

Research Article

Development of a Tool (CACTIS) to Aid the Design of Behaviour Change Interventions Using the COM-B Model, Behaviour Change Wheel, and Behaviour Change Techniques Ontology

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Background and aims: Developing and updating behaviour change interventions using the Capability, Opportunity, Motivation – Behaviour (COM-B) model and the Behaviour Change Wheel (BCW) framework includes three steps: 1) Problem specification including the ‘behavioural goal’; 2) Identifying specific ‘COM-B targets’ to try to influence in order to achieve the behavioural goal; and 3) Selecting ‘BCW Intervention Functions (IF)’ and ‘Behaviour Change Techniques (BCTs)’ (from the BCT Ontology) judged to be most appropriate for influencing those targets. This paper reports the development of the CACTIS (‘COM-B Assessment Criteria To Intervention Strategy’) tool, an online resource that guides users through these steps to make intervention development more effective, efficient, and systematically documented.

Methods: An iterative process, involving initial drafting, functional evaluation, literature review and team discussion by the authors, and wide stakeholder feedback, was used throughout the development of CACTIS. Data structures were created covering the ‘problem specification’, ‘potential COM-B targets’, ‘potential IF/BCT combinations’, and ‘potential COM-B target to IF/BCT mappings’. These underpinned a form-based interface, created in parallel, to take users through the intervention development process.

Results: A list of 27 potential COM-B targets was created: 8 capability targets, 9 opportunity targets and 10 motivation targets. 112 BCTs were selected from the BCT Ontology, contributing to 148 potential IF/BCT combinations; 239 mappings were created between potential COM-B targets and potential

IF/BCT combinations. The CACTIS user interface began as a Google Sheets Workbook and was then transformed into an HTML file that could be run online or locally. The user interface provides detailed prompts and help sheets; it allows users to save and restore their projects as JSON files, and to record the basis for decisions made. It creates a structured report, together with a prompt for a Large Language Model (LLM) to generate a draft intervention strategy.

Conclusions: CACTIS guides users through the process of creating or updating a behaviour-change intervention strategy using the COM-B model, BCW and BCT ontology, recording the decisions made and providing a structured report and an LLM prompt that users can apply to build a draft intervention blueprint.

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Background

The Behaviour Change Wheel (BCW) is a widely used framework for developing and updating behaviour-change interventions.^{[1][2]} Using the framework includes three steps: 1) Specifying the problem, including one or more ‘behavioural goals’; 2) For each goal, specifying what aspects of an individual’s, group’s or population’s capability, opportunity and/or motivation to target in order to best achieve that goal, based on the Capability, Opportunity, Motivation – Behaviour (COM-B) model; and 3) For each ‘COM-B target’, selecting ‘Intervention Functions’ (IFs) and ‘Behaviour Change Techniques’ (BCTs) judged to be best suited to achieve the desired change. Combined with the selection of appropriate implementation options (legislation, regulation, guideline development, service provision, fiscal policies, communications/marketing, and environmental/social planning) this can form the basis for the full specification of the intervention. It is recommended that the three steps are taken using: relevant theories, models and evidence reviews; primary research involving the target population where feasible; and expert and stakeholder input.

With many COM-B targets to select from, and thousands of possible ways to combine COM-B targets with IFs and BCTs, it can be challenging for those developing interventions to navigate all the possibilities and make informed decisions about intervention options. This paper reports the development of an online tool, ‘CACTIS’ (COM-B Assessment Criteria To Intervention Strategy), to guide users through the steps leading up to and including the selection of IF/BCT combinations.

The COM-B model is a general model that aims to predict behaviour in context.^[3] In the case of an individual in a given context it provides a basis for predicting the *likelihood, frequency or amount* of the behaviour, while in the case of groups, sub-populations or populations¹ it provides a basis for predicting the *prevalence, incidence or average frequency or amount* of the behaviour. This in turn allows COM-B to be used to predict the impact of specified behaviour change interventions that target different aspects of capability, opportunity and motivation, and so provides a basis for developing interventions aimed at influencing behaviour.

In the problem specification step (Step 1), intervention developers need to include several items of information: a) *The behavioural goal*: What they want to achieve with the intervention regarding a target behaviour in terms of its likelihood, prevalence, frequency, or amount. b) *Features of the target population(s)*: Demographic or other features that define the population plus other features that may bear on the intervention strategy (e.g., men in England between the ages of 40 and 65 years who are currently defined as sedentary). c) *The intervention setting(s)*: Locations, facilities and/or contexts where the intervention will take place (e.g., hospital outpatient departments, people's residences, online platforms). d) *Constraints and opportunities*: Contextual factors that need to be taken into account when developing the intervention (e.g., practical, ethical, financial or other constraints, time limits, or specific requirements set by managers or commissioners of the intervention).

To identify high-priority COM-B targets (Step 2), intervention developers need to identify what features of capability, opportunity and/or motivation to focus on in order to achieve the behavioural goal. For example, when attempting to reduce traffic crash rates by reducing speeding in an accident black spot, a COM-B analysis might indicate that it is more productive to focus on limiting opportunities for speeding than trying to influence motivation or understanding of the risks of speeding. The original version of the COM-B model identified two components each of capability (physical and psychological), opportunity (physical and social) and motivation (reflective and automatic) and gave examples of aspects of these. While useful for broad categorisations of behavioural influences, a more precise list of COM-B targets enables intervention developers to specify their target in more concrete terms and make more specific links between COM-B targets and intervention components. The more precise list of COM-B targets contained in CACTIS needs to be granular enough that each is distinct from the others, yet not so granular that it becomes overwhelming for users to navigate.

Selection of high-priority COM-B targets involves identifying those that are relevant to the behavioural goal and where there is most scope for improvement in the target population. The CACTIS tool needs to

provide a structured way of making this selection and documenting the evidence supporting the choice. For example, when it comes to the behavioural goal of increasing the use of domestic recycling facilities in a local area, research may have found that most residents already believed it to be worthwhile but were unsure as to what items were recyclable in their area.

