THE BEHAVIOUR CHANGE WHEEL APPROACH

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Background

The Behaviour Change Wheel (BCW) approach is a set of interrelated tools and principles intended to guide decision making and facilitate systematic development of behavioural interventions (Michie et al., 2015). BCW was developed to reduce the reliance of much, if not most, intervention design on the 'ISLAGIATT' principle, a term created by Martin Eccles, Emeritus Professor of Clinical Effectiveness. The letters stand for 'It Seemed Like A Good Idea At The Time'. This idea refers to an approach in which intervention strategies are arrived at on the basis of intuitive 'hunches' or 'best guesses' of what needs to change (i.e. before having conducted a thorough assessment of the appropriate behavioural target(s), what it would take to achieve change in these and how best to implement this) (Lorencatto et al., 2018). Instead, personal experience, a preferred theory or superficial analysis is used as the starting point for intervention design, often resulting in ineffective interventions and wasted resources.

Often ISLAGIATT interventions represent a set of arguably naive assumptions that dissemination of guidelines, introduction of new policies or delivery of education will be sufficient to enable effective and sustained behaviour change. However, one would not prescribe a particular medication without first assessing patient symptoms and using this diagnosis as a basis for selecting the treatment that is most likely to be successful (Lorencatto et al, 2018). In this chapter, we define behaviour change intervention as "an action or co-ordinated set of activities that aims to get an individual or population to behave differently from how s/he or they would have acted without such an action" (Michie et al., 2011c).

The Medical Research Council guidance for developing and evaluating complex interventions (defined as interventions with several interacting components) recommends taking a systematic, theoretically-informed approach to intervention design (Craig et al., 2013, Craig et al., 2008). However, the guidance itself provides limited advice on how to do this successfully and therefore lacks flesh on its bones. In order to design effective interventions, it is important to match the choice of intervention strategy to the key barriers and enablers to the behaviour of interest. Designers should consider the full range of options and techniques available and use a systematic method for selecting from among them. This requires an appropriate framework for characterising or describing interventions and linking them to an understanding of the selected target behaviour.

There have been several attempts to be more systematic about intervention design, involving frameworks that draw attention to a variety of options and in some cases to ways of selecting these from an analysis of the particular behaviour change problem. These include MINDSPACE (Dolan et al., 2010), an approach favoured by the UK government, and Intervention Mapping (Bartholomew et al., 2001, Bartholomew et al., 1998, Eldredge et al., 2016) an approach that has been adopted in a number of other countries. However, none of these frameworks cover the full range of available intervention options. In addition, few

of them are conceptually coherent or clearly linked to a theoretical model of behaviour change. Some of the frameworks assume that behaviour is primarily driven by beliefs and perceptions, while others place greater emphasis on unconscious biases and yet others focus on the social environment. Clearly, all of these are important but there remained an obvious need to bring them together in a coherent fashion. The BCW aimed to address these limitations, and put flesh on the bones of the Medical Research Council guidance, by synthesizing the common features of the frameworks and linking them to a theoretical model of behaviour that was sufficiently broad so it could be applied to any target behaviour in any setting.

The systematic literature review of frameworks of behaviour change interventions identified 19 frameworks which comprised nine intervention functions (defined as functions served by an intervention targeting factors that influence behaviour) and seven policy categories (representing types of decisions made by authorities that help to support and enact the interventions) (Michie et al., 2011c). The resulting integrated framework linked these intervention functions and policy categories to the Capability Opportunity Motivation - Behaviour (COM-B model), which forms the hub of the wheel (see Figure 1). For further detail on the 19 frameworks and the methods used to synthesise them please refer to the BCW guide (Michie et al., 2015).
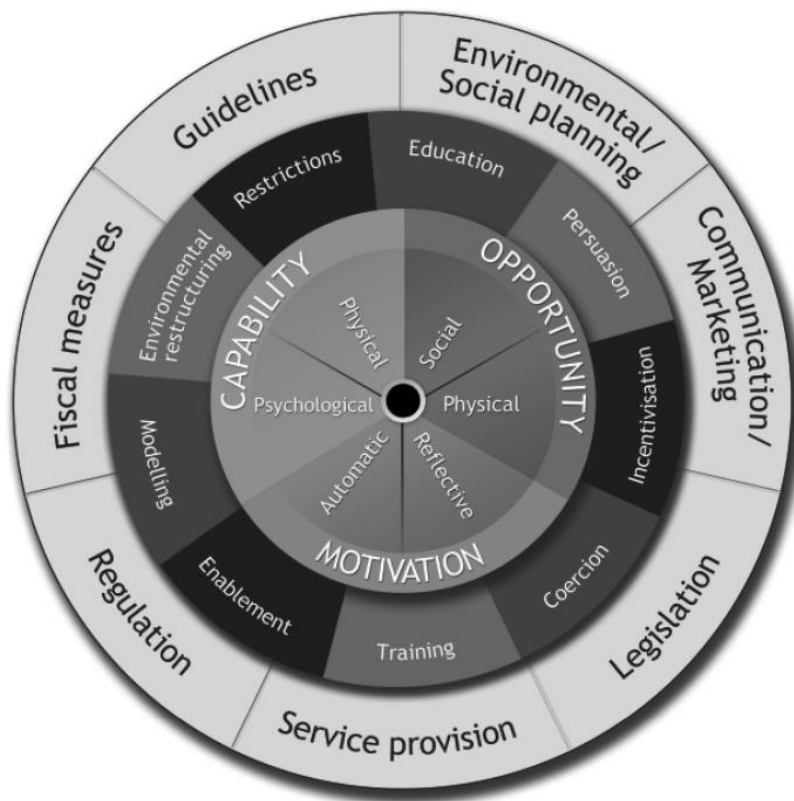

Figure 1: The Behaviour Change Wheel (BCW)

Introduction to the Tools and Steps to Intervention Design

The BCW approach includes four behavioural science tools and demonstrates how they interlink and can be applied as a system for understanding behaviour and designing behaviour change interventions. The four tools are the following:

- Capability Opportunity Motivation – Behaviour (COM-B) model
- Theoretical Domains Framework (TDF)
- Behaviour Change Wheel (BCW)
- Behaviour Change Techniques Taxonomy (BCTTv1)

The COM-B model (Michie et al., 2011c) and TDF (Michie et al., 2005, Cane et al., 2012) guide understanding of behaviour, and the BCW (Michie et al., 2011c) and BCTTv1 (Michie et al., 2013) guide the development, and specify content, of behaviour change interventions. These tools interlink along with a number of key principles to form a system of five steps to guide intervention design:

- Step 1: Behavioural target specification
  Involves the selection and specification of a target behaviour through systematic exploration of a system of behaviours that are related to the broader outcome of interest.
- Step 2: Behavioural diagnosis using COM-B model or TDF which is an elaboration of COM-B
  Involves use of theory to understand the influences on the chosen behaviour and therefore identify what might need to change in order to achieve the desired outcome.
- Step 3: Intervention strategy selection using the BCW
  Involves use of the BCW framework to systematically identify possible intervention functions and decide between them based on evidence and consideration of the local context.
- Step 4: Implementation strategy selection using the BCW
  Involves use of the BCW framework to systematically identify possible policy categories and decide between them based on evidence and consideration of the local context.
- Step 5: Selection of specific Behaviour Change Techniques (BCTs) from the BCTTV1
  Involves use of the BCW framework to systematically identify possible BCTs and decide between them based on evidence and consideration of the local context.

The primary text describing the BCW is the Behaviour Change Wheel Guide (www.behaviourchangewheel.com), which provides a step-by-step approach to intervention design and evaluation (Michie et al., 2015). The following sections of this chapter provide specific detail on each step of the BCW approach to intervention design. In order to help illustrate how the BCW approach can be used in its entirety, an end-to-end example from the implementation research literature has been broken down and is included at the end of each detailed step description below. The example that we have selected is the development of the

MultimorbiditY COllaborative Medication Review And DEcision Making (MY COM-RADE) implementation intervention using the BCW (Sinnott et al., 2015b). This implementation intervention was developed to improve medication management in multimorbidity by General Practitioners (GPs). Multimorbidity (defined as the presence of two or more chronic health conditions) has been shown to affect over 60% of patients in primary care (Glynn et al., 2011) yet systems and healthcare professionals are not necessarily well supported to provide optimal care to these patients. Multimorbidity frequently leads to the prescription of multiple long-term medications (polypharmacy) and therefore medication management is a particular area in which GPs would benefit from additional support.

Step 1: Behavioural Target Specification

When thinking about intervention design, it is common to think in terms of the outcomes that one wants to achieve. However, in order to design a behaviour change intervention, it is essential to define the problem in behavioural terms. For example, a desired outcome may be to reduce infection rates, but these are not behaviours. Instead, they are outcomes of multiple behaviours that interact and compete with one another as part of a system. Behaviours do not exist in a vacuum but occur within the context of many other behaviours of the same or other individuals. These behaviours might occur at different levels. Therefore, the first stage of behavioural target specification involves exploring the system of behaviours.

