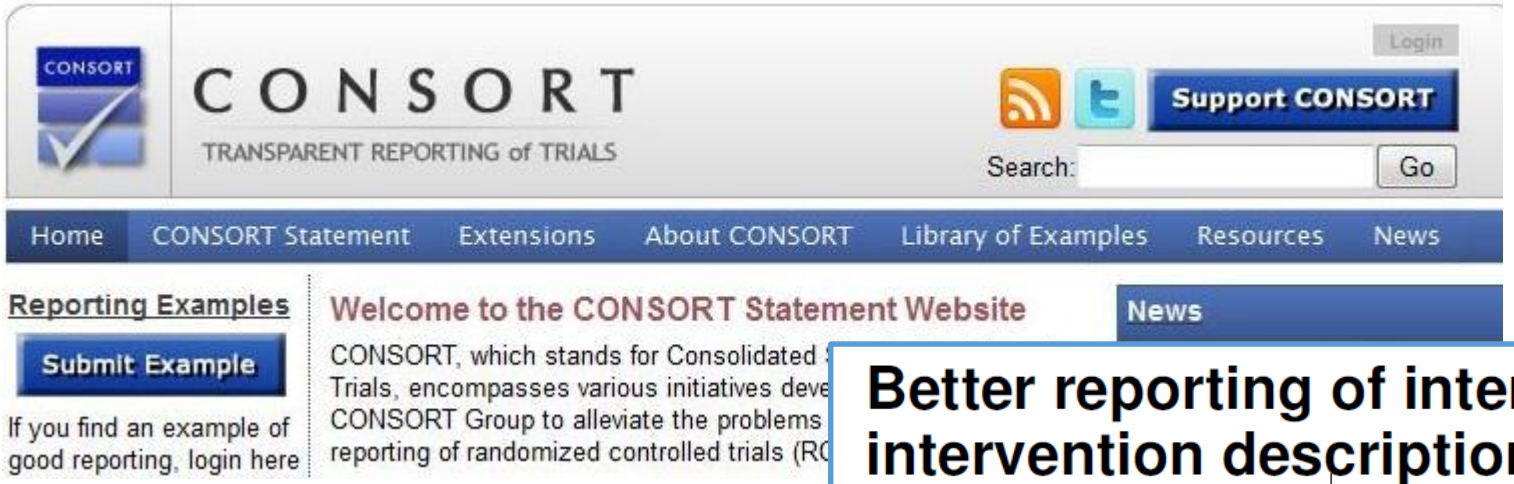

Better reporting of interventions: template for intervention description and replication (TIDieR) checklist and guide

Tammy C Hoffmann *associate professor of clinical epidemiology*[1], Paul P Glasziou *director and*

Behaviour change techniques: the
evaluation of a taxonomic metho
and describing behaviour change interventions
(a suite of five studies involving consensus methods, randomised controlled trials and analysis of qualitative data)

Susan Michie, Caroline E Wood, Marie Johnston, Charles Abraham, Jill J Francis and Wendy Hardeman

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PICO

Behaviour change techniques (BCTs)

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- Aim to be the smallest components that on their own can bring about change
- Have the *potential* to be the 'active ingredients' of an intervention
- Observable and replicable
- Can be used alone or in combination

ann. behav. med. (2013) 46:81–95
DOI 10.1007/s12160-013-9486-6

ORIGINAL ARTICLE

>2000 citations

The Behavior Change Technique Taxonomy (v1) of 93 Hierarchically Clustered Techniques: Building an International Consensus for the Reporting of Behavior Change Interventions

Susan Michie, DPhil, CPsychol · Michelle Richardson, PhD · Marie Johnston, PhD, CPsychol · Charles Abraham, DPhil, CPsychol · Jill Francis, PhD, CPsychol · Wendy Hardeman, PhD · Martin P. Eccles, MD · James Cane, PhD · Caroline E. Wood, PhD

Published online: 20 March 2013

BCT Taxonomy v1: 93 items in 16 groupings

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Page	Grouping and BCTs	Page	Grouping and BCTs	Page	Grouping and BCTs
1	**1. Goals and planning**	8	**6. Comparison of behaviour**	16	**12. Antecedents**
	1.1. Goal setting (behavior) 1.2. Problem solving 1.3. Goal setting (outcome) 1.4. Action planning 1.5. Review behavior goal(s) 1.6. Discrepancy between current behavior and goal 1.7. Review outcome goal(s)		6.1. Demonstration of the behavior 6.2. Social comparison 6.3. Information about others' approval		12.1. Restructuring the physical environment 12.2. Restructuring the social environment 12.3. Avoidance/reducing exposure to cues for the behavior 12.4. Distraction 12.5. Adding objects to the
		9	**7. Associations**		
			7.1. Prompts/cues		

