Defining the Behavioural Design Space

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Behavioural Design is a critical means to address human behaviour challenges including health, safety, and sustainability. Practitioners and researchers face difficulties in synthesising relevant perspectives from across fields, as behavioural challenges are complex and multi-dimensional. This study takes a three step theory-building approach. First, we review behavioural theories and models primarily rooted in psychology, and discuss them in relation to design perspectives to identify parameters key to behavioural design. Next, we synthesise previously fragmented behavioural and design parameters and propose the Behavioural Design Space (BDS) framework, including: Cognition, Ability, Motivation, Timing, Social, and Physical Context. Last, as a demonstration of its use, we apply the BDS framework as lens on observed expert behavioural designer's ideation. Our findings are twofold. First, the synthesis of generic behavioural and design parameters allow us to investigate expert behavioural designer's ideation across five diverse cases. This illustrates the BDS' potential of providing relevant overview across diverse domains. Second, the expert behavioural designers observed often utilised the less abstract parameter, Physical Context, and favoured low variation of parameters within concepts. This point to a need for support to help designers discover potential pitfalls and blind spots, as well as further study of behavioural design ideation.

Keywords – Behavioural Design, Case Study, Design Space, Expert Designers, Framework, Ideation.

Relevance to Design Practice **–** The proposed Behavioural Design Space (BDS) framework allows designers and researchers to overview and evaluate behavioural design work. Applying the BDS as a lens on expert behavioural designer's ideation, the empirical results reveal two ideation patterns, high variation and low variation, for behavioural designers to be aware of.

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Introduction

Behavioural Design has emerged as an important means for encouraging desired behaviour in a number of areas. These for example include health, safety, and sustainability (Bhamra et al., 2011; Cash et al., 2017a; Catania et al., 1990; McDonald et al., 2002; Tromp & Hekkert, 2014, 2018). Behavioural design (also often referred to as Design for Behaviour Change) focuses on redirecting behavioural patterns by understanding current behaviour patterns, and designing interventions aiming at achieving desired behavioural effects (Khadilkar & Cash, 2020). As such, behavioural design builds on key insights from design, social science, and cognitive psychology (Niedderer et al., 2017). A number of (primarily behavioural) parameters have been used across theories and design domains. For example, people's motivation and ability have been used in persuasive technology in Fogg's (2009b) Behavioural Model, and cognition, timing and social context are key in Catania et al.'s (1990) Aids Risk Reduction Model. However, to date, no framework captures key parameters across both psychology (behaviour) and design domains. In behavioural design, working with multiple disciplines and application areas is key to achieve desired behavioural effects (Niedderer et al., 2017). As such, this lack of a crosscutting framework for understanding the behavioural design space is problematic. Thus, there is a need for a synthesised representation of the behavioural and design parameters defining the behavioural design space.

Prior research offers a number of important insights highlighting aspects of the behavioural design space. These range from lists of specific web-based interventions (Kelders et al., 2012), to approaches and processes (e.g., Cash et al., 2017a; Fogg, 2009b; Niedderer et al., 2017; Tromp & Hekkert, 2014), as well as broader implementation frameworks geared towards policy development (Michie et al., 2014a; Michie et al., 2014b). As such, the literature is very diverse, and two main perspectives become important. First, behavioural literature describes a fragmented and broadly scoped implementation. This spans from computer mediated interactions (Fogg, 2003; Gerber & Martin, 2012) to aspects of multi-dimensional policy development (Kelders et al., 2012; Kelly & Barker, 2016). Second, the behaviour and behaviour change literature has typically focused on various behavioural parameters independent of artefact-related design parameters used in understanding the embodiment of interventions themselves. For example, specific cognitive mechanisms, such as ability of the individual (e. g., Fogg, 2009a) or broader environmental and social interactions (Michie et al., 2014a) are little connected to design parameters, such as an intervention's embodiment in a product or system. Also, while there are multiple general theories and models of behavioural change, e.g., Morewedge and Kahneman's Two Systems (2010), these operate on different

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levels of detail (Niedderer et al., 2017), and are not concretely connected to major design parameters. This impedes efforts to develop effective interventions, where synthesising multiple parameters are essential (Cash et al., 2017b; Michie et al., 2014a). The absence of a crosscutting behaviour-design framework hinders navigation through the behavioural design space (Leifer & Steinert, 2011), and prevents connecting behavioural design insights to existing design process theory (Girard & Robin, 2006; Leifer & Steinert, 2011). Thus, there is an important theoretical and practical need for a common understanding of key parameters relevant to the behavioural design space.

This paper presents three initial steps of theory-building (Cash, 2018). First, we review behavioural theories and models, primarily rooted in psychology. These are discussed in relation to perspectives on design in order to identify parameters key to behavioural design. Second, based on these findings, we synthesise previously fragmented behavioural and design parameters to propose the Behavioural Design Space (BDS) framework (Figure 1). Third, as a demonstration of its use, we apply the BDS framework as lens on observed expert behavioural designer's ideation. Based on this, we establish a number of implications for design theory and practice, as well as avenues for further research.

Theory and Literature Review

The design of products, infrastructures, and social environments enable or inhibit behaviour (Norman, 1988; Tromp & Hekkert, 2018; Verbeek, 2005). Here, understanding and designing *human-artefact-interactions*, which are referred to as interventions in behavioural design, is key to achieving desired behavioural effects. The main difference between more traditional design approaches and behavioural design is the shift from focusing on designing (tangible/intangible) artefacts with the aim to satisfy needs, to designing interventions with the aim to affect behaviour (Cash et al., 2020; Khadilkar & Cash, 2020). Behavioural effects are achieved through interactions with (tangible/intangible) artefacts, however, the artefacts themselves play a secondary role, as desired behavioural effects can be achieved through various, different artefacts (Tromp et al., 2011). As a result, behavioural design is a cross-disciplinary field building on behavioural sciences and spanning research in psychology and design (Niedderer et al., 2017). It aims to ethically shape behavioural change through carefully designed interventions (Nielsen et al., 2018), bringing together individual and collective concerns to encourage desired behaviours and/or discourage undesired behaviours (Cash et al., 2017a; Tromp et al., 2011). As such, the overall scope of behavioural design is first focusing on understanding current underlying behavioural patterns, and then designing desired behavioural effects, realised through designed interventions (Khadilkar & Cash, 2020).

Literature Review

To understand behavioural patterns, researchers have introduced several theories and models of both behaviour and behaviour change (e.g., Bronfenbrenner, 1986; Chaiken & Trope, 2000; Petty & Cacioppo 1986), which hint at the potential design space available. However, these have not been connected to discussions in the design literature. Thus, in order to synthesise and connect behavioural and design parameters relevant to behavioural design in general we conduct an inductive, thematic, literature review in several rounds (Grant & Booth, 2009). Due to the primacy of behaviour in behavioural design, we took Michie et al.'s (2014b) compendium of 83 behaviour change theories as a starting point for the review. Branching out, the first author reviewed works in behaviour change and behavioural design connecting to this seminal repository of behaviour change theory. Together, this provided a starting point for an abductive process with three main iterations focusing on identifying overall groupings of parameters relevant both to behaviour change (Michie et al., 2014b) and design (Andreasen et al., 2015; Van Boeijen et al., 2014). In each iteration the first author carried out the initial organisation and grouping of parameters which was then discussed by the whole research team. As such, proposed parameters were distilled, reviewed, and refined until consensus was reached at each stage.