To select BCW Intervention Functions and BCTs to influence the prioritised COM-B targets (Step 3), intervention developers need to be able to narrow down the options from the thousands of possible mappings to ones that are most likely to achieve the objective. The original BCW publication set out potential mappings of the six COM-B components to the nine intervention functions.^[1] Subsequent BCW publications have used the BCT Taxonomy v1 for its mapping of COM-B components onto specific BCT classes.^[4] In addition, an online tool has been developed mapping mechanisms of action (broadly similar to COM-B targets) to a set of widely used BCTs in the BCT Taxonomy v1.^[5]

Recently, a more comprehensive and semantically coherent ‘ontology’ of BCTs has been developed: the BCT Ontologyⁱⁱ (BCTO).^[6] Because the same class of BCT can serve more than one intervention function, depending on its specific content, it is necessary to map COM-B targets to IF/BCT *combinations*. For example, the BCT ‘Increase Salience of Behaviour’ using ‘Persuasion’ would involve using communication to highlight the behaviour, for example through storytelling. The same BCT using ‘Environmental Restructuring’ would involve making the behaviour more visible in the environment. The way in which a BCT varies according to one IF or another can be subtle, so CACTIS needs to provide clear descriptions of how IF/BCT combinations can be implemented.

Thus, CACTIS needs to be able to present users with a curated set of potential mappings of COM-B targets to IF/BCT combinations from which they can select those that are most relevant to their scenario. The IF/BCT combinations need to be drawn from the BCT Ontology to promote interoperability with existing research and to maximise the contribution of any evidence gathered to research going forward. It also needs to provide users with an opportunity to document the reasons for the choices made and provide any additional details that will help with concretising and implementing the intervention.

Much of the use of the BCW Framework and the COM-B involves qualitative exploration of factors underpinning behaviours and how best to influence them. The CACTIS tool therefore needed to provide support for users who would be adopting a qualitative approach rather than quantitative modelling.

In the BCW framework, a set of criteria is proposed for making choices throughout the development process: the APEASE criteria (Acceptability, Practicability, Effectiveness/cost-effectiveness, Affordability,

Spill-over effects, and Equity) set out in the BCW framework.^[7] In principle, these criteria could be applied at any stage of the process and could potentially be brought into the CACTIS tool.

The above considerations provided a set of basic requirements for the CACTIS tool. Other aspects of functionality build on this basic use-case. A complete structured use-case specification is provided in Supplementary File A.

Aims

This paper reports the development of the CACTIS tool, taking account of the requirements set out above, and describes the main features of the current version of the tool (CACTIS 1.8.2). CACTIS is continually being upgraded, with improvements being made to the user interface and additional functionality being added. In addition, the COM-B targets and the mappings to IF/BCT combinations are regularly reviewed. Therefore, users should refer to the COM-B website for updates (<https://com-b.org/cactis>).^[8]

Because much of the development work for CACTIS involved elaboration and clarification of aspects of the COM-B model, it went hand in hand with an updated COM-B model specification, which will be reported in a separate paper.

Methods

Stakeholder involvement

Key stakeholders were involved throughout the development process. Initially, this was the Behavioural Science Team in Public Health Wales and its community of practice made up of behavioural practitioners and public health professionals. Then versions of CACTIS were presented to and trialled by teams of intervention developers in national government, international governmental organisations, private companies and university academics.

Overview of the development process

Development of CACTIS involved:

1. Creating the 'CACTIS Reference Database' containing:

1. The *Problem Specification Template*, including any constraints and opportunities that should be taken into account (e.g., whether this is an intended update of an existing intervention,

whether the intervention is limited to particular approaches such as communications or training sessions).

2. *Potential COM-B Targets* from which users can refer to the research literature, theory, primary data collection and stakeholder involvement to select high-priority targets that would be most appropriate to achieving the behavioural goal.
3. *Potential IF/BCT Combinations* that would be most relevant to users of CACTIS, with BCTs drawn from the BCT Ontology.
4. *Potential COM-B Target to IF/BCT Mappings* to support presentation of a limited set of promising IF/BCT options for each COM-B target.

2. Creating the *CACTIS User Interface* that would draw on this database to prompt users for relevant information in each of the three main steps of the intervention development process (problem specification, identifying high-priority COM-B targets, and identifying appropriate IF/BCT combinations based on the high-priority COM-B targets) and provide additional functionality as set out in the use-case specification.

These processes (creating the CACTIS Reference Database and creating the CACTIS User Interface) were interdependent and were undertaken alongside each other, with advances in one component influencing decisions made about other components. Therefore, the following sections describe the development of the CACTIS Reference Database together with the relevant part of the user interface.

Problem specification

An initial version of the problem specification was created with reference to the BCW Guide,^[2] and other core publications,^{[7][9]} including: 1) specification of the behaviour and in what way it was intended to change it (e.g., increase prevalence), 2) the target population and 3) the intervention setting(s). This was revised in response to stakeholder feedback to include specification of constraints and opportunities. Stakeholder feedback was also used to create a detailed set of instructions for users.

Potential COM-B targets

A set of 24 potential COM-B targets had already been co-created by the authors with the Behavioural Science Unit at Public Health Wales and its community of practice at a level of specificity that would be meaningful to users of the COM-B model while minimising overlap and not having so many that it would be unmanageable for users. This list had been through several rounds of comment and stakeholder

feedback.^[7] These were further evaluated with reference to the Theoretical Domains Framework,^[10] the PRIME Theory of motivation,^[11] Social Cognitive Theory,^[12] Operant Learning Theory,^[13] and skills development theories^[14]. They were further reviewed and discussed with stakeholders, and evaluated against the mechanisms of action in the Theory And Techniques Tool (TATT).^[5] Each of the resulting COM-B targets was defined and incorporated into the CACTIS Reference Database.