No.	Label	Definition	Examples
1. Goals and planning			
1.1	***Goal setting (behavior)***	Set or agree on a goal defined in terms of the behavior to be achieved *Note: only code goal-setting if there is sufficient evidence that goal set as part of intervention; if goal unspecified or a behavioral outcome, code **1.3, Goal setting (outcome)**; if the goal defines a specific context, frequency, duration or intensity for the behavior, also code **1.4, Action planning***	Agree on a daily walking goal (e.g. 3 miles) with the person and reach agreement about the goal Set the goal of eating 5 pieces of fruit per day as specified in public health guidelines

However, we need to identify all components of interventions to answer …

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When it comes to behaviour change interventions:

What works,
compared with what,
for what behaviours,
how well, for how long,
with whom, in what setting,
and why?

What components?

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1. The intervention
   - Content (behaviour change techniques)
   - Delivery (source, schedule, style, mode)
2. Exposure to the intervention (engagement and reach)
3. Mechanisms of action
4. The context
   - Population, setting
5. The target behaviour

Part of solution

Human Behaviour-Change Project

1. Better reporting of all aspects of interventions, their mechanisms of action and their contexts
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Automating knowledge accumulation

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1. Identifying components allows one to define interventions and their context in a way that is machine readable
2. Enables extraction and synthesis of information from world literature that is not possible by hand
3. Computation can generate
   - new evidence and insights based on up-to-date research findings, and
   - inferences from what we know to what we don't

The Human Behaviour-Change Project

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Participating organisations

University of Aberdeen

University of Cambridge

IBM Research

www.humanbehaviourchange.org

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A Collaborative Award funded by the

wellcome trust

osf.io/efp4x/

[1]UCL [2]IBM Research Dublin
[3]Aberdeen University
[4]Cambridge University

Funding: The Wellcome Trust

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	Behavioural science	Computer science	System architecture
Grant-holders	Susan Michie[1] Marie Johnston[3] Robert West[1] Mike Kelly[4]	John Shawe-Taylor[1] Pol MacAonghusa[2]	James Thomas[1]
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Consultants: Janna Hastings, Julian Everett, Bryan Vernon
Collaborator: Marta Marques
PhD Students: Paulina Schenk[1], Eva Jermutus[1], Anneliese Arno[1], Gaurav Singh[1], Tobias Baumann[1]

Vision of the project

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To develop an understanding of human behaviour
to answer variants of the 'big question'

When it comes to behaviour change interventions:

What works,
compared with what,
for what behaviours,
how well, for how long,
with whom, in what setting,
and why?

The problem

"Messy" evidence, growing faster than humans can keep up with

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The problem

"Messy" evidence, growing faster than humans can keep up with

Messy evidence gets turned into well organised, useful scientific insights

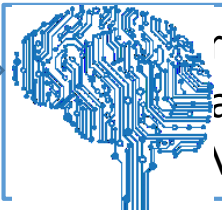
Human Behaviour-Change Project

- Up to date estimates of the effectiveness of behaviour change interventions
- Unpacking reasons for heterogeneity in intervention effectiveness
- Generating new testable hypotheses about behaviour change

The problem

"Messy" evidence, growing faster than humans can keep up with

What the HBCP does



rtificial Intelligence
al Language Processing
Machine Learning

Messy evidence gets turned into well organised, useful scientific insights

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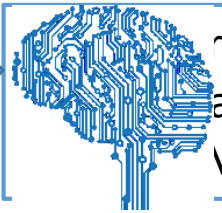
HBCP
Human Behaviour-Change Project

The problem

"Messy" evidence, growing faster than humans can keep up with

What the HBCP does

Ontology provides organising structure to guide



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Messy evidence gets turned into well organised, useful scientific insights

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HBCP
Human Behaviour-Change Project

The Human Behaviour-Change Project

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Will create and evaluate a Behaviour Change Intervention (BCI) Knowledge System:

1. An ontology of BCIs and evaluation reports
2. A largely automated feature extraction system to read BCI evaluation reports
3. A BCI database containing information from evaluation reports structured according to the ontology
4. Reasoning and machine learning algorithms to synthesise this information in response to user queries
5. An interface for computers and human users to interact with the system

Ontologies: potential contribution to behavioural and social sciences

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1. Improve clarity of thinking and reporting
2. Generate new ideas and testable hypotheses
3. Identify information gaps and promotes lateral thinking
4. Facilitate interoperability across domains of knowledge and knowledge representations
5. Provide a powerful and intuitive basis for automated querying and reasoning

Upper-level
Behaviour Change Intervention Ontology

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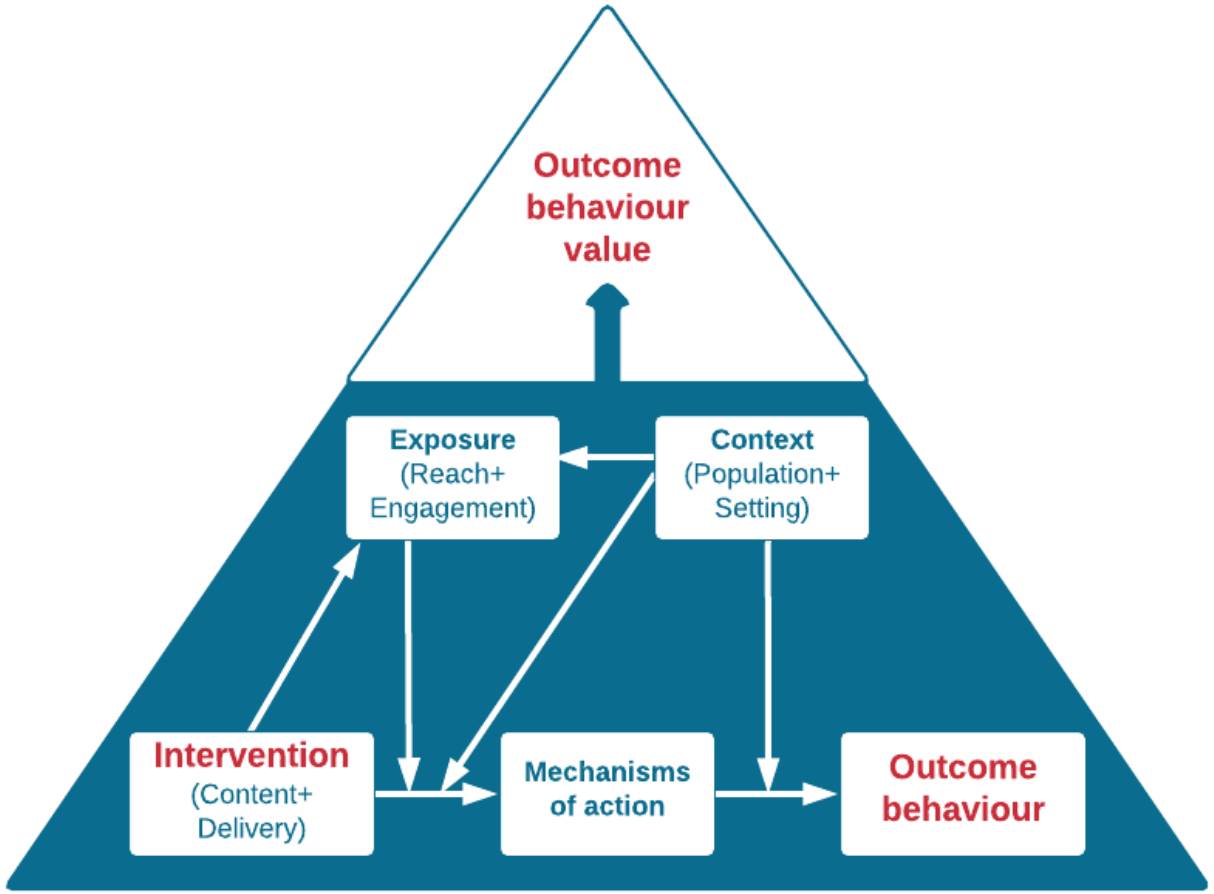