In the first iteration, collected theories and models of behaviour and behaviour change were initially coded inductively based on the emerging themes (initial parameters) to identify overall groupings. The first author assessed the behavioural theories and models collected one by one on initial parameters (themes) self-reported in the literature. Subsequent literature was then coded against these initial parameters, as well as assessed for additional ones, which were reviewed and added to the list. In the second iteration, the list of initial parameters was discussed, grouped, and named within the research team. Here, all theories and models where re-assessed according to the updated list of initial parameters. This enabled the identification of parameters related to major aspects of behaviour and behaviour change, which were then then contrasted to literature of both behavioural design and general perspectives of design in the third iteration. This was done

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in order to i) identify connections, such as the basic characteristics linking behaviour change techniques and interventions, and ii) identify contrasts, such as the specific areas highlighted in the behavioural literature but neglected in design and vice versa. This allowed us to iteratively refine the detailed traits of identified parameters and, where necessary, distinguish them from existing conceptualisations following the framework for theory building provided by Wacker (2008). Lastly, we synthesised our findings focusing on defining the parameters and their traits concretely with respect to existing work in behavioural design, in order to ensure both their conceptual coherence and practical relevance for this literature. Based on this process we identified six final parameters dealing with major factors relevant to both behaviour change and the design of interventions: Cognition, Ability, Motivation, Timing, Social, and Physical context.

Table 1 illustrates the generality of the six parameters and how they connect to existing work using a range of acknowledged theories/models of behaviour and behaviour change. Table 1 includes 24 theories/models, a short description of each, the main parameter(s) it relates to, and a primary reference. Figure 1 gives an overview of the literature review process. Cognition, Ability, Motivation, Timing, Social, and Physical Context are discussed in the following sections in order to illustrate their centrality as parameters crosscutting behaviour and design.

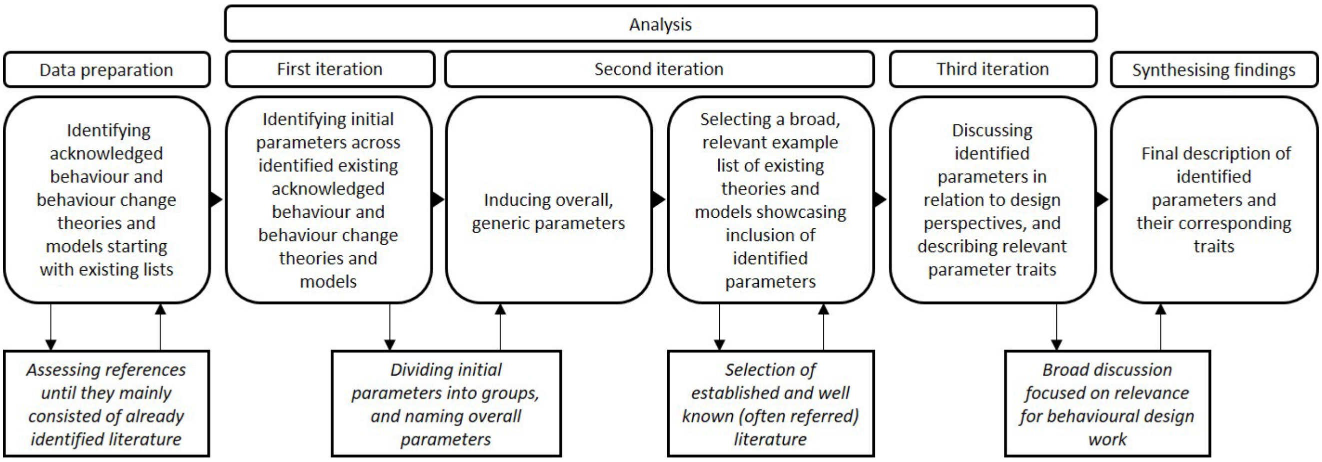

Figure 1. Overview of analysis–literature review.

Table 1. Theories and models of behaviour and behavioural change.

Theory/model & reference	Description	Parameters					
		Cognition	Ability	Motivation	Timing	Social context	Physical context
Theories and models of behaviour							
Theory of interpersonal behaviour (Triandis, 1977)	Behaviour is neither fully deliberative nor fully automatic; it is influenced by intentions and habits	■					
Dual-process theory (Chaiken & Trope, 2000)	Individuals process stimuli consciously (slow and explicit), none-consciously (fast and implicit)	■					
Two Systems (Morewedge & Kahneman, 2010)	People process stimuli by: system 1 (automatic, fast, implicit), system 2 (reflective, slow, explicit)	■					
Heuristics and biases (Tversky & Kahnemann, 1974)	People rely on a limited number of heuristic principles and biases reducing the complexity of assessing probabilities and predicting values	■					
Social identity theory (Tajfel & Turner, 1979)	A person's behaviour is influenced by different social personalities expressed in different groups					■	
Social ecological model (Bronfenbrenner, 1986)	Five levels of behavioural influence: individual, interpersonal, organizational, community, policy					■	
ABC model (Miltenberger, 2011)	All behaviour has an Antecedent triggering the Behaviour resulting in a Consequence				■		

Table 1. Theories and models of behaviour and behavioural change (continued)**.**

Theory/model & reference	Description	Parameters					
		Cognition	Ability	Motivation	Timing	Social context	Physical context
Theory of self-efficacy (Bandura, 1977)	Expectations of confidence in own abilities (self-efficacy) influence own performance	■	■				
Social cognitive theory (Bandura, 1989)	People self-regulate behaviour by exploratory personal experience and observational learning	■		■		■	
Social cognitive theory of self-regulation (Bandura, 1991)	Behaviour is extensively motivated and regulated by: self-monitoring, personal standards, environmental circumstances, affective self-reaction	■		■		■	
Self-determination theory (Ryan & Deci, 2000)	Behaviour can be motivated in three ways: amotivation, intrinsic, extrinsic motivation	■		■		■	
Theory of Planned Behaviour (Ajzen, 1991)	Behaviour can be explained by: attitudes, subjective norms, perceived behavioural control, intentions	■	■	■		■	
The COM-B model (Michie et al., 2014a)	Behaviour results from: interaction of physical/psychological Capabilities, social/environmental Opportunities, reflective/automatic Motivations	■	■	■		■	■
Theories and models of behavioural change							
Influence (Cialdini, 1984)	Persuasion can happen through six principles of influence: reciprocation, commitment and consistency, social proof, liking, authority, scarcity	■				■	
Elaboration likelihood model (Petty & Cacioppo, 1986)	Persuasion can happen via two routes: central route (high cognitive processing), peripheral route (low cognitive processing)	■					
Loughborough model (Lilley, 2009)	Decision making power is influenced by users or products through feedback, steering, or persuasion					■	■
Transtheoretical model (Prochaska & Velicer, 1997)	Change processes can be described through five stages: precontemplation, contemplation, preparation for action, action, maintenance				■		
Fogg's functional triad (Fogg, 2003)	Computers can persuade in three ways: as a tool increasing capabilities, as a medium providing experience, as a social actor creating relationships	■	■			■	■
Nudging (Thaler & Sunstein, 2009)	Behaviour can be changed by implementing small interventions exploiting automatic behaviour	■				■	■
Heuristic-Systematic model (Eagly & Chaiken, 1993)	People process persuasive messages: heuristically [low cognition (most likely)], systematically [high cognition (less likely)]	■				■	■
Aids Risk Reduction Model (Catania et al., 1990)	Behaviour change efforts are predictable through three stages: labelling, commitment, enactment	■			■	■	
Health belief model (Rosenstock, 1974)	Health related change can be predicted by a mix of individual perceptions and modifying factors	■				■	■
Habit loop (Duhigg, 2012)	Behaviour can be changed by interrupting the loop of: cue, routine, and reward	■			■	■	■
Fogg's Behaviour Model (Fogg, 2009a)	Behaviour results from three factors present at the same time: motivation, ability, triggers		■	■			■

