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Ambiguity in behavioural design: exploring how ambiguity in motivation, capabilities, and opportunities leads to unexpected outcomes

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ABSTRACT

Behavioural change approaches are often used to address societal challenges. However, the resulting behavioural interventions often evoke inconsistent and heterogeneous results. Ambiguity is a potentially key lens in helping to explain different interpretations of singular behavioural interventions, and hence unexpected outcomes, yet remains overlooked in current behavioural change research. In response to this, we take a case study approach to examine the role of ambiguity in designing behavioural interventions in a highly ambiguous context. We conduct a thematic analysis of the data collected, and identify three major types of ambiguity that each evoke heterogenous responses in specific ways. We synthesise the results in the form of the 'Ambiguity in Behavioural Design framework'. Our framework highlights the need to acknowledge ambiguity when designing for behavioural change and is the first to identify this element within the field of behavioural design. It sets a foundation for understanding ambiguity in behavioural design and has implications for design theory and practice.

Introduction

Behavioural change approaches are often used to address societal challenges ranging from the sustainable use of resources to controlling spread of infection, notably during the COVID-19 pandemic. However, while successes have been achieved (e.g. Hansen et al. 2021), current behavioural change approaches are hotly debated, due to their inconsistent outcomes and, often, failure to change behaviour as intended (Kristal and Whillans 2019; Schmidt and Stenger 2021). For example, behavioural interventions have largely failed to improve vaccine uptake (Karafillakis et al. 2016) or to encourage preventive behaviours (Sasaki, Kurokawa, and Ohtake 2021). People often respond in heterogeneous ways to interventions (Entwistle 2021; Toussaert 2017), including counterproductive behaviours. This raises concerns regarding how behavioural design approaches and resulting interventions

deal with diverse user communities (Bessi et al. 2015), community dynamics (Getman et al. 2018), and complex real-world applications (Schmidt and Stenger 2021). Thus, despite a focus on generalised, theory-driven behavioural interventions, these consistently evoke heterogeneous interpretations and unintended responses. This raises a key question in how such heterogeneity can be understood and designed for.

Ambiguity provides a key lens in helping to explain different interpretations of singular situations. As such, this has the potential to help explain different interpretations of singular behavioural interventions, and hence unexpected outcomes. Ambiguity is generally defined as one expression that has the characteristic of accommodating two or more meanings (Zhang 1998). More specifically, ambiguous situations are open to multiple perspectives or interpretations (Weick 2015). Conversations often exemplify this ambiguity; for example, if one says 'I saw the person with a binocular', the listener can interpret that the person saw another person carrying a binocular, or that they used a binocular to see the person. This property of ambiguity is frequently explored by designers in stimuli (e.g. sketches) to foster perspective taking and aid the generation of ideas (Lawson, Loke, and Ming Loke 1997; Wiegers, Langeveld, and Vergeest 2011). However, while accommodating multiple perspectives can be advantageous (e.g. it aids creative processes), it can also pose challenges, like communication problems and poor decision-making (Stacey and Eckert 2003). While not previously discussed in the behaviour change literature (Basso and Krpan 2023; Cane, O'Connor, and Michie 2012; Thaler and Sunstein 2009), ambiguity is often identified in describing real world challenges. For example, nursing homes provide both (medical) care and housing and have the potential to produce various ambiguous situations for residents and staff alike. In such contexts, isolated interventions aimed at stimulating specific target behaviours like hand hygiene (care focused) often fail to succeed. This can potentially be explained by the fact that the *care* and *housing* perspectives imply substantially different implications for hygiene compliance, risks, and social care (Hammerschmidt and Manser 2019). More generally, Schmidt and Stenger (2021) highlight how behaviour change interventions struggle to succeed when ignoring the existence of multiple perspectives on a singular issue or situation. By explaining how singular interventions or situations can evoke different perspectives, ambiguity has the potential to provide a valuable lens for understanding heterogeneous responses to behavioural design.

Current behaviour change literature generally neglects ambiguity, despite a growing recognition among researchers that interventions need to consider the context where they are implemented (Brand et al. 2018; Kemp, Wagenaar, and Haroz 2019), be acceptable to a diverse public (Michie et al. 2014; Michie and West 2013), and be co-created with people from the targeted population (Lee et al. 2021). In contrast, conventional design approaches typically explicitly address these requirements, and offer various methods to explore contexts and address problems that are ambiguous by their nature (Bowen et al. 2016; Ney and Meinel 2019; von Thienen, Meinel, and Nicolai 2014). Hence, there is an urgent need to understand how ambiguity can be understood in behavioural change approaches and how design methodology and participatory design approaches can operationalise this understanding.

We address this need by exploring the following research question: *How can ambiguity be understood and addressed in design for behavioural change*? In doing so, we adopt a case study approach and examine the design of behavioural change interventions for a nursing

home context, which are generally characterised by high levels of ambiguity (e.g. Rijnaard et al. 2016; Wikström and Emilsson 2014). The case comprised a Research through Design (RtD) process structured along three distinct design stages in the front-end of a behavioural design project. The results contribute to behavioural design theory in two distinct ways: (1) We propose a theoretical framework for understanding the role of ambiguity in behavioural design, which extends the widely adopted COM-B model, (2) through the proposed framework, we advance understanding of how heterogenous behaviours can emerge when there is ambiguity in the stimuli and conditions that precede behaviour.

Background

Behaviour change and behavioural design

Behavioural change approaches are central to addressing societal challenges, such as public health (Michie 2008) and sustainability (Gwozdz, Reisch, and Thøgersen 2020). For example, successful behavioural change is crucial to reducing pressure on the healthcare sector, with challenges ranging from preventing non-communicable diseases (Dimatteo et al. 2002) to preventing the spread of infections (West and Michie 2020). In this domain, the desired outcome of behavioural interventions are behavioural actions (e.g. reducing sugar intake) that can be linked to health improvements (e.g. lower glucose levels) based on causal relationships established by Randomised Controlled Trails (RCTs). The latter are typically regarded as the most reliable method of providing clinical evidence (Deaton and Cartwright 2018). Several behavioural scientists follow this generalised rationale and use RCTs (e.g. Dai et al. 2021; Duncan et al. 2020) when testing behavioural interventions more broadly. Yet at the same time, behavioural science-based interventions and policies in healthcare often fail or backfire (Krpan et al. 2021; Kurdi, Elliott, and Chen 2020).

An explanation for such failures lies in the nature of healthcare problems, which are often entangled with complex social and economic factors and present characteristics of wicked problems (Kreuter et al. 2016). This implies for example that different stakeholders may have different views on the same problem (Rittel and Webber 1973), which renders linear approaches to problem solving less useful (Kreuter et al. 2016). Most current approaches to behaviour change adopt a linear logic to problem solving (Bay Brix Nielsen, Cash, and Daalhuizen 2024). Although valuable for advancing the behavioural change field, such approaches presume well-defined problem – and target behaviours, and homogenous participant groups. Yet such assumptions poorly represent real-world populations (Averitt et al. 2020). In response, several authors have highlighted the need to address behaviour change as a wicked problem (Bay Brix Nielsen, Cash, and Daalhuizen 2024; Schmidt 2019; Schmidt and Stenger 2021).

Recent work in behavioural design advocates for a balance between behavioural sci-ence – and design-led approaches able to accommodate both tame and wicked problems (Bay Brix Nielsen, Cash, and Daalhuizen 2024; Reid and Schmidt 2018; Schmidt and Stenger 2021). It places behavioural change as the primary goal of a design process and uses designed artefacts, whether experiences or objects, to achieve this primary goal (Khadilkar and Cash 2020). For example, designers are increasingly employing technology-based interventions that incorporate persuasive techniques to encourage behavioural change

(Oyibo 2024). This includes the use of gamified product-service system (PSS) solutions to promote sustainability-oriented behaviours (Villamil 2023), as well as smart appliances that provide technology-enabled feedback and intuitive interfaces to support more conscious energy consumption in domestic settings (Dirienzo et al. 2014).