For the user interface, multiple rounds of stakeholder feedback and functional analysis were undertaken to generate the forms for CACTIS users to review the potential COM-B targets and prioritise them, as well as to record the evidence and/or stakeholder review used to make the priority rating. This involved trialling various ways of describing the COM-B targets and prompting users for information to help guide the priority-setting process.

Potential IF/BCT combinations

To identify potential IF/BCT combinations, as a first step all ~300 BCTs from the Behaviour Change Technique Ontology^[6] were reviewed by three of the authors (EF, RW & SM). The aim was to narrow down the list to those that would be most useful for CACTIS. There was no target for how many BCTs to keep; instead, a set of criteria were applied for non-inclusion:

- Too general – BCTs in too broad a category for practitioners to know how to apply them in practice (e.g., ‘goal directed BCT’ which is a group of goal-related BCTs).
- Too specific – BCTs defined so specifically that they would only apply in particular circumstances (e.g., ‘inform about positive social consequences BCT’).
- Overlapping – BCTs which would be likely to be covered satisfactorily by other BCTs (e.g., ‘Review behaviour goal plan BCT’ which was judged to be sufficiently similar to ‘Review behaviour goal BCT’).

In the course of the review process, if gaps in the BCT Ontology were identified, these were raised with the team responsible for the ontology and, if necessary, were proposed as additions to the ontology.

During the review process, it was recognised that some BCTs would be directed at increasing the likelihood of a *wanted* version of a behaviour, while others would be directed at decreasing the likelihood of *unwanted* versions of it. This adaptation involved, where appropriate, amending the description of the BCT to signify whether it was targeting the wanted or unwanted version of the behaviour (e.g., decrease exposure to people doing the *unwanted* behaviour or increase exposure to people doing the *wanted* behaviour).

It was also recognised that BCT descriptions in CACTIS would need to vary according to what intervention function they were fulfilling. Therefore, bespoke CACTIS IF/BCT descriptions were generated and reviewed for presentation to CACTIS users. For example, when the ‘level of confidence in ability to perform the behaviour’ COM-B target is combined with the IF ‘Persuasion’ and ‘Persuade about personal capability’ BCT, the CACTIS description was ‘Present arguments and examples to persuade them as to their level of ability to perform the behaviour.’

Mapping COM-B targets to relevant IF/BCT combinations

For every COM-B target, CACTIS provides a curated set of IF/BCT combinations that are relevant, from which CACTIS users choose those that they wish to include in the intervention. To achieve the mapping, EF, RW and SM started with the database of potential BCTs and asked, ‘What COM-B targets *could* this BCT influence at least under some circumstances?’

For example, the ‘Increase salience of behaviour’ BCT could influence the COM-B target ‘Level of awareness of the behaviour’, serving the Intervention Function ‘Persuasion’. The ‘Increase salience of behaviour’ BCT could also influence the COM-B target ‘Extent to which behaviour is common and visible in their social environment’, serving the IF ‘Environmental restructuring’. The rationale for this combination is that a behaviour can be made more salient by exposing people to others undertaking it, in their environment. Thus, the same class of BCT can be concretised differently depending on what IF it serves.

Once initial mappings of COM-B targets to IF/BCT combinations were completed, they were cross-checked with similar content from the Behaviour Change Wheel Guide and the Theory and Techniques Tool (TATT). These cross-checks identified further combinations to be considered for inclusion.

CACTIS User Interface design considerations

The CACTIS user interface was designed to meet the following criteria:

- be accessible without specialist software
- be able to be created and updated easily without specialist programming skills
- involve a clear step-by-step approach from behavioural specification, through identification of COM-B targets, to selection of appropriate IF/BCT combinations

Initially, this was implemented as a single Google Worksheet. Then a continual cycle of review, user feedback and amendment was implemented, resulting first of all in expansion of the interface to multiple Worksheets and ultimately an HTML version that could be accessed online or downloaded to a local computer and run from there. The HTML was created and updated iteratively by Claude.ai in response to prompts from RW, starting with the Google Sheets version of the tool.

During the CACTIS development, increasing use was made of ‘explainers’ linked to key concepts that could be accessed online or downloaded to help users as they progressed through the CACTIS steps, and for their future applications of the tool.

Results

The current version of CACTIS is 1.8.2. It is available for use through <https://com-b.org/cactis>. It can be downloaded via: <https://github.com/robertjwest/Unlocking-Behaviour-Change/tree/main/CACTIS%20public%20versions>. The com-b.org/cactis webpage also links to the older Google Sheets version that is now deprecated and the HTML version that is hosted on GitHub. The com-b.org/cactis page provides a brief description of CACTIS and always points to the most up-to-date version. It also links to a page that describes the version history.

The CACTIS Reference Database

The CACTIS Reference Database can be downloaded from the CACTIS tool, but is also provided as an Excel file in Supplementary File B. It contains worksheets covering:

1. Specification of the 27 COM-B targets,
2. Definitions and examples of the nine Intervention Functions,
3. The 112 BCTs with their BCI Ontology label, the Intervention Functions that they support, the COM-B Domains (psychological capability, physical capability, etc.) and COM-B Targets that they are mapped to, and a brief description,
4. The 148 IF/BCT combinations with fields for the BCI Ontology label, Intervention Function, COM-B Domain, COM-B Targets that they map to, the BCI Ontology reference number (taken from the Ontology ID), and description,
5. The 239 COM-B Target to IF/BCT mappings with the COM-B Domains, COM-B Targets, Intervention Functions, BCT names (CACTIS versions specifying whether they relate to wanted or unwanted behaviours), and CACTIS descriptions,

6. A matrix showing COM-B Targets as rows and Intervention Functions as columns, with cells specifying the BCTs mapped to COM-B Target and Intervention Function.

COM-B targets

The list of 24 COM-B Targets from the Public Health Wales Guide was modified to arrive at a total of 27 COM-B targets for inclusion in CACTIS Version 1.8.2 (Table 1), and the target labels were reframed from questions to constructs representing the 'level', 'strength', 'amount' or 'degree' of characteristics of people or their environment. This was a result of user feedback, which indicated that it was easier to connect this language to specific problems they were trying to address.