If one selects a behaviour that is dependent on other behaviours, this needs to be taken into account in the design process as the intervention will need to target this set of behaviours. Therefore, when considering which behaviour(s) to target, designers should think about all relevant behaviours performed by the relevant individual(s) and group(s) and how they relate to one another. This can be achieved through behavioural mapping, which is a process in which all relevant behaviours are identified and the relationships between them are represented diagrammatically. What might seem a simple set of behaviours, such as hospital nurses keeping their hands disinfected, is influenced in different ways by the behaviours of several others, including senior doctors disinfecting, or not disinfecting, their hands, patients asking them whether they have cleaned their hands, and the domestic staff ensuring that there is enough alcohol gel in the dispensers. Prior literature and knowledge from the local context can be used to systematically identify behaviours and the relationships between them.

From this system of behaviours a target behaviour(s) must then be selected. It is possible to select more than one target behaviour though we advise to restrict the intervention to just one or a few behaviours in the first instance. Introducing change incrementally and building on small successes is likely to be more effective than trying to do too much too quickly. In terms of which behaviours to choose, there may be obvious indications in some cases. The following criteria may also be helpful in selecting the target behaviour(s) and can be applied with support from local contextual information and/or the relevant research evidence:

1.   The likely impact if the behaviour were to be changed.

2.   How easy it is likely to be to change the behaviour; this will be influenced by local circumstances, for example, financial and human resources, acceptability and preference.

3.   The centrality of the behaviour in the system of behaviours: thus, the positive 'spillover' effect if that behaviour were to be changed. Some behaviours are more 'central' in the system, and changing them is likely to have an impact on other behaviours, either positive in that it may support desired behaviour change or negative in that there may be negative consequences. Estimating this can be helped by gathering local evidence or by consulting the research literature.

4.   Ease of measurement: if one wishes to evaluate the extent to which the intervention has changed the target behaviour, it should be measurable, either by routine data or by introducing new data collection procedures.

Having selected the target behaviour(s), the next step is to specify the behaviour(s) in appropriate detail and in its context. So, for example, 'washing hands' will be less likely to help a health professional decide what to do than 'nurses washing hands in accordance with the specific technique outlined in guidance before and after examining each patient at the sink in the corner of the ward'. Specifying behaviours more precisely can inform more focused behavioural diagnoses, targeted intervention development, and in some cases can also support the identification of key metrics to evaluate intervention success in terms of behaviour change.

We recommend that the behaviour is specified in terms of:

- Who needs to perform the behaviour?
- What does the person need to do differently to achieve the desired change?
- When will they do it?
- Where will they do it?
- How often will they do it?
- With whom will they do it?

End to End Example

The research team conducted a systematic review and qualitative interview study with GPs in order to explore the behaviours associated with medication management in multimorbidity in primary care.

They identified two relevant quantitative reviews (Patterson et al., 2014, Smith et al., 2016) and a number of related qualitative studies. Therefore, they conducted a systematic review and synthesis of the qualitative studies, the methods of which have been published elsewhere (Sinnott et al., 2013). They addressed the gaps identified from the qualitative synthesis by conducting a qualitative interview study with GPs, specifically to generate further information on their approaches to prescribing in multimorbidity. The methods for the interview study have also been published elsewhere (Sinnott et al., 2015a).

From the aggregated qualitative synthesis and interview data, they identified the modifiable GP behaviours relating to medication management in multimorbidity and selected one key

behaviour to target in their intervention. This judgement was informed by the criteria set out above (i.e. the likelihood that behavioural change would be implemented, the likely impact of changing the behaviour, the spillover or knock on effect of change on other behaviours and the ease with which each behaviour could be measured).

The target behaviour was specified as active, purposeful medication review instead of passive 'maintaining the status quo' for patients with multimorbidity (WHAT), to be conducted by GPs (WHO), in routine general practice (WHERE), on a regular basis (WHEN/HOW OFTEN).

Step 2: Behavioural Diagnosis: Using Capability Opportunity Motivation – Behaviour (COM-B) Model or Theoretical Domains Framework (TDF)

Having specified the target behaviour you wish to change, the next step is to identify what needs to change in the person and/or the environment in order to achieve the desired change in behaviour. Devoting time and effort to fully understanding the target behaviour is a critical and often overlooked step in intervention design. The more accurate this analysis of the target behaviour, the more likely it is that the intervention will change the behaviour in the desired direction. This analysis can be described as a behavioural diagnosis.

Conducting a behavioural diagnosis is facilitated by the use of theory. There is some indication that theory-based behaviour change interventions are more effective than those which are not (Noar et al., 2007, Noar and Zimmerman, 2005, Trifiletti et al., 2005, Glanz and Bishop, 2010, Webb et al., 2010) although the evidence is neither consistent nor strong (Prestwich et al., 2014, Dalgetty et al., 2019). This further illustrates the need for more effective theory-based intervention development in order to provide a better test of the theory-effectiveness hypothesis (Dalgetty et al., 2019). A multitude of theories from the behavioural and social sciences have been used to explain or predict behaviour in the general population. However, though multiple behaviour change theories are available, until recently (e.g. see Birken et al (Birken et al., 2018)) systematic procedures for selecting one theory over another have been lacking and this has resulted in confusion and sometimes disengagement from non-specialists. In turn, behavioural and social scientists have invested in efforts to synthesize available theories and frameworks, in order to reduce complexity resulting from the overlap between individual theories and increase the accessibility of theory. Two examples of such synthesis efforts are the COM-B model and the TDF, which were developed by synthesizing a core set of 33 behaviour change theories (Michie et al., 2011c, Michie et al., 2005, Cane et al., 2012).

The COM-B (Figure 2) model allows a simple approach to understanding behaviour in context. It stands for Capability Opportunity Motivation – Behaviour. The central tenet of the model is that for any behaviour to occur:

    1)   There must be the **Capability** to do it: the person or people concerned must have the physical strength, knowledge, skills, stamina etc. to perform the behaviour. Capability can be either physical (having the physical skills, strength or stamina) to perform the behaviour or psychological (having the knowledge, psychological skills, strength or stamina) to perform the behaviour;

2) There must be the **Opportunity** for the behaviour to occur in terms of a conducive physical and social environment: e.g. it must be physically accessible, affordable, socially acceptable and there must be sufficient time. Opportunity can be physical (what the environment allows or facilitates in terms of time, triggers, resources, locations, physical barriers, etc.) or social (including interpersonal influences, social cues and cultural norms);

3) There must be sufficient strong **Motivation**: i.e. they must be more highly motivated to do the behaviour at the relevant time than not to do the behaviour, or to engage in a competing behaviour. Motivation may be reflective (involving self-conscious planning and evaluations (beliefs about what is good or bad) or automatic (processes involving emotional reactions, desires, impulses and reflex responses). These elements of reflective and automatic motivation form the different levels of the human motivational system described in PRIME Theory of Motivation: Plans, Responses, Impulses, Motives (emotional reactions) and Evaluations (West and Brown, 2013).
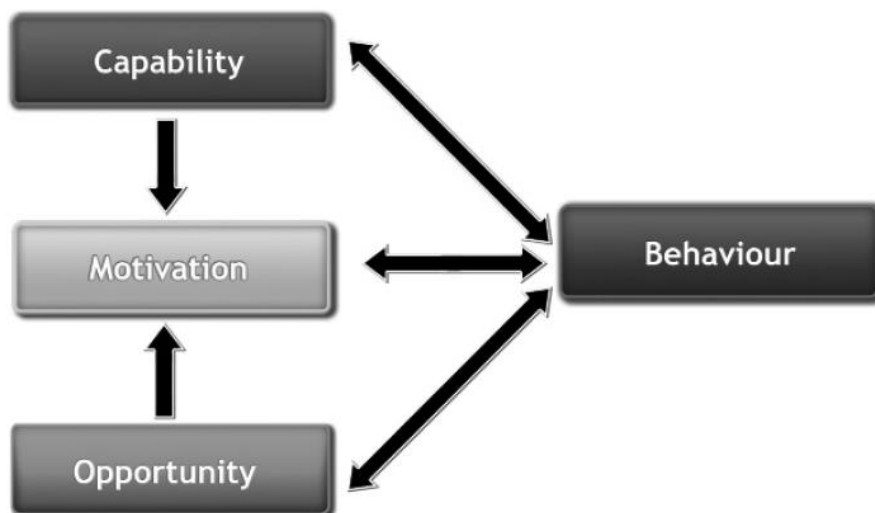

Figure 2: Capability Opportunity Motivation – Behaviour (COM-B)

These components interact as illustrated by the interlinking arrows so that, for example, increasing opportunity or capability can increase motivation. Increased motivation can lead people to do things that will increase their capability or opportunity by changing behaviour. For example, having access to alcohol gel (opportunity) or knowing how to wash one's hands (capability) might increase motivation to wash hands but motivation alone will not improve hand washing skills or enable access to alcohol gel unless the individual acts (demonstrates behaviour) on this motivation to practice hand washing effectively and/or ask domestic staff to replace the gel. Table 1 provides definitions and examples of the COM-B model components.

