Guidance through the jungle of behavioral science theories, models, and concepts for non-behavioral scientists

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ABSTRACT
Interdisciplinary research is becoming increasingly important to tackle complex problems such as climate change. Human behavior is one key factor that needs to be considered to find solutions to these complex problems. Working in an interdisciplinary field requires scientists to engage in tedious studies of disciplines that are beyond their core expertise. This is also true for the selection of behavioral science approaches best suitable for the research question at hand. To provide a concise introduction to behavioral science, this article provides four clusters of behavioral science approaches. These four clusters, in conjunction with the further developed 4 DBC framework, can assist the analyst in systematically selecting the most suitable behavioral science approach. To illustrate the application of the framework, the examples of cycling and Practice Theory are used.

Introduction

Sustainability research calls for interdisciplinarity (Bettencourt & Kaur, 2011; Pezzey, 1992; Shahadu, 2016) and it is acknowledged that understanding human behavior is key to achieving a sustainability transition (Akenji et al., 2019; De Coninck et al., 2018; Kuhnenn et al., 2021; Newell, Daley et al., 2021; Nielsen et al., 2021; Williamson et al., 2018). Researchers engaging in interdisciplinary research might be confronted with a scientific field they have no background in (Spalding et al., 2017). Finding out which theory, model, or concept to use within a certain scientific field might be a difficult and time-consuming endeavor (Wallnoefer & Riefler, 2021). This also applies to (environmental) behavioral science, which is itself an interdisciplinary field (a. G. Miller, 1995; Gintis, 2007; Günther, 2009; Kwon & Silva, 2020). Though even within the field of sociology or psychology, there is a great number of theories, models, and concepts one has to navigate through (Darnton, 2008; Jackson, 2002).

This article aims to provide guidance to those researchers who need to navigate through the jungle of behavioral science approaches but have no background in this field. Overviews of behavioral science models already exist. Darnton (2008) reviewed more than 60
behavioral (change) models. Jackson (2002) focused on behavioral (change) models from the consumer perspective. Kwon and Silva (2020) also review more than 60 theories and provide a sophisticated categorization of those theories. A shorter overview, which culminated in the development of a new behavioral model, has been provided by Kollmuss and Agyeman (2002). Similarly, Williamson et al. (2020) provide their own behavioral change model after reviewing some other approaches. Tian and Liu (2022) provide an overview of the most relevant theories for pro-environmental behavior. Heimlich and Ardoin (2008) review ten behavioral change models relevant to environmental education. Recently another working paper summarizing behavioral science approaches was published (Biely, 2022). The work by Biely (2022) builds on the work of Darnton (2008) and Jackson (2002), amongst others. However, she further expands on certain aspects such as systems thinking, and practice theory. For a more detailed overview of the most important behavioral science models rooted in psychology, the reader may consult the working papers mentioned above (Darnton, 2008; Jackson, 2002; Kwon & Silva, 2020). Although these overviews exist, it might still be difficult to select the appropriate theories for the research question at hand (Kwon & Silva, 2020). Working through a list of over 60 theories might still be overburdening (Darnton, 2008). That might even be the case if a sophisticated categorization is presented (Kwon & Silva, 2020).

The lack of guidance through the jungle of behavioral models might have the effect that prominent theories are chosen, rather than theories that best fit the research question (Kwon & Silva, 2020). Therefore, this paper provides 1) a further simplification of behavioral science categorizations, and 2) guidance on how to go about finding the theories that best suit the behavior under scrutiny. In this paper, behavioral science approaches are presented in four different clusters to provide a concise overview. This clustered overview is meant to help researchers with their first selection of behavioral science theories, models and, concepts to study in more detail. In the following the term approach is used to capture the terms theories, models, and concepts.

The four behavioral science clusters that are introduced in this paper are based on, and thus limited to, behavioral science approaches that focus on the individual. Hence, for example, group behavior, or the behavior of institutions, or companies is not covered. This paper neither addresses physiological aspects of individual human behavior (see for example: Neil & Melissa, 2016). Furthermore, the approaches covered in this article are, for the most part, connected to psychology and sociology. However, Günther (2009) illustrates that environmental behavioral science consists of many more disciplines. Similarly, Gintis (2007) lists several disciplines that are part of behavioral science. Some of the approaches included in this article capture the diversity suggested by Günther (2009) or Gintis (2007). For, example, education, design, and economics are captured to a certain extent. Additionally, systems science has been included in this article. Gintis (2007) argues that due to the various disciplines dealing with questions of individual behavior, behavioral science is not unified. While he argues for the unification of behavioral science (see also, a. G. Miller, 1995; Thoits, 1995), others (Bolton, 1963) argue to appreciate the differences between the respective discipline’s views on behavior. These differences relate to the framing of behavior itself. In psychology, behavior might be framed as something reactive, learned, observable, and predictable. In sociology, behavior might be understood as an interaction between individuals, emerging from
and creating circumstances. It might be understood as a constantly evolving act, which in turn makes predictability difficult.

However, these relevant ontological differences are not further discussed in this paper. Such a discussion would require in-depth knowledge of behavioral science. Though, the target group of this paper are researchers who do not have such knowledge. Furthermore, the paper attempts to not apply a disciplinary lens to behavioral science. That is to support interdisciplinarity and to approach the analysis from the behavior under scrutiny rather than from a predefined ontological perspective.

As stated, this article provides four clusters of different behavioral science approaches. Approach does not refer to a specific discipline, but rather to the angle through which human behavior can be understood and analyzed. For example, is behavior understood as a mechanistic linear process, or part and result of a web of interwoven factors? It needs to be pointed out that others may cluster the various behavioral science approaches differently. The structure chosen for this paper is based on a similar clustering found in literature reviewing behavioral science models (Bögel & Upham, 2018; Darnton, 2008; Jackson, 2002; Schill et al., 2019; Steg & Vlek, 2009). Furthermore, this paper does not aim at making any statement about the superiority of one approach over another. Human behavior is complex, and no approach will be able to fully reflect this complexity (Kasper, 2009; Kollmuss & Agyeman, 2002). Even if a model reflecting the whole complexity of human behavior existed, it may no longer be operationalizable. Nevertheless, it is still possible to combine some approaches or specific elements from different approaches. Which approaches to connect is a choice guided by the analysis one wants to undertake.