COM-B Domain	Original COM-B targets	CACTIS 1.8.2 COM-B targets
Psychological Capability	How aware are they of the behaviour and precisely what constitutes it?	Level of awareness of the behaviour
Psychological Capability	How well do they know how to do it?	Level of understanding of how to do the behaviour
Psychological Capability	How well do they understand the benefits of doing it or costs of not doing it?	Level of understanding of reasons for and against the behaviour
Psychological Capability	How far do they have the cognitive, perceptual and psychomotor skills to do it? How far do they have ability to make judgements needed to do it?	Level of reasoning, analytical, memory, attention and decision-making ability relative to what the behaviour requires
Psychological Capability	How far do they have the self-regulatory capacity for it?	Level of self-control and resilience relative to what is required by the behaviour
Psychological Capability	(Not present)	Level of interpersonal skills relative to what the behaviour requires
Physical Capability	How far do they have the physical strength and stamina for it?	Level of physical strength, stamina, flexibility and sensory abilities needed for the behaviour
Physical Capability	How far do they have the physical skills, coordination, balance and reaction times for it?	Level of physical skills, coordination, balance and reaction times relative to what the behaviour requires
Social Opportunity	How far is it considered 'normal' within their social environment?	Level of acceptability or desirability of the behaviour within the social environment
Social Opportunity	(Not present)	Level of exposure to the behaviour in the social environment
Social Opportunity	How far are there formal rules stipulating the behaviour?	Strength of social rules regarding the behaviour
Social Opportunity	How much support do they have in their social networks to do it	Level of social support for the behaviour

COM-B Domain	Original COM-B targets	CACTIS 1.8.2 COM-B targets
Physical Opportunity	How many prompts, cues and reminders for them to do it are they exposed to?	Level of exposure to reminders or cues for the behaviour
Physical Opportunity	How well can they afford it?	Amount of money needed for the behaviour
Physical Opportunity	How far do they have access to resources or equipment that facilitate or enable it?	Level of access to appropriate resources or equipment for the behaviour
Physical Opportunity	How far do they have the time to do it?	Amount of time needed for the behaviour
Physical Opportunity	How easily do they have access to places where they can do it?	Level of access spaces or facilities for the behaviour
Reflective Motivation	How worthwhile do they think it is?	Level of belief that the behaviour is worthwhile
Reflective Motivation	How confident are they that they can do it?	Level of confidence in ability to perform the behaviour
Reflective Motivation	How well does it fit with their self-identity?	Degree to which the behaviour fits with self-identity
Reflective Motivation	How strong is their intention to do it?	Strength and clarity of intention to perform the behaviour
Reflective Motivation	How strong a priority is it over other things they could be doing?	Level of priority ascribed to the behaviour over other behaviours
Reflective Motivation	(Not present)	Level of perceived agency to perform the behaviour
Automatic Motivation	How much enjoyment or satisfaction do they expect to get from it?	Level of expected enjoyment or satisfaction from the behaviour
Automatic Motivation	How far do they expect it to reduce any mental or physical discomfort?	Level of expected relief or avoidance of discomfort afforded by the behaviour
Automatic Motivation	How far is it provoked by an emotion or a drive state	Degree to which the behaviour is affected by emotions or urges

COM-B Domain	Original COM-B targets	CACTIS 1.8.2 COM-B targets
Automatic Motivation	How far is it a habit or routine?	Level of automaticity of the behaviour

Table 1. COM-B targets in the Behavioural Science Unit Guide and CACTIS 1.8.2

Regarding the additional COM-B Targets that emerged from use of the tool and stakeholder review:

- Although interpersonal skills could be thought of as a kind of psychological skill, it was thought that it merited its own target.
- We split the original COM-B target on social norms into two separate ones: one for ‘descriptive norms’ – level of exposure to the behaviour, and one for ‘prescriptive norms’ – level of acceptability or desirability.
- ‘Level of perceived agency to perform the behaviour’ arose from work with stakeholders who noted that this was an important factor separate from confidence in ability to enact the behaviour.

Users expressed a desire to see how the potential COM-B targets relate to the TDF and TATT mechanisms of action. These mappings are shown in Supplementary files C and D (Table 1) respectively. With regard to the TDF, it may be noted that some TDF domains, such as ‘reinforcement’, were found not to be things that would be targeted by interventions, but rather processes of change or intervention components. Other TDF domains, such as ‘professional identity’, would only be relevant in a limited number of domains. A third set of TDF domains, such as ‘knowledge’, were too broad, heterogeneous or ambiguous to be mapped onto COM-B targets. It also became apparent that the TDF did not include some important potential targets, such as financial resources, facilities or physical capability features required for the behaviour. Similarly with the TATT, some of the mechanisms of action were processes of change rather than targets, while others were broader and more heterogeneous than COM-B targets; and many COM-B targets were not covered by TATT.

Potential BCTs

A total of 91 BCTs were identified from the BCT Ontology (part of the Behaviour Change Intervention Ontology, BCIO) – see BCT list in the CACTIS Reference Database. An additional 21 BCTs were identified

that were not in the BCT Ontology, and these were proposed for addition to the Ontology. They were primarily located within the 'Restructure the physical environment' and 'Restructure the social environment' classes. At the time of writing, 19 have been added to the BCT Ontology, while the other two are under discussion (Table 2). With the new BCTs added, the final number of BCTs included in the CACTIS tool was 112.

