Advancing the Sciences of Implementation and Behaviour through Ontologies

Susan Michie

Director of Centre for Behaviour Change,
University College London, UK

@SusanMichie

Implementation of effective interventions

- Requires behaviour change of multiple actors
- Implementation and behaviour change interventions tend to have modest and variable effects
- Need to develop new knowledge fast!

Despite methodological advances …

- Current methods of generating new knowledge about interventions are too slow
  1. Aren't able to identify and integrate the large amounts of data needed to
     - identify **effective components** within complex interventions
     - understand **variation** and **processes of change**
  2. Can't make accurate **inferences** from what we know to what we don't know
     - Important e.g. for LMIC settings where there may be little research

There is an urgent need ….

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?

Challenges and solutions in evidence synthesis

Challenge	Solution
Research conduct: Diversity of research methods and topics; inconsistency and incompleteness in reporting	

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Challenges and solutions in evidence synthesis

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Research conduct: Diversity of research methods and topics; inconsistency and incompleteness in reporting	Ontology of behaviour change interventions to organise evidence
Resource limitations: Insufficient human resources given the increasing volume of research and need for timely knowledge	

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Challenges and solutions in evidence synthesis

Challenge	Solution
Research conduct: Diversity of research methods and topics; inconsistency and incompleteness in reporting	Ontology of behaviour change interventions to organise evidence
Resource limitations: Insufficient human resources given the increasing volume of research and need for timely knowledge	Use of automated literature searching and study feature extraction
Research findings: Equivocal or contradictory findings; sparseness of findings relative to the variety of behaviours, interventions, contexts; complexity of interactions between intervention components, contexts and behaviours	

The Human Behaviour-Change Project

Participating organisations

A Collaborative Award funded by the

www.humanbehaviourchange.org

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The collaboration

	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]
Researchers	Alison Wright[1] Ailbhe Finnerty[1] Marta Marques[1] Emma Norris[1]	Debasis Ganguly[2] Lea Deleris[2]	Alison O'Mara-Eves[1] Gillian Stokes[1] Patrick O'Driscoll[1]

Project Manager: Leonor Fontoura[2]; *Administrator:* Candice Moore[1]; *Consultants:* Janna Hastings, Julian Everett, *PhD Students:* Paulina Schenk[1], Anneliese Arno[1], Gaurav Singh[1], Tobias Baumann[1]

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

The problem

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

The problem

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

Messy evidence gets turned into well organised, useful scientific insights

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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

What the HBCP does

Messy evidence gets turned into well organised, useful scientific insights

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

Artificial Intelligence
Natural Language Processing
Machine Learning

Up to date estimates of the effectiveness of behaviour change interventions

Unpacking reasons for heterogeneity in intervention effectiveness

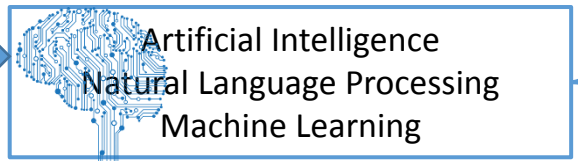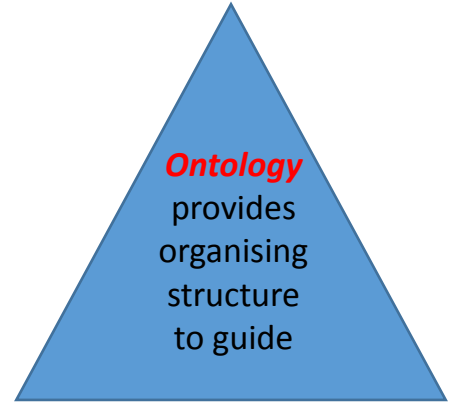Generating new testable hypotheses about behaviour change

The problem

What the HBCP does

Messy evidence gets turned into well organised, useful scientific insights

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

Ontology provides organising structure to guide

Artificial Intelligence
Natural Language Processing
Machine Learning

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

What is an ontology?