Table 1: Definitions and examples of COM-B components

COM-B model component Definition	Example
Physical capability Physical skill, strength or stamina	Having the skill to take a blood sample
Psychological capability Knowledge or psychological skills, strength or stamina to engage in the necessary thought processes	Understanding the impact of CO_2 on the environment
Physical opportunity Opportunity afforded by the environment involving time, resources, locations, physical barriers	Being able to go running because one owns appropriate shoes
Social opportunity Opportunity afforded by interpersonal influences, social cues and cultural norms that influence the way that we think about things, e.g. the words and concepts that make up our language	Being able to smoke in the house of someone who smokes but not in the middle of a boardroom meeting
Reflective motivation Reflective processes involving plans and evaluations	Intending to stop smoking
Automatic motivation Automatic processes involving emotional reactions, impulses and reflex responses that arise from associative learning and/or innate dispositions	Feeling anticipated pleasure at the prospect of eating a piece of chocolate cake

The components of COM-B can be further elaborated into 14 domains, using a more detailed tool to understand the range of potential factors influencing a behaviour (i.e. the barriers and enablers).

The TDF (Cane et al., 2012, Michie et al., 2005) is an integrative framework synthesising key theoretical constructs used in relevant theories and was developed in a collaboration between psychologists and implementation researchers. The framework comprises 14 domains: 'knowledge'; 'skills'; 'memory, attention and decision processes'; 'behavioural regulation'; 'social/professional role and identity'; 'beliefs about capabilities'; 'optimism'; 'beliefs about consequences'; 'intentions'; 'goals'; 'reinforcement'; 'emotion'; 'environmental context and resources'; and 'social influences'.

Definitions of these domains and their component constructs are listed in Table 2. Each domain of the TDF relates to a COM-B component. Figure 3 illustrates how domains of the TDF link to each COM-B component. If a more detailed understanding of the behaviour is required, it is possible to use the TDF to expand on COM-B components identified in the behavioural diagnosis. In this sense, COM-B analysis can be used as a screening tool to give an indication of which domains to explore in more detail if it is not feasible to assess all 14 domains (e.g. by conducting more detailed diagnostic interviews).

Table 2: Definitions of the TDF domains and constructs.

Domain Definition	Theoretical constructs represented within each domain
Knowledge An awareness of the existence of something	Knowledge (including knowledge of condition /scientific rationale); procedural knowledge; knowledge of task environment

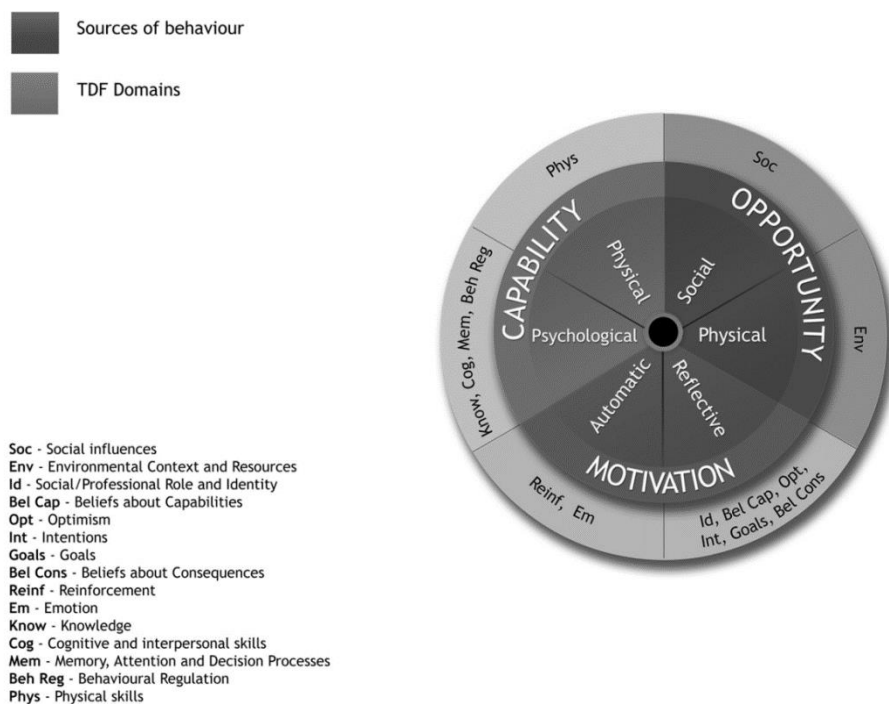| Domain Definition	Theoretical constructs represented within each domain
Skills An ability or proficiency acquired through practice	Skills; skills development; competence; ability; interpersonal skills; practice; skill assessment
Memory, attention and decision Processes The ability to retain information, focus selectively on aspects of the environment and choose between two or more alternatives	Memory; attention; attention control; decision making; cognitive overload / tiredness
Behavioural regulation Anything aimed at managing or changing objectively observed or measured actions	Self-monitoring; breaking habit; action planning
Social/professional role and identity A coherent set of behaviours and displayed personal qualities of an individual in a social or work setting	Professional identity; professional role; social identity; identity; professional boundaries; professional confidence; group identity; leadership; organisational commitment
Beliefs about capabilities Acceptance of the truth, reality, or validity about an ability, talent, or facility that a person can put to constructive use	Self-confidence; perceived competence; self-efficacy; perceived behavioural control; beliefs; self-esteem; empowerment; professional confidence
Optimism The confidence that things will happen for the best or that desired goals will be attained	Optimism; pessimism; unrealistic optimism; identity
Beliefs about consequences Acceptance of the truth, reality, or validity about outcomes of a behaviour in a given situation)	Beliefs; outcome expectancies; characteristics of outcome expectancies; anticipated regret; consequents
Intentions A conscious decision to perform a behaviour or a resolve to act in a certain way	Stability of intentions; stages of change model; trans-theoretical model and stages of change
Goals Mental representations of outcomes or end states that an individual wants to achieve	Goals (distal / proximal) ; goal priority; goal / target setting; goals (autonomous / controlled); action planning; implementation intention
Reinforcement Increasing the probability of a response by arranging a dependent relationship, or contingency, between the response and a given stimulus	Rewards (proximal / distal, valued / not valued, probable / improbable); incentives; punishment; consequents; reinforcement; contingencies; sanctions
Emotion A complex reaction pattern, involving experiential, behavioural, and physiological elements, by which the individual attempts to deal with a personally significant matter or event	Fear; anxiety; affect; stress; depression; positive / negative affect; burn-out
Environmental context and resources Any circumstance of a person's situation or environment that discourages or encourages the development of skills and abilities, independence, social competence, and adaptive behaviour	Environmental stressors ; resources / material resources ; organisational culture /climate ; salient events / critical incidents; person x environment interaction; barriers and facilitators
Social influences Those interpersonal processes that can cause individuals to change their thoughts, feelings, or behaviours	Social pressure; social norms; group conformity; social comparisons; group norms; social support; power; intergroup conflict; alienation; group identity; modelling

Sources of behaviour

TDF Domains

Phys
Soc
CAPABILITY
OPPORTUNITY
Know, Cog, Mem, Beh Reg
Physical
Social
Psychological
Physical
Env
Automatic
Reflective
MOTIVATION
Reinf, Em
Id, Bel Cap, Opt, Int, Goals, Bel Cons

Soc - Social influences
Env - Environmental Context and Resources
Id - Social/Professional Role and Identity
Bel Cap - Beliefs about Capabilities
Opt - Optimism
Int - Intentions
Goals - Goals
Bel Cons - Beliefs about Consequences
Reinf - Reinforcement
Em - Emotion
Know - Knowledge
Cog - Cognitive and interpersonal skills
Mem - Memory, Attention and Decision Processes
Beh Reg - Behavioural Regulation
Phys - Physical skills

Figure 3: Relationship between domains of the TDF and COM-B components

End to End Example

The research team used the COM-B model to frame their analysis of the qualitative evidence synthesis and interview data (described in the previous step). They coded empirical data relevant to GPs' psychological and physical capabilities, social and physical opportunities and reflective and automatic motivations to highlight why GPs were or were not engaging in the target behaviour (active, purposeful medication review instead of passive 'maintaining the status quo' for patients with multimorbidity, to be conducted by GPs, in routine general practice, on a regular basis) and what needed to change for the target behaviour to be achieved.

The results of this analysis were presented to the broader research team at a consensus meeting and refined accordingly. The themes that emerged from this analysis are presented in the published article, with illustrative quotations from both the qualitative synthesis and the interview study. Some high-level examples are provided in Table 3.

Table 3: Example behavioural diagnosis from (Sinnott et al., 2015b)

COM-B component	Theme
Psychological Capability	GPs were uncertain about which medications were most valuable in patients with multimorbidity. This was exacerbated by the lack of satisfactory guidelines in the field.

Physical Opportunity	GPs felt that they had insufficient time within consultations to conduct a medication review.
Social Opportunity	GPs found medication review difficult because of a cultural belief that treatment for chronic disease is lifelong.
Automatic Motivation	Many GPs had developed a habitual response to 'not rock the boat' in patients with multimorbidity. This often led to them not making changes to medications unless there was an obvious need to do so. This behaviour was also reinforced by prior experiences of the negative consequences of stopping or changing medications for patients with multimorbidity.
Reflective Motivation	GPs reflected on the opportunity cost of using their professional time for this purpose and a fear of negative consequences from rationalising medications. GPs also had motivations to review medications which included improving patient outcomes, being confident that they are delivering the best possible care, and preventing any medico-legal repercussions.