Higher order BCT	BCTs added
Restructure the physical environment BCT	1. <u>Remove objects from the environment BCT</u> 2. <u>Modify objects in the environment BCT</u> 3. <u>Protect time to perform behaviour BCT</u> 4. <u>Reduce time needed to perform behaviour BCT</u> 5. <u>Facilitate access to spaces where behaviour is performed BCT</u> 6. <u>Impede access to spaces where behaviour is performed BCT</u> 7. <u>Increase financial affordability BCT</u> 8. <u>Decrease financial affordability BCT</u> 9. <u>Create a more pleasant environment for behaviour BCT</u> 10. <u>Create a less pleasant environment for behaviour BCT</u> 11. Facilitate access to equipment to enable wanted behaviour* 12. Impede access to equipment that is needed for unwanted behaviour*
Restructure the social environment BCT	13. <u>Increase exposure to people doing the behaviour BCT</u> 14. <u>Decrease exposure to people doing the behaviour BCT</u> 15. <u>Create social rule BCT</u>
Awareness of other people's thoughts, feelings and actions BCT	16. <u>Inform about social rule BCT</u> 17. <u>Increase salience of social rule BCT</u> 18. <u>Increase awareness of others' disapproval BCT</u> 19. <u>Present behaviour as a choice BCT</u>
Increase awareness of behaviour BCT	20. <u>Prompt immediate action BCT</u>
Increase awareness of consequences BCT	21. <u>Inform about positive consequences BCT</u>

Table 2. New BCTs identified and added to CACTIS. Table entries provide links to the entries in the ontology with definitions.

* *BCT under discussion for the BCT Ontology*

Potential IF/BCT Combinations

A total of 148 potential IF/BCT combinations were identified, indicating that many BCTs could be implemented differently depending on the Intervention Function they served. These are listed in the BCT-IF Combination tab of the CACTIS Reference Database. Bespoke descriptions were created that went beyond the definitions in the BCT Ontology to reflect the Intervention Function they were serving. For example, the BCT ‘Prompt comparative imagining of future outcomes’ serving the IF ‘Education’ was described in terms of ‘Inform them of what is likely to happen if they perform the behaviour versus not doing it, helping them to understand why it should be a priority over other behaviours.’

Mapping COM-B targets to relevant Intervention Function-BCT combinations

The result of the mapping process is shown in several tabs of the CACTIS Reference Database as described above (e.g., the ‘BCT Reference List’). Each of the 239 combinations of COM-B target, Intervention Function and BCT had a unique description to provide users with information to help them determine whether to use it or not.

Supplementary File D (Table 2) shows how COM-B Target to IF/BCT links relate to those in TATT. Many of the TATT links were preserved while in some cases additional links were included, especially where TATT did not include a mechanism of action that corresponded to a COM-B Target.

The CACTIS User Interface

CACTIS is implemented as a single, self-contained HTML file that runs entirely within a web browser, with no server-side component and no external dependencies. All assets are embedded within the file and may be saved and run locally.

The tool presents a persistent *interface frame* around a sequence of *task screens*. A header spanning every screen shows the tool name and version alongside a free-text ‘Project name’ field. Immediately beneath it, a save bar confirms that the user’s data is retained automatically within the browser session and offers

controls to save the current work to a file, restore it from a previously saved file, or clear all entries.

Navigation is by a horizontal tab bar providing direct access to seven screens:

1. an Instructions (landing) screen,
2. four numbered steps,
3. an intermediate 'Detail BCTs' screen designated Step 3b, and
4. an 'About CACTIS' screen.

Entries made on any screen persist as the user moves between tabs, so the steps may be completed and revisited in any order.

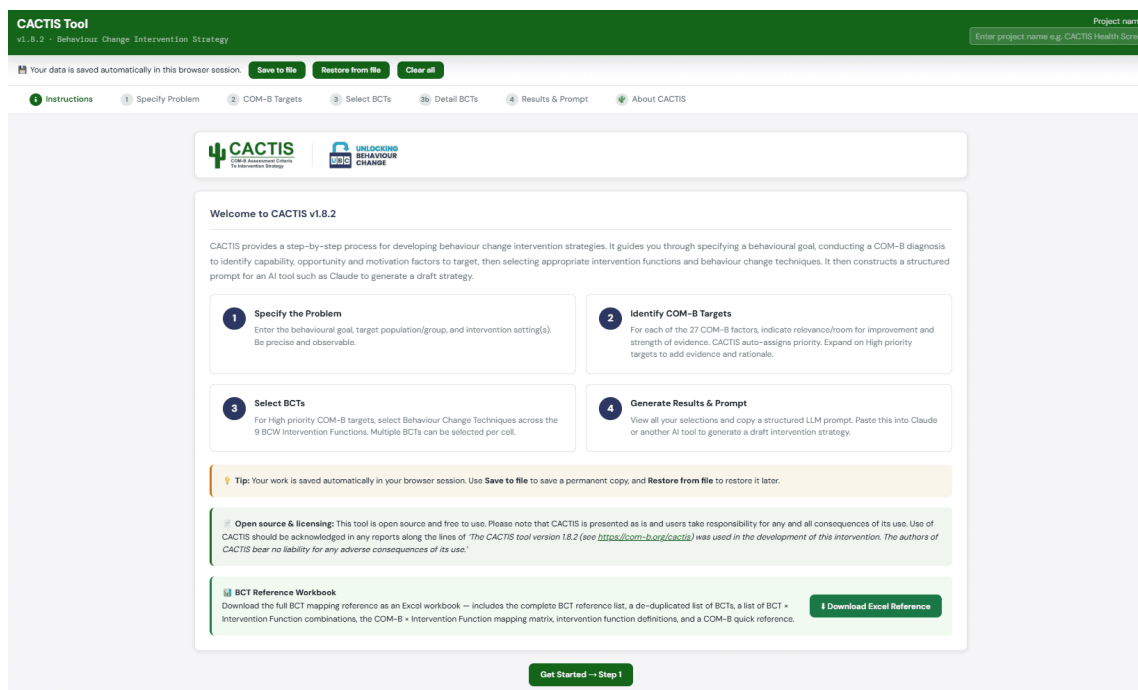


Figure 1. The CACTIS interface frame: header with project name, auto-save bar, and the seven-tab navigation.