To refer to the (in-)compatibility of different disciplinary approaches within behavioral science, some may argue that, for example, a sociological model should not be combined with a psychological model of individual behavior (Gintis, 2007). Whether this should be done is not the subject of this paper. Discussions of the benefits of combining different disciplines can be found elsewhere (Cinner, 2018). The paper merely aims to outline different clusters to provide a starting point for a scientific inquiry into human behavior.

Chatterton and Wilson (2014) have developed a framework to support the selection of behavioral interventions. They differentiate among four dimensions: actor, domain, durability, and scope. Each of the four dimensions is further segmented into five specific levels. A specific behavior, such as taking the bike for the commute, can be matched with the respective relevant fields within the framework to identify which characteristics a behavior has. Once identified, this can assist in selecting the appropriate behavioral intervention addressing all relevant levels. The framework by Chatterton and Wilson (2014) is not intended to support the selection of behavioral science approaches. Nevertheless, their framework could be a useful starting point for selecting suitable behavioral science theories, models, or concepts. Building on the work of Chatterton and Wilson (2014), their framework is combined with the four behavioral science clusters introduced in this paper. Combining these two supports the selection of an approach that best fits the behavior under scrutiny and the research goal at hand. Once a fitting cluster has been identified, the framework also helps to select suitable behavioral science theories, models, or concepts. It needs to be highlighted that the aim of this paper is not to suggest which behavioral science approach one has to choose when aiming to study a specific behavior. For example, Kurz et al. (2015) explain that habits can be understood from a psychological or a sociological perspective. As noted above, human
behavior is complex, and no approach will capture all aspects of human behavior. Accordingly, the choice of a behavioral science approach depends on the aspects of the respective human behavior one wants to study as well as on the research goals.

In the next section, the method applied to gather the necessary literature is outlined. Then the categorizations of behavioral science found in the literature are provided. Thereafter, the four behavioral science clusters derived from literature are introduced in more depth. In section five, these four clusters are then combined with the framework developed by Chatterton and Wilson (2014). In the same section, the application of the extended framework is outlined. Section six summarizes the contribution of this paper in concluding remarks.

**Method**

To cluster different behavioral science approaches, the literature describing different types of behavioral science approaches was reviewed. The aim was not to build the clusters from scratch but rather to rely on existing categorizations of behavioral science approaches. Thus, the starting point was literature that already provides some overview and categorization of different behavioral science approaches. This body of literature should also connect to sustainability science in the broadest sense. Furthermore, since the goal of this paper is not to be limited to one discipline, the literature should at least partly transcend disciplinary confinements.

It was attempted to perform a systematic literature review starting with a search query on Web of Science. However, this approach has proven to not be successful. The search query was limited to review papers, and different search terms have been tested, such as: behavioral models, behavioral theories, behavior AND sustainability, or pro-environmental behavior. Additionally, different configurations have been tested, such as limiting the query to Web of Science categories (e.g. behavioral science, environmental science, social science interdisciplinary). Most results did not provide an overview of behavioral science approaches. Several papers provide a review of factors influencing behavior (Farrow et al., 2017; Li et al., 2019, Yamin, Fei et al. 2019). Some papers found in the query were reviews of behavioral theories. Though the models either focused on one discipline (e.g. psychology (Han, 2021)), or behavioral models were looked at from a specific angle (e.g. design (Coskun et al., 2015)), or the categorization pertained to different types of behaviors (Lange, 2022). Other papers found, highlight the general importance of behavioral science for sustainability (Fischer et al., 2012). Two papers (Kwon & Silva, 2020; Tian & Liu, 2022) were identified using the Web of Science database. The rest of the literature was found via Google Scholar and snowballing (Jalali & Wohlin, 2012; Wee & Banister, 2016).

The work of Darnton (2008) and Jackson (2002) was found using Google Scholar. This literature has been of great value in two ways; 1) they provide an extensive overview of behavioral models, 2) they provide a starting point for snowballing. Darnton (2008) reviews more than 60 different behavioral science models. Similarly, Jackson (2002) reviews a great number of behavioral science models but from a consumer behavioral perspective. Other literature (Bögel & Upham, 2018; Klaniecki et al., 2018; Schill et al., 2019; Steg & Vlek, 2009; Wallnoefer & Riefler, 2021) that reviews and clusters behavioral science approaches have been added through Google Scholar searchers.
To gain a better understanding of the behavioral science approaches that were reviewed and clustered within this body of literature, specific literature about these approaches was consulted. Snowballing was the main method applied. Though targeted Google Scholar searchers were also conducted.

**Literature clustering behavioral science approaches**

The clusters presented in this paper are based on similar categorizations found in the literature. Table 1 provides an overview of the four different clusters, together with key concepts and a visual representation. Darnton (2008), as well as Jackson (2002), to some extent, structure the reviewed behavioral science models into four categories; linear, closed, habitual, and contextual. However, these clusters, as well as the approaches therein, are explored to different degrees. For example, Jackson (2002) hardly discusses Practice Theory.

Similar clusters can be found in a paper by Steg and Vlek (2009). They differentiate between 1) Perceived costs and benefits, 2) Moral and normative concerns, 3) Affect, 4) Contextual factors, and 5) Habits. In this article, the first three categories used by Steg and Vlek (2009), are summarized in linear approaches. The finer differentiation within the linear behavioral science cluster by Steg and Vlek (2009) can be explained by them having a greater focus on one discipline (psychology). A similar categorization can also be found in the review article by Bögel and Upham (2018), who also focus on linear approaches. Reviewing the role of human behavior for sustainability transitions, Kaufman et al. (2021) distinguish between rational one-off (linear) and habitual, repeated behavior. They also identified behavior related to a specific context. Though these behaviors are further distinguished in deliberate and automated behaviors.