In information science, a system for representing knowledge in the form of:

1. A set of unique identifiers of 'entities'

2. Labels and definitions for these

3. Specification of relationships between them
   - 'is a', 'part of', 'positively influences' …
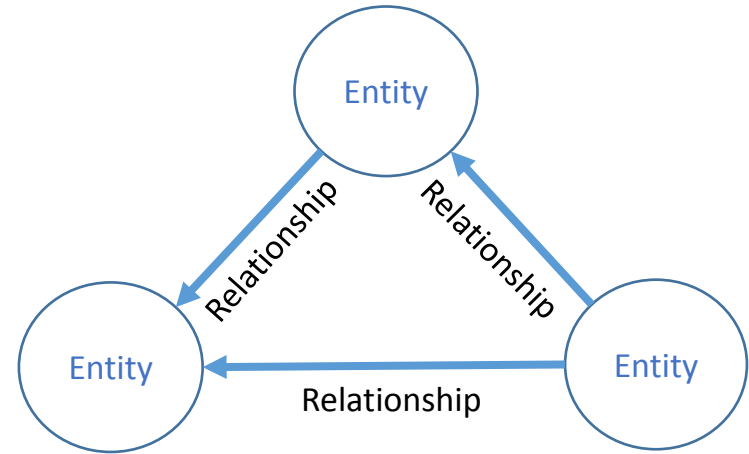
Arp R, Smith B, & Spear AD (2015). Building ontologies with basic formal ontology. Cambridge: MIT Press.

A mini-ontology
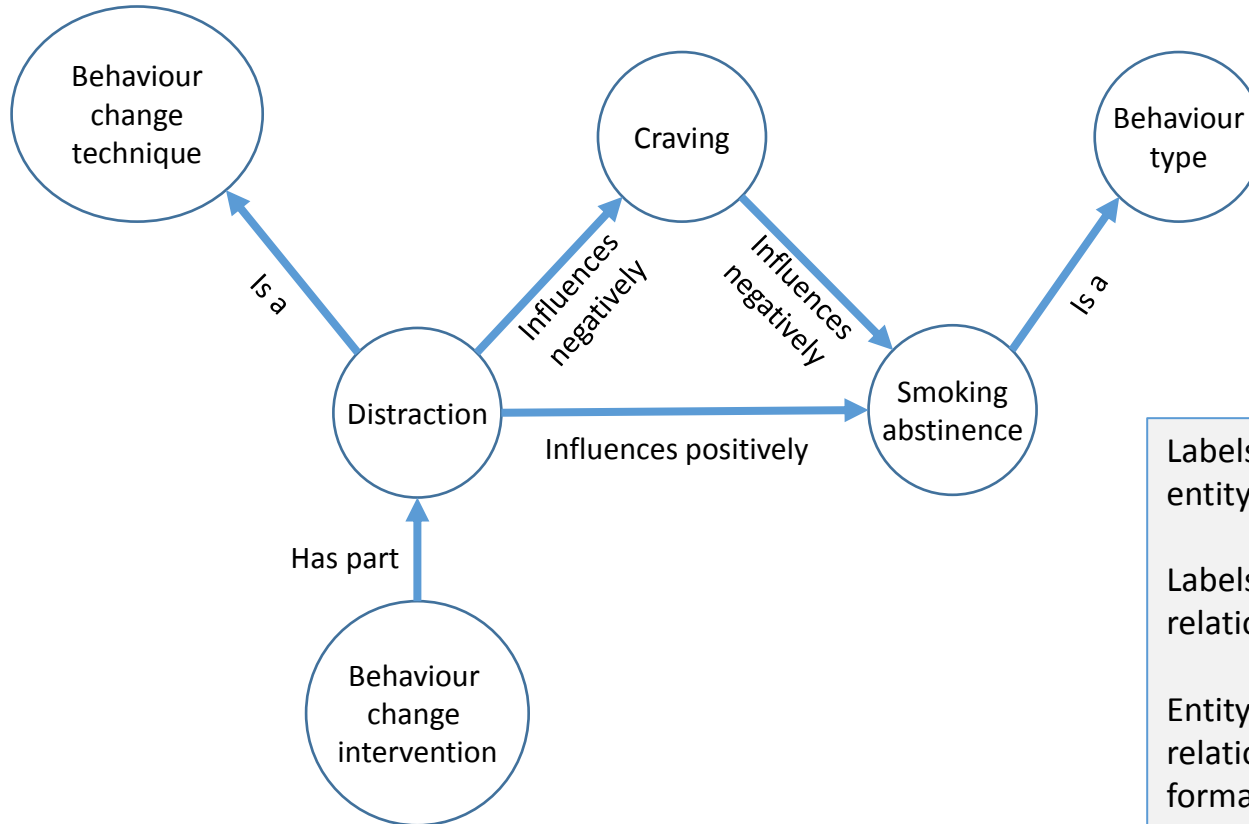
Labels in circles identify entity types