Ontologies making up the BCIO

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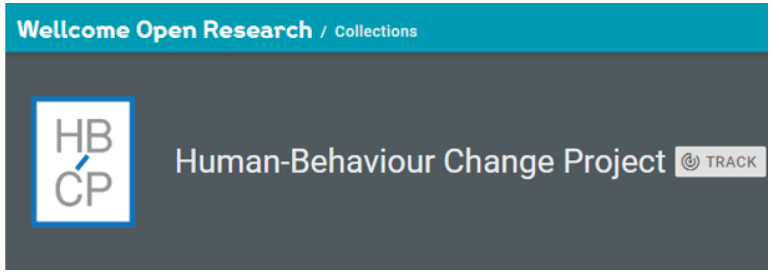
1. **Published**
    1. Behaviour change techniques – *BCTTv1 (Annals Beh Med, 2013)*
    2. Behaviour Change Intervention Ontology Upper Level
    3. Mode of delivery
    4. Intervention setting
    5. Ontology development methods
2. **Under development**
    a. Intervention source, schedule & style of delivery
    b. Exposure of intervention (Reach and Engagement)
    c. Mechanisms of action
    d. Target behaviour
    e. Target population



https://wellcomeopenresearch.org/collections/humanbehaviourchange

Upper level entities in BCIO

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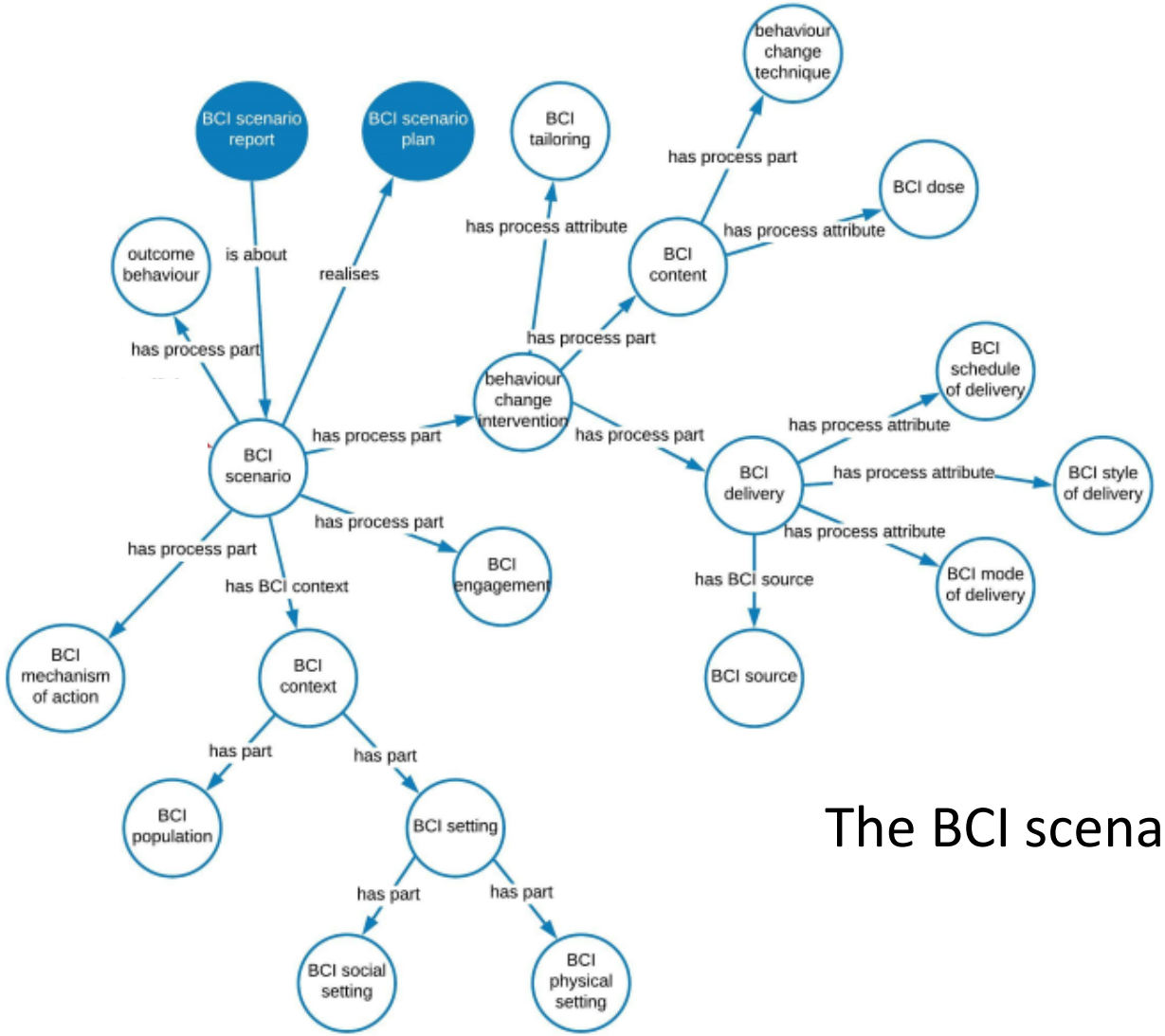