Schill et al. (2019) categorize behavioral science approaches, without focusing on linear approaches. They distinguish between 1) homo economics and quasi rationality-focused approaches (linear), 2) context-focused approaches, and 3) adaptive systems

**Table 1. Categorization of behavioral science approaches.**

| Behavioral science approaches | Key concepts | Graphic representation |
|------------------------------|--------------|------------------------|
| Linear                       | Rationality, information, motivation, utility, economics, psychology, heuristics, atomistic, isolated behavior | ![Linear Diagram] |
| Context                      | Context, structure, agency, sociology, reciprocity, embeddedness, hierarchy, interdisciplinary, practice, habitus | ![Context Diagram] |
| Closed                       | Circularity, feedback, connectivity, systems thinking, leverage points, complex, learning/(self-)reflection | ![Closed Diagram] |
| Habits                       | Repetition, pattern, routine, lock-in, heuristic, automation, cue | ![Habits Diagram] |
suitable mechanisms. Tian and Liu (2022) differentiate between pro-environmental behavior theories within psychology, sociology, and economics. Kwon and Silva (2020) review more than 60 behavioral science theories and provide a sophisticated categorization of those. They apply an interdisciplinary approach, though most of the theories they found belong to psychology or economics. Despite their valuable contribution they point out that the selection of appropriate theories remains difficult as guidance is lacking.

Wallnoefer and Riefler (2021) have developed a taxonomy to classify pro-environmental behaviors. Similarly, to the goal of this paper, their taxonomy aims to help guide researchers find the appropriate constructs to study a specific behavior. Though they mostly focus on behavior from a psychological perspective. The overview provided in this paper transcends disciplinary confinements. Furthermore, by combining the clusters with the 4 DB framework, researchers are not only equipped with a broad categorization of behavioral science approaches, they also get guidance on how to select suitable approaches based on the characteristics of the behavior under scrutiny.

While some (Schill et al., 2019) may prioritize one vantage point to analyze and frame human behavior, such a prioritization is not the aim of this paper. Here, it is argued that the appropriate analytical approach will depend on the behavior under scrutiny and the respective research question. The aim is to provide a broad perspective on behavioral science approaches organized in four clusters.

Compared to the disciplines contributing to environmental behavioral science identified by Günther (2009), the clusters of behavioral science approaches provided in this paper are still somewhat limited. The clusters incorporate aspects of psychology, economics, sociology, learning theory, and systems thinking. Though, the four different clusters are not distinguished by their disciplinary root. Nevertheless, the disciplinary root influences the way behavior is understood. Hence, some disciplines might be more represented in one of the clusters than in the other ones.

**Behavioral science clusters**

The first cluster of behavioral science approaches introduced in this article are linear approaches. Darnton (2008) refers approaches based on Rational Choice Theory and Behavioral Economics as linear models. The linearity does not necessarily refer to simplicity, as some models are multi-linear. However, what these linear approaches have in common is that they do not include feedbacks. Thus, the models can be depicted as a unidirectional cause and effect chain, usually ending with the behavior. The simplest one might be the Information Deficit model, where information feeds into attitude, which feeds into behavior.

The closed behavioral science cluster describes approaches that include some sort of feedback mechanism. Darnton (2008) covers closed approaches in several sections (self-regulation, change as learning, change in systems). Jackson (2002) focuses less on closed approaches but includes learning theory, which inherently includes some feedback mechanisms. To a certain degree, approaches that capture habits also have commonalities with closed approaches as past behavior affects future behavior. Context-focused
approaches may also overlap with closed approaches since some context approaches emphasize the reciprocal relationship between context and action. It is necessary to point out that the clusters are not describing clear-cut differences between behavioral science clusters. There is considerable overlap between all of them. Still, one may have to approach an analysis from one specific perspective. Thus, one may focus on feedback mechanisms to understand a specific behavior or underlying mental processes (Laland & Brown, 2006; Schaffernicht, 2019; Van Egeren, 2009).

Approaches focusing on habits have been singled out since habits are a specific type of behavior. Though, as stated above, they can be connected to all other clusters or could be understood as a sub-cluster within them (Kurz et al., 2015). For example, linear approaches may include habits (e.g. the Theory of Interpersonal Behavior). Viewed from a context perspective, one may emphasize the structuring aspect of repetitive behavior (Sarigil, 2015) or the specific context in which habits take place (Kurz et al., 2015).

Finally the context cluster focuses on the context in which behavior takes place. Darnton (2008) and Jackson (2002) also address context approaches. Darnton (2008) discussed them in the sections about ‘external factors’, ‘societal factors’ as well as in ‘change via social networks’. Jackson (2002) captures context in the chapter on ‘sociality and self’ as well as in the section on ‘structuration and social practices’.

The distinction between these four clusters (linear, habit, context, closed) has analytical purposes and provides researchers with a lack of behavioral science knowledge with some guidance in the jungle of behavioral science approaches. However, there are not many clean approaches, that only belong to one category. Approaches are historically grown (Darnton, 2008; Jackson, 2002; Kollmuss & Agyeman, 2002), and there has been cross-fertilization between different approaches.

**Linear**

The idea of an individual being a homo economics, thus being a rational utility-maximizing entity, is the basis for many models aiming at explaining human behavior (Darnton, 2008; Heiskanen & Laakso, 2019, Williamson et al., 2020). Predictability of behavior is a main goal of linear behavioral models. Rationality is not necessarily limited to economic utility maximization but can include other cost-benefit considerations as well (Quackenbush, 2004). The assumptions made within linear approaches are simplistic and atomistic (Kasper, 2009). However, this simplicity allows for building more complex models (Darnton, 2008).

Linear behavioral science models can typically be depicted as a linear sequence of factors affecting human behavior. Some of these models are more complex (e.g. Theory of Planned Behavior (Ajzen, 1991), the Values Beliefs Norms Theory (Stern et al., 1999)) than others (e.g. the Information or Knowledge Deficit Model (Owens & Driffill, 2008; Simis et al., 2016)), and some do even include feedbacks (e.g. Model of Pro-environmental Behavior (Kollmuss & Agyeman, 2002)). Apart from the different degrees of complexity (linearity, multi-linearity), one can differentiate between information, motivation, and heuristic-focused models. Though, other differentiations could be made (Steg & Vlek, 2009).
**Information**

Information-focused models are the most basic approaches, assuming that with the provision of information human behavior will change (Heimlich & Ardoin, 2008). This assumption is itself based on the premise that humans always act rationally (Simis et al., 2016). Rational Choice Theory (or Subjective Expected Utility Theory) builds the theoretical foundation for this category of linear models.