In this regard, behavioural designers base their work on the assumption that artefacts shape perceptions of how one is supposed to behave by encouraging or discouraging behaviours in context (Niedderer, Clune, and Ludden 2017; Norman 2013; Tromp and Hekkert 2018). To approach problems, behavioural design integrates multidisciplinary knowledge from fields like psychology, human–computer interaction, and decision research (Lockton 2017), as well as behavioural change models and frameworks (Niedderer, Clune, and Ludden 2017). Crucially, the design-led principles of behavioural design enable designers to more effectively deal with uncertainty, while the behavioural science-led aspects enable designers to more appropriate to handle fine-grained aspects of problem and target behaviours (Cash, Gamundi, and Daalhuizen 2022; Schmidt 2019). Yet, despite close conceptual ties to uncertainty, and acknowledged impact in the wider design literature, the concept of ambiguity and its implications on behavioural design are not currently addressed or even discussed.

Ambiguity and behavioural design

Ambiguity is understood as an essential element in the design process (Bucciarelli 1994) and emerges from the relationship between people and artefacts in context (Gaver, Beaver, and Benford 2003) by accommodating diverse interpretations of a singular situation. In design, ambiguity can be used to accommodate multiple perspectives and spark multiple ideas (Lawson, Loke, and Ming Loke 1997; Wiegers, Langeveld, and Vergeest 2011) and creative insights (Finke 1993). It can foster perspective-taking and engagement (Durrant et al. 2018; Gaver, Beaver, and Benford 2003). As such, it is especially useful for co-designing, given its capacity to accommodate and facilitate multiple interpretations in collaborative processes (Eppler, Mengis, and Bresciani 2008) and to engage participants in solving challenges together (Mattelmäki, Brandt, and Vaajakallio 2011).

While ambiguity has been widely explored in the design literature, its role in behavioural design remains poorly understood. However, several studies indicate that ambiguity has a potential impact on users' behavioural responses. For example, behavioural responses can be reinforced or discouraged when users interact with highly ambiguous objects (Boon, Rozendaal, and Stappers 2018) or when users know the intention of the designer (Silva, Crilly, and Hekkert 2015). Additionally, users' professional background (Self 2019) can impact how people appreciate ambiguous stimuli (e.g. design artefacts, sketches, or words). Exposure to primes can also influence people's perceptions and choices (Kay et al. 2004) or interpretations of ambiguous images or texts (Feist and Gentner 2007; Filippova and Kostina 2020; Goolkasian and Woodberry 2010). Further, in the care context, ambiguous tasks can hinder guideline compliance (Gurses et al. 2008). Therefore, given that designed artefacts are inherently ambiguous, and their interpretation in use situations impacts resulting behaviours, ambiguity provides a highly salient, yet little explored, lens in the behaviour change context. Thus, there is a need to further understand the role ambiguity plays in behavioural design.

Conceptual framework

To explore ambiguity in behavioural design, we take a starting point in the widely used COM-B model. This model is used to identify underlying determinants of individual-level behaviours and point towards possible intervention principles when used together with the behavioural change wheel (Michie et al. 2014).

The COM-B model describes three behavioural dimensions: capability, opportunity, and motivation (Michie et al. 2014). Here, *capability* deals with an individual's psychological and physical ability to perform a specific behaviour. In behavioural design, enhancing capability involves providing the necessary information, education, and training to enable individuals to perform the desired behaviour. *Opportunity* deals with the external factors that facilitate or constrain behaviours, including environmental, social, and cultural influences. In behavioural design, creating favourable opportunities involves manipulating the environment to make the desired behaviour more accessible, convenient, and socially acceptable, for instance, placing hand sanitisers in prominent locations and encouraging social acceptance of frequently sanitising hands at various times. Finally, *motivation* deals with the conscious and unconscious processes that can encourage or hinder a behaviour. It includes reflective motivations (beliefs, attitudes, and values) and automatic motivations (habits and emotional responses). In behavioural design, influencing motivation involves impacting individuals' intrinsic and extrinsic motivations to promote desired behaviours. This can be achieved through feedback loops and rewards that align with individuals' values and aspirations.

In the context of design, designers first seek to *understand the context* of a behaviour, using behavioural models, such as COM-B, to structure behavioural problems' features and potential solutions (Cash et al. 2020). Based on this, *stimuli* are then developed in the form of a designed artefact intended to provoke a desired behavioural change (Khadilkar and Cash 2020). Stakeholders then *interpret* the affordances, signifiers or artefact in a way that results in some *response* (e.g. following signs to find to room). As such, the three dimensions of the COM-B model provide a framework for exploring ambiguity in the aspects contributing to behaviour as well as the intervention stimuli itself.

This initial understanding is illustrated by the framework in Figure 1. However, note that we refrain from including ambiguity in this figure as it is not currently acknowledged in the behavioural design literature or the COM-B model. Thus, the elements in Figure 1 provide a set of foci for examining how ambiguities play a role in behavioural design.

Method

Given the lack of theory on ambiguity in behavioural design, and its entanglement with the context from which it emerges, we adopt a theory building approach (Cash 2018). More specifically, we use an inductive case study (Eisenhardt 1989) with a single case study design (George and Bennett 2005). Here, we elicit deep insight into a behavioural design process by collecting data following a Research through Design logic, which allows designers to reframe problems as a manner of inquiring and can provide rich insight into design work (Zimmerman and Forlizzi 2014). A small team of two master students that were part of a design program at a technical university was recruited and ran the Research through Design
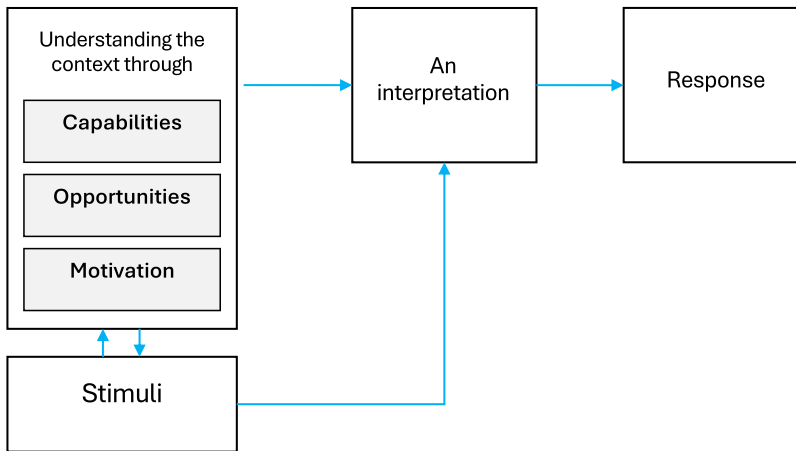
Figure 1. Conceptual framework bringing together current understanding of context factors, stimuli and response in behavioural design.

Note: Ambiguity is not included due to its current neglect in the literature on behavioural design.

project under the supervision of the first author. As a starting point for this investigation, and following our conceptual framework, we set our initial research question as:

RQ0: How does ambiguity emerge in design for behavioural change?

Sampling

Given our focus on ambiguity we selected a case context in which ambiguities are known to be exacerbated. As such, we sampled an *extreme case* (Yin 2018) and centred our data collection on hygiene and infection prevention in the context of nursing homes. To observe a wide range of situations involving hygiene in everyday life, we included two nursing homes with approximately seventy and one hundred residents respectively and with a comparable range of services (e.g. in terms of food, laundry and cleaning).

To sample participants who experience ambiguity in their daily work, we chose primarily nursing assistants and helpers employed as permanent staff (N = 6). We based this choice on prior research, which has shown that care workers in nursing homes experience the ambiguity of meeting organisational tasks (e.g. documentation and cleaning) whilst also sticking to their care values (e.g. spending time with the residents) (Falcão Duarte, Daalhuizen, and Schwennesen 2024; Lundin, Bülow, and Stier 2021).