The BCI scenario

Upper level entities in BCIO

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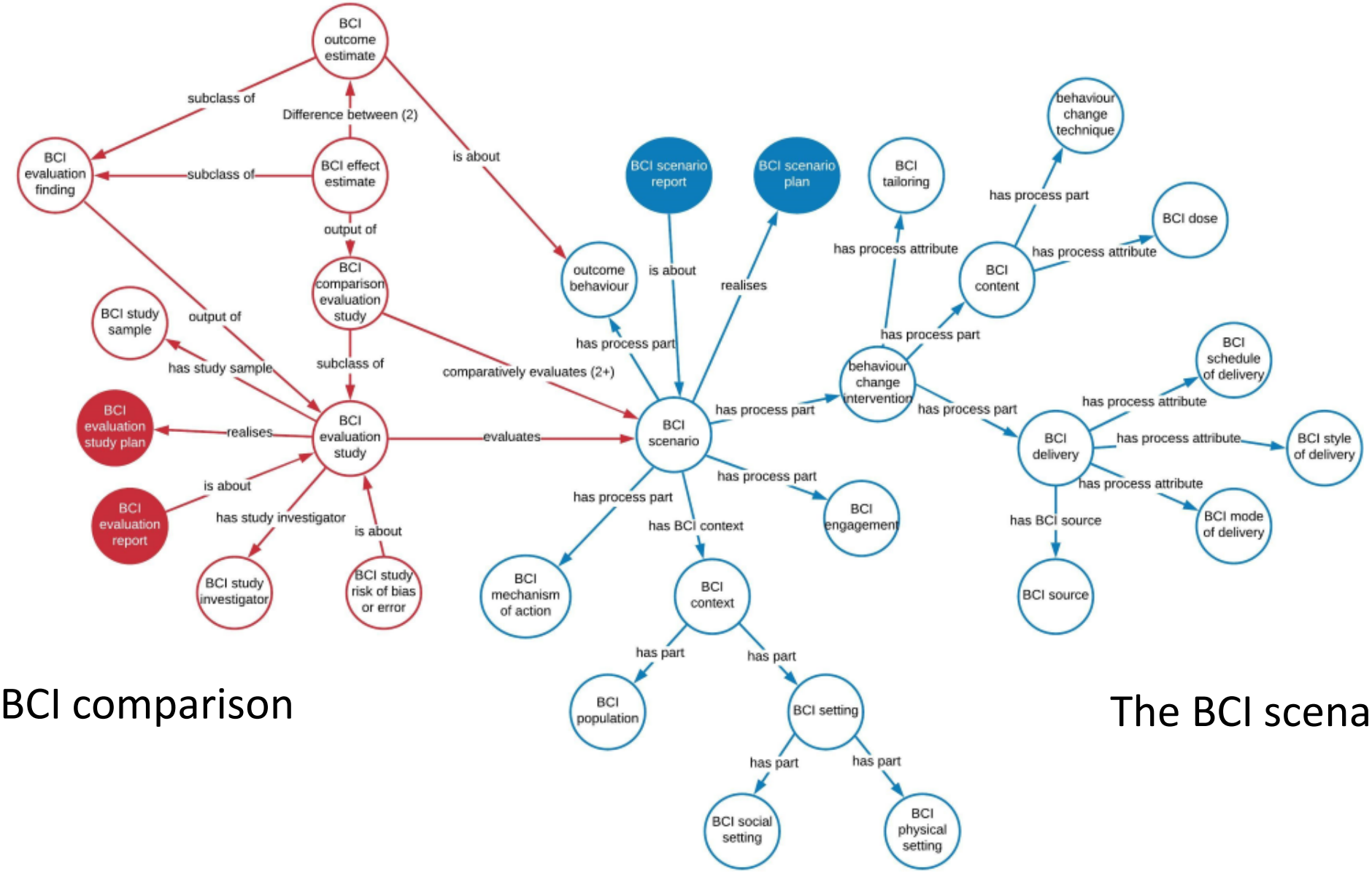