However, humans are not always thinking *rationally*, hence information-based models do not necessarily work (Jackson, 2002; Kollmuss & Agyeman, 2002; Verplanken & Whitmarsh, 2021). Accordingly, other factors need to be considered to capture the complexity of human behavior. Motivations are key factors that help understanding human behavior. Another factor are heuristics, which are mental shortcuts, that help to understand the rationally irrational side of human decision-making. Motivation, as well as heuristics, are briefly covered below.

**Motivation**

Within the linear cluster, motivations are internal (mental) factors that stimulate or hinder behavior. These factors are values (Bouman & Steg, 2022; Cieciuch & Schwartz, 2020; Schwartz et al., 2012), beliefs (Bernard & Terjesen, 2020; Carlitz & Rios, 2020), attitudes (Carlitz & Rios, 2020; Richardson et al., 2020), emotions (Brosch, 2021; Brosch & Steg, 2021; Grills, 2014; See, 2020; Shipley & van Riper, 2022) as well as agency and skills (Moscarello & Hartley, 2017). To better understand what motivates human behavior, these factors are added to Rational Choice Theory models. Some suggest that these factors can be ordered in a hierarchical manner (Darnton & Evans, 2013), with values building the base of motivation and agency as well as skills building the top. Furthermore, some describe motivations as the invisible part of human behavior using an iceberg analogy (Bernard & Terjesen, 2020).

The hierarchical order among motivations might be relevant when considering identity or individuals’ worldview since values are understood to build the basis of someone’s personality (Cieciuch & Schwartz, 2020). Darnton (2008) provides a list of models that focus on values. Among those are the (adjusted) Expectancy Value Theory (see for example: DeBacker & Nelson, 1999; Lin et al., 2018; Loh, 2019; Vest & Simpkins, 2011), the Theory of Reasoned Action (LaCaille, 2013), the Values Beliefs Norms Theory (Fornara et al., 2016; Nordfjærn & Zavareh, 2017; Stern et al., 1999, 1993, 1995).

While agency is at the top of the ‘motivation pyramid’, agency is no less important for understanding human behavior. Many behavioral theories about agency assume that an agent only acts if the action is perceived to be effective and meaningful (Darnton, 2008; Darnton & Evans, 2013; Williamson et al., 2018). According to Darnton (2008) models focusing on agency are for example, the (adjusted) Expectancy Value Theory (see for example: DeBacker & Nelson, 1999; Loh, 2019), the Theory of Planned Behavior (Greaves et al., 2013; De Leeuw et al., 2015), or the Theory of Self Efficacy (Bandura, 1991; Lippke, 2020), or the concept of Locus Control (Heimlich & Ardoin, 2008). The concept of agency is indeed not only used in linear models. It also connects to habits (Sarigil, 2015; Wagner, 2021), as well as Structuration Theory (context; Darnton, 2008; Giddens, 1979; Jackson, 2002).

Though, even if motivations are included in the analysis, they do not fully explain human action and inaction (Heiskanen & Laakso, 2019, Wendel 2020). For example,
Heiskanen and Laakso (2019), found that awareness only explains 4–5% and attitude only 13–18% of human behavior. Other factors, such as costs, structures, conflicting interests, or simply the lack of opportunity, may need to be considered to fully understand human behavior (Bouman & Steg, 2022; Cieciuch & Schwartz, 2020). Blake’s Value Action Gap Model describes factors that stand between intention and action. Among individual barriers, social and institutional barriers are identified as potential factors for inaction. Thus, it also bridges with approaches that have a greater focus on contextual aspects. As already mentioned, there are some linear approaches that also consider other factors such as habits or social concerns (Jackson, 2002).

**Heuristics and biases**

The concept of heuristics and biases has been developed by Kahneman and Tversky. Relevant theories related to heuristics and biases are Bounded Rationality (Collet, 2009; Kahneman, 2003; Rubaltelli, 2020) and Prospect Theory (Kahneman, 2003; Rubaltelli, 2020). Heuristics is an umbrella term for a multitude of mental shortcuts (Bowes & Lilienfeld, 2020; Rubaltelli, 2020). There are more than 100 heuristics (Wendel 2020). Some of the more often referred to heuristics are; loss aversion (Kahneman, 2011; Bujold et al., 2020, Wendel 2020), or moral licensing (Newell, Twena et al., 2021).

In Kahneman’s and Tversky’s understanding, biases are characteristics of heuristics. They are: ‘departures from the normative rational theory that served as markers or signatures of the underlying heuristics’ (Gilovich & Griffin, 2002). Examples of biases are confirmation bias or status quo bias (Cinner, 2018; Carlitz & Rios, 2020, Wendel 2020). The former describes the tendency to seek and recognize information that supports one’s pre-existing perceptions, and the latter captures individuals’ preference for the current, familiar state.

Models focusing on heuristics and biases are another essential subcategory of linear behavioral approaches captured by Behavioral Economics. Behavioral Economics is a combination of psychology and economics and developed out of the recognition that humans are not always acting rationally (Barnett, 2021; Bickel & Christensen, 2010; Darnton, 2008; Worldbank, 2015).

Choice architecture denotes a suite of interventions that capitalize on heuristics, frames, and anchors. This is done by reducing choices (choice editing, see, e.g. O’Rourke and Lollo (2015)), favoring specific choices (default choice, see for example, Pichert and Katsikopoulos (2008)), or presenting a specific choice in a certain way (e.g. by framing and anchoring), to nudge people into making a certain decision (Heiskanen & Laakso, 2019; Klotz et al., 2018; Newell, Twena et al., 2021). Nudging has become synonymous with choice architecture within behavioral economics (Hampton & Adams, 2018). ; see also, Kwon & Silva, 2020) even indicate that behavioral economics owes its breakthrough to the success of the books Nudge (Thaler, 2021) and Thinking Fast and Slow (Kahneman, 2011).