Data collection

Following best practice, we collected data from diverse sources including, official documents (e.g. infection prevention guidelines), interviews, direct observations, and design activities held in nursing homes (see Table 1) (Miles, Huberman, and Saldaña 2014). Interviews, observations, and activity data were transcribed. Materials generated by participants during co-creative activities were photographed. This allowed the research team to triangulate data, reflect and use it to explore the research questions, and inform the next process phase.

Table 1. Data collected.

Method	Number and duration	Observations
Documents and existing literature on hygiene, infections and NHs	73	Documents, guidelines and literature about life in NHs, infection routes and hygiene were read.
Interviews with hygiene experts	3 (50–60 min)	Semi-structured interviews were conducted with experts in hygiene and NHs.
Interviews with staff members and residents	6 (30–40 min)	The interviewees consisted of 3 NH employees (N = 3), 3 residents (N = 3), and a relative (N = 1).
Observations	10 (30–60 min)	Observation of everyday life situations were done in the two participating NHs. The researchers looked for situations where there was a potential risk of transmitting infections, for example, meal situations and the cleaning of apartments.
Co-Creation Session	6 (30–40 min)	Care workers (N = 6) The sessions were conducted individually
Critical design workshop	6 (30–40 min)	Care workers (N = 6) The sessions were conducted individually

Data collection followed three phases of an RtD process (see Figure 2). Research insights and new questions emerged from the analysis of the data collected in each phase. In the first phase we examined the first research sub-question (RQ1): *What factors contribute to the emergence of ambiguity in the context where behavioural change is expected?* We explored the context in which behaviours related to hygiene and infection prevention occur and how stakeholders perceive and interpret such situations, as well their intentions related to hygiene. To do so, the design team used the Social Implication Design method (SID) (Tromp and Hekkert 2018). From this first phase, we derived an initial set of thematic dimensions (see Reflection on theoretical contribution I).

In the second phase, we examined the second research sub-question (RQ2), which was developed based on the insights from phase one: *What are the factors that shape different interpretations of desired behaviours?* Phase two thus had the goal of identifying the factors shaping different interpretations. To answer this goal the design team conducted co-creation sessions with staff members. From analysis of the data collected during the co-creation sessions, we derived additional thematic dimensions and refined our existing themes (see Reflection on theoretical contribution II).

In the third phase, we examined the third research sub-question (RQ3), which was in turn developed based on insights from the previous phases: *What factors shape different interpretations of situations in which an intervention is expected to change behaviours?* Phase three thus had the goal of identifying the factors shaping participants' interpretations of contextualised situations in which designers expected to intervene and facilitate a desired behaviour. To answer this goal the design team developed a critical design workshop that involved the participation of staff members. This resulted in further refinement and verification of our thematic dimensions (see Reflection on theoretical contribution III). Thus, across this process, we develop theory regarding the nature and role of ambiguity in behavioural design.

Data analysis

To analyse the date, we used a thematic analysis approach as it facilitates a reflexive and iterative development of insights from data (Braun and Clarke 2006) suited to theory building.
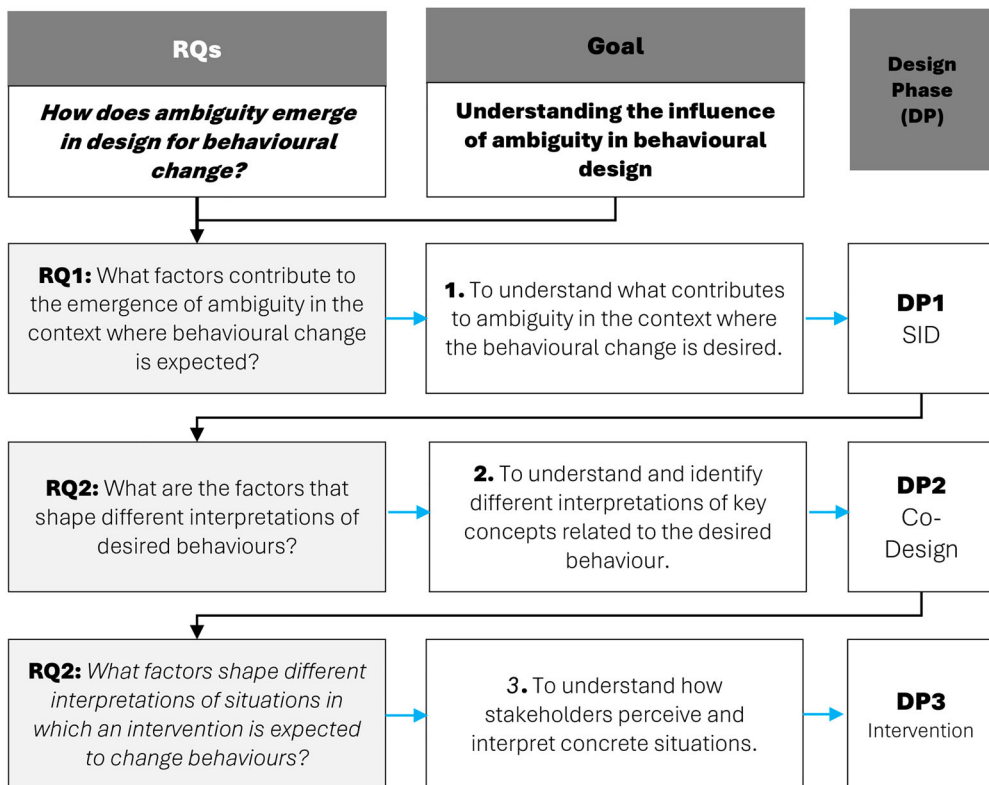
Figure 2. The Research through Design process and research questions.

First, we familiarised ourselves with the data. Second, we generated initial codes and looked for relations between the codes. Third, we combined the codes in themes and potential dimensions, using visual representations, and sought to connect them to the literature. Finally, we revisited the data multiple times and defined and refined themes as new data emerged through the RtD process.

To ensure rigour and consistency in our analysis, at each stage, we collected data, coded and iterated the themes, following reflexive thematic analysis best practices (Braun et al. 2019). The research team reflected on the data and discussed the formation of new categories and themes, triangulating the data to achieve validity (Miles, Huberman, and Saldaña 2014). Data was collected and themes were iterated until saturation was achieved (Saunders et al. 2018).

Results

In this section we present the results and development of our thematic analysis following the phases of the RtD process, starting with RQ1: *What factors contribute to the emergence of ambiguity in the context where behavioural change is expected?*

Table 2. Initial analysis of results.

Dimensions	Category	Examples from the data
Motivation	Different ways of understanding key concepts	Different residents had different notions and perceptions of what is a home.
Capability	Multiple levels of relevant professional experience	People with very different levels of knowledge and experience on hygiene worked in the NHs.
Opportunity	Organisation's dual mission	NHs should promote homelike environments, yet we observed how several safety standards may hinder this. This gives space for care workers to prioritise complying strictly with hygiene guidelines or to prioritise behaving in ways that emphasise social contact with residents.
	Societal pressures	The population is getting older, and more individuals are requiring assistance, yet NHs are understaffed and struggle to find qualified workers.

Design phase I: domain exploration

In the first phase of the process, the design team aimed to understand the broader context of hygiene in NH. The idea was to understand how ambiguity emerges in the context where behaviours related to hygiene occur, by exploring potential sources of ambiguity and define areas for further investigation. To do that, two design team members collected data from observations and interviews with experts from the field. Interviews and observations made by the first author with various cohorts of NH stakeholders (visitors, residents, and staff members) were also used, as well as official documents from the national health authorities regarding hygiene and admission to NHs (see Table 1).