The BCI comparison

The BCI scenario

Use of ontologies in the HBCP

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1. To annotate intervention reports, building the knowledge base for the HBCP

2. To facilitate algorithms performing reasoning and inference about evidence on the effectiveness of interventions

3. To help users frame questions to ask of the knowledge system?
    - e.g. ontology may serve to structure drop-down menu options in the query interface

The Knowledge System

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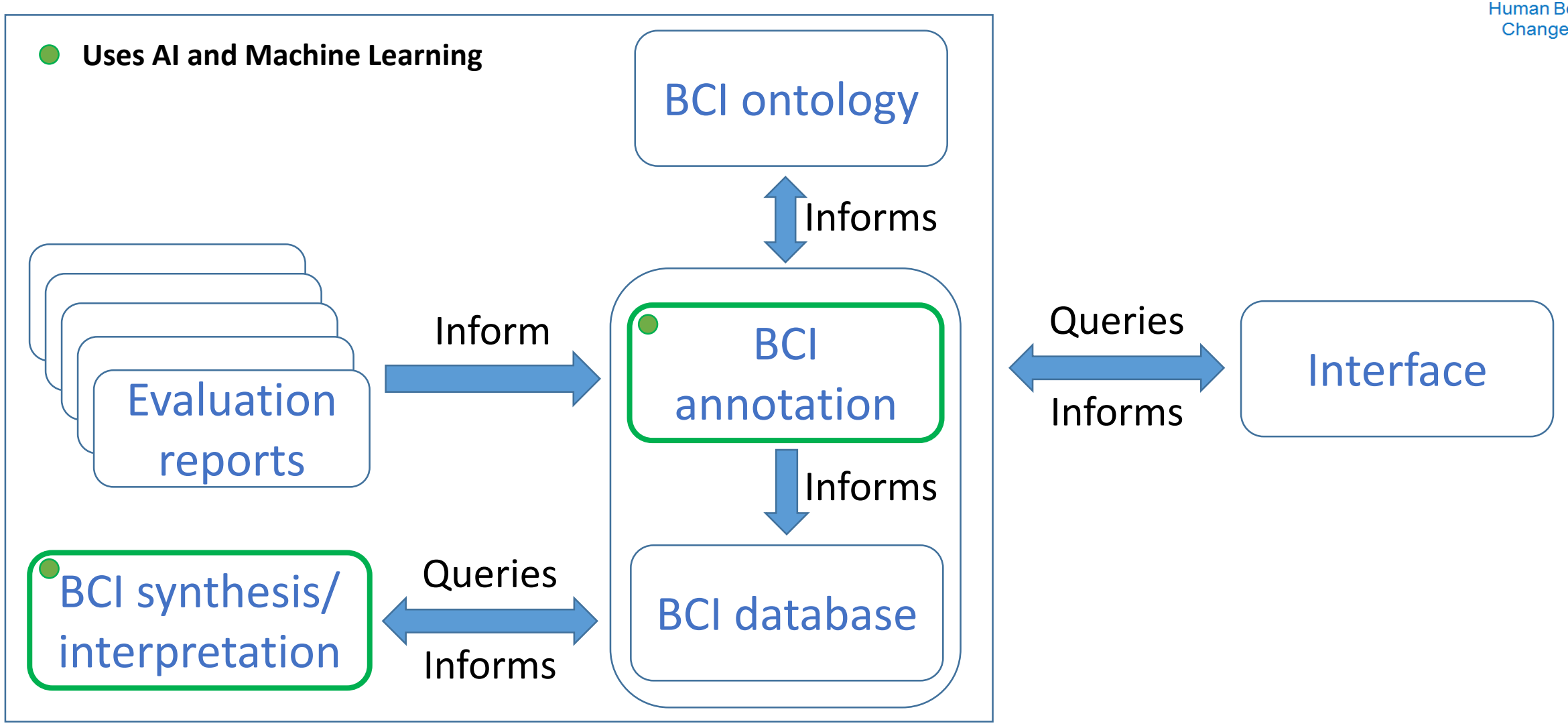