Step 3: Intervention Strategy Selection using the Behaviour Change Wheel (BCW)

The behavioural diagnosis resulting from the COM-B or TDF analysis (described in the previous step) is a key starting point for designing an intervention. It identifies what needs to shift for the target behaviour to occur and therefore what to target in an intervention. The BCW identifies intervention functions likely to be effective in bringing about change.

By 'intervention function', we mean broad categories of means by which an intervention can change behaviour. We classify intervention functions rather than interventions because any particular intervention strategy may have more than one function. For example, a message such as 'Please make sure you use soap when washing your hands - just rinsing them is not enough to kill the bacteria that cause nasty stomach bugs', can serve to improve knowledge but also with words such as 'nasty' it can evoke emotions in a way that goes beyond this into persuasion.

The nine intervention functions identified in synthesising the 19 frameworks are: 'education', 'persuasion', 'incentivisation', 'coercion', 'training', 'restriction', 'environmental restructuring', 'modelling' and 'enablement' (definitions and examples are given in Table 4).

Table 4: Definitions and examples of intervention functions

Intervention function	Definition	Example of intervention function
Education	Increasing knowledge or understanding	Providing information to promote healthy eating
Persuasion	Using communication to induce positive or negative feelings or stimulate action	Using imagery to motivate increases in physical activity
Incentivisation	Creating an expectation of reward	Using prize draws to induce attempts to stop smoking
Coercion	Creating an expectation of punishment or cost	Raising the financial cost to reduce excessive alcohol consumption
Training	Imparting skills	Advanced driver training to increase safe driving

Intervention function	Definition	Example of intervention function
Restriction	Using rules to reduce the opportunity to engage in the target behaviour (or to increase the target behaviour by reducing the opportunity to engage in competing behaviours)	Prohibiting sales of solvents to people under 18 to reduce use for intoxication
Environmental restructuring	Changing the physical or social context	Providing on-screen prompts for GPs to ask about smoking behaviour
Modelling	Providing an example for people to aspire to or imitate	Using TV drama scenes involving safe-sex practices to increase condom use
Enablement	Increasing means/reducing barriers to increase capability (beyond education and training) or opportunity (beyond environmental restructuring)	Behavioural support for smoking cessation, medication for cognitive deficits, surgery to reduce obesity, prostheses to promote physical activity

As outlined previously, interventions are more likely to be effective if they include components that target the main influences on the selected behaviour. Different intervention functions are more or less relevant and effective to addressing barriers and enablers within different domains. For example, the intervention function 'training' will be effective in addressing behaviours where a lack of capability is present, but not a lack of motivation or opportunity. Similarly, we can restructure the environment to increase opportunity, but this will not change behaviour if the issue is a lack of capability or motivation. It is therefore of great significance to ensure congruence between choice of intervention strategy and behavioural diagnosis.

To facilitate this decision making, the links between COM-B, TDF and the intervention functions, identified by a group of experts in a consensus exercise are shown in Table 5. For each COM-B component or TDF domain identified as relevant in bringing about the desired change in the target behaviour, Table 5 shows which intervention function is likely to be effective in bringing about that change. Using this information we can move from understanding the behaviour to identifying potentially appropriate intervention functions.

Table 5: Links between COM-B, TDF and intervention functions, identified through expert consensus

COM-B	TDF	Intervention functions
Physical capability	Physical skills	Training
Psychological capability	Knowledge	Education
	Cognitive and interpersonal skills	Training
	Memory, attention and decision processes	Training Environmental restructuring Enablement
	Behavioural regulation	Education Training Modelling Enablement

COM-B	TDF	Intervention functions
Reflective motivation	Professional/social role and identity	Education Persuasion Modelling
	Beliefs about capabilities	Education Persuasion Modelling Enablement
	Optimism	Education Persuasion Modelling Enablement
	Beliefs about consequences	Education Persuasion Modelling
	Intentions	Education Persuasion Incentivisation Coercion Modelling
	Goals	Education Persuasion Incentivisation Coercion Modelling Enablement
Automatic motivation	Reinforcement	Training Incentivisation Coercion Environmental restructuring
	Emotion	Persuasion Incentivisation Coercion Modelling Enablement
Physical opportunity	Environmental context and resources	Training Restriction Environmental restructuring Enablement
Social opportunity	Social influences	Restriction Environmental restructuring Modelling Enablement

<u>The APEASE Criteria</u>

Having identified the potential intervention functions to use, these can be narrowed down using the APEASE (Acceptability, Practicability, Effectiveness/cost-effectiveness, Affordability, Safety/side-effects, Equity) criteria set out in Table 6. The criteria are useful when deciding on the intervention strategy in the given context. They should be applied in a structured way using available evidence combined with expert judgement. In terms of considering evidence, it is recommended to give greatest weight to high quality field experiments in the target population concerned addressing the behaviour in question, if available. One should give progressively less weight to studies with lower degrees of experimental

control, weaker outcome measures, smaller sample sizes, populations that differ from the target population, contexts that differ from the one in question and behaviours that differ from the target behaviour.

Table 6: Descriptions of the APEASE (Acceptability, Practicability, Effectiveness/cost-effectiveness, Affordability, Safety/side-effects, Equity) criteria

Criterion	Description
Affordability	Every intervention has an implicit or explicit budget. It does not matter how effective, or even cost-effective it may be if it cannot be afforded. An intervention is affordable if within an acceptable budget it can be delivered to, or accessed by, all those for whom it would be relevant or of benefit.
Practicability	An intervention is practicable to the extent that it can be delivered as designed. For example, an intervention may be effective when delivered by highly selected and trained staff and extensive resources but in routine clinical practice this may not be achievable.
Effectiveness and cost-effectiveness	Effectiveness refers to the effect size of the intervention in relation to the desired objectives in a real world context. It is distinct from efficacy which refers to the effect size of the intervention when delivered under optimal conditions in comparative evaluations. Cost-effectiveness refers to the ratio of effect (in a way that has to be defined, and taking account of differences in timescale between intervention delivery and intervention effect) to cost. If two interventions are equally effective then clearly the most cost-effective should be chosen. If one is more effective but less cost-effective than another, other issues such as affordability, come to the forefront of the decision making process.
Acceptability	Acceptability refers to the extent to which an intervention is judged to be appropriate by relevant stakeholders, including the general public. Acceptability may differ for different stakeholders. For example, the general public may favour an intervention that restricts marketing of alcohol or tobacco but politicians considering legislation on this may take a different view. Interventions that appear to limit agency on the part of the target group are often only considered acceptable for more serious problems (Bioethics, 2007).
Side-effects/safety	An intervention may be effective and practicable, but have unwanted side-effects or unintended consequences. These need to be considered when deciding whether or not to proceed.
Equity	An important consideration is the extent to which an intervention may reduce or increase the disparities in standard of living, wellbeing or health between different sectors of society.

End to End Example

The research team determined which intervention functions would be most likely to affect behavioural change in their intervention by mapping the individual components of the COM-B behavioural diagnosis onto the published BCW linkage matrices. Each intervention function seen to be potentially relevant to the data was considered in detail. The APEASE criteria was used to grade the potentially relevant intervention functions into first and second line options. Table 7 illustrates how the barriers identified relate to COM-B components and selected intervention functions. The three intervention functions most

relevant for the intervention were enablement, environmental re-structuring and incentivi-
sation.

Table 7: Relationships between barriers identified, COM-B components and selected inter-
vention functions extracted from Sinnott et al (Sinnott et al., 2015b)

Barrier identified	COM-B component	Intervention function
Uncertainly about what medica-tions were most valuable	Psychological Capability	Enablement
Perceptions that social norms make patients unwilling to stop long-term medications	Social Opportunity	Enablement
Lack of time to properly review medication	Physical Opportunity	Environmental Restructuring
An instinct not to 'rock the boat'	Automatic Motivation	Environmental Restructuring Enablement
Opportunity cost of using time to conduct medication reviews	Reflective Motivation	Incentives
Fear of negative consequences	Reflective Motivation	Incentives

Step 4: Implementation Strategy Selection using the Behaviour Change Wheel

The next step in developing the intervention strategy is to consider what policy options
would support the long-term implementation of the intervention functions identified in the
previous step.

Not all intervention designers have or need access to policy levers (depending on the be-
havioural problem at hand), so this can be considered an optional 'extra' step. However, it
is important to consider, especially when designing an intervention that is likely to depend
upon some level of policy influence.

In synthesising the 19 frameworks, seven policy options were identified, representing types
of decisions made by authorities that help to support and enact the interventions: 'Commu-
nication/marketing' (using print, electronic, telephonic or broadcast media); 'guidelines'
(creating documents that recommend or mandate practice, this includes all changes to ser-
vice provision); 'fiscal' (using the tax system to reduce or increase the financial cost); 'regu-
lation' (establishing rules or principles of behaviour or practice); 'legislation' (making or
changing laws); 'environmental/social planning' (designing and/or controlling the physical
or social environment); 'service provision' (delivering a service) (definitions and examples
are given in Table 8).