Design phase I output

The design team created clusters related to individuals' identities in terms of how they perceived themselves, subjective interpretations of hygiene guidelines, diverse understandings of risks, diverse cleaning standards, and barriers to hygiene in the everyday life of NHs. The team iterated on the clusters until they could organise them into a concise structure giving insights into the context of the domain (Tromp and Hekkert 2018). Relationships between the clusters were explored and organised into a visual representation.

Reflection on theoretical contribution I

We analysed the results of design phase I in relation to the elements of our conceptual framework (Figure 1) and we identified initial indicators of ambiguity associated with motivation, capability, and opportunity, as shown in Table 2.

Within each theme we observed factors indicating initial evidence for ambiguity. In *motivation* we observed multiple subjective interpretations of concepts like 'home'. For example, residents personalise their living quarters in different ways and expressed different frustrations in relation to living in a nursing home. In *capability*, we observed varying levels of knowledge and skills regarding hygiene among care workers, leading to the identification of 'multiple levels of experience'. In *opportunity*, we observed that the mission of nursing homes gives rise to conflicting values, such as fostering a sense of home while also maintaining strict hygiene standards. Similarly, we observed how *societal pressures* create forces that can conflict with an organisation's mission affecting the perceptions of staff as well as their practical work situation. For example, the older population is increasing while

nursing homes struggle to find qualified staff to respond to this growth, which creates perceptions of inadequacy and work pressure among staff and negatively impacts the capacity to fulfil their mission.

Based on this, it was clear that a more nuanced understanding of the behavioural problem (e.g. understanding different perspectives on hygiene) was needed to explore the potential influence of ambiguity in individual behaviours. As such, we proposed RQ2: *What are the factors that shape different interpretations of key concepts connected to the desired behaviour?*

Design phase II: revealing the ambiguities in key hygiene concepts

In the second phase of the RtD process, the design team aimed to understand care workers' perspectives on behaviours related to hygiene. The idea was to explore perspectives and stimulate participants to talk about key concepts in hygiene. To do that, two design team members collected data from two co-creation workshops that exposed participants to ambiguity during three rounds of activity aiming to provoke responses regarding perceptions and definitions of specific behaviours as clean or unclean. In the first round, participants were invited to talk about their perspectives on hygiene and their work as care workers by taking cards that suggested topics for a dialogue (see Table 2) in order to understand aspects of motivation at work and identity. In the second round, the design team presented participants with cards describing everyday situations of care work in nursing homes in order to expose participants to ambiguity and understand the factors driving their interpretations of different situations. To capture the nuanced perspectives of 'clean' and 'unclean' situations, they asked each participant to classify each situation by placing the cards on an axis that ranged from 'clean' to 'unclean' procedures. To understand the factors driving these interpretations, the design team asked participants to explain the reason behind their classification. Finally, in the third round, participants were asked to reflect on how a self-selected fictitious care worker, presented on persona cards, would deal with situations faced in their daily activities (e.g. sending food around the table), in order to explore how participants would take a different perspective on hygiene.

Design phase II output

The first round of the workshop revealed topics related to *motivation*; for example, most participants expressed how their relationship with the residents was the most satisfying aspect of their work. Most participants also expressed frustration about when their professional tasks conflicted with spending time and building a good relationship with the residents. Further, diverse views on hygiene between participants were revealed, for example, some participants expressed that they wore gloves to protect themselves, while others expressed, they wore gloves to protect the residents from infections. These points are illustrated in Table 3.

The Round 2 results highlighted diverse interpretations of what constitutes 'clean processes' and 'unclean processes' (see Figure 3). We captured these perspectives by analysing the materials generated and the dialogues with participants (see Figure 3). When explaining the reasons why they would consider something clean or unclean, they revealed multiple perceptions of the situations presented on the cards and mapped these situations across the axis.

Table 3. Examples of participants answers during Round 1.

Round	Prompt	Answers
1	'For me the most important aspect of my work is _____.'	'What I find motivating about my work is, of course, helping the older ones; that's my meditation. And then I like that what I do has to do with people.' (Participant 01)
2	'For me, hygiene means _____.'	'We've just been through a big epidemic of infection. Still, I'll be honest: I'm not the one who's hysterical. I feel like if I'm faced with something, I'll do it, while many people say, 'I can't do that without wearing gloves' or something. My hands can be washed afterwards. The hands can just be washed. It's no worse.' (Participant 02)
3	'I use disposable gloves to protect _____ from____.'	' … to protect myself from spreading infection, and then I also protect the citizen from contracting infection' (Participant 03)
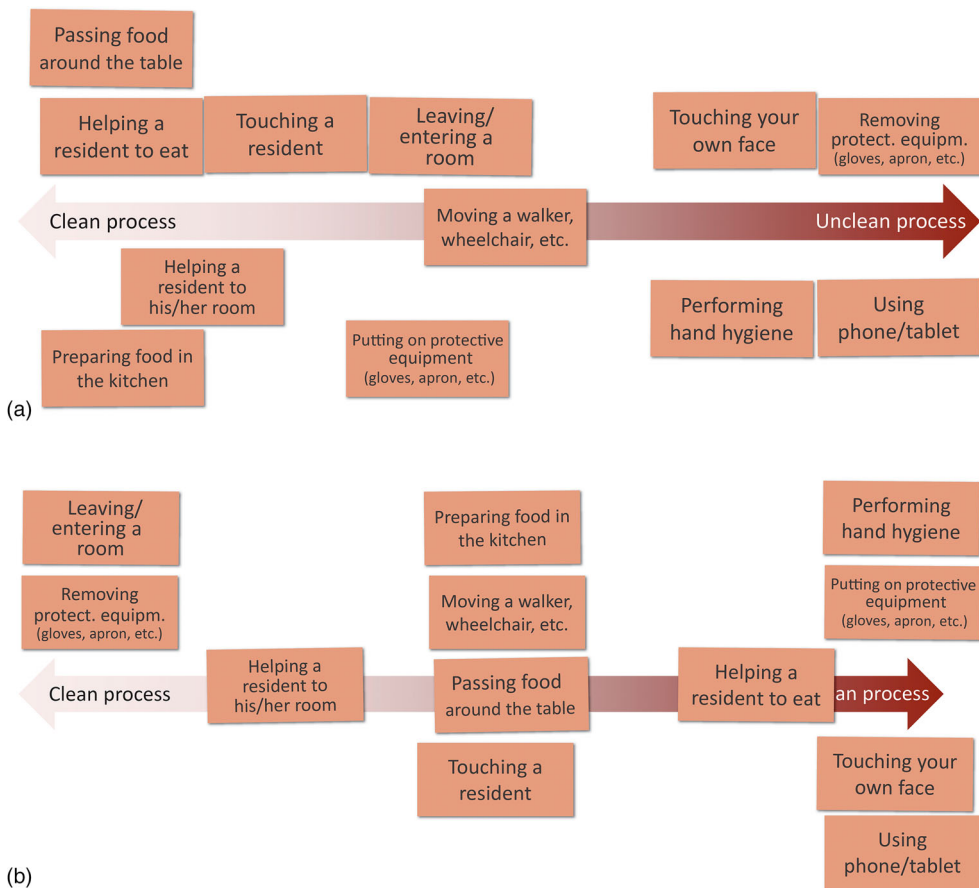
Figure 3. Sample of two different participants' co-creation results.

The Round 3 activities revealed how participants recognised different colleagues in the presented personas. The dialogues and the materials generated showed that participants recognised how various carers would have different ways of approaching the same problem and that the way to deal with the situation would be influenced by the condition and the preferences of each resident.

Table 4. Iteration of results.