Building the Knowledge System

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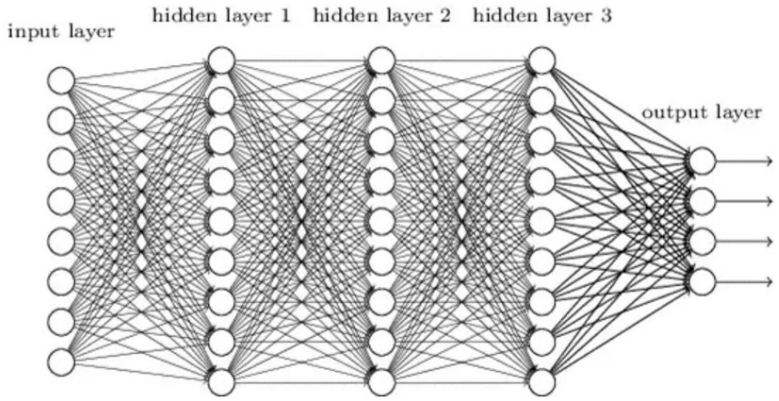
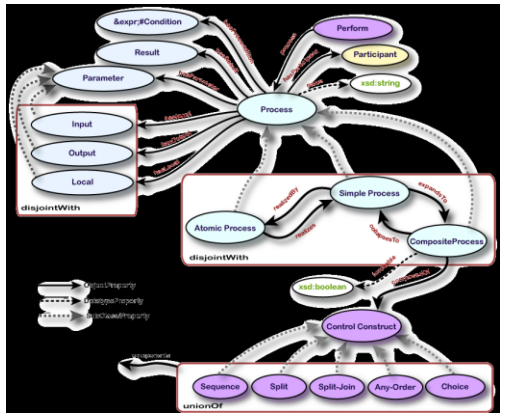


Machine Learning

Find optimal connections and weights to classify outputs from input data



Reasoning Algorithms

Using entity relationships and axioms to infer new entity relationships

The HBCP will deliver an end-to-end system to

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1. Identify relevant research publications
   - For smoking cessation, regularly updated database of > 230 million study reports
2. Extract entities appearing in the BCIO from study reports via Natural Language Processing
3. Train AI entity-extraction algorithms; learning initially via human annotation of literature
4. Analyse the information at scale using Prediction Algorithms from Vector Space to produce knowledge of likely effectiveness of BCIs
5. Provide an interface for users to pose questions and receive answers
6. Integrate end-user feedback to further train the Knowledge System

Engagement: collaboration is encouraged!