Choice architecture shares some similarities with behavioral design (Wendel 2020). While nudging has been accused of being manipulative (Bujold et al., 2020; Heiskanen & Laakso, 2019; Wilkinson, 2013), Wendel (2020) argues that behavioral design would only assist in making decisions that a person anyway would have wanted to make. Though, both, nudging as well as behavioral design interventions may only be able to make people act in a way, they already have intended to (Hampton & Adams, 2018; Klotz et al., 2018).
This may be a weakness of choice architecture, as it might not be able to facilitate deeper changes, such as changes in one’s worldview (Bujold et al., 2020; Chatterton & Wilson, 2014; Newell, Daley et al., 2021). If one wants to instigate deeper changes, choice architecture may thus not be the right tool.

Context

Behavioral science approaches that provide more insights into contextual aspects are the second cluster of approaches. Linear approaches have their root in psychology, contextual ones in sociology (Biely, 2022). Some linear approaches consider contextual factors. The Theory of Planned Behavior (Ajzen, 1991) considers perceptions of other people, and the Theory of Interpersonal Behavior (Triandis, 1977) considers social factors as well as facilitating conditions (Darnton, 2008; Jackson, 2002; Steg & Vlek, 2009). Though, these theories do not focus on the reciprocal relationship between the context and the individual (Darnton, 2008). Furthermore, contextual factors are less prominently and systematically featured in linear approaches (Steg & Vlek, 2009). While linear approaches understand the individual and the context as two separate variables, context approaches do not separate the individual from the context. The individual is understood as part of the context (Bujold et al., 2020; Giddens, 1979; Jones & Karsten, 2008; Kasper, 2009; Worldbank, 2015). Necessarily, the context and the structures in which behavior takes place become key factors for analysis taking a context stance (Günther, 2009).

Structure – actor

Factors that were relevant in linear approaches are relevant in context approaches as well, though, they are viewed in relation to the context. For example, Structuration Theory focuses on the reciprocal relationship between the agent and the structures (Giddens, 1979; Jones & Karsten, 2008). Thus, it is not only about the degree of agency and how this affects behavior, but also about how structures shape agency and vice versa. Reciprocity between factors indicates that context approaches are often closed approaches since there are feedbacks between two factors (e.g. actor and structure).

Apart from agency, one can look at what motivates an agent to act. These motivations, e.g. values, beliefs, attitudes, and emotions, have a context component (Kopnina, 2017; Schill et al., 2019; Secchi & Bui, 2018; Steg et al., 2016). How we emotionally react to something can be influenced by society (Grills, 2014). Social values and individual values are connected (Bouman et al., 2021). Individual and community values can also be understood as the basis for societal organization, such as legislations and regulations (Fischer et al., 2012). Social norms have also shown to be a key factor of an individual’s behavior (Cialdini & Jacobson, 2021).

The connection between the context and the individual can also provide some explanations for certain phenomena. The attitude-behavior-gap provides some insights into social (context) factors inhibiting action (Kollmuss & Agyeman, 2002; Salonen & Helne, 2012). Heuristics can have a context component as well. For example, Newell, Daley et al. (2021) refer to behavioral contagion, and Wendel (2020) refers to descriptive norms as heuristics related to the social context.
Although context approaches focus on the reciprocity between the individuum and the context, the internal (mental) world of the agent is no less relevant (Giddens, 1979). Here too, the context becomes relevant to understand the unconscious realm of an agent. An influential and insightful contribution that needs to be mentioned here is Bourdieu’s notion of habitus. This concept sheds light on the idea that the context shapes the individuum, without the individuum necessarily taking note of this process (Bourdieu, 2010; Kasper, 2009, 2016; Rehbein & Saalmann, 2014). This, in turn, leads to an unreflected, unconscious reproduction of the context.

**Structure – behavior**

Context approaches are not limited to the reciprocity between actor and structure. They can also focus on behavior and structure. The relationship between behavior and context can be understood using a linear, a habit, or a closed cluster point of view. If understood in a non-reciprocal manner (linear), one would be interested in, for example, contexts facilitating or hindering certain behaviors. Using a closed approach, one would analyze, for example, how behavior creates structure and how structure creates behavior (Connolly, 2016; Sarigil, 2015). Another way would be to see how repeated actions are reproduced and reproducing structures.

One theory that focuses on the reciprocal relationship between (repeated) behavior and structure is Practice Theory (Spaargaren, 2003). It is a newer theory that focuses on practices instead of on behavior (Heiskanen & Laakso, 2019; Kurz et al., 2015). Though the notion of practice has already been used by Giddens (1979) and Bourdieu (2010), who have laid the foundation of Practice Theory. In Practice Theory, practices are the unit of analysis, and practices are understood to be consistent behavioral patterns that are socially organized and embedded within social and material structures. These structures are understood to support as well as hamper certain practices (Adams, 2014; Heiskanen & Laakso, 2019; Spaargaren, 2003). Because of the consistency of practices, they could also be understood as habits (Kurz et al., 2015).

Although originally practice was understood in relation to agency and structure, Practice Theory sidelined the role of the individual. For this reason, Adams (2014) suggests connecting Practice Theory with Critical Social Theory.

**Onion model**

Apart from contextual approaches that are rooted in sociology, there are context approaches that combine various disciplines. Within these, a reappearing theme are onion models (Baum & Gross, 2017; Bujold et al., 2020; Darnton & Evans, 2013; Schill et al., 2019). At the core of these onion models is the individual, or even the mental processes within each individual. The onion core is then surrounded by multiple layers of other spheres that represent the context in which behavior takes place. There is a notion of hierarchies in these onion models. Baum and Gross (2017) argue that the distance between a layer and the core indicates the amount of influence the core can have on the respective layer. For example, they depict the techno-economic context as the outermost layer. Hence, this is the layer individuals have the least impact on. These models also include questions about the directionality of influence (Williamson et al., 2020). Thus, does the context influence the individual to the same degree as the individual influences
the context? All these questions relate to closed models, or more specifically, to systems thinking and leverage points, which will be discussed below.