Dimensions	Category	Examples from the data
Motivation	Professional values	'Hygiene for me is actually 100 percent everything.'
	Individual values	"For me, nothing is unclean. It's people we're dealing with, for God's sake."
Capability	Multiple levels of experience	'… some colleagues can observe each other, so you can give each other advice and know what you are doing right, or what you are doing wrong.'
	Skills acquired through education to perform a behaviour	'It's different diseases we're dealing with and then of course we also need knowledge … I think if you work in this NH then you're skilled.' Temporary staff are often less well trained
	Evaluation of rules	'They can be difficult to comply with, but we do it as a starting point. But then you can be in situations where you have to bend them.'
Opportunity	Interactions with others	'They have difficulty swallowing, and that makes them cough when they get something wrong in their throat. So, it can be quite an unclean process, especially for the people around you and for yourself.'
	Dynamics of power in the environment	'It's important to me when I go out and be a professional that I go with an open mind and respect the residents' homes and knock and see if they invite me in.'
	Information available in the environment	'In every sink we have some information hanging up that shows what proper hand washing or hand hygiene is. So, we actually use that a lot.'
	Lack of resources	Care workers need to perform a series of practices and hygiene on the run, due to a lack of staff and time.
	Organisation's mission	Participants reported that they prioritise respecting residents individual needs and right of self-determination and, at the same time, consider hygiene and avoiding the spread of infections highly important .
	Societal pressures	'… it is about our whole society, it's our time pressures, it's our lack of staff.(…) When for example, there are only four of us at work, and that is simply because we do not have enough people on staff (…) And then I can see some things are skipped, or done with less detail. (…) it starts to get back to the resident'
Indication for multiple intentions	Diverse interpretations of concepts related to desired behaviours	Participants have diverse and nuanced interpretations of the concepts 'clean' and 'unclean' that are closely related to the desired behaviour

Reflection on theoretical contribution II

We analysed the results of design phase II in relation to the themes from Table 2, resulting in an iteration and expansion, as outlined in Table 4.

Within the dimension of *motivation*, we refined our understanding of subjective interpretations of concepts. This resulted in two distinct categories reflecting participants' diverse explanations for why certain behaviours were considered clean or unclean. The first, 'Professional values', refers to one's values as a professional on duty. The second 'Individual values' refers to one's personal values. One can manifest professional values in non-professional situations and individual values in professional situations. There were no clear reasons for what set of values would dominate in any given situation involving a staff member. For example, many participants explained they were more attentive to hygiene in their personal lives because they considered it extremely important, thus manifesting professional values in their personal lives. Others explained they would bring values such as demonstrating closeness even when required to observe social distance within the NH environment, as one participant expressed:

> They also need somebody contact without it becoming too sterile. It is the citizen's own home. (Participant 04)

Within the dimension of *capability*, we confirmed the category 'Multiple experiences' with additional evidence and we identified new categories. The first 'Skills to perform a behaviour' refers to the multiple levels of experience, training, and instruction to perform and identify the need to perform a behaviour. The second 'Evaluation of rules' refers to one's evaluation of how possible and feasible it is to comply with a rule. The following quote exemplifies how some participants perceived rules:

> Well, it can be that when I put someone on the toilet, I might not have just put gloves on and get pee on my fingers. (…) I am not so hysterical about that. It can be washed. (Participant 02)

Within the dimension of *opportunity*, additional evidence confirmed the two categories previously identified. Further, we identified four new categories. The 'Interaction with others' and 'Dynamics of power in the environment', refer to factors in the social environment that impact intentions to perform behaviours. For example, when a care worker interacts with a resident, they need to adjust their notions of power to administer medicine at the prescribed hour and yet not be invasive, according to the residents' individual standards of privacy. For example, participant 04 expressed how she dealt with residents' right of self-determination.

> (…) One of our most important tasks is their right of self-determination. So they are allowed to decide for themselves about their lives and what they want. (participant 04)

There are no wrong or right answers; one needs to evaluate the situation and form a notion of how to respond to each situation. The categories 'Information available in the environment' and 'Lack of resources' refer to actors available in the physical environment. For example, a care worker needs to be attentive to hygiene; however, if there is a staff shortage or limited time to perform a task, this might affect the intention of performing hand sanitation according to the guidelines, and care workers might perceive it as a behaviour that is not feasible to achieve.

Finally, we identified the dimension 'Indication of multiple intentions'. This refers to participants responses that indicated multiple interpretations of central ideas relating to desired behaviours, with multiple dissonant notions of what an appropriate behavioural response to a situation should be.

This data raised the question of what other insights could be identified if participants were presented with contextualised everyday situations in nursing homes. Thus, we formulated RQ3 as: *What factors shape multiple interpretations of situations in which an intervention is expected to change behaviours*?

Design phase III – revealing multiple perspectives

In the third phase of the process, the design team aimed to understand what shaped interpretations of situations when participants were exposed to reduced levels of ambiguity. To do that, the design team iterated on an activity in three rounds.

First, to sensitise participants, they were invited to provide examples of diseases that could be transmitted through different types of transmission routes. Second, to understand

Table 5. Example of situations described on flash cards and how these situations were enacted and contextualised on video clips.

Situation described on flash cards	Situation enacted in the video clip
Preparing food in the kitchen	A worker does not perform hand hygiene before preparing food
Putting on protective equipment (gloves, apron, etc.)	A worker picks his nose and does not clean his hands before putting on gloves and dealing with food
Putting on protective equipment (gloves, apron, etc.)	A worker is putting on gloves in a manner that can lead to the spread of infect
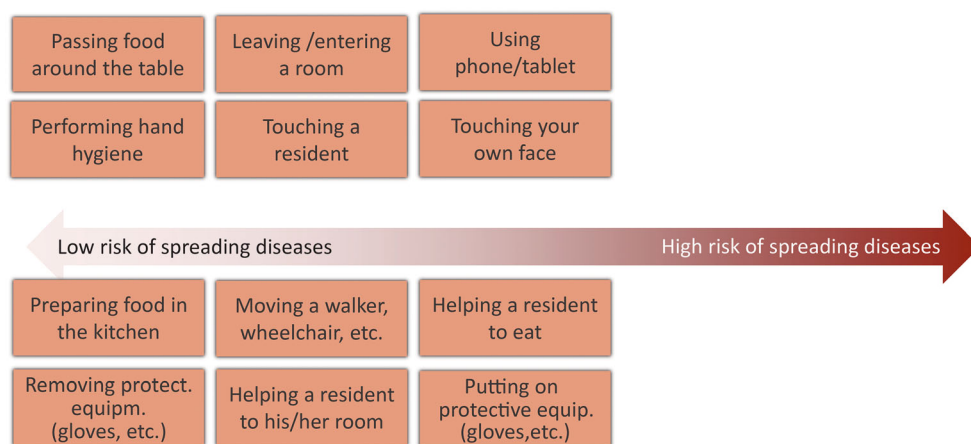
Figure 4. Example of flash cards and axis used during the activity.

the factors driving their interpretations of behaviours as adequate (low risk of transmitting infections) or inadequate (risk of transmitting infections), the design team showed participants video clips that depicted the situations previously described on flash cards (see Figure 3 and Table 5). This included enacting interactions with residents and other care workers in scenarios (e.g. kitchen) and moments (e.g. mealtime) when these situations occurred in NHs (see Table 5).

The design team then asked participants to stop the video every time they spotted a situation they considered 'risky', meaning an inadequate behaviour, and asked the participants to explain why they considered that situation risky. Finally, to capture a nuanced perspective on the situations, they asked each participant to create their own definitions of the situation enacted in the videos, described on flash cards, by placing the cards on an axis with 'low risk of spreading diseases' on one end and 'high risk of spreading diseases' on the other (see Figure 4).