Cognition

Design support (guidelines, tools, methods, etc.) rarely link explicitly to cognitive theory. Nevertheless, the link between cognition and people's reaction to interventions is evident (Cardoso et al., 2014; Solomon et al., 2012). Here, cognitive theory helps explain the underpinning mechanisms in design. Examples include Theory of scripts (Arkrich, 1992) and User eXperience (UX) design (Desmet & Hekkert, 2007; Tullis & Albert, 2013). The connection between people's cognition and interaction with artefacts is fundamental in behavioural design (Cash et al., 2017a). Petty and Cacioppo (1986) highlight how interventions can be focused on either a central cognitive route (high reflection level) or a peripheral cognitive route (low reflection level). This aligns with Morewedge and Kahneman's (2010) Two Systems, and Chaiken and Trope's (2000) Dual-process theory. This *dual-process cognition* has been discussed as foundation for behavioural approaches in a variety of fields. These include Persuasive Technology (Fogg, 2009b), Design for Sustainable Behaviour (Bhamra et al., 2011), and Social Responsible/Social Implication Design (Tromp et al., 2011; Tromp & Hekkert, 2014, 2018). While behaviour is controlled by an interaction between system 1 (fast and automatic) and system 2 processing (slow and reflective) (Triandis, 1977), the majority is fast and automatic (Chaiken & Trope, 2000; Stanovich, 2009; Thaler & Sunstein, 2009; Tversky & Kahneman, 1974;). System 1 processing uses fewer mental resources (Bargh & Chartrand, 2000) and drives most behavioural responses. It is therefore a strong means of changing behaviour (Cialdini, 1984; Morewedge & Kahneman, 2010; Thaler & Sunstein, 2009). This highlights the importance of considering habitual, automatic processing (Aarts & Dijksterhuis, 2000) in addition to targeting deliberate, intentional processing (Stanovich & Toplak, 2012). This aligns with other works emphasising the importance of combining system 1 and system 2 strategies in designs involving human interaction (Cash et al., 2017b; Dolan et al., 2012; Lockton et al., 2010). Thus, the first key parameter identified, Cognition, provides a foundation for understanding how interventions are processed by people during interaction. Here, system 1 and system 2 cognition are important traits to consider.

Ability

People's ability (and perception hereof) is relevant in understanding behaviour and behavioural change as well as interactions with artefacts. People's skills are impacted by social norms, observing other's behaviour, as well as perception of own and other's abilities (Ajzen, 1991; Bandura, 1977, 1989, 1991; Hardeman et al., 2002). Ability has typically been operationalised as a continuous scale (level). For example, ability addresses the level of training needed to achieve a desired interaction (Fogg, 2009a; Michie et al., 2014a). This level understanding of ability is applied across design domains. However, Michie et al. (2014a) also distinguishes between physical and mental capabilities (abilities). This is mirrored in UX approaches, dealing with people's physical and mental abilities in product usage (Cho et al., 2013). In addition, this physical/mental distinction is found in other types of design, for example in game design where Schell (2014) differentiates between physical skills (e.g., coordination and strength) and mental skills (e.g., observation and memory). Overall, these can be understood as practical mechanisms of people's abilities. Thus, the second key parameter, Ability, provides a foundation for understanding what practical mechanisms interventions utilise to change behaviour. Here, mental and physical ability are important traits to consider.

Motivation

Multiple researchers point to an interplay between ability and motivation (Gössling et al., 2012; Michie et al., 2014a; Prochaska & Velicer, 1997). Fogg (2009a) uses this explicitly in the Fogg Behaviour Model showing co-existence of high ability and motivation as ideal conditions for triggering behavioural change. In addition, Fogg (2009a) states that increasing motivation is easier than increasing ability, as increasing skills are often *system 2 heavy*. Further, Tromp et al. (2011) emphasise that encouragement (increasing motivation) of desired behaviour and discouragement (decreasing motivation) of undesired behaviour are both viable strategies for behavioural change. In this context, Tromp et al. (2011) define four types of influence: decisive, coercive, seductive, and persuasive, each relying on various extrinsic or intrinsic motivational factors. From a psychological point of view, Ryan and Deci (2000) describe three distinct motivation types: intrinsic (internal) motivation, extrinsic (external) motivation, and *amotivation*; the latter referring to the complete lack of motivation resulting in non-behaviour/no action. Chan (2009) combine level of motivation with classifications of extrinsic and intrinsic motivation on a scale from *controlled* to *autonomous* behavioural regulation. Even though motivation is treated in various ways across design and psychology, it is considered an important mechanism for both behavioural change and product interaction. Thus, the third key parameter, Motivation, provides an additional parameter for understanding what practical mechanisms interventions utilise to change behaviour. Here, intrinsic and extrinsic motivation are important traits to consider.

Timing

Timing plays an important role in understanding and influencing behaviour. For example, both ability and motivation fluctuate over time. Also, professional motivation is closely linked to ability, which often reaches a peak at the end of education (Dahlgren et al., 2014; Kunrath et al., 2020). In addition, timing is connected to cognition, as system 1 and system 2 processes are shaped by experience and learning (Evans, 2008). In design, temporality is a recognized design aspect critical to areas such as health (Orji et al., 2013; Reddy et al., 2006). While timing is dealt with to varying degrees and with varying levels of attention across design approaches, it is a central aspect of behavioural design (Daae et al., 2018). Theories of behavioural change typically operate on a specific *Before-During-After* timeline captured by Miltenberger's (2011) *Antecedent-Behaviour-Consequence* (ABC) model bringing together a range of works from across fields (e.g., Catania et al., 1990; Rosenstock, 1974). Duhigg (2012) uses a similar model, *cue–routine-reward*, in describing habit loops. However, where Miltenberger (2011) and Duhigg (2012) focus on small timescales, Prochacka and Velicer (1997) divide the behavioural timeline into *precontemplation, contemplation, preparation for action, action, and maintenance*. Following this, Velicer et al. (1998) aggregate these five stages, dividing them into *before the target behaviour occurs* (precontemplation, contemplation, and partially preparation for action), and *after the behaviour change has occurred* (partially preparation for action, action, and maintenance). Linking to Miltenberger (2011) and Velicer et al. (1998) focus on a combined *antecedent and behaviour* and a combined *behaviour and consequence*. Though existing timelines vary in number of steps, they all reflect a general before, during, and after separation. Relevant for behavioural design, this timeline draws attention to the different interactions with the designed intervention over time (Daae et al., 2018). Thus, the fourth key parameter, Timing, provides a foundation for understanding when interventions are active. Here, before, during, and after the (potential) problem behaviour timings of interaction with interventions are important traits to consider.