**Closed**

Closed approaches specifically focus on reciprocal interconnections among factors influencing or creating a specific behavior. These interconnections may form feedback loops and can thus be described by a closed circle. The field of systems science deals with the identification of feedback loops (Mobus & Kalton, 2015). It is suggested that the closed cluster is best captured by systems science. The connection between systems science and behavioral science is visible in the merger of the journals *Behavioral Science* and *Systems Research* (J. G. Miller, 1997). J. G. Miller (1997), the editor in chief of the now merged journal *Behavioral Science*, states in the first issue of the new journal that the merger can be explained by the inherently interdisciplinary nature of behavioral science and system science. Another reason was that systems science would help to shed light on the rules that govern the social realm and thus help to understand human behavior.

Darnton (2008) states that circular approaches might be better suited to understand behavioral change. That is, as linear approaches may rather describe a point in time behavior. In contrast, closed approaches allow understanding how a point in time behavior and the factors that caused it, may influence that very behavior and behavior impacting factors in the future. That explains why habits inherently exhibit a closed character. A habit is not a one-off behavior; it is a repeated behavior happening in a certain context, triggered by cues.

**Systems science**

Systems Science is a meta-science, transcending disciplinary limitations (Mobus & Kalton, 2015). Thus, Systems Science is an approach used, for example, by psychologists as well sociologists (Guy, 2018). Systems Science is problem-oriented, taking all necessary factors into account to better understand the problem under scrutiny. According to the respective problem formulation, the system boundaries are defined. Hence a system is an analytical unit. Mobus and Kalton (2015) state that all applications of Systems Science share ‘the exploration of virtually any phenomenon as a web of relationships among elements; it looks to cross-referenced and interdependent causal networks rather than assuming chains of deterministic mechanical causes as in the analytic model inherited from the Enlightenment’ (see also, Armah, 2020; Laszlo & Laszlo, 1997). This web of relationships is mapped out in diagrams containing circular causality (feedback loops; Guy, 2018).

Systems Science provides qualitative as well as quantitative tools. Causal loop diagrams allow to map a system using qualitative data. Mapping can take the form of a participatory process. Another possibility is the construction of a stock and flow model, which can be fed with quantitative and qualitative data. This tool allows to visualize system behaviors over time and analyze potential effects of changes within the system. Systems Science allows to create new models rather than relying on some existing model. E.g. when using the Theory of Planned Behavior, the model already suggests which factors are part of the analysis. Though, the models developed using Systems
Thinking can also rely on previously established models. For example, system archetypes have been identified which explain a specific behavior (Guo et al., 2015; Hogenson, 2009). An individual can be framed as a system. Though when behavior of individuals within a system is modeled, systems science can be combined with Agent-Based-Modeling (Acheson et al., 2013; Silva & Braga, 2020), which is a commonly used tool to model human behavior (Kwon & Silva, 2020).

### Mental models

Systems science is not only appealing to understand human behavior by offering a tool to visualize and model observable behavior. It also offers tools to visualize mental models (non-observable). Similarly, to heuristics, mental models provide shortcuts. Due to the complexity of real-world situations, humans are not able to include all factors in decision-making. Hence humans simplify reality. This simplified representation of reality is called a mental model (Lissack, 2021; Mobus & Kalton, 2015). Furthermore, mental models also relate to the concept of habitus since people are usually not aware of their own mental models. By visualizing and thus making something implicit explicit, systems science offers tools for self-reflection (Darnton, 2008).

In this respect Systems Science connects to Double-, Triple-, or Multi-Loop Learning (Darnton, 2008). Single Loop learning refers to an adaptation process that does not require questioning underlying assumptions, attitudes, or worldviews. Additional feedbacks, though, facilitate questioning these underlying assumptions and hence allow deeper changes to happen (Fahrenbach & Kragulj, 2019; Pahl-Wostl, 2009; Peschl, 2007). This hierarchy of possible change refers to another key concept within Systems Science; leverage points.

### Leverage points

The concept of leverage points entails the idea of hierarchies among intervention points. The relevance of hierarchies for interventions has been indicated in the context cluster. A leverage point analysis allows, for example, to understand if an intervention on the individual level is overpowered by some contextual factors. Such an understanding can help to guide effective interventions or intervention bundles.

The hierarchy among the intervention points refers to the potency of an intervention point to change the entire system (Meadows, 1999). The most potent leverage points facilitate deep changes by changing the system’s paradigm. Woiwode et al. (2021) have applied the leverage point concept to behavioral change. Translated to insights from psychology, the structures that sit deeper, such as values, beliefs, or worldviews, are harder to change. Woiwode et al. (2021) highlight the difference among different leverage points and connect more potent leverage points to learning and the ability to self-reflect. One could argue that behavioral interventions, such as nudging, do not stimulate a reflection process and do thus only stimulate low-level behavioral changes (Newell, Daley et al., 2021). Some low leverage point interventions may even have unintended antipodal effects. Green-advertisement may, for example, lead to rebound effects as they may stimulate more consumption (Fischer et al., 2012). In contrast, interventions that trigger higher leverage points, by e.g. facilitating a self-reflection process, may lead to long-lasting and more general behavioral changes.
**Habits**

Wendel (2020) distinguishes between habits, heuristics, and actions based on utility considerations. Which type of action one uses depends on the amount of cognitive activity one needs to invest. Habits require almost no thinking, heuristics some degree of thinking, and utility considerations ask for a lot of mental work. Habits are a form of heuristic (Sarigil, 2015; Wendel, 2020), but since they are a specific form of heuristic and a specific type of behavior, habits are singled out as a separate cluster. Others have also looked at behavioral science approaches dealing with habits as separate category (Darnton, 2008; Jackson, 2002; Kaufman et al., 2021; Steg & Vlek, 2009).

The Theory of Interpersonal Behavior (Triandis, 1979) is a multi-linear model that includes some contextual variables as well as habits to explain someone’s behavior (Jackson, 2002). Though, linear models are potentially not the most suitable way to illustrate habits since habits necessarily have a reference to past behavior. Thus, a habit is depicted by a spiral; a circular structure, instead of a linear structure. The circularity of habits might be the reason why many linear models omit habits (Darnton, 2008; Kurz et al., 2015; Verplanken & Whitmarsh, 2021). Nevertheless, there are connections between habits and linear approaches. While habits inherently have a feedback loop element, they can be understood from a linear or from a contextual perspective. For example, Kurz et al. (2015) differentiate between habitual behaviors or patterns of practice. The former focuses on the internal processes that underly a repeated action, the latter focuses on the context in which this repeated action unfolds.