Design phase III output

The output of the above design work highlighted that participants were able to identify most of the behaviours connected to risks of spreading infections enacted in video clips and achieve similar answers regarding identifying and considering certain behaviours as 'risky'. Still, there were different interpretations of which behaviours were inadequate. Further, the final part of the design phase showed that participants maintained diverse interpretations
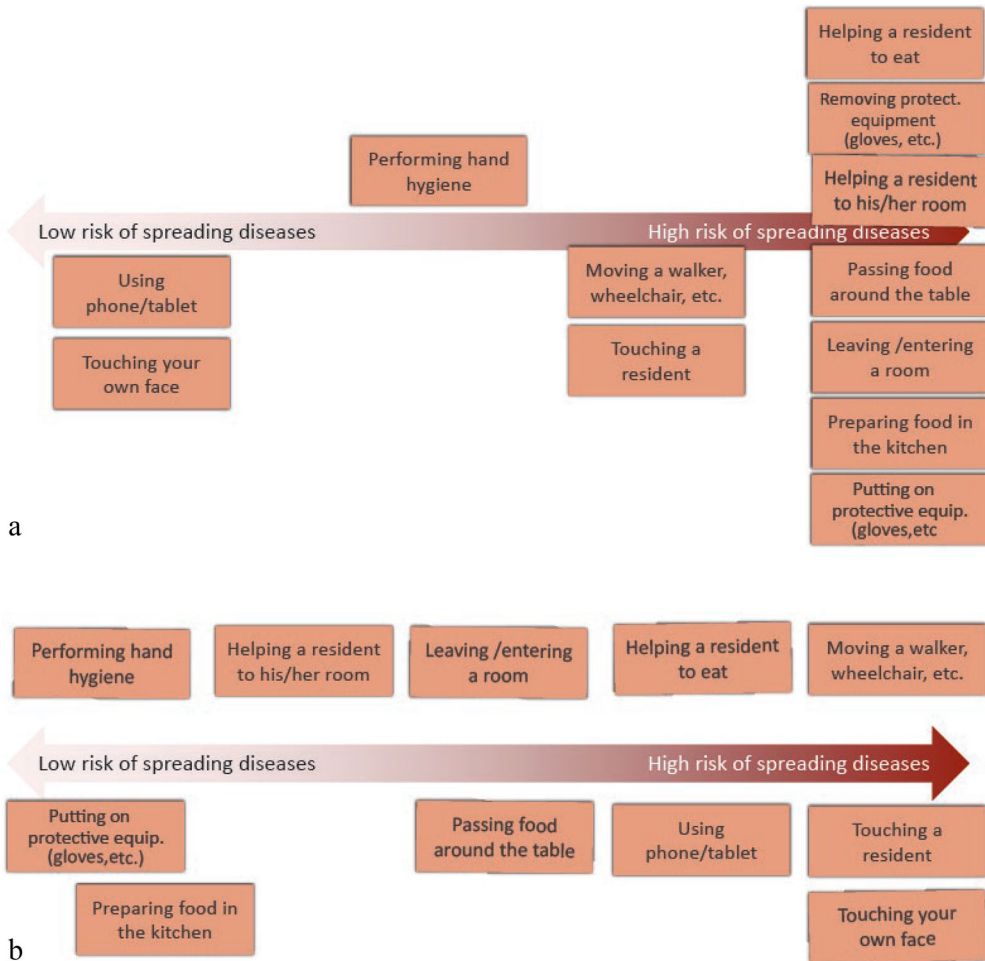
Figure 5. Example of participants responses during Round 03.

of the situations described on flash cards as 'risky' and 'not risky' even after watching these situations contextualised in video clips (see Figure 5).

Reflection on theoretical contribution III

We analysed the results of design phase III in relation to the themes from Table 3, to develop a final iteration of our analysis as outlined in Table 6.

First, we characterise *ambiguity in motivation* as the capacity to accommodate dissonant values within one's motivation. This dissonance is shaped by differing 'Individual values' and 'Professional values' and potential conflict between them. The data shows that, when responding to a stimulus, one can recall individual values and, at other times, recall professional values, and it is uncertain which will be emphasised in any given situation.

Second, we characterise ambiguity in capabilities as the capacity to accommodate 'Ambiguity in know-how' and 'Ambiguity in the decision processes' in one's capacity to respond to a stimulus. 'Ambiguity in know-how' refers to the ability to accommodate

Table 6. Final structure.

Dimensions	Theme	Category	Description
Ambiguity in Motivation	Ambiguity in values and identities	Professional values	Principles, beliefs, and standards that guide what individuals within a specific profession consider important
		Individual values	Individual principles and beliefs, that guide what individuals consider important in life
Ambiguity in Capability	Ambiguity in know-how	Multiple levels of experience	People within the same group of professionals have diverse levels of experience in responding to specific situations and performing behaviours
		Skills acquired through education to Perform a behaviour	People within the same group (e.g. same professional group) have diverse levels of training to responding to specific situations and performing behaviours
	Ambiguity in the decision process	Evaluation of rules	People subjectively assess if rules are feasible to comply with and if the rules are crucial or just a formality
		Perceptions of risk in the environment	People subjectively assess the risks of harming oneself or another person for a given situation
Ambiguity in opportunities	Ambiguity in the social environment	Trust and distrust in others	People speculate whether it is possible to trust that another person has performed or will perform an action that impacts a situation relevant to them. For example, a person may consider an object clean, because she trusts that a colleague has cleaned that object before
		Interactions with others	People interpret a situation and how they believe they should act according to whom they are interacting with. Interactions can encourage or discourage desired responses to a stimulus
		Dynamics of power in the environment	One's perception of one's power in a situation can encourage or discourage desired responses to stimuli
	Ambiguity in the incentive structure	Information available on the environment	The environment provides cues that encourage one's responses to stimuli
		Lack of resources	A scarcity of resources discourages behaviours simultaneously encouraged by other environmental cues
		Organisation's mission	The mission of an organisation serves multiple stakeholders, thus it accommodates ambiguous interests
		Societal pressures	The societal context adds pressure that can reinforce or weaken the strength of other categories
		Diverse interpretations of concepts related to desired behaviours	Participants have diverse and nuanced interpretations of concepts that are closely related to the desired behaviour
Multiple responses	Diverse interpretations	Diverse interpretations of situations	People can interpret and respond differently to the same situations.
		Diverse interpretations of concepts related to desired behaviours	People can have diverse and nuanced interpretations of concepts that are closely related to the desired behaviour

diverse levels of skills acquired through education and diverse levels of skills acquired through experience to perform a behaviour. The data shows that within a homogenous group of people (e.g. people with the same professional profile and education), individuals may show substantial differences in knowledge, for example differences in theoretical knowledge about a topic central to responding to stimulus (e.g. infection routes). Similarly, within the same group, individuals may show substantial differences in level of experience related to responding to a stimulus (e.g. recognising a potential risk of transmission). It is uncertain whether the skills acquired through education are more dominant in responding to a stimulus compared to one's previous experiences.

'Ambiguity in the decision processes' refers to the dissonance between one's 'Evaluation of rules' and one's Perceptions of risk at the moment' driving one's capacity to decide. The data shows that, when responding to a stimulus, one's evaluation of risks interferes with one's evaluation of whether it is critical to comply with the rules. For example, when one judges that the situation offers low risks of harming oneself or another person, one might bend the rules. It is uncertain how one assesses the risk in the moment and, consequently, decides to follow or bend the rules.

Third, we characterise *ambiguity in opportunities* as the capacity of accommodating 'Ambiguity in the social environment' and 'Ambiguity in the incentive structure' within the external factors that make one's behaviour possible. 'Ambiguity in the social environment' refers to the interaction between: 'Dynamics of power in the environment', 'Interactions with others' and 'Trust and distrust in others.' The data shows that, adjusting behaviours according to whom one interacts with, and how one trusts their peers, create diverse notions of how one believes one should act and expect others to act. 'Ambiguity in the incentive structure' refers to the interaction between 'Information available on the environment', 'Lack of resources', 'Organisation's mission' and 'Societal pressures'. The data shows that these categories shape an incentive structure that can simultaneously hinder and provide opportunities to perform a behaviour.