Social Context

Multiple aspects of behaviour and design are dependent on social context. For example, Bandura (1991) describes how behaviour is contingent on both internal factors (self-monitoring and personal standards), and external factors (environmental circumstances). In addition, Bandura (1991) and Ryan and Deci (2000) highlight the importance of external stimuli's impact on motivation. In addition, perceived norms are highly dependent on social context (Cialdini, 2007). Tajfel and Turner (1979) and Ibarra (1999) respectively describe how people's social and professional identities (and thereby their behavioural responses) are influenced by social context. While social context is often discussed in general terms, some models distinguish between different social layers. Most commonly used is Bronfenbrenner's Ecological model (1986), distinguishing between: *individual*, *interpersonal*, *organizational, community*, and *policy* layers. In connection to Bronfenbrenner's model (1986), Gallivan and Srite (2005) describe a social *onion* including: *individual*, *workgroup*, *organizational*, *professional*, *national*, *ethnic group*, and *religion*. Based on these, social context can be considered broadly in terms of *Individual, Inter-personal,* and *Community*. Thus, the fifth key parameter, *Social context*, provides a foundation for understanding *where* interventions act. Here, *individual*, *interpersonal*, and *community* levels of the social contexts are important traits to consider.

Physical Context

Finally, physical context forms a second contextual parameter critical to shaping behaviour and artefact design (Bhamra et al., 2011; Kelders et al., 2012). For example, Lilley (2009) explains how interactions with both products and people influence behaviour. Generally, influencing behaviour through physical products, systems, and environments is core to behavioural design (Cash et al., 2017b). These include, e.g., computational (Fogg, 2003) and architectural approaches (Lockton et al., 2010). Here, physical context provides a range of pathways for shaping specific behavioural responses (Lockton et al., 2010). That is, behavioural design can consider physical context on product and urban-architectural levels, yet also in terms of complex, physical systems. For example, in engineering design the TRIZ method comprises sub-systems, system, and super-systems (Cameron, 2010). Also, physical products are often understood as a interplays of parts, products, and systems (Andreasen et al., 2015; Rantanen et al., 2017). The differentiation of these are relative to each other and depend on design context, following existing methods such as chunking (Miller, 1956), function trees (Hansen & Andreasen, 2002), and the 9 windows (Cameron, 2010). Thus, it is important to apply these consistently within cases, nevertheless, this differentiation provides a basis for designers to discuss and agree on contextual levels. Thus, the final key parameter, Physical context, provides an additional foundation for investigating where interventions act. Here, part, product, and system of the physical context are important traits to consider.

The Behavioural Design Space (BDS)

The theories and models explored in the previous section, summarised in Table 1, each deal with sub-set of the identified parameters. However, none include all six, mainly due to the fragmentation between discussions of primarily behavioural parameters on one side, and those more closely linked to artefact design on the other. The Behavioural Design Space (BDS) framework thus brings together six parameters that each connect behaviour and design (Figure 1). This serves to link perspectives across psychology and design, by connecting aspects related to the fundamental understanding of behaviour and behaviour change, to those aspects related to fundamental understanding of artefact design. As such, the BDS provides a set of common, crosscutting parameters linking understanding of behaviour change techniques as well as the design of artefact-based interventions, relevant for behavioural design across application areas. Figure 1 shows six key parameters, their corresponding traits, and how they correspond to four practical aspects of intervention design. Details of each parameter and its traits are further elaborated with examples in Table 2, providing details relevant for applying the BDS in practice.

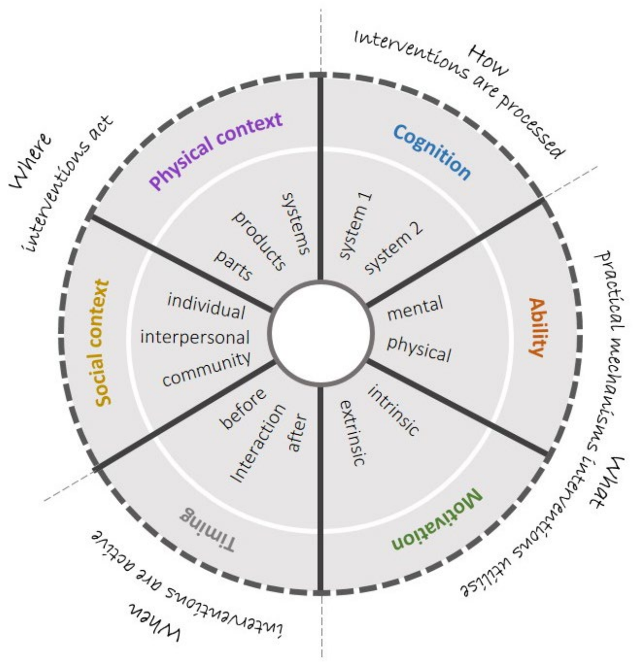

Figure 2. The Behavioural Design Space (BDS) framework.

Table 2. Overview and description of the six parameters included in the BDS framework.

Practical guideline	Parameter	Trait	Description	Example
How	**Cognition**	**System 1**	When interventions utilise **automatic** information processing	E.g., *"make better cycle space to decrease cars"*
		System 2	When interventions utilise **rational** information processing	E.g., *"provide info by newsletters"*
What	**Ability**	**Mental**	When interventions require specific **brainpower** in successful interaction	E.g., *"provide directions on a map"*
		Physical	When interventions require specific **bodily** capabilities in successful interaction	E.g., *"make women's parking lots close to the main entrance"*
	Motivation	**Intrinsic**	When interventions en- or discourage behaviour utilising **inherent** attractions	E.g., *"provide employees with more freedom"*
		Extrinsic	When interventions en- or discourage behaviour utilising **external** attractions	E.g., *"prompt for answers by e-mail"*
When	**Timing**	**Before**	When interventions are active **prior t**o potential undesired behaviour	E.g., *"call farmers to tell them to wait sell grains to decrease loss"*
		During	When interventions are active in **moment** of potential undesired behaviour	E.g., *"apply awareness zones at door entrances"*
		After	When interventions are active **post t**o potential undesired behaviour	E.g., *"make a 'park legally' contest"*
Where	**Social context**	**Individual**	When interventions acts in a **person-intervention**-interaction	E.g., *"install a lamp to show parking availability"*
		Interpersonal	When interventions acts in a **person-person-intervention**-interaction	E.g., *"make car pool parking lots"*
		Community	When interventions acts in a p**erson-multiple people**/**societal-intervention**-interaction	E.g., *"get influencers to share the message"*
	Physical context	**Part**	When interventions take form of an individual **piece**	E.g., *"install a sign"*
		Product	When interventions take form of a **cohesive** unit	E.g., *"provide parking clip cards"*
		System	When interventions take form of **co-existing** individual pieces and/or cohesive units	E.g., *"introduce a rotation system for parking lots"*

Applying BDS as a Lens to Understand Practice

In order to evaluate the potential explanatory power of the proposed BDS framework for mapping behavioural design work we carried out an initial case-based study. We apply the BDS framework as a lens for exploring a case study of expert behavioural designer's ideation practice with two goals in mind: 1) to investigate the applicability and explanatory power of the BDS framework in assessing behavioural design across different cases/intervention application areas, and 2) to gain an initial understanding of how expert behavioural designers currently navigate in the design space.