Landing page (Instructions)

The landing screen (Figure 1) opens with a brand strip carrying the CACTIS and Unlocking Behaviour Change logos (The Unlocking Behaviour Change Community Interest Company being the host for the tool), followed by a welcome panel that summarises the tool's purpose: to guide the user through specifying a behavioural goal, conducting a COM-B diagnosis to identify the capability, opportunity and motivation factors to target, selecting appropriate intervention functions and behaviour change

techniques, and finally constructing a structured prompt for an AI tool such as Claude to generate a draft strategy.

A four-part visual overview restates the workflow – specify the problem; identify high-priority COM-B Targets; select behaviour change techniques across the nine intervention functions; and generate the results and LLM prompt.

Three information panels complete the screen. The first reiterates the auto-save behaviour and the save-to-file and restore-from-file controls. The second sets out the tool's open-source status and licensing position, including the wording recommended for acknowledging CACTIS in reports and a link to com-b.org/cactis. The third offers a download of the CACTIS Reference Database as an Excel file.

A prominent 'button' advances the user to Step 1.

Step 1: Specifying the Problem

Step 1 collects the user's specification of the problem through four free-text fields. The first three – the behavioural goal, the target population, subpopulation, group or person, and the intervention setting(s) – are accompanied by hint text and a worked placeholder example encouraging precise, observable specification (for instance, expressing a goal as a change in a named behaviour, in a stated direction, by a stated amount, within a stated timeframe). A fourth, optional field captures any implementation and delivery constraints and opportunities already fixed, such as mode of delivery, budget or timing. Each field carries an information button that opens a help sheet for the behavioural goal; this covers levels of behavioural specificity and the types of behavioural goal. All entries are saved automatically as they are typed (Figure 2).

CACTIS Tool
v1.6.2 · Behaviour Change Intervention Strategy

Project name:

Your data is saved automatically in this browser session. [Save to file](#) [Restore from file](#) [Clear all](#)

1 Instructions 2 **Specify Problem** 3 COM-B Targets 4 Select BCTs 5 Detail BCTs 6 Results & Prompt 7 About CACTIS

Step 1: Specify the Problem

Behavioural Goal
Describe the specific behaviour you want to promote or reduce. Be precise: what is the behaviour, in what direction, how much, and by when?
Increase the proportion of those cigarette smokers who use the Smoke Free app who succeed in maintaining tobacco (including cigarette) abstinence for at least 6 months.

Target Population, Group or Person
Describe who the intervention is aimed at. Include relevant characteristics such as age, health status, geography, or setting.
Adult cigarette smokers in multiple countries, including people with high levels of cigarette addiction, who are willing to use an app to support their quit attempt, including those who may have used the app before.

Intervention Setting(s)
Where will the intervention take place? Include all relevant settings.
Use of the app could be in principle anywhere, including at home, at work and while travelling. The setting will often have access to licensed medicines to aid cessation but some might not.

Implementation and Delivery Constraints
Optional. Describe any constraints already in place regarding how the intervention will be delivered – e.g. mode of delivery, policy options, budget, timing. Leave blank if none.
The app can currently be used for up to 6 months, with most of the content front-loaded. Here is a list of existing BCTs Broad category of BCT BCT Name BCT ID
Goal setting set measurable behaviour goal BCT0:007300
set measurable outcome goal BCT0:007301
affirm commitment BCT0:007015

[Next: COM-B Targets →](#)

Figure 2. Step 1 screen with the four problem-definition fields with an example.

Step 2: Prioritising COM-B Targets

Step 2 presents prompts for the behavioural diagnosis in which users record research findings and stakeholder feedback against each of the relevant COM-B targets, and then prioritise the COM-B Targets (Figure 3). The 27 COM-B targets are grouped under the three COM-B components – Capability, Opportunity and Motivation, distinguished by a consistent red, green and orange colour scheme – and further subdivided into six sub-domains: Psychological and Physical Capability, Social and Physical Opportunity, and Reflective and Automatic Motivation. Each target is displayed with a stable reference code (for example, C.PS.01 for the first Psychological Capability target) and an information button giving an explanation of that target.

Although in principle prioritising COM-B Targets could involve the APEASE criteria set out in the BCW Guide, in practice it was found that this presented too high a bar in most cases, and could also lead to premature closure of options, so CACTIS prompts users to make just two judgements from dropdown menus: extent of room for improvement (little or no room, some room, major room, not relevant, or not known) and the strength of the supporting evidence (limited, moderate or strong, or not known). From these two inputs, CACTIS automatically derives a priority rating, shown as a colour-coded badge.

A judgement of major room for improvement supported by moderate or strong evidence yields a High priority; some room yields Medium; and little or no room yields Low. Where the evidence is limited or either judgement is left unset, the target is rated Unclear, signalling that further evidence may be needed; where the room for improvement is marked not relevant or not known, the target is rated N/A and its evidence dropdown is disabled.

Each target can be expanded to reveal two optional free-text fields – research evidence or rationale, and evidence or input from stakeholders – which are carried forward into the prompt generated in Step 4.

CACTIS Tool
v1.0.2 - Behaviour Change Intervention Strategy

Project name:

Your data is saved automatically in this browser session. [Save to file](#) [Restore from file](#) [Clear all](#)

1 Instructions 2 Specify Problem 3 **COM-B Targets** 4 Select BCTs 5 Detail BCTs 6 Results & Prompt 7 About CACTIS

Step 2: Identify COM-B Targets
For each factor, use the dropdowns to indicate room for improvement and evidence strength. CACTIS will automatically assign a priority. Use the [Expand](#) button on high priority targets to add evidence and rationale.