Table 8: Definitions and examples of policy categories

Policy category	Definition	Example
Communication/ marketing	Using print, electronic, telephonic or broadcast media	Conducting mass media campaigns

Policy category	Definition	Example
Guidelines	Creating documents that recommend or mandate practice. This includes all changes to service provision	Producing and disseminating treatment protocols
Fiscal measures	Using the tax system to reduce or increase the financial cost	Increasing duty or increasing anti-smuggling activities
Regulation	Establishing rules or principles of behaviour or practice	Establishing voluntary agreements on advertising
Legislation	Making or changing laws	Prohibiting sale or use
Environmental/social planning	Designing and/or controlling the physical or social environment	Using town planning
Service provision	Delivering a service	Establishing support services in workplaces, communities etc.

As per the intervention functions, the BCW suggests which policy options are likely to be appropriate and effective in supporting each intervention function (Table 9).

Table 9: Links between intervention functions and policy categories, identified through expert consensus

Intervention function	Policy categories that could deliver intervention functions
Education	Communication/marketing Guidelines Regulation Legislation Service provision
Persuasion	Communication/marketing Guidelines Regulation Legislation Service provision
Incentivisation	Communication/marketing Guidelines Fiscal measures Regulation Legislation Service provision
Coercion	Communication/marketing Guidelines Fiscal measures Regulation Legislation Service provision
Training	Guidelines Fiscal measures Regulation Legislation Service provision
Restriction	Guidelines Regulation Legislation

Intervention function	Policy categories that could deliver intervention functions
Environmental restructuring	Guidelines Fiscal measures Regulation Legislation Environmental/social planning
Modelling	Communication/marketing Service provision
Enablement	Guidelines Fiscal measures Regulation Legislation Environmental/social planning Service provision

Having identified the potential policy options to use, they can be considered using the APEASE criteria introduced in the previous step and presented in Table 6.

<u>End to End Example</u>

The research team were not primarily concerned with changing policy in this study and therefore did not undertake this step in detail. They simply listed the options that may be relevant to levering the intervention in the future. The broad policy options, signposted by the BCW matrices as being potentially useful for achieving behavioural change, were communication/marketing, service provision policy, legislation, guidelines and regulation.

Step 5: Selection of Specific Behaviour Change Techniques (BCTs) using the Behaviour Change Technique Taxonomy (BCTTv1)

This step is concerned with identifying which BCTs can deliver the identified intervention functions under the relevant policy options. Having selected broad intervention functions it is important to identify precisely how they will be achieved (i.e. how will education, training, enablement etc. be enacted?). Intervention functions are made up of smaller component BCTs (defined as "an active component of an intervention designed to change behaviour"). The defining characteristics of a BCT are that it is an observable, replicable, and irreducible component of an intervention designed to change behaviour and a postulated active ingredient within the intervention. It is thus the smallest component compatible with retaining the postulated active ingredients, i.e. the proposed mechanisms of change, and can be used alone or in combination with other BCTs (Michie et al., 2013). Examples of BCTs include, "feedback on behaviour", "demonstration of the behaviour", "adding objects to the environment" and "instruction on how to perform the behaviour".

Despite guidelines that advocate for detailed reporting of interventions (e.g. the Consolidated Standards of Reporting Trials (CONSORT) guidelines (Boutron et al., 2008)), systematic reviews show that they are often not reported in full, focusing on parameters of delivery such as who, when and how often as opposed to what (i.e. the specific content of the intervention). This is problematic as it precludes effective interpretation, replication and implementation at scale. Taxonomies of BCTs (defined as extensive hierarchical classifications of clearly labelled, well-defined BCTs with a consensus that they are proposed active

components of behaviour change interventions, that they are distinct (non-overlapping and non-redundant) and precise, and that they can be used with confidence to describe interventions) have been developed to provide a common language for improving reporting.

The first behaviour change taxonomy included 28 BCTs and was developed by Abraham and Michie (Abraham and Michie, 2008). Since then BCTs have been identified in relation to particular types of behaviour such as physical activity, healthy eating, condom use, smoking, excessive alcohol use, professional practice and medication adherence (Leeman et al., 2007, Abraham and Michie, 2008, Michie et al., 2011a, West et al., 2010, Michie et al., 2011b, Michie et al., 2012, Morrissey et al., 2016, Albarracín et al., 2005, Garnett et al., 2018). These behaviour-specific 'taxonomies' of BCTs have been synthesised and refined in an internationally supported piece of work to produce BCT Taxonomy v1, with 93 BCTs. Because 93 items are too many to keep in mind, they were organised into 16 groupings by experts using a 'card sort' technique (Michie et al., 2013) (see www.ucl.ac.uk/health-psychology/BCTtaxonomy/). The BCT labels within their groupings are shown below in Table 10.

Table 10: BCT labels within their groupings

Grouping and BCTs	Grouping and BCTs	Grouping and BCTs
1. Goals and planning	6. Comparison of behaviour	12. Antecedents
1.1. Goal setting (behaviour) 1.2. Problem solving 1.3. Goal setting (outcome) 1.4. Action planning 1.5. Review behaviour goal(s) 1.6. Discrepancy between current behaviour and goal 1.7. Review outcome goal(s) 1.8. Behavioural contract 1.9. Commitment	6.1. Demonstration of the behaviour 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 behaviour 12.4. Distraction 12.5. Adding objects to the environment 12.6. Body changes
	7. Associations	
	7.1. Prompts/cues 7.2. Cue signalling reward 7.3. Reduce prompts/cues 7.4. Remove access to the reward 7.5. Remove aversive stimulus 7.6. Satiation 7.7. Exposure 7.8. Associative learning	
2. Feedback and monitoring		13. Identity
2.1. Monitoring of behaviour by others without feedback 2.2. Feedback on behaviour 2.3. Self-monitoring of behaviour 2.4. Self-monitoring of outcome(s) of behaviour 2.5. Monitoring of outcome(s) of behaviour without feedback 2.6. Biofeedback 2.7. Feedback on outcome(s) of behaviour		13.1. Identification of self as role model 13.2. Framing/reframing 13.3. Incompatible beliefs 13.4. Valued self-identify 13.5. Identity associated with changed behaviour
	8. Repetition and substitution	
	8.1. Behavioural practice/rehearsal 8.2. Behaviour substitution 8.3. Habit formation 8.4. Habit reversal 8.5. Overcorrection 8.6. Generalisation of target behaviour 8.7. Graded tasks	14. Scheduled consequences
		14.1. Behaviour cost 14.2. Punishment 14.3. Remove reward 14.4. Reward approximation 14.5. Rewarding completion 14.6. Situation-specific reward 14.7. Reward incompatible behaviour 14.8. Reward alternative behaviour
3. Social support		
3.1. Social support (unspecified) 3.2. Social support (practical) 3.3. Social support (emotional)	9. Comparison of outcomes	
	9.1. Credible source 9.2. Pros and cons 9.3. Comparative imagining of	

Grouping and BCTs	Grouping and BCTs	Grouping and BCTs
4. Shaping knowledge	future outcomes	14.9. Reduce reward frequency
4.1. Instruction on how to perform the behaviour		14.10. Remove punishment
4.2. Information about Antecedents	10. Reward and threat	15. Self-belief
4.3. Re-attribution	10.1. Material incentive (behaviour)	15.1. Verbal persuasion about capability
4.4. Behavioural experiments	10.2. Material reward (behaviour)	15.2. Mental rehearsal of successful
	10.3. Non-specific reward	performance
5. Natural consequences	10.4. Social reward	15.3. Focus on past success
5.1. Information about health consequences	10.5. Social incentive	15.4. Self-talk
5.2. Salience of consequences	10.6. Non-specific incentive	
5.3. Information about social and environmental consequences	10.7. Self-incentive	16. Covert learning
5.4. Monitoring of emotional consequences	10.8. Incentive (outcome)	16.1. Imaginary punishment
5.5. Anticipated regret	10.9. Self-reward	16.2. Imaginary reward
5.6. Information about emotional consequences	10.10. Reward (outcome)	16.3. Vicarious consequences
	10.11. Future punishment	
	11. Regulation	
	11.1. Pharmacological support	
	11.2. Reduce negative emotions	
	11.3. Conserving mental resources	
	11.4. Paradoxical instructions	

The BCTTv1 serves two purposes. Firstly, it can be used to guide intervention development. BCTs appropriate for each intervention function, as judged by a consensus of four experts in behaviour change, are shown in Table 11. For example, education includes the BCTs "information about social and environmental consequences" and "self-monitoring of behaviour" and persuasion includes the BCTs "credible source" and "identity associated with changed behaviour".

The first step when selecting BCTs is to consider all the BCTs that could be considered for a particular intervention function. When considering BCTs, it is essential to be guided by the definition not by the label. The next step is to narrow the 'long list' of BCTs down to ones that are most likely to be appropriate for the situation in which you are intervening. In addition to considering the APEASE criteria (Table 6), another way of narrowing down the list is to first consider BCTs used most frequently before considering less frequently used BCTs. These are also shown in bold in Table 11.