Method

In order to evaluate the BDS framework's applicability and explanatory power across behavioural design contexts it was necessary to examine how the identified parameters were utilised in practice. As such, an in-depth case study approach was used to provide both depth and diversity in data (Yin, 2018). Following this, the key sampling criteria were diversity in intervention application area and focus on tasks connecting behavioural and design understanding (i.e., behavioural design conceptualisation as opposed to pure behavioural research). This allows us to collect insights on contrasting cases in order to evaluate more general patterns in how the BDS parameters function (Eisenhardt & Greabner, 2007), as well as providing a foundation for future generalisation (Creswell & Poth, 2016) by contextualising the results with respect to key parts of behavioural design work.

Case Company

The observed case company has nine years of experience with consulting behavioural design across diverse organisations. These include small, medium, and large-sized organisations from the public and private sectors. The case company consists of approximately 15 employees with multiple competences including psychology, engineering design, software development, innovation, etc. Each employee has extensive industrial experience with behavioural design. Further, the company has been profitable since its formation and, at time of study, was considered a leader in behavioural design in Denmark. As such, the case company is well-suited to examine expert behavioural design practice. The dataset consists of five ideation sessions for five diverse, real-world, client provided challenges, where the behavioural designers generated ideas/solutions for interventions (Table 3) aiming at achieving specific behavioural effects. As such, the five cases fulfil our sampling criteria and provide access to rich data.

Data Collection: *Observations of Current Ideation Practice*

The data was collected during 2016 by the first author. All five sessions were conducted according to the company's existing ideation practices. The project leader(s) introduced the behavioural challenge provided by the client. Afterwards, the project leader(s) ideated solutions together with the present employees from the behavioural consultancy using semi-structured, free, group ideation. The employees were neither interrupted nor instructed by the research team during the ideation sessions. All sessions were video recorded. Prior to the first ideation session, five employees including the CEO was interviewed to establish an understanding of the company and its core work. This was done secondary to the observations, and only to confirm that observed sessions covered a broad range of the company's projects and work practices.

Data Preparation, Coding, and Analysis

The five ideation sessions were recorded and transcribed by the first author. From the transcriptions, the first author identified *idea fragments* (Sosa, 2019), and listed these in Excel. For simplicity, Cash and Štorga's (2015) *actionable object-verb associated with a potential solution* was used as a characterisation of a distinct idea fragment. All ideated interventions were treated as isolated idea fragments with respect to the target behaviour. Ideally, overall behavioural design strategies incorporate multiple interventions (Cash et al., 2017a; Michie et al., 2014a). However, for the sake of clarity, we here describe each intervention on the level of single idea fragments. This resulted in a list of idea fragments that was discussed and agreed upon within the full research team. Then, the first author coded each idea fragment on the six BDS parameters following the descriptions in Table 2. Idea fragments not providing enough detail to determine BDS parameter trait was given a *0* in that particular parameter. For example, in Session 1 idea number 15, *Introduce a system where this week, number plates xxxx → xxxx have to park over there*, was coded as follows:

- Draws upon rational information processing (*system 2* Cognition)
- Does not address type of ability needed (*0* / not addressed Ability)
- Encourages behaviour by utilising externally added attraction (*extrinsic* Motivation)
- Activates prior to potential illegal parking (*before* Timing)
- Acts on a societal level (*community* Social context)
- Consists of multiple co-existing units and pieces (*system* Physical context)

In this way, all idea fragments were coded in Excel. This coding was then discussed within the full research team until agreement was reached. Repeated, identical idea fragments were identified by the first author, and excluded for further analysis in agreement with the full research team. Following the same procedure, idea fragments uncodable on all six parameters were also excluded; these constituted only 22 idea fragments (4.24%) out of a total of 519 (Table 4). In discussing the uncodable *idea fragments* in closer detail, in S2, all 13 excluded *idea fragments* were process ideas rather than design features of interventions, e.g., *collect data on current routines* and *do interviews by phone.* In S1 and S5, the two excluded *idea fragments* were generally formulated, and did not provide details about an idea on their own, e.g., *make sure that there is value for the user.* In S3 and S4, the eight excluded *idea fragments* were either vague and/or not behavioural related, e.g., *expand the market*, and *charge competitors 0.5% of shopping bag value*. As such, more than > 95% of all idea fragments identified across diverse cases were codable using the BDS framework. As an additional check on coding reliability, a blind third party was trained, and then coded two sets of 25 idea fragments (4.8 % of total idea fragments) from across the five cases, with clarification discussion between the two sets. Krippendorff alpha inter-coder reliability was calculated for each of the BDS parameters separately, in the first set ranging from $\alpha = 0.58$ (Physical context) to $\alpha = 1$ (Social Context) and averaging $\alpha = 0.81$ across all six parameters. This improved in the second set to range from $\alpha = 0.70$ (Motivation) to $\alpha = 1$ (Social Context), and averaging $\alpha = 0.83$ across all six parameters. Even though there was a relatively low agreement on Physcial Context in the first set ($\alpha = 0.58$) this was resolved in the second set by clarification of the criteria ($\alpha = 0.82$), while agreement on all other parameters was high in both sets.

Table 3. Overview of raw data (five observed ideation sessions, S1-S5)**.**

Ideation session	Topic	Length	No. of employees present
S1	Preventing illegal parking in a big company	01:32:26	4
S2	Enforcing better timing of purchase and sell routines	00:53:16	7
S3	Increasing product sales	00:54:25	5
S4	Enforcing purchase and compliance through software	00:58:20	3
S5	Increasing organizational employee health and happiness	01:25:27	3

Idea fragments were also grouped into *concepts*. Here, concepts are defined as *sets of idea fragments operating on the same theme* based on Sosa's (2019) *accretion of fragmented ideas*. The idea fragments were grouped using Linkography (Goldschmidt, 2014); each idea fragment was examined in relation to all proceeding idea fragments, asking whether a link (relation) existed or not. Idea fragments were only linked if they were mentioned within a maximum of 15 seconds apart. This lower boundary was applied to account of people's limited working memory (Atkinson & Shiffrin, 1971). As an aid to decide whether a link existed or not, a set of relationship criteria were developed specifically for this study:

1. Direct related idea fragments: an idea fragment adds additional detail including further explanations and/or sub-components to a previous idea fragment.
2. Similar idea fragments: an idea fragment is equivalent to a previous idea fragment.
3. Alternative idea fragments: an idea fragment is an alternative to a previous idea fragment, however, they are still operating on the same theme.