Finally, we characterise *multiple responses* as the responses that follow dissonant interpretations of situations. This dissonance is shaped by 'Diverse interpretations of concepts related to desired behaviours' and 'Diverse interpretations of situations'. The data shows that participants with the same training use assumptions about the context when interpreting the same concepts and situations presented. It is uncertain what assumptions one will make when forming an interpretation that will shape one's intention to respond to a stimulus.

To conclude, our analysis of the data gathered during the third design phase refined our understanding of different dimensions of ambiguity linked to the COM-B model. We advanced our understanding of categories that shape distinct themes of ambiguity within each dimension of the COM-B model. We also identified how the interplay between these categories shapes ambiguity in each dimension and results in multiple intentions of how to behave.

Discussion

In this paper, we explored ambiguity in behavioural design. To do this, we analysed data collected through a Research through Design process involving a participatory approach to investigate ambiguity in behavioural design and we answered the central research
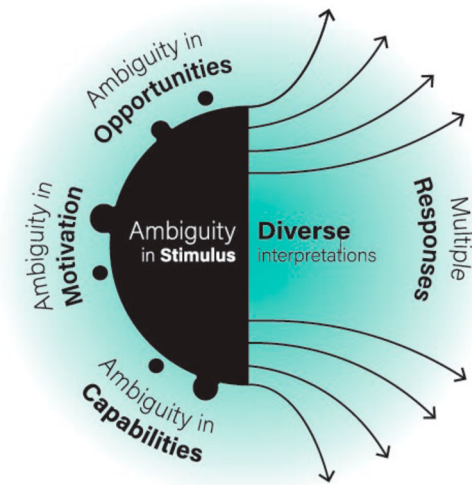
Figure 6. Ambiguity in behavioural design (ABD) framework.

question: 'How to understand ambiguity in BD'. Contrasting our results with our initial conceptual framework (see Figure 1), we: (1) propose a theoretical basis for understanding the role of ambiguity in behavioural design, which extends the widely adopted COM-B model, (2) through this, we advance understanding of how heterogenous behaviours can emerge when there is ambiguity in the stimuli and conditions that precede behaviour.

Ambiguity in behavioural design

Based on our analysis, we contrast our findings with our initial conceptual framework (Figure 1) and introduce ambiguity as a major element in the conditions for behaviours to happen and in the stimuli to provoke behaviour change. This has significant implications on stakeholders' intentions. As such, we understand Ambiguity in behavioural design as:

> The existence of dissonant conditions and perspectives on situations and behaviours that result in heterogeneous responses to a designed stimulus.

The crucial point here is the existence of multiple perspectives and dissonance in conditions for behaviours to occur and in the stimulus itself, which have not been addressed by previous work in the behavioural design field (e.g. Basso and Krpan 2023; Fogg 2009; Michie, van Stralen, and West 2011). We bring the insights from this case analysis together and propose a framework to understand ambiguity in behavioural design (Figure 6) as well as support designers in inquiring and exploring ambiguity when designing for behavioural change.

The ambiguity in behavioural design (ABD) framework

To develop the ABD framework, we integrated the empirical findings of the case study with theoretical insights from the behavioural design literature, specifically building on the COM-B model. This framework advances understanding of ambiguity in behavioural

design and helps explain possible outcomes of behavioural interventions when considering sources of ambiguity and ambiguity in the behavioural intervention.

We structured the framework in three distinct parts. First, we link ambiguities found in the context (*Ambiguity in opportunities, motivation,* and *capabilities*), to *Ambiguity in stimulus*. Here, there is an interplay between these elements in a given context, shaping the relationship between the individual and the stimulus. Following Michie, van Stralen, and West (2011), we do not attribute dominance to any one of these conditions, instead it is the interaction between each component that shapes the conditions for a behaviour to occur. However, we do identify types of ambiguity in each condition. *Ambiguity in motivation* emerges from the simultaneous existence of differing values, in our case 'Professional values' and 'Individual values'; that is, people hold sets of values that are often differently directed and even conflicting in a given situation. *Ambiguity in capabilities* emerges from differing knowledge, in our case 'Ambiguity in know-how' (e.g. responding to a given situation with conflicting or dissonant knowledge acquired through education or experience) and in 'Decision processes' (e.g. assessing simultaneously the need of complying with rules and the risk that a situation presents requiring deviating actions). Finally, *Ambiguity in opportunity* emerges from differing ambitions in the social environment and in incentive structures.

Second, *Ambiguity in stimulus* emerges from designed stimuli and their property to accommodate and facilitate multiple perspectives and interpretations. Here, the relationship between the stakeholder and the stimulus, interacts with *ambiguity in opportunities*, in *motivation* and *capabilities*, and shapes the mechanism of action as responses to ambiguity. This mechanism results in multiple, different responses of participants driven by their 'Diverse interpretations' of the stimulus. Hence, the three types of COM-B related ambiguity interact with *Ambiguity in stimulus* to shape diverse interpretations. We visualise these three distinct mechanisms in Figure 6.

Overall, our proposed framework introduces ambiguity as an important element necessary to understanding behavioural responses and hence essential to the practice of design for behavioural change. As such the Ambiguity in Behavioural Design (ABD) framework (Figure 6) and its elements extend current understanding of the emergence and impact of ambiguity in behavioural design.

Implications for theory and methodology

Our work has four main implications for theory and methodology, which we will discuss here. First, our proposed framework (Figure 6) advances understanding of ambiguity in behavioural design and paves the way for theory building. Typically, approaches to behavioural change (e.g. Fogg 2009; Michie, van Stralen, and West 2011) do not integrate or address the existence of ambiguity. For example, although the COM-B model, used to understand behaviours, mentions that capability, motivation, and opportunity can be broken down into more categories (e.g. motivation can be divided into reflective and automatic motivation), it does not mention the impact of the existence of ambiguity in or across these subcategories nor in the possible responses to behavioural interventions. Instead, the model aims to help behavioural designers to map behavioural components, by having a well-defined behavioural target as a starting point. In contrast, we showed that each dimension is ambiguous by containing one or more categories that can have contrasting directions, which impact what responses one may expect from an intervention. For

example, one's motivation can be driven by professional or individual values that can both co-exist and contrast, and it is uncertain which set of values will dominate when responding to a stimulus. Further, we showed that it is necessary to explore and accept ambiguity when addressing a behavioural challenge, conflicting with the common aim to achieve a single well-defined characterisation of a situation and behavioural target. In this aspect, our work aligns with (Bay Brix Nielsen, Cash, and Daalhuizen 2024) in acknowledging the importance of embracing the wickedness of behavioural problems and investigating them with, for example, design methods that allow for the simultaneous evolution of understanding of the behavioural challenge and possible solutions.

Second, acknowledging how ambiguity in people's perceptions of a stimulus results in different responses and intentions, positions ambiguity as a property of the artefact that impacts intended behavioural change and cannot be detached from it. Here, our findings significantly reframe previous studies, which have shown how ambiguity in a design artefact opens the doors to multiple interpretations and responses (Boon, Rozendaal, and Stappers 2018; Gaver, Beaver, and Benford 2003; Sengere and Gaver 2006). This also contrasts with traditional approaches to behavioural change that assume predictable and singular courses of action in response to interventions (e.g. increasing the number of times one uses a sanitiser dispenser). Instead, we showed that interventions may lead to different courses of action, which emerge from the user-stimulus interaction and the interplay between the various ambiguities in Figure 6 and corresponding diverse perceptions of the user. Here we highlight that further work is required to explore the impact of multiple responses in systems and the ripple effects of such variability of outcomes across systems. In terms of methodology, recognising the role of ambiguity and the diversity of behavioural outcomes challenges conventional linear behavioural design models (e.g. Fogg 2009; and Michie, van Stralen, and West 2011) and underscores the importance of adopting a systems-thinking perspective. This aligns with recent efforts to integrate socio-ecological frameworks with behaviour change strategies (e.g. De Salas et al. 2022; Veer, Golf-Papez, and Zahrai 2019), which may be particularly important in addressing complex challenges in product-service systems (PSS), such as promoting sustainable consumption or reducing the prevalence of non-communicable diseases.