**Linear approach**

A habit is a form of heuristic (Sarigil, 2015; Wendel, 2020) that is triggered by a cue (Wendel 2020, Verplanken & Whitmarsh, 2021). The automation aspect of behavior is what distinguishes it from repeated behavior. Kurz et al. (2015) refer to weekly waste sorting. This might be a repeated behavior, but it might not be habitual because of the cognitive load involved in sorting waste. Similarly, a habitual behavior might not be habitual if it is applied in a new setting, which requires deliberate considerations. Once habits have formed they are related to lock-ins (Sarigil, 2015; Verplanken & Whitmarsh, 2021) and thus to resistance to change (Darnton, 2008; Kurz et al., 2015).

The development of habits provides connections to behavioral science approaches. Kurz et al. (2015) argue that a linear approach to habits focuses on the cognitive processes, rather than the external circumstances that support the formation of habits. Before a habit was formed, it was a one-off action. Why this one-off action has taken place might be related to certain motivations (Verplanken & Whitmarsh, 2021).

But a linear perspective might not only be useful when looking at a habit as a single action. Habits might be interesting when studying the relationship between behavior and identity. It could be argued that repetitive behaviors impact a person’s identity and vice versa (Agu et al., 2021; Fahrenbach & Kragulj, 2019).

**Context approach**

It has already been explained that habits are understood as a distinct form of behavior (Darnton, 2008; Jackson, 2002; Steg & Vlek, 2009). The special role of habits is highlighted by Sarigil (2015). He states that one cannot only differentiate between homo
economicus (utility) and homo sociologicus (norms). A third type of action that is neither based on utility nor on norms is needed. This third form is habits (homo habitus). Habits connect to context approaches since they are also in a reciprocal relationship with structures (Sarigil, 2015). Not only may it be easier to pick up a habit that is supported by structures, but repeated behavior may also create structures. Context approaches related to repeated action, such as Practice Theory, do not focus on the individual but rather on the action per se and the environment in which repeated action takes place (Kurz et al., 2015). In Practice Theory, not only the structures that facilitate repeated actions matter. The meaning of practices matter as well. Though, the meaning is socially constructed. Thus, it is suggested that individuals repeatedly do certain things a specific way because it is the socially accepted thing to do (ibid).

Closed approaches
Habits as inherently circular structures can, of course, be studied using a closed cluster perspective. Then the main focus is not on either mental or contextual factors that influence the habit. Rather the focus is on the feedbacks within the system. It has been outlined above that systems science establishes the system boundaries based on the research question at hand. Thus, the factors included in a model are not based on some predefined ontological perspectives (Laszlo & Laszlo, 1997).

To understand the feedback loops within a system, mental as well as contextual factors may need to be considered. Structures in place may create a certain repetitive behavior (a feedback loop). Someone’s identity may create a repetitive behavior, and vice versa (Fahrenbach & Kragulj, 2019; Peschl, 2007). But there might also be a connection between the mental world and the context that, in conjunction, create a certain behavior. Or some factors within the system may overpower other ones and impede the formation of a habit. Thus, the systems scientist is interested in how factors are connected to create a certain repetitive behavior (a positive feedback loop). Furthermore, leverage points might be identified to foster or suspend the repetitive behavior.

Identifying a suitable behavioral science approach
The synthesis of behavioral science approaches into clusters builds the basis for the extension of the framework developed by; Table 2). Their framework has been translated into a table (Table 3) to accommodate the extension, being the four different behavioral science clusters.

Table 2. The 4 dimensions of behavior framework from Chatterton and Wilson (2014).

| Dimension | Levels |
|-----------|--------|
| Actor     | Individual | Inter-personal | Community | Segment/Group | Population |
| Domain    | Psychologically | Bodily | Technologically | Institutional/Social | Infrastructural/Environmental |
| Durability| One-off | Repeated | Dependent | Enduring | Norm-Setting |
| Scope     | Discrete | Inter-Related | Bundled | Structuring | Pervasive |
Table 3. 4 DBC framework, behavioral science approaches, and their coverage of levels and dimensions of the 4 DB framework.

| Dimension | Level            | 4 DB | Behavior | Approach | Cluster |
|-----------|------------------|------|----------|----------|---------|
| Actor     | Individual       |      | Cycling  | Practice theory | Linear | context | Habits | closed |
|           | Interpersonal /Network | | x | x | x | x | x |
|           | Community        | | x | x | x | x | x |
|           | Segment /Group   | | x | x | x | x | x |
|           | Population       | | x | x | x | x | x |
| Domain    | Psychologically  | | x | x | x | x | x |
|           | Bodily           | | x | x | x | x | x |
|           | Technologically  | | x | x | x | x | x |
|           | Institutional /Social | | x | x | x | x | x |
|           | Infrastructural /Environmental | | x | x | x | x | x |
| Durability| One-off          | | x | x | x | x | x |
|           | Repeated         | | x | x | x | x | x |
|           | Dependent        | | x | x | x | x | x |
|           | Enduring         | | x | x | x | x | x |
|           | Norm-Setting     | | x | x | x | x | x |
| Scope     | Discrete         | | x | x | x | x | x |
|           | Inter-Related    | | x | x | x | x | x |
|           | Bundled          | | x | x | x | x | x |
|           | Structuring      | | x | x | x | x | x |
|           | Pervasive        | | x | x | x | x | x |

The four dimensions of behavior (4 DB) framework (Table 2) developed by Chatterton and Wilson (2014) was originally meant to inform policymakers and practitioners about the multifaceted character of human behavior. The reflection, guided by the 4 DB framework, on the complexity of human behavior should illuminate that interventions addressing only one facet of human behavior may not suffice to achieve a specific behavioral outcome (Williamson et al., 2020). Applying, the 4 DB framework should support selecting interventions that address multiple facets of a specific behavior. However, the 4 DB framework could also be used to help scientists identify relevant behavioral science clusters. Thus, it can help at an initial research stage providing orientation for further in-depth research. It can help researchers who have no background in behavioral science to get an idea of what they can or may focus on to study the behavior they are interested in.