Grouping into concepts was done by the first author and a third party (research assistant) in parallel, to calculate inter-coder agreement. The inter-coder agreement was calculated by the percentage of agreement of allocation of idea fragments between the first author and the research assistant. Percentage of inter-coder agreement was calculated for session 1-5 respectively to: 83%, 88%, 97%, 94%, and 74%. Averaging to 87% agreement of concept allocation across the five sessions. The lower score in session 5 is due to a disagreement on two concepts consisting of 5 and 4 idea fragments, respectively. This discrepancy, as well as all others across sessions, was discussed within the full research team until 100% agreement on final concept groupings was reached. Based on this, we also investigated how the six BDS parameters where treated within concepts. Only *rich* concepts were taken further for analysis, i.e., concepts that consisted of four or more idea fragments. Here, the first author mapped out the BDS parameters utilised within each concept, which was then discussed within the full research team. Figure 3 gives an overview of the analysis process, and Table 4 provide an overview of the data.

Findings

The findings are presented at two levels: idea fragment level and concept level. At the idea fragment level, we assess the identified idea fragment's distribution across the six BDS parameters. We also assess the number of links between idea fragments in the linkographs. At the concept level, we assess the distribution and progression across the six BDS parameters within concepts.

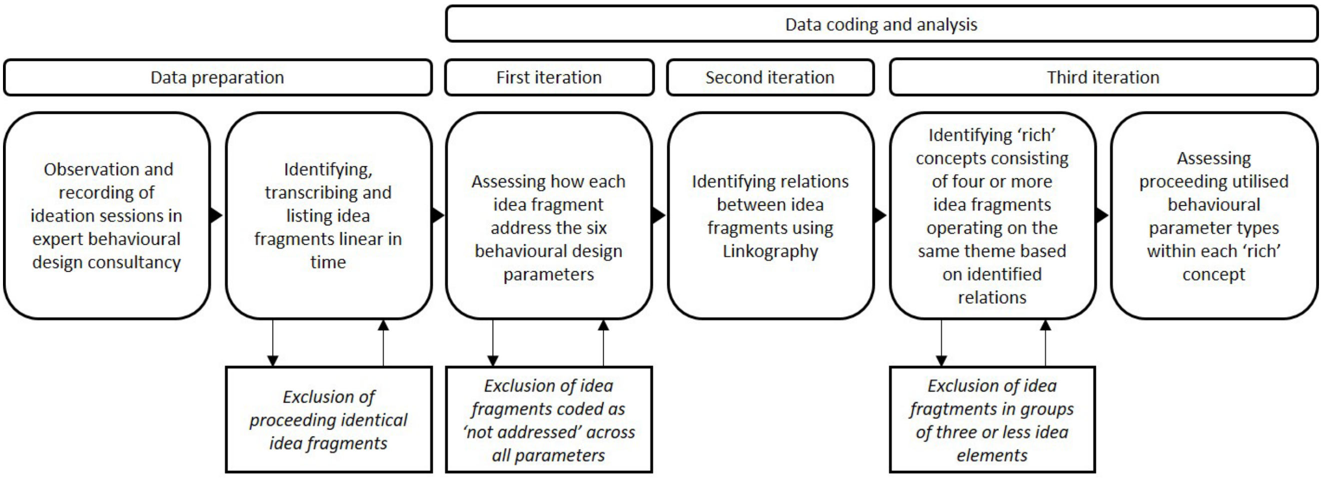

Figure 3. Overview of analysis–case study.

Table 4. Overview of collected data.

Ideation session	No. of idea fragments identified*	No. of idea fragments excluded	Total no. of links between total no. of idea fragments	No. of rich concepts identified	No. of idea fragments excluded after identifying rich concepts**
S1	123	1	318	15	42
S2	66	12	165	11	6
S3	110	5	287	15	17
S4	145	3	384	20	28
S5	75	1	197	11	0
TOTALS	519	22	1351	72	93

*After excluded idea fragments. ** Number of idea fragments in groups of 1-3 idea fragments.

At the idea fragment level, we explore what BDS parameters and to which degree they are utilised by the behavioural designers. Figure 4 shows six pairs of columns. In each pair, the first column shows the distribution of idea fragments across the six BDS parameters. All has not *addressed* at the bottom. The second column in each pair shows the weighted number of links (relations) corresponding to each of the BDS parameter traits.

From this analysis, we identify a number of findings. There is a substantially higher representation of *system 2* than *system 1* Cognition. Both *not addressed* and *mental* Ability is highly represented, whereas *physical* Ability is nearly absent. There is a somewhat equal distribution of *intrinsic* and *extrinsic* Motivation. In Timing, *before* is most represented, followed by *during*, and lastly *after*. In Social context, there is a substantially higher representation of *individual*, and *inter-personal* is close to missing. Lastly, Physical context has a relatively low representation of *product* compared to *part* and *system*. In addition, the distribution of corresponding links is very close to the distribution of BDS parameters. The distribution of links indicate the importance of each group of BDS parameter traits. Here, importance refers to the number of idea fragments linked to a group of traits, where a similar distribution indicates a *neutral* importance, and a higher or lower distribution of links would indicate a high or low importance. For example, a higher representation of weighted links would indicate that these ideas had sparked a higher number of related ideas. Here, the weighted number of links show a similar distribution as the distribution of BDS parameter traits. As such, this finding underpins the distribution identified across the BDS parameters.

Concept Level

At the concept level, we explore how and to which degree the BDS parameters are combined within concepts by the behavioural designers. From this analysis, we identify two overall ideation patterns: *high variation* and *low variation*. Here, low variation refers to designers *holding* most of the BDS parameters and varying only one or two. *Holding* is defined as utilising the same parameter trait across idea fragments within a concept, e.g., referring only to *system 2* Cognition (see Excerpt 1). High variation refers to designers varying multiple BDS parameters within a concept, e.g., switching between *part*, *product*, and *system* Physical context. In 85% of the identified concepts, the designers held 4-6 BDS parameters. As such, the designers favoured low over high variation.