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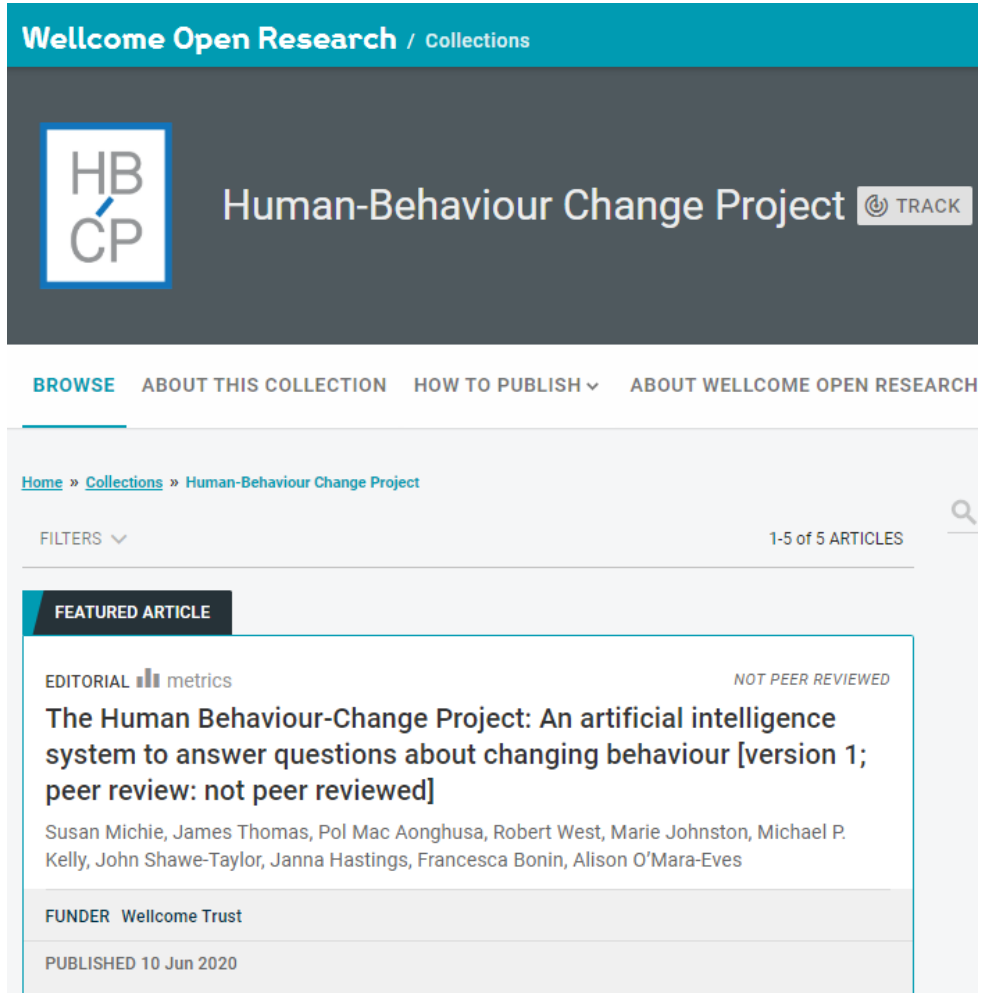
- Scientific Advisory Board
  - International, interdisciplinary
- Expert input e.g. reviews of ontologies
- Users and Stakeholders
  - Input into evaluation and developing the user interface
- Collaborators e.g.
  - Cochrane Collaboration
  - Society for the Study of Addiction
  - Covid-MAP

Publications: Open access



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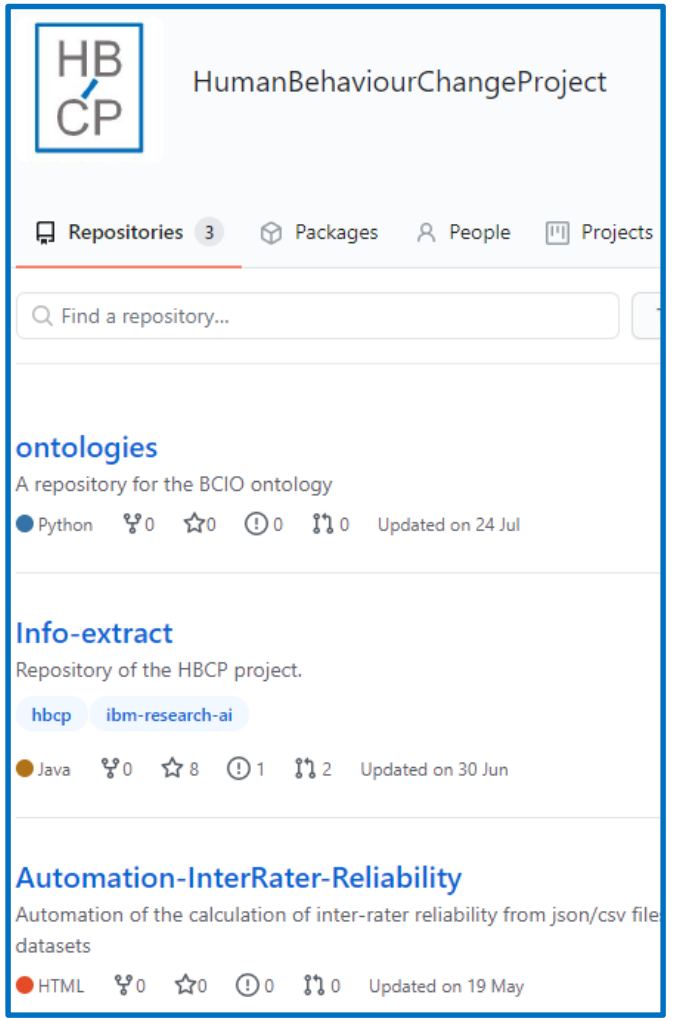
GitHub



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Questions?

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