Third, recognising multiple courses of action as a result of interventions suggests that traditional evaluation methods of interventions may fail, or be insufficient, when applied to complex contexts. This calls for more nuanced approaches to evaluation capable of capturing a broader spectrum of outcomes. For example, it is recognised that current evaluation methods often overlook unintended effects such as risk compensation and rebound effects (Papaioannou et al. 2024). It also points to the need for further research into adaptive and iterative design approaches, particularly in interventions such as product-service systems (PSS) aimed at promoting specific behavioural outcomes. These approaches must accommodate diverse behavioural patterns and adapt to contextual changes over time. While recent work has explored user-friendly, adaptive service systems (e.g. Wang and Jiao 2022), current research often focuses on well-defined problems (e.g. increasing the value a customer gives to a restaurant). There remains a critical gap in extending these adaptive design methodologies to more complex challenges, if the field of behavioural design aims to tackle domains like healthcare and sustainability. In sum, this work underscores the importance of iterative development and real-world testing to account for diverse user responses and

contextual variability, offering a direction for future methodological research in behavioural design.

Finally, given that ambiguity is an integral part of ill-defined and wicked problems (Rittel and Webber 1973), our work takes a step forward in exploring ill-defined problems within the behavioural change field and linking fundamental understanding of design to applications in behavioural design. This contrasts with previous work which typically deals with well-defined behavioural problems (e.g. Caris et al. 2018; Gaube et al. 2021), downplaying individual perspectives (Ogden 2016), and approaching ambiguity as a hindrance to interventions' success (e.g. Lorencatto et al. 2018; Moore et al. 2015) or a problem that can lead to human error (Gurses et al. 2008; Spear and Schmidhofer 2005). Instead, our work offers arguments for framing behavioural problems as inherently ill-defined and complex. This adds to previous work that advocates for acceptance of complexity in the behavioural change field (Bay Brix Nielsen, Cash, and Daalhuizen 2024; Schmidt 2019; Schmidt and Stenger 2021). Further work is needed to explore how the integration of design methods and a design mindset in behavioural design may contribute to dealing with ambiguity in behavioural change.

Implications for practice

Our work has three main implications for practice. First, our proposed framework (Figure 6) supports designers in investigating and understanding ambiguity when designing for behavioural change. Specifically, designers should renounce the idea of 'solving' ambiguity and, instead, build comfort with it. In this work, we identified *Ambiguity in motivation*, *Ambiguity in opportunities*, *Ambiguity in capabilities,* and *Ambiguity in stimulus*, thus situating ambiguity as integral to understanding both the problem behaviour as well as responses to any intervention. This needs to be acknowledged and managed by behavioural designers.

Second, our work showed the importance of investigating multiple contextual conditions and diverse perspectives towards behavioural problems and embracing their fuzziness. Behavioural designers should therefore consider involving users in investigating the multiple facets of a behavioural challenge. This could be achieved through participatory methods and forms of 'making' (Sanders and Stappers 2014) as ways to elicit diverse insights and ambiguities early in the behavioural design process. Refraining from striving toward a single definitive and unambiguous characterisation is critical to addressing behavioural challenges that are entangled with complex social problems. This demands that designers reframe challenges multiple times, use methods to elicit stakeholders' perspectives, and plan time to explore, understand, and document ambiguities in the challenge. This strongly connects with general discourse on the importance of reframing in design (Tromp and Hekkert 2018).

Finally, our work shows that behavioural designers should avoid fixating on a single course of action as a response to a behavioural intervention. Rather they should consider how they can curate a variety of responses that are all desirable by accounting for the ambiguities in the situation. Understanding variability not as a failure of an intervention but rather as a consequence of ambiguity requires that designers refrain from taking a single course for 'solving' behavioural challenges and, instead, conceptualise strategies involving multiple interventions to address such challenges considering real world scenarios. Examining, evaluating, and validating solution directions with users may be necessary to anticipate possible responses and design interventions that users consider acceptable.

Limitations

Our work has advanced the understanding of ambiguity in behavioural design, yet it is essential to discuss the limitations of this study. First, the focus of this work in understanding ambiguity demanded the selection of a case study held in a highly ambiguous context and a with specific profile of participants, which limits the insights regarding the specific instantiations of the ambiguities identified. Selecting such a case has been crucial for an intensive study of ambiguity, for revealing insights regarding ambiguities found in the context, and in tracing the impact of these ambiguities on responses to stimuli. This has allowed us to take a step forward in understanding the general mechanisms of ambiguity in participants' responses, but also highlighted the need for further research in this area. To refine and deepen this understanding research may benefit from study cases held in different ambiguous contexts and involving different sets of participants. Further, future research may use empirical testing, for example, testing the impact of exposing participants to ambiguous interventions (e.g. Boon, Rozendaal, and Stappers 2018) in ambiguous contexts (e.g. kindergartens) to help examine the causal linkages between ambiguity and response. Exploring these linkages in real-world settings is particularly important to account for diverse user responses and contextual variability, which is typically found in, for example, systems designed to encourage sustainable habits of consumption (e.g. product-service systems that encourage reducing energy consumption), health related behaviours (e.g. remote monitoring of patients) and other contexts that demand considering different contextual perspectives regarding the problem and possible desirable solutions.

Second, we draw on the COM-B model to elaborate our conceptual framework. As such, we limit our proposed framework to ambiguities identified within the dimensions of the COM-B model. Although this is widely used as an aid for structuring the underlying conditions for behaviours (e.g. Chater et al. 2023; Essack and Sartorius 2018), previous works have shown that combining elements from behavioural models may offer rich insights regarding understanding behavioural drivers (e.g. De Leo et al. 2021). While our work highlighted the need to understand the implications of ambiguity in other elements of behavioural design, such as the stimuli and the range of user responses, future research could expand the theoretical and empirical scope to explore how these findings might connect to other models used in behavioural design.

Conclusion

In this paper, we proposed a theoretical framework for understanding the role of ambiguity in behavioural design. This helps to explain how ambiguity can lead to heterogeneous behavioural responses (Figure 6). To structure our inquiry, we used the COM-B model as a starting point for our investigation. We analysed data collected in a case context characterised by pronounced ambiguity. A thematic analysis of the data collected revealed themes that demonstrate how ambiguity is present in conditions for behaviours to occur and in the stimulus, as well as how these ambiguities drive heterogeneity in participants' responses. Our key findings are summarised in Table 5, encompassing four primary dimensions: *Ambiguity in motivation*, *Ambiguity in capabilities*, *Ambiguity in opportunities*, and *Multiple responses*. These findings build on our understanding of ambiguity as illustrated in the *Ambiguity in Behavioural Design* (ABD) *framework* (Figure 6).

The ABD framework integrates the empirical findings of our study and theoretical insights from the behavioural change literature. It conceptualises our understanding of the emergence of ambiguity in conditions for behaviours to occur (*Ambiguity in motivation, Ambiguity in capabilities, Ambiguity in opportunities*), in the stimulus (*Ambiguity in stimulus*), and the impact of ambiguity in responses to ambiguous stimuli (*Multiple responses*).

Finally, the framework (Figure 6) and findings (Table 5) highlight how understanding of ambiguity has several critical implications for behavioural design theory, methodology, and practice, when considering ill-defined behavioural problems that involve multiple perspectives. Our work, thus, provides a foundation for understanding ambiguity in behavioural design and highlights the need for understanding and managing ambiguity when designing for behavioural change and considering the outcomes of behavioural interventions.

Disclosure statement

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