Table 11: Links between intervention functions and BCTs, identified through expert consensus

Intervention function	Individual BCTs

Education	**Most frequently used BCTs:**
	    Information about social and environmental consequences
	    Information about health consequences
	    Feedback on behaviour
	    Feedback on outcome(s) of the behaviour
	    Prompts/cues
	    Self-monitoring of behaviour
	
	Less frequently used BCTs:
	    Biofeedback
	    Self-monitoring of outcome of behaviour
	    Cue signalling reward
	    Satiation
	    Information about antecedents
	    Re-attribution
	    Behavioural experiments
	    Information about emotional consequences
	    Information about others' approval

Persuasion	**Most frequently used BCTs:**
	    Credible source
	    Information about social and environmental consequences
	    Information about health consequences
	    Feedback on behaviour
	    Feedback on outcome(s) of the behaviour
	
	Less frequently used BCTs:
	    Biofeedback
	    Re-attribution
	    Focus on past success
	    Verbal persuasion about capability
	    Framing/reframing
	    Identity associated with changed behaviour
	    Identification of self as role model
	    Information about emotional consequences
	    Salience of consequences
	    Information about others' approval
	    Social comparison

Incentivisa-tion	**Most frequently used BCTs:**
	    Feedback on behaviour
	    Feedback on outcome(s) of behaviour
	    Monitoring of behaviour by others without evidence of feedback
	    Monitoring outcome of behaviour by others without evidence of feedback
	    Self-monitoring of behaviour
	
	Less frequently used BCTs:
	    Paradoxical instructions
	    Biofeedback
	    Self-monitoring of outcome of behaviour
	    Cue signalling reward
	    Remove aversive stimulus
	    Reward approximation

Intervention function	Individual BCTs
	Rewarding completion Situation-specify reward Reward incompatible behaviour Reduce reward frequency Reward alternate behaviour Remove punishment Social reward Material reward Material reward (outcome) Self-reward Non-specific reward Incentive Behavioural contract Commitment Discrepancy between current behaviour and goal Imaginary reward

Coercion	**Most frequently used BCTs:**
	   Feedback on behaviour
	   Feedback on outcome(s) of behaviour
	   Monitoring of behaviour by others without evidence of feedback
	   Monitoring outcome of behaviour by others without evidence of feedback
	   Self-monitoring of behaviour
	
	Less frequently used BCTs:
	   Biofeedback
	   Self-monitoring of outcome of behaviour
	   Remove access to the reward
	   Punishment
	   Behaviour cost
	   Remove reward
	   Future punishment
	   Behavioural contract
	   Commitment
	   Discrepancy between current behaviour and goal
	   Incompatible beliefs
	   Anticipated regret
	   Imaginary punishment

Training	**Most frequently used BCTs:**
	   Demonstration of the behaviour
	   Instruction on how to perform a behaviour
	   Feedback on the behaviour
	   Feedback on outcome(s) of behaviour
	   Self-monitoring of behaviour
	   Behavioural practice/rehearsal
	
	Less frequently used BCTs:
	   Biofeedback
	   Self-monitoring of outcome of behaviour
	   Habit formation
	   Habit reversal
	   Graded tasks
	   Behavioural experiments

Intervention function	Individual BCTs

	Mental rehearsal of successful performance
	    Self-talk
	    Self-reward

Restriction	No BCTs in BCTTv1 are linked to this intervention function because they are focused on changing the way that people think, feel and react rather than the way the external environment limits their behaviour.

Environmental restructuring	**Most frequently used BCTs:**
	    Adding objects to the environment
	    Prompts/cues
	    Restructuring the physical environment
	
	Less frequently used BCTs:
	    Cue signalling reward
	    Remove access to the reward
	    Remove aversive stimulus
	    Satiation
	    Exposure
	    Associative learning
	    Reduce prompt/cue
	    Restructuring the social environment

Modelling	**Most frequently used BCTs:** **Demonstration of the behaviour**

Enablement	**Most frequently used BCTs:**
	    Social support (unspecified)
	    Social support (practical)
	    Goal setting (behaviour)
	    Goal setting (outcome)
	    Adding objects to the environment
	    Problem solving
	    Action planning
	    Self-monitoring of behaviour
	    Restructuring the physical environment
	    Review behaviour goal(s)
	    Review outcome goal(s)
	
	Less frequently used BCTs:
	    Social support (emotional)
	    Reduce negative emotions
	    Conserve mental resources
	    Pharmacological support
	    Self-monitoring of outcome of behaviour
	    Behaviour substitution
	    Overcorrection
	    Generalisation of a target behaviour
	    Graded tasks
	    Avoidance/reducing exposure to cues for the behaviour
	    Restructuring the social environment
	    Distraction

Intervention function	Individual BCTs
	Body changes
	Behavioural experiments
	Mental rehearsal of successful performance
	Focus on past success
	Self-talk
	Verbal persuasion about capability
	Self-reward
	Behavioural contract
	Commitment
	Discrepancy between current behaviour and goal
	Pros and cons
	Comparative imagining of future outcomes
	Valued self-identity
	Framing/reframing
	Incompatible beliefs
	Identity associated with changed behaviour
	Identification of self as role model
	Salience of consequences
	Monitoring of emotional consequences
	Anticipated regret
	Imaginary punishment
	Imaginary reward
	Vicarious consequences

Some intervention designers proceed directly from understanding the behaviour using the TDF to selecting BCTs for the intervention (see (French et al., 2012) for an example of this process). This process has been guided by a matrix of domains and BCTs developed using the 2005 version of the TDF and a preliminary list of BCTs (Michie et al., 2008). More recent work drawing on an expert consensus exercise using the 2012 update and BCTs has linked 12 of the domains to 59 BCTs from BCT Taxonomy v1. For those wishing to use this approach, this linking is shown in Table 12 (Cane et al., 2015).

Table 12: Links between TDF domains and BCTs

TDF domain	BCT
Knowledge	Health consequences
	Biofeedback
	Antecedents
	Feedback on behaviour
Skills	Graded tasks
	Behavioural rehearsal / practice
	Habit reversal
	Body changes
	Habit formation

TDF domain	BCT
Professional Role and Identity	*No BCTs are linked to this domain*
Beliefs about Capabilities	Verbal persuasion to boost self-efficacy
	Focus on past Success
Optimism	Verbal persuasion to boost self-efficacy
Beliefs about Consequences	Emotional consequences
	Salience of consequences
	Covert sensitisation
	Anticipated regret
	Social and environmental consequences
	Comparative imagining of future outcomes
	Vicarious reinforcement
	Threat
	Pros and cons
	Covert conditioning
Reinforcement	Threat
	Self-reward
	Differential reinforcement
	Incentive
	Thinning
	Negative reinforcement
	Shaping
	Counter conditioning
	Discrimination training
	Material reward
	Social reward
	Non-specific reward
	Response cost
	Anticipation of future rewards or removal of punishment
	Punishment
	Extinction
	Classical conditioning
Intentions	Commitment
	Behavioural contract
Goals	Goal setting (outcome)
	Goal setting (behaviour)
	Review of outcome goal(s)
	Review behaviour goals

TDF domain	BCT
	Action planning (including implementation intentions)
Memory, Attention and Decision Processes	*No BCTs are linked to this domain*
Environmental Context and Resources	Restructuring the physical environment
	Discriminative (learned) cue
	Prompts / cues
	Restructuring the social environment
	Avoidance / changing exposure to cues for the behaviour
Social Influences	Social comparison
	Social support or encouragement (general)
	Information about others' approval
	Social support (emotional)
	Social support (practical)
	Vicarious reinforcement
	Restructuring the social environment
	Modelling or demonstrating the behaviour
	Identification of self as role model
	Social reward
Emotion	Reduce negative emotions
	Emotional consequences
	Self-assessment of affective consequences
	Social support (emotional)
Behavioural Regulation	Self-monitoring of behaviour

The recently developed Theory and Techniques Tool (https://theoryandtechniquetool.humanbehaviourchange.org/) is an interactive resource providing information about links between BCTs and their mechanisms of action. This information is based on MRC-funded research triangulating evidence of links made by authors in published scientific studies and by expert consensus. It was developed to sup-port intervention designers, researchers and theorists in the development and evaluation of theory-based interventions.

As previously mentioned, the taxonomy can also be used to identify active ingredients of existing interventions by coding intervention descriptions and synthesising across studies. This further supports the unpacking of the 'black box' of complex interventions to identify active ingredients.

<u>End to End Example</u>

The research team used the links previously drawn between the BCW and the BCTTv1 to list those techniques most frequently used with the selected intervention functions. They

held an expert panel consensus meeting to review the suitability of each of these techniques, in the light of the previously collected qualitative data, the context of the intervention and by referring to the APEASE criteria. Each member of the panel had expertise in one or more areas of relevance (clinical pharmacology and prescribing, general practice, behavioural science and intervention design and multimorbidity).

The five techniques eventually selected as 'active ingredients' were social support (practical), restructuring the social environment, use of prompts/cues, action planning and self-incentives. The combination and integration of each technique resulted in the overall intervention, named MultimorbiditY COllaborative Medication Review And DEcision Making (MY COMRADE). Table 13 below illustrates how the barriers identified relate to COM-B components, intervention functions, BCTs and their operationalisation in the final implementation intervention.