Capability

COM-B TARGET	ROOM FOR IMPROVEMENT	STRENGTH OF EVIDENCE	PRIORITY
PSYCHOLOGICAL CAPABILITY			
C.PS.B1 Level of awareness of the behaviour Expand	Not relevant	Select	N/A
C.PS.B2 Level of understanding of how to do the behaviour Expand	Major room for ir	Moderate eviden	HIGH
C.PS.B3 Level of understanding of reasons for and against the behaviour Expand	Little or no room	Moderate eviden	LOW
C.PS.B4 Level of reasoning, analytical, memory, attention and decision-making ability relative to what the behaviour requires Expand	Not relevant	Select	N/A
C.PS.B5 Level of self-control and resilience relative to what is required by the behaviour Expand	Major room for ir	Strong evidence	HIGH
C.PS.B6 Level of interpersonal skills relative to what the behaviour requires Expand	Major room for ir	Moderate eviden	HIGH
PHYSICAL CAPABILITY			
C.PH.B1 Level of physical strength, stamina, flexibility and sensory abilities needed for the behaviour Expand	Not relevant	Select	N/A
C.PH.B2 Level of physical skills, coordination, balance and reaction times relative to what the behaviour requires Expand	Not relevant	Select	N/A
Opportunity			
COM-B TARGET	ROOM FOR IMPROVEMENT	STRENGTH OF EVIDENCE	PRIORITY
SOCIAL OPPORTUNITY			

Figure 3. Step 2 showing the COM-B targets grouped by component, the two assessment dropdowns, the auto-assigned priority badges, and an expanded evidence panel. Users have to scroll down to reveal the full list of COM-B targets.

Step 3: Selecting IF/BCT combinations

Step 3 is organised as a matrix in which the rows are COM-B targets and the columns are the nine Behaviour Change Wheel Intervention Functions – Education, Persuasion, Incentivisation, Coercion, Training, Rule-making (formerly Restriction), Environmental restructuring, Modelling and Enablement – preceded by a column repeating each target’s priority (see Figure 4). To keep attention on the working set,

the matrix applies priority filtering: High, Medium and Unclear targets are shown by default, with Unclear deliberately retained as a reminder that it still requires consideration, while Low and N/A targets are collapsed behind a toggle that reveals them on demand. This filtering only affects the display and does not alter the saved assessment.

Within each cell, CACTIS offers only those IF/BCT combinations that have been curated as potentially relevant for each COM-B Target. Cells for which no IF/BCT combination applies are disabled. An ‘add’ icon in the cell opens a list of the applicable techniques, each with its identifying number, label and definition, and allows one or more to be selected. Selected techniques are displayed in the cell.

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v1.0.2 · Behaviour Change Intervention Strategy

Project name:

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1 Instructions 2 Specify Problem 3 COM-B Targets 4 Select BCTs 5 Detail BCTs 6 Results & Prompt 7 About CACTIS

Step 3: Select Behaviour Change Techniques
For each High priority COM-B target, click the + button under each Intervention Function to select one or more BCTs. You can select multiple BCTs per cell.

[Show 11 lower-priority targets](#)

COM-B Target	Priority	Education	Persuasion	Incentivisation	Coercion	Training	Rule-making
PSYCHOLOGICAL CAPABILITY							
C.PS.02: Level of understanding of how to do the behaviour Psychological Capability	HIGH	Instruct how to perform... + Add	+ Add	+ Add	+ Add	+ Add	+ Add
C.PS.05: Level of self-control and resilience relative to what is required by the behaviour Psychological Capability	HIGH	Inform about antecedents... + Add	+ Add	+ Add	+ Add	Enable person to manage... + Add	+ Add
C.PS.06: Level of interpersonal skills relative to what the behaviour requires Psychological Capability	HIGH	+ Add	+ Add	+ Add	+ Add	Demonstrate wanted behaviour Instruct how to perform... Practice wanted behaviour Reinforce wanted behaviour Self-monitor behaviour + Add	+ Add
SOCIAL OPPORTUNITY							
S.SO.04: Level of social support for the behaviour Social Opportunity	MEDIUM	+ Add	+ Add	+ Add	+ Add	+ Add	+ Add
PHYSICAL OPPORTUNITY							
O.PI.01: Level of exposure to reminders or cues for the behaviour Physical Opportunity	MEDIUM	+ Add	+ Add	+ Add	+ Add	+ Add	+ Add
O.PI.03: Level of access to appropriate resources or equipment for the behaviour Physical Opportunity	MEDIUM	+ Add	+ Add	+ Add	+ Add	+ Add	+ Add

Figure 4. Step 3, showing the COM-B Target - IF/BCT matrix with priority filtering. Users have to scroll down to see the full list of COM-B Targets, and across to see the full set of IF/BCT options.

Step 3b: Providing details of selected IF/BCT combinations

Step 3b lists each IF/BCT combination that the user has selected as High Priority and provides, for each, two optional free-text fields: the rationale for selecting it, and an account of what the technique could or should look like in practice (both guided by evidence and stakeholder feedback). Guidance buttons explain what each field requires and where the information might come from. Both fields are optional and, where completed, are incorporated into the structured report and prompt produced in Step 4.

Step 4: Structured report and LLM prompt

Step 4 brings the design together. It opens with a summary of the problem definition and the prioritised targets and selected techniques, followed by a control that exports a decision record as a formatted Word document – a complete record capturing the problem definition, the full COM-B assessment, the selected techniques with their implementation detail, and the generated prompt. A table then summarises the selected techniques.

The screen's central output is a structured prompt for an LLM, presented in full with a one-click copy control. The prompt is assembled from all of the user's entries and organised under clear headings: the behavioural goal, target population and intervention setting; any implementation and delivery constraints; the High and Medium priority COM-B targets, each identified by its reference code; and the selected IF/BCT combinations, each presented with its COM-B target, intervention function, and technique label and definition, together with any rationale and practice detail recorded in Step 3b.

Where the user has expanded high-priority targets with additional research evidence and stakeholder feedback, this is appended. The prompt closes with a task instruction directing the LLM to design a detailed intervention strategy and, for each component, to state explicitly which COM-B target(s) it addresses, which technique(s) it employs, how it would be implemented in the specified setting, and why it is appropriate for the target population. The tool frames the LLM's output as a draft: a starting point for further design work rather than a finished intervention.

Discussion

CACTIS provides a structured route through three core steps of the Behaviour Change Wheel method for intervention development/improvement: from specifying a behavioural goal, through identifying and prioritising COM-B targets, to selecting the IF/BCT combinations that are most likely to influence them. By narrowing the very large number of possible mappings to a manageable set, and by recording the judgements with supporting evidence on which decisions are made, the tool aims to make intervention design (and updating/improvement) more effective, systematic, reproducible and easier to communicate.