Labels on arrows identify relationship types

Entity types and relationship types require formal definitions

Upper-level
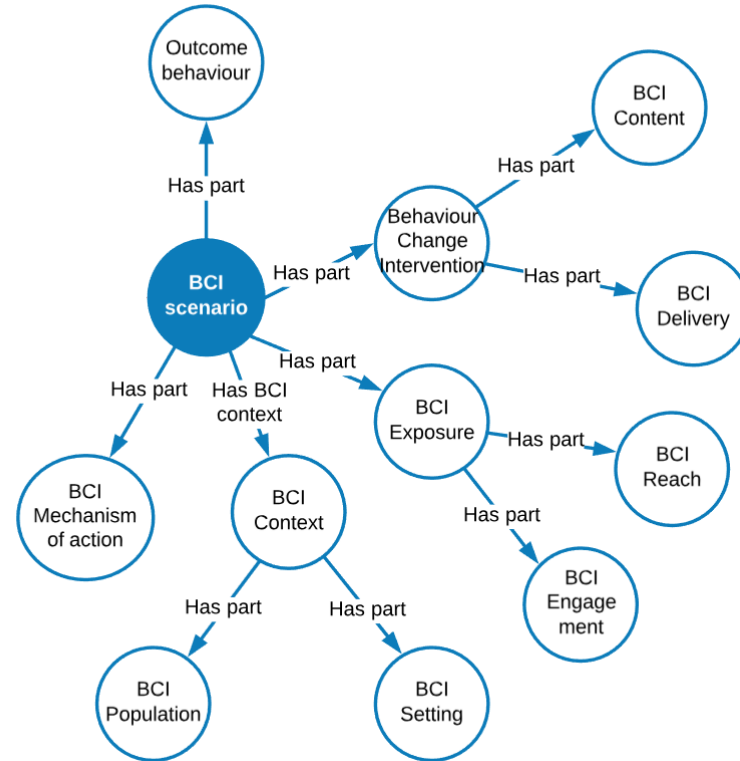# Behaviour Change Intervention Ontology (BCIO)
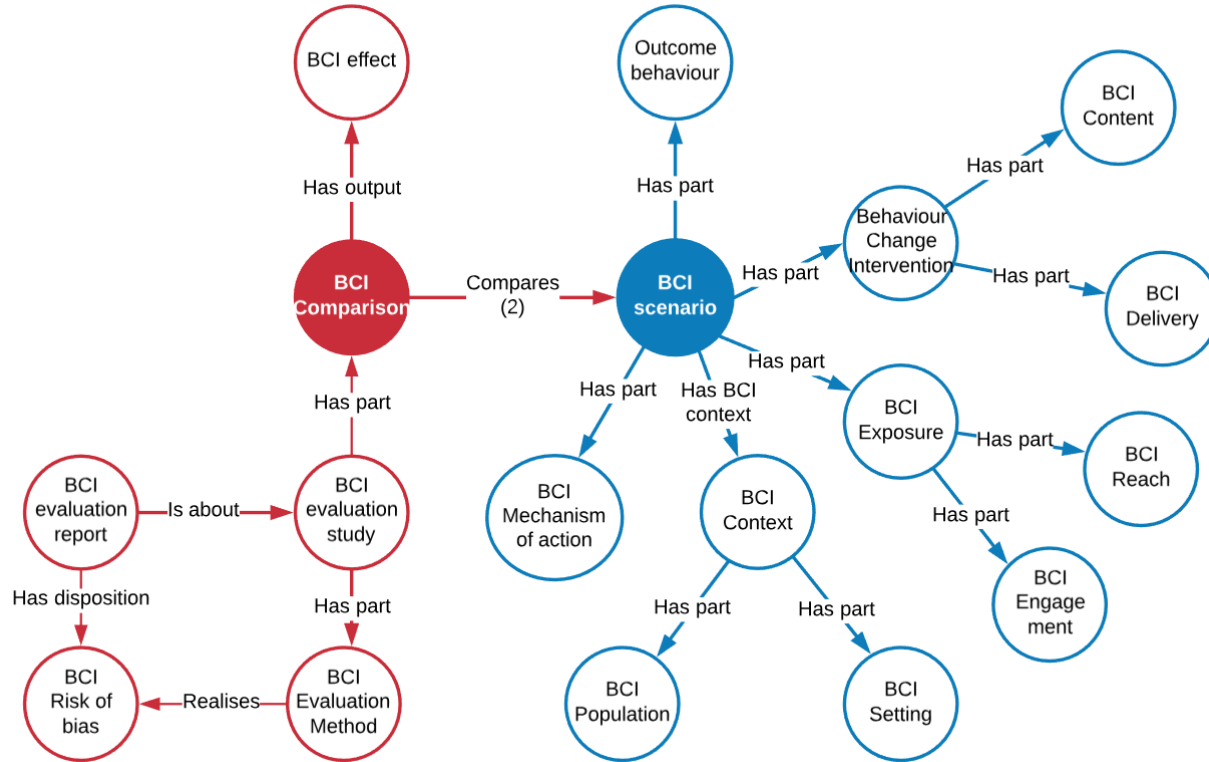
Upper level entities in BCIO