Table 13: Relationships between barriers identified, COM-B components, selected intervention functions, selected BCTs and examples of operationalisation in the final intervention extracted from Sinnott et al (Sinnott et al., 2015b)

Barrier identified	COM-B component	Intervention function	BCT	Operationalisation
Uncertainly about what medications were most valuable	Psychological Capability	Enablement	Social support (practical)	Two GPs support each other to review medication.
Perceptions that social norms make patients unwilling to stop long-term medications	Social Opportunity	Enablement	Social support (practical)	Two GPs support each other to review medication.
Lack of time to properly review medication	Physical Opportunity	Environmental Restructuring	Restructuring social environment Action planning	Planning and agreeing on protected time for the two GPs to come together to conduct the review.
An instinct not to 'rock the boat'	Automatic Motivation	Environmental Restructuring Enablement	Prompts/cues	List of generic prompts to cue the medication reviews.
Opportunity cost of using time to conduct medication reviews	Reflective Motivation	Incentives	Self-incentives	Professional development points awarded to GPs for conducting the reviews.
Fear of negative consequences	Reflective Motivation	Incentives	Self-incentives	Professional development points awarded to GPs for conducting the reviews.

Applications to Implementation Science

Implementing new practices and/or changing existing practices in organisations, services and systems require changes in individual (e.g. health care professional) and collective (e.g.

clinical team) human behaviour. Therefore, the BCW approach is of great relevance to implementation research. The end-to-end example used throughout the previous sections has already provided one illustration of how the BCW approach can be used in its entirety to support an implementation research study. However, the selection and sequencing of these activities will depend on the context and goals of the specific project and key stakeholders. For example, in some cases it may be possible to start with a blank slate and be willing to contemplate any of the implementation options, whereas in others the need may be to update or refine an existing intervention strategy. In many cases it will generally be necessary to cycle back and forth among the steps and related activities, refining and improving the proposed intervention strategy. Constraints on the development process (i.e. budget, timescale, human resources) will also determine how much time and effort can be spent on various aspects of the process. Sometimes intervention development has to take place within a few days or weeks while on other occasions a more thorough development process is possible.

The implementation research literature contains multiple examples of how the BCW approach has been applied in different ways for different purposes. Below we report on ways in which the various tools have predominantly been used, with accompanying examples to illustrate objectives, methods and high-level outcomes where relevant. Further detail on specific implementation findings can be found in the associated references.

One key way in which the BCW approach has been used in implementation research is to explore implementation problems using COM-B or the TDF. In other words, behavioural diagnoses have been conducted to identify barriers and facilitators to implementing specific evidence-based behaviours. Precisely selecting and specifying the target behaviour is particularly important for implementation behaviours, which are often complex, involving multiple actions across different time points in the healthcare pathway/care continuum and requiring interprofessional effort across different clinical and managerial roles.

Both COM-B and the TDF have been applied to conduct behavioural diagnoses of 'what needs to change' for numerous clinical behaviours (Francis et al., 2012). Commonly used methods for these purposes are semi-structured interviews, focus groups and surveys. Both COM-B and the TDF can be used to inform data collection (e.g. interview or survey questions designed to elicit information on individual components/domains) and analysis (e.g. deductive qualitative coding or statistical analysis guided by the theoretical frameworks). The TDF tends to be the tool of choice when the focus is on understanding an implementation problem in depth, as opposed to conducting a behavioural diagnosis as the starting point for intervention design using the BCW.

A detailed guide to using the TDF to investigate implementation problems, with an emphasis on qualitative methods, has recently been published (Atkins et al., 2017). Examples of interview studies that have used the TDF to explore implementation problems include investigating facilitators and barriers to offering a family intervention to families of people with schizophrenia (Michie et al., 2007), transfusing with red blood cells (Francis et al., 2009), discussing human papillomavirus (HPV) vaccination with patients (McSherry et al., 2012), effectively managing perioperative temperature (Boet et al., 2017), error-free prescribing (Duncan et al., 2012), managing acute low back pain without ordering an X-ray (Bussières et al., 2012), dementia diagnosis and management (Murphy et al., 2014), mild

traumatic brain injury management (Tavender et al., 2014) and paediatric asthma management in primary care settings (Yamada et al., 2018).

The TDF has also been used in questionnaire studies to investigate implementation problems. There are three published validated questionnaire measures of the TDF to identify influences on the following behaviours: health care professionals' patient safety behaviours (Taylor et al., 2013b), physical activity in the general population (Taylor et al., 2013a) and generic health professional behaviours (Huijg et al., 2014a, Huijg et al., 2014b). Huijg et al (Huijg et al., 2014a) developed a generic questionnaire in English and in Dutch assessing the 14 domains of behavioral influences from the TDF that can be tailored to suit different targets, actions, contexts, and times of interest. The questionnaire was shown to be able to discriminately assess the majority of TDF domains (Huijg et al., 2014b). Other examples of questionnaire studies include investigating facilitators and barriers to hand hygiene (Dyson et al., 2011), providing tobacco use prevention and cessation counselling among dental providers (Amemori et al., 2011) and midwives engaging with pregnant women to stop smoking (Beenstock et al., 2012). The TDF is also potentially applicable to other research designs for which methods can be further developed, e.g. structured observations, documentary analysis, case study designs.

In many cases, the BCW approach has been used to design implementation interventions from start to end. This involves following all steps in the process (as outlined previously) and using established tables, matrices and evidence from the literature to guide decisions based on behavioural diagnosis and application of the APEASE criteria. The aforementioned ISLAGIATT ('It Seemed Like A Good Idea At The Time') principle is an important problem for implementation science specifically as it results in the waste of valuable implementation resources and efforts, and precludes replication, scaling up, learning from success and/or failure of individual interventions and cumulative learning via evidence synthesis. There is evidence to suggest that implementation interventions often lack a clear and systematic rationale for their selection of intervention strategy. For example, Colquhoun et al (Colquhoun et al., 2013) conducted a systematic review of the use of theory in randomised controlled trials of audit and feedback interventions and found that only 14% of 140 included studies reported the use of theory in any aspect of the study design, measurement, implementation or interpretation.

The end-to-end break down provided in the previous description of the BCW approach is one example of this (Sinnott et al., 2015b). Further examples include supporting GPs, physiotherapist and chiropractors to manage acute low back pain (McKenzie et al., 2010); emergency department staff management of mild traumatic brain injury (Tavender et al., 2015); hospital clinician adherence to national guidelines on the management of suspected viral encephalitis (Backman et al., 2015); implementation of guidelines to promote safe use of nasogastric tubes (Taylor et al., 2014); implementation of international sexual counselling guidelines in hospital cardiac rehabilitation (Mc Sharry et al., 2016); and health provider smoking cessation care for Australian Indigenous pregnant women (Gould et al., 2017).

Although behavioural and social science theories, methods and frameworks have primarily been applied in such a 'bottom-up' approach to designing interventions, they also have value in refining existing implementation interventions. Indeed, a common scenario in implementation research is not that of 'starting from scratch' to design new interventions, but rather of having existing interventions that have already been implemented in practice, yet

have achieved only modest or inconsistent success, and may thus benefit from refinement (Lorencatto et al., 2018). The BCW approach can be used to support this process.

A pre-requisite for identifying potential refinements is fully specifying the current intervention and the BCTs it incorporates. For example, Steinmo et al (Steinmo et al., 2015a) aimed to improve a multicomponent intervention to increase the implementation of a sepsis care bundle that had been implemented with moderate success within three pilot wards of a UK hospital. To specify the existing intervention, the research team observed the intervention being delivered and conducted a content analysis of the intervention materials, applying the BCW and BCT taxonomy to characterize the intervention in terms of both intervention functions and techniques. They found 19 behaviour change techniques (e.g. prompts/cues, instruction on how to perform the behaviour) and seven intervention functions (e.g. education, enablement and training). They then used the TDF to conduct interviews with intervention designers, providers and recipients to characterize the intervention's potential theoretical mechanisms of action and barriers/enablers to its implementation. On the basis of their findings, they were able to propose a number of theory based modifications to the intervention package, including changes to the existing staff education programme to address fears about harming patients (e.g. with intravenous fluid) (i.e. behaviour change technique: 'information about health consequences') and provision of sepsis equipment bags to night coordinators, who previously reported lack of access to the necessary equipment as a key barrier (i.e. behaviour change technique: 'adding objects to the environment')(Steinmo et al., 2015b).

Monitoring and evaluation of the performance of implementation interventions will usually be necessary because of the complexity of human behaviour and ever-changing contexts. There are many ways of doing this to suit different budgets and contexts. Primarily, evaluations take the form of outcome evaluations that aim to answer whether or not interventions 'work'. However, it is also extremely important to look at 'how' interventions work. This is particularly important in the field of implementation science where it may be necessary and/or desirable to inform the implementation of interventions in new settings or on a bigger scale, and to inform their refinement.

Process evaluations are increasingly used in parallel with outcome evaluations to investigate the mechanisms through which interventions have their effect. Whilst outcome evaluations can tell us whether interventions 'work' (or not) they cannot tell us why or how they 'work' (or not). For example, whether or not the intervention was implemented as intended, if there were deviations or adaptations and what the level of response and engagement from participants was. This poses challenges in terms of scalability, replicability in new or similar contexts and the general ability to explain and understand successes or failures. A process evaluation is defined as "a study aiming to understand the functioning of an intervention by examining fidelity and quality of implementation, clarifying causal mechanisms and identifying contextual factors associated with variation in outcomes" (Craig et al., 2008).