Using CACTIS in real-world settings

In applied settings, the intervention design/improvement process is commonly a team activity involving people with differing levels of behavioural science expertise. CACTIS supports this in two ways.

First, the step-by-step structure, together with the embedded definitions and explainers, gives practitioners with limited behavioural science expertise a shared language and a logical process to follow, while allowing more experienced users to work quickly using concepts they are familiar with. It also potentially helps to improve the capabilities of those using the tool.

Second, the ability to export and import projects allows work to be shared, reviewed and discussed, and supports the creation of reusable templates for recurring types of intervention. The automatically generated report and the structured prompt for use with LLMs help to carry the output of the COM-B analysis forward into the more concrete stages of intervention development/improvement. Because evidence and rationale are recorded alongside each COM-B target judgement and BCT selection, CACTIS also produces an audit trail, which can be valuable for accountability, peer review and evaluation and learning.

It should be noted that CACTIS structures and documents expert judgement rather than replacing it. Using the tool requires knowledge of the behaviour in question, a working understanding of the BCW Framework and the COM-B model, and familiarity with the underlying constructs such as BCTs and Intervention Functions. The supporting materials are intended to reduce this requirement, but they do not remove it.

Flexibility, iteration and next steps

CACTIS is intended to be a living tool rather than a fixed artefact. The list of COM-B Targets and their mapping to IF/BCT combinations are all kept under review in the light of new theory, evidence and practice, and the tool is designed so that these can be revised without disrupting existing work. New IF/BCT combinations can be added or amended as the evidence base develops and as the BCT Ontology itself continues to evolve. Because exported projects record the specific selections a user has made, care is taken when updating the underlying content to preserve compatibility with work that practitioners have already saved.

The current version of CACTIS does not explicitly incorporate the BCW APEASE criteria into the development process. Users can refer to these criteria when they expand on their selections, but it may be useful to include an option for a more structured way to do this in a future version.

CACTIS has not yet been formally evaluated. Future studies should include usability studies with practitioners of varying experience, and studies examining whether using CACTIS improves the quality,

completeness and consistency of intervention strategies, and whether different users arrive at comparable strategies for the same problem.

Balancing evidence with professional judgement

A central design principle of CACTIS is that it should sharpen intervention design by narrowing the field of intervention options to a practical level but still offer ample choice and creativity. By offering, for each prioritised COM-B Target, a shortlist of IF/BCT combinations, the tool helps users to avoid overlooking plausible options and discourages the premature selection of familiar techniques. It does not specify the concrete content or mode of delivery of an intervention. The same BCT can be operationalised in many ways, so the step from a selected combination to real-world intervention design remains a creative activity that draws on the practitioner's knowledge of the target population, the setting and the operating environment. The final design will depend on professional judgement, local insight, research and innovation. One risk to guard against is that the structure of CACTIS could encourage mechanical, box-ticking application. The emphasis on recording rationale, and the supporting explanatory materials, are intended to make the user's reasoning transparent. Thus, CACTIS only takes users to the point of identifying potential intervention components. The fully formed intervention happens outside of the CACTIS tool, potentially with the help of AI.

Planned developments to CACTIS include embedding artificial intelligence (AI) within the tool itself, so that draft intervention content can be generated, refined and iterated within the tool. Other AI assistance could be applied to tasks such as summarising the evidence relevant to a given target, or suggesting ways of operationalising a chosen IF/BCT combination. The intention is that such features should support and accelerate the user's work while keeping the underlying theoretical logic, and the human judgements, explicit and open to review.

CACTIS licence and ethics

CACTIS is offered as an open-source product that is free to use with appropriate attribution (see the 'About CACTIS' page in the tool for specific wording). Users take responsibility for its use, including all liabilities resulting from this. The authors intend that the tool be used to promote wellbeing and sustainability.

Conclusions

The CACTIS tool has evolved over many iterations to a version that takes users through a series of steps towards creating an intervention strategy, with the option of using that strategy as a prompt for an LLM. This is an ongoing programme of work, and a next step will be to undertake formal evaluations.

Statements and Declarations

Funding

The development of CACTIS has been funded by a grant from the Public Health Wales Behavioural Science Unit, and in-kind support from the Unlocking Behaviour Change Community Interest Company.

Potential Competing Interests

RW is a paid advisor to Public Health Wales Behavioural Science Unit, the Freuds communications agency, Godot Inc, the NIH-funded APRICOT programme and Lilly and Qnovia pharmaceutical companies, which have an interest in developing smoking cessation medications. RW is an unpaid advisor to the UK's National Centre for Smoking Cessation and Training and the Smoke-Free mobile application. RW is an unpaid Director of the Unlocking Behaviour Change Community Interest Company.

EF is a Director of the Unlocking Behaviour Change Community Interest Company who undertakes paid consultancy and training.

SM is an unpaid Director of the Unlocking Behaviour Change Community Interest Company and a paid advisor to Godot Inc.

AG has no potential competing interests to declare.

CACTIS has been developed as an open-source tool that is free to use, with attribution. RW and EF use it in training and consultancy.

Use of Generative AI

Artificial Intelligence was used in two ways in the work reported here. In the development of the CACTIS tool, a large language model (Claude, Anthropic) was used as a coding assistant to help build and refine the web-based version of the interface, under the direction and review of authors. In the preparation of this manuscript, the same tool was used to assist with drafting and editing portions of the text. The

authors directed this work, checked all output for accuracy, revised content accordingly, and take full responsibility for the content of the tool and of this paper.

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Footnotes

ⁱ For ease of reference from hereon this paper refers to individuals, groups, populations and subpopulations of behavioural interventions as the ‘target population’.

ⁱⁱ Ontologies are formal systems for representing ‘entities’ in the world, including behaviour-change intervention components in a way that makes clear their properties.

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