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The BCI
scenario

# Upper level entities in BCIO

The BCI comparison

The BCI scenario

How ontologies help science

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

Examples of Human Users
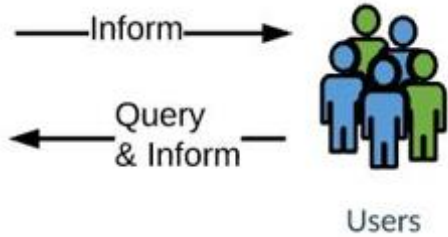
Desirable qualities

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- Clear definitions for all terms i.e. non-overlapping terms without redundancy

- Well-organised, hierarchical structure

- Comprehensive coverage of the area

- Granularity
    - appropriate level to information sources and purpose of ontology

Specific ontologies being developed for…

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1. Behaviour change techniques – *BCTTv1*

2. Mode of delivery – *complete*

3. Target population – *peer review stage*

4. Intervention setting – *peer review stage*

5. Target behaviour – *under development*

6. Mechanisms of action – *under development*

7. Exposure of intervention (Reach and Engagement)
   – *conceptualisation stage*

Scope

- Initially reports of RCTs of smoking cessation interventions
  - In Cochrane meta-analyses
- Expanding to RCTs of interventions targeting other behaviour types
  - Physical activity, alcohol consumption, dietary behaviours
- Eventually extend across behaviours and study designs and quality

Addressing the problem upstream

- Template for reporting BCIs and their evaluations using the BCIO

- To enable
  - clear, full reporting
  - data synthesis
  - interoperability i.e. link to other, related ontologies to extend knowledge

Feature in BCIO	Value
Sample_mean_age_yrs	35.4
Sample_female_%	52.1
Intervention_brand	ACT
Intervention_content_BCTs	1,3,12,34,45,60
Comparator_content_BCTs	1,3,12
Behavioural_target_type	Smoking cessation
Outcome_type	Sustained_abstinence
Setting_clinical_type	GP practice
Etc.	Etc.

Concluding messages

- The Ontology is a core and key part of the HBCP

- The HBCP will:
  - Enable researchers to identify research for inclusion in evidence syntheses with far more precision and speed than is currently possible
  - Be available for other organisations and domains
    - behavioural and implementation sciences, and beyond
  - Eventually enable practitioners and policy-makers to query a dynamically updated database of BCI reports to find answers to the questions that most matter to their specific areas of work

STUDY PROTOCOL

Open Access

CrossMark

The Human Behaviour-Change Project: harnessing the power of artificial intelligence and machine learning for evidence synthesis and interpretation

Read Supplementary Files!

Susan Michie[1*], James Thomas[2], Marie Johnston[3], Pol Mac Aonghusa[4], John Shawe-Taylor[5], Michael P. Kelly[6], Léa A. Deleris[4], Ailbhe N. Finnerty[1], Marta M. Marques[1], Emma Norris[1], Alison O'Mara-Eves[2] and Robert West[7]

'Intelligence Interventions' Workshop

- **Building an ontology** of behaviour change interventions
    - Susan Michie

- **Building a knowledge system** to synthesis and use evidence from behaviour change intervention evaluations
    - Robert West

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Questions and discussion

www.humanbehaviourchange.org

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Slides not used

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Brings together behavioural science, computer science and information science to create and evaluate a Behaviour Change Intervention (BCI) Knowledge System:

1. An ontology of BCI interventions and evaluation reports
2. A largely automated feature extraction system to read BCI evaluation reports, using Natural Language Processing
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

The Behaviour Change Intervention (BCI) Knowledge System

Uses AI and Machine Learning

BCI ontology

Informs

Evaluation reports → Inform → BCI annotation ← Queries / Informs → Interface

Informs

BCI synthesis/ interpretation ← Queries / Informs → BCI database

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