The MRC have now developed a new integrative framework that builds on the process evaluation themes described in the 2008 MRC complex interventions guidance (Moore et al., 2015). The framework identifies three core components of a process evaluation. These are context (how does context affect implementation and outcomes), implementation (what is implemented and how?) and mechanisms of impact (how does the delivered inter-

vention produce change?). A recently published systematic review demonstrated that although implementation researchers are increasingly recognising the importance of using theory to develop interventions, there remains a need to circle back and use such theories to process evaluate interventions too (McIntyre et al., 2018). Using theory in this way offers a valuable opportunity to test it in applied settings and can be used to inform refinement of both theory and interventions.

The BCW approach has been used to support different components of process evaluation of implementation interventions. The examples that we include below focus on fidelity (as a component of implementation) and mechanisms of impact.

Lorencatto et al (Lorencatto et al., 2013) assessed fidelity of delivery in two English Stop-Smoking Services; and compared the extent of fidelity according to session types, duration, individual practitioners, and component behaviour change techniques (BCTs). Treatment manuals and transcripts of 34 audio-recorded behavioural support sessions were obtained from two Stop-Smoking Services and coded into component BCTs using a smoking cessation taxonomy of 43 BCTs (Michie et al., 2011b). Fidelity was assessed by examining the proportion of BCTs specified in the manuals (i.e. intended practice) that were delivered in individual sessions (i.e. implemented). This was assessed by session type (i.e., pre-quit, quit, post-quit), duration, individual practitioner, and BCT. They found that on average, 66% of manual-specified BCTs were delivered per session (SD 15.3, range: 35% to 90%).

Curran et al (Curran et al., 2013) used the TDF to qualitatively explore mechanisms of impact in the Canadian CT Head Rule trials among emergency physicians. Eight physicians from four of the intervention sites in the Canadian CT Head Rule trial participated in the interviews which were based upon the TDF. Barriers likely to assist with understanding physicians' responses to the intervention in the trial were identified in six of the theoretical domains: beliefs about consequences; beliefs about capabilities; behavioural regulation; memory, attention and decision processes; environmental context and resources; and social influences.

The BCW approach can also provide a useful framework for synthesising implementation research. Depending on the purpose of the evidence synthesis, different tools from the BCW system can be adopted. For example, Presseau et al (Presseau et al., 2015) applied the BCTTv1 to trials of implementation interventions for managing diabetes to assess the capacity and utility of this taxonomy for characterising active ingredients. They concluded that the identification of BCTs may provide a more helpful means of accumulating knowledge on the content used in trials of implementation interventions, which may help to better inform replication efforts. In addition, prospective use of a BCT taxonomy for developing and reporting intervention content would further aid in building a cumulative science of effective implementation interventions. Evidence of poor reporting is an issue in implementation research and is often highlighted as a core limitation of systematic reviews of implementation interventions (e.g. (Brouwers et al., 2011, Gardner et al., 2010, Ivers et al., 2012, Colquhoun et al., 2013)). The BCT taxonomy can be used in systematic reviews to disentangle the effects of interventions. It is often a finding of systematic reviews of implementation interventions that overall they work with modest worthwhile effects. However, there is often wide, unexplained variability and the use of BCTs and intervention functions in evidence synthesis can help to unpack this and inform the refinement of interventions going forwards.

The TDF also has the potential to inform systematic reviews by synthesising influences on specific implementation behaviours across studies according to theoretical. Graham-Rowe et al (Graham-Rowe et al., 2016, Lawrenson et al., 2018) used the TDF to synthesize studies reporting modifiable barriers/enablers associated with retinopathy screening attendance in people with Type 1 or Type 2 diabetes. Sixty-nine primary studies were included. They identified six theoretical domains ['environmental context and resources' (75% of included studies), 'social influences' (51%), 'knowledge' (51%), 'memory, attention, decision processes' (50%), 'beliefs about consequences' (38%) and 'emotions' (33%)] as the key mediators of diabetic retinopathy screening attendance. Heslehurst et al (Heslehurst et al., 2014) used a similar approach to synthesise the barriers and facilitators to healthcare professionals' maternal obesity and weight management practice (also using the TDF). The domains most frequently identified included 'knowledge', 'beliefs about consequences' and 'environmental context and resources'. Craig et al (Craig et al., 2016) used a similar approach to synthesise the barriers and enablers for a triage, treatment, and transfer clinical intervention to manage acute stroke patients in the emergency department. Five qualitative studies and four surveys out of the 44 studies identified met the selection criteria. The majority of barriers reported corresponded with the TDF domains of "environmental, context and resources" (such as stressful working conditions or lack of resources) and "knowledge" (such as lack of guideline awareness or familiarity). The majority of enablers corresponded with the domains of "knowledge" (such as education for physicians on the calculated risk of haemorrhage following intravenous thrombolysis [tPA]) and "skills" (such as providing opportunity to treat stroke cases of varying complexity). The BCT that best aligned to the strategy each enabler represented was then selected for each of the reported enablers.

As with all research, the appropriate study design depends on the research question and the state of current knowledge in the given field. For example, qualitative interviews may be more useful when little is known about an implementation problem. This study design allows researchers to explore in greater detail providing richer data which can be helpful when developing theory-informed interventions (i.e. they may provide better insight into the needed content). They are also likely to be useful for understanding the mechanisms of action in interventions. Survey studies may be more appropriate when a greater amount is known about the problem and potentially relevant influencing factors, but the aim is to identify those factors in a more representative sample. This design is also useful for exploring mechanisms of action of interventions quantitatively (i.e. through mediation analyses). Structured observation and approaches such as documentary analysis may be useful to supplement interview/survey studies, but they are unlikely to be sufficiently comprehensive for capturing all influences on a behaviour (for example cognitions are not observable or documented).

The validity of findings are likely to be improved through the integration or 'triangulation' of data (Munafò et al., 2017). Triangulation can be defined as the considered use of multiple methodological approaches to address one research question. A number of triangulation techniques are available to researchers, and integration can be carried out at the analysis and/or interpretation stages (for an overview of methods, see (O'Cathain et al., 2010)). If possible, therefore, implementation researchers should collect data using a variety of methods, including interviews and focus groups, questionnaires, direct observation, review of relevant local documents such as service protocols and expert opinion. If a consistent

picture of a behaviour and the factors influencing it is obtained from more than one source and using more than one method, it increases confidence in the analysis.

When collecting information to understand an implementation problem, data should be collected from as many relevant sources as possible as the most accurate picture will be informed by multiple perspectives. In a healthcare setting this might be frontline staff who perform the target behaviour, managers, patients, or other key 'stakeholders'. It is well established that often we have poor insight into why we behave as we do (Nisbett and Wilson, 1977). However, the nature of the behaviour may constrain the method of data collection; for example, observation is obviously unlikely to be feasible if the behaviour occurs infrequently or privately as occurs behind screens in hospital wards. The project conducted by Steinmo et al (Steinmo et al., 2015a, Steinmo et al., 2015b), and described previously, provides a methodological example of triangulation.

Concluding Remarks

The behavioural and social sciences offer a host of frameworks and methods that can facilitate a systematic approach to intervention design based on a contextual understanding of the behaviour of interest. The BCW approach is one such set of interrelated tools that aim to guide systematic intervention development and cumulative learning. The tools are appropriate for end-to-end design of implementation interventions yet can also be used for more specific purposes such as exploring implementation problems in depth, refining existing interventions and evaluating fidelity and mechanisms of impact as part of a process evaluation. This chapter provides a number of examples of where and how these approaches have been used and for what purpose, as well as a thorough description of the tools. It also provides guidance on methodological decisions and high quality application, where appropriate. The greater efforts implementation researchers make to use theories and frameworks in implementation research (including the design and evaluation of interventions) and fully report on their interventions, the greater the learning that will be accumulated within the discipline.

In terms of future developments, many of these tools are syntheses of the available evidence at the time which means that by necessity, they will need to be updated as the evidence base expands. The Human Behaviour-Change Project (HBCP) is a collaboration between behavioural scientists, computer scientists and system architects which has set out to create an online 'Knowledge System' that uses Artificial Intelligence, in particular Natural Language Processing and Machine Learning, to extract information from intervention evaluation reports to answer key questions about the evidence (Michie et al., 2017). The Knowledge System will continually search publication databases to find behaviour change intervention evaluation reports, extract and synthesise the findings, provide up-to-date answers to questions, and draw inferences about behaviour change. Practitioners, policy makers and researchers will be able to query the system to obtain answers to variants of the key question: 'What intervention(s) work, compared with what, how well, with what exposure, with what behaviours, for how long, for whom, in what settings and why?'. A user-friendly guide to applying the BCW approach to design interventions for local and national government is currently being developed in collaboration with Public Health England. Experience has shown that policy makers need something that is more user friendly while covering the key ideas and steps. The guide should further support the embedding of behavioural science in practice.

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