Example 1—*Low Variation*

Concept 15 in Session 1 (Excerpt 1) displays an example of low variation. Here, the designers hold the majority of BDS parameters. In this example, the designers only utilise one trait of Cognition,

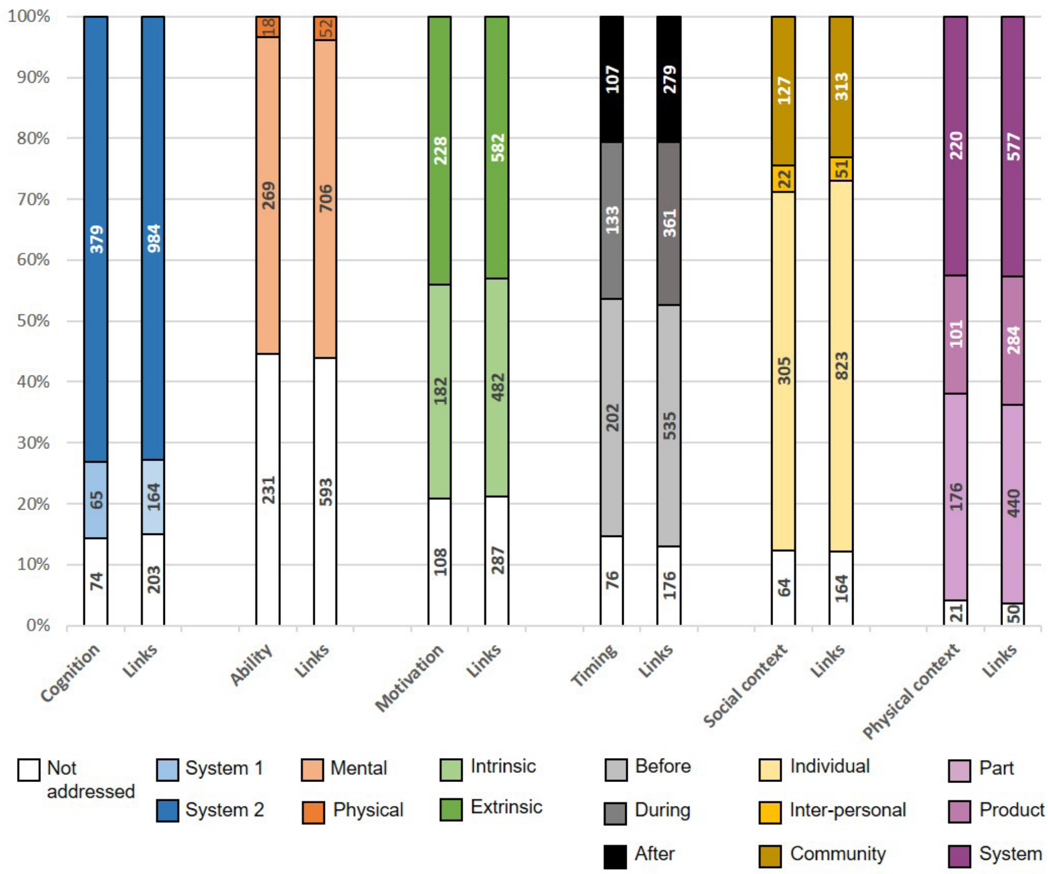

Figure 4. Distribution of BDS parameter traits, and corresponding links.

Motivation, Timing, and Social context. In our analysis, Ability is coded as holding *not addressed*. Physical context is also coded as holding, as one shift from *part* to *system* between idea fragment 1 and 2 out of 6 in total is very little variation. By holding BDS parameters, the designers reduce complexity and develop an initial idea in more depth. This is first seen by the *linear string of thought* present in the idea fragment transcripts. From a generic creativity point of view, the idea transcripts show some variation as the designers propose alternative conditions for behaving well: *show pictures of all cars that drive through the tunnel* and alternatively *employees that park legally get blitzed*. Also, two alternative ways/contexts of exposing the desired behaviour are proposed: *at every Friday bar expose all employees that have behaved well* and *the blitzed pictures are showed on a large screen in the lunch room*. At the same time, using the BDS framework as a lens reveals no/very little variation of utilised parameter traits. Thus, from a behavioural design perspective, this particular concept is an example of low variation.

Example 2—*High Variation*

Concept 8 in Session 1 (Excerpt 2) displays an example of high variation. Here, the behavioural designers vary 5 out of 6 BDS parameters. In this example, the designers vary all BDS parameters except for Social context. Here, the behavioural designers develop the concept in *two strings of thought.* This is both present in the idea fragment transcripts and in the BDS parameters Cognition, Ability, Motivation, and Timing. At the same time, the designers vary Physical context in each proceeding idea fragment. By varying BDS parameter traits in pairs, the designers use a more explorative ideation strategy and reduce some complexity. As such, the variation in this example is both identifiable from a generic creativity point of view assessing the idea fragment transcripts, and across the majority of BDS parameters. Thus, this particular concept is an example of high variation.

Variation across BDS Parameters

As an additional analysis, we examine what BDS parameters and to which degree the behavioural designers vary them. Table 5 shows the number of concepts varying each parameter out of the total 74 concepts. Here, Physical context is varied most often, in 41 concepts. In comparison, Timing is varied second most often, only in 20 concepts. Ability is varied least often, only in 3 concepts. Overall, this highlights a discrepancy in the degree to which the designers vary each of the BDS parameters, pointing to a biased exploration of the design space focused on Physical context.

Excerpt 1. Example 2 – Example of low variation - concept 15 from Session 1.

Idea fragment transcriptions	Cognition	Ability	Motivation	Timing	Social context	Physical context
1: “Replace negative feedback with positive feedback”	System 2	Not addressed	Extrinsic	After	Not addressed	Part
2: “Reward wanted behaviour”						System
3: “At every Friday bar expose all employees that have behaved well”					Community	
4: “Show pictures of all cars that drove through the tunnel”						
5: “Employees that park legally get blitzed”						
6: “The blitzed pictures are showed on a large screen in the lunch room”						

Excerpt 2. Example of high variation - concept 8 from Session 1.

Idea fragment transcriptions	Cognition	Ability	Motivation	Timing	Social context	Physical context
1: “Create a separate cycle path”	System 1	Physical	Intrinsic	Before	Individual	Product
2: “Divide the road into a walking and a biking section”						System
3: “Information: ‘Cyclists in here”	System 2	Mental	Extrinsic	During		Part
4: “Put the information on a big sign”						Product

Table 5. Total number of concepts varying BDS parameter.

	Cognition	Ability	Motivation	Timing	Social context	Physical context
No. of concepts varying BDS parameter	7	3	12	20	11	41

Discussion

This work provides the basis for a number of contributions to design theory and practice. First, we propose the Behavioural Design Space (BDS), a framework consisting of six key parameters connecting understanding of behaviour and design, and their corresponding traits. The BDS connects parameters cutting across behaviour change and design in order to link understanding of behaviour change techniques to their embodiment in designed artefact-based interventions. This substantially extends prior work, which has typically focused on only one or few, primarily behavioural parameters (Table 1). Existing theories and models of behavioural change often focus on domain-specific aspects, for example seen in the Aids Risk Reduction Model (Catania et al., 1990), and limit consideration to the identification of behaviour change techniques, without addressing intervention design itself. As a complement to these works, the BDS focuses on parameters that cut across behaviour and design, and thereby offer a framework tailored for behavioural design work requiring linking of behaviour change techniques to concrete intervention artefacts across diverse application areas. As such, the BDS framework constitutes an important step forward in the delineation of the available design space, based on a generic set of parameters relevant for behavioural design. This provides an important building block in establishing the overall domain of behavioural design theory (Wacker, 2008), as well as synthesising of major aspects important to behavioural design work, e.g., intervention development (Tromp et al., 2011). The majority of existing theories and models showcased in Table 1 either focus on one parameter (e.g., Bronfenbrenner, 1986; Cialdini, 1984; Morewedge & Kahneman, 2010) or a few parameters at a time (e.g., Fogg, 2009a; Ryan & Deci, 2000). Exceptionally, Michie et al.'s COM-B model (2011, 2014a) combines five parameters, although still conceptualised as primarily behavioural. This focus potentially explains why Michie et al. (2011) include multiple BDS parameters under one label; e.g., Opportunity is defined as: "…all the factors that lie outside the individual that make the behaviour possible or prompt it" (p. 4). Here, Michie et al. (2011, 2014a) combine what we separate into Physical and Social context due to the importance of this distinction in artefact design. Mitchie et al.'s approach is ideal for general policy making for which the COM-B model is developed. However, it is difficult to apply in detail and on its own in, for example, intervention development across application areas involving multiple artefacts. In addition, the COM-B model does not directly include timing. Timing is a crucial aspect of intervention development, as artefact interaction is often time sensitive. Similarly, models focusing on timing such as the ABC model (Miltenberger, 2011) and the Transtheoretical model (Prochasha & Velicer, 1997) lack other behavioural and design parameters. To the authors' knowledge, no existing theory or model explicitly include all six parameters identified, and conceptualise these as explicitly cutting across behavioural and design related aspects. As such, the BDS framework provides an important step towards linking previously fragmented parameters of behavioural design from across disciplines and domains.

Second, in applying the BDS framework as a lens, we identified a high variation of Physical context, but in general an unexpectedly low variation in other BDS parameters. This low variation limits the possibilities for developing synergies and combining diverse interventions key to effective behavioural design (Cash et al., 2017b; Tromp & Hekkert, 2018), as a high amount of ideas utilising the same BDS parameter traits decreases variation of ideated interventions. This is supported in general creativity studies where high diversity is associated with more successful solutions, e.g., measured on willingness to pay for products (Dahl & Moreau, 2002). This finding of low variety is despite the fact that all observed designers are experts in behavioural design and familiar with the implications of dual-process cognition and other models of behaviour. This finding could be explained in two ways. First, currently no framework for assessing behavioural design work exists, hindering reflective exploration of the overall behavioural design space which may have resulted in the designers not being aware that they had only explored a limited part of the behavioural design space. Here, our findings show generally low exploration, and particularly of the more abstract BDS parameters (Cognition, Ability, and Motivation). This is even though aspects of these, as well as of timing and social context, are crucial for analysing behavioural patterns, and for changing behaviour in designing behavioural effects (Cash et al., 2017a; Fogg, 2009a; Miltenberger, 2011). These findings point to a need for a means enabling designers to reflect on ideation outputs, directing them towards considering underexplored parameters during conceptualisation. Such methods should operate as mental tools for designers (Daalhuizen et al., 2019), and already exist in other fields. For example, the Sociotechnical System hexagon (Davis et al., 2014) (an interconnecting six-dimensional representation of complex organisations) operates on a reflective overview level. In engineering design, TRIZ (Cameron, 2010), a comprehensive functional trade-off matrix, also operates on a reflective detailed level. Second, some of the BDS parameters are more abstract than others, which can lead to difficulty of concurrently facilitating the complexity and abstract aspects of behaviour (von Thienen et al., 2014). For example, motivation and ability are more abstract than aspects of a physical part or product. In our study, these more abstract parameters received less attention. Bringing these two points together, the BDS framework provides an important additional lens to investigate and reflect upon behavioural design work.

Third, the BDS framework provides an overview of the available design space relevant to behavioural design work. This is important, not only to behavioural designers, but for designers working with human-artefact-interactions in general. The BDS framework follows similar advances in fields such as sociotechnical design where overall descriptions of the design space is essential to developing design practice. Connecting to the challenge of dealing with a multi-dimensional design space, Challenger and Clegg (2014) introduced the Sociotechnical system framework. In the context of behavioural design, the multi-dimensional nature of behavioural problems has formed the focus of a number of related works including the Behaviour

Change Wheel (Michie et al., 2014a) and MINDPSACE (Dolan et al., 2012). These works provide high-level overviews and guidelines for policy-level intervention development. In contrast, the BDS framework provides crosscutting parameters and corresponding traits aimed specifically at design disciplines. As such, these works are complementary. The overview provided by the BDS framework is especially important for behavioural designers, as they aim at designing behavioural effects manifested in a combination of multiple artefacts and systems utilising multiple interventions (Niedderer et al., 2017; Tromp et al., 2011). As such, the BDS framework provides an important contribution to supporting and investigating behavioural design practice providing an overview of the general behavioural design space.

Limitations and Further Work

There are two main limitations to be considered when evaluating the contribution of this work. First, while the current BDS framework offers a means of understanding relevant aspects of the behavioural design space, it does not treat interdependencies between variables. As such, it is limited in its utility for judging strengths, weaknesses, and overall behavioural design work quality. Particularly in the behavioural design context, solutions often leverage interactions between parameters to create a more holistic system of interventions (Niedderer et al., 2017; Tromp et al., 2011; Tromp & Hekkert, 2018). However, evaluating interdependencies and interactions is not possible without first mapping the major variables (Cash, 2018). Thus, the BDS framework provides an important first step towards a more structured understanding of the behavioural design space. Here, further work could explicitly examine possible interactions between BDS parameters and suggest guidelines for how designers might leverage these.

Second, while the case-based method used in this study allowed for a deep understanding of the applicability of the BDS framework across five diverse cases studied, the specific results should not be generalised without further study. Here, using the BDS framework as a lens on five different behavioural cases provides important initial findings. First, the BDS framework proved to be applicable in assessing behavioural design work across diverse intervention application domains, as the majority of identified idea fragments (> 95%) were codable across all five cases. Second, the analysis highlighted possible challenges of ideating solutions to complex behavioural problems. As such, while the case study did support evaluation of the BDS frameworks' explanatory power across behavioural design contexts, further study is needed in order to actually understand current practice, particularly as behavioural design is a fast-emerging and rapidly developing field. Building on these findings, further work could examine potential diversities across companies and/or a wider range of problem scopes, combining additional case studies and, for example, surveys. In addition, further work could investigate how behavioural design can benefit from awareness of level of exploration of the BDS in intervention development.

Conclusion

As an essential step for further theory building in behavioural design, the aim of this work was twofold. First, to provide a common understanding of relevant parameters of the design space. Second, to initially understand what these can potentially reveal about behavioural design practice. To this end we proposed, and examined via case study, the Behavioural Design Space (BDS) framework (Figure 1 and Table 2), linking six key parameters: *cognition, ability, motivation, timing, social,* and *physical context,* and their corresponding traits. In doing so we extend prior work on behavioural design by offering a framework that via common, crosscutting parameters links understanding of behaviour change techniques and the design of artefact-based interventions.

This provides the foundation for further theory development as well as recommendations for practice. In addition, our empirical results reveal a number of practical challenges pointing to a need for further study in current practice. Specifically, we found that expert designers favour low variation of BDS parameters, except from Physical context, limiting ideation across the available behavioural design space. Further, they were challenged in synthesising concepts with multiple interacting BDS parameters. This highlights the need for structured reflection and more systematic exploration of the behavioural design space. Also, it highlights a number of potentially important areas for further research and development of behavioural design support. In particular, future work is needed to investigate means for reflectively dealing with complex behavioural problems combining multiple behaviour change techniques and intervention artefacts.

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