**Identifying the dimensions and levels of behavior**

It is suggested that using the 4 DB framework by Chatterton and Wilson (2014) is a useful starting point for researchers and analysts to identify the dimensions and levels relevant to a specific behavior. At least one level within each dimension should be included to outline the complexity of a specific behavior. Though, if necessary multiple levels within a dimension can be attributed to a specific behavior. For example, going by bike is connected to all five domain levels. Cycling requires 1) a certain attitude or motivation (psychologically), 2) the bodily ability to ride a bike, 3) a certain technology choice (e.g. type of bike), 4) social and/or institutional support (e.g. financial support to go by bike), and 5) infrastructure (e.g. bike lanes).

Populating the 4 DB framework helps to illustrate the complexity of the behavior under scrutiny. As pointed out above, having an awareness of the complexity of behavior
is relevant. Though, it may not be possible to perform an analysis considering all levels and dimensions due to, for example, resource constraints. Even if a full analysis is not undertaken, the gained awareness helps to be considerate about blind spots of the undertaken analysis. Furthermore, the awareness of the complexity of a specific behavior can help select the most appropriate approach(es) for an analysis.

To perform an analysis, practical decisions have to be made about which levels and dimensions to include in the analysis. The choice of dimensions will depend on various factors such as the respective behavior under scrutiny, data availability, the possibility to collect data, resource constraints, the research question, etc. Though, once a choice has been made, researchers may be confronted with a jungle of behavioral science approaches, not knowing how to navigate through this jungle and select the suitable approach (Kwon & Silva, 2020).

Table 3 is an extension of the 4 DB framework, the 4 DBC framework. It is a combination of the 4 DB framework with the four different behavioral science clusters (C) introduced above. After using the 4 DB framework, the results can be transferred into the 4 DBC framework to 1) see which cluster could fit best the behavior under scrutiny and 2) check different behavioral science approaches individually for their fit. The whole workflow is illustrated in Figure 1.

**Selecting appropriate behavioral science approaches**

In Table 3, the four different clusters have been added, indicating which dimensions and levels they typically cover. As pointed out above, there are models and theories within each approach that are cross-cutting. For example, the Theory of Interpersonal Behavior by Triandis is a linear model that also includes contextual variables as well as habits (Jackson, 2002). Thus, Table 3 indicates the tendency of a cluster, but it should not be understood as an absolute.

Table 3 indicates that linear approaches usually mostly cover the individual level, they focus on factors that affect an individual’s motivation, such as attitudes and values. Therefore, they are mostly limited to the psychological level within the domain dimension. Linear approaches may excel at analyzing a one-off behavior rather than repeated behavior. Furthermore, these one-off behaviors are usually framed as discrete events. Such a siloed view of behavior may have disadvantages, but it may also help to provide answers to a specific research question. For example, if one wants to understand psychological aspects of human behavior, such as motivation, linear approaches offer a great richness of theories, models, and concepts. Furthermore, as already indicated, a linear approach may have characteristics of other approaches, and several linear approaches can be combined (Darnton, 2008). Though, it also needs to be indicated

Figure 1. Workflow to identify potentially relevant behavioral science approaches.
that some approaches might be conflicting (Darnton & Evans, 2013). For example, a linear approach cannot be closed. Though, even there, some mixed models exist. One example is the Model of Environmental Behavior by Kollmuss and Agyeman (2002), which contains some feedbacks but still descends from the Theory of Planned Behavior (a linear approach; Darnton, 2008).

Despite the lack of clear-cut borders between the four clusters, Table 3 helps to identify which body of literature might provide the most suitable theories, models, and concepts for a specific analysis.

Commuting by bicycle has been used as an example in Table 3. The table has been populated following the example provided by Chatterton and Wilson (2014). Based on this categorization of cycling, linear models may not be suitable for understanding cycling, since it is not a discrete, one-off action (Kurz et al., 2015). Though, Kurz et al. (2015) illustrate that transportation habits, such as cycling, can be analyzed using a linear or a context-focused approach. Furthermore, one could neglect the ‘durability’ and ‘scope’ dimensions and use a linear approach to, for example, better understand individuals’ motivations to take the bike (see for example: Biernat et al., 2018; Winters et al., 2011). This would be a combination of the dimension ‘actor’ and ‘domain’ with the levels ‘individual’ and ‘psychology’.

Although a linear approach may only include two domains, it does not necessarily equate to such an approach being simplistic. Within each of the four behavioral science approaches, complex models and theories exist that analyze specific variables in more detail. Hence, if a researcher has, for example, decided to use a linear approach, because one wants to focus on motivations from a psychological point of view, one still needs to review psychological models that specifically target motivation.

The framework developed by Baum and Gross (2017) is an example of a context approach that covers many levels within the 4DBC framework. They cover the levels ‘individual’ and ‘psychologically’ by e.g. including personal values, attitudes, and preferences. By including habits, they also cover the level ‘repeat’. Also, the levels ‘technologically’, ‘institutionally’, and ‘infrastructural’ are covered. While many levels are covered, their framework does neither cover all levels. For example, the level ‘bodily’ is not addressed.

Using the 4DBC framework increases the awareness that e.g. a linear approach may need to be adapted to, for example, also reflect the domain characteristics of cycling. In a meta-literature review Javaid et al. (2020) found that motivational factors are key for a transportation mode shift. However, they also point out that without the needed structural support (domain dimension), people may still not use the bike.

Having populated the 4DBC framework may, help understand the limitations of an analysis or may explain why a specific attitude still does not translate into the corresponding behavior. Thus, the 4DBC framework may help to understand which levels need to be considered when confronted with an attitude-behavior gap. Accordingly, this can help to guide further research and the selection of a suitable behavioral science approach.

**Choosing suitable behavioral science theories, models, or concepts**

The four columns that summarize the strengths of the behavioral science clusters only provide initial guidance. Within each cluster, many different theories, models, and concepts exist, and the analyst still has to find out which one(s) might be suitable for
Table 4. Guiding questions of the 4DB framework applied to behavioral models.

| Dimension          | Level                                                                 |
|--------------------|----------------------------------------------------------------------|
| **Actor**          | *Individual* – Is the model focusing on the individual in isolation?  |
|                    | *Interpersonal/Network* – Does the model include a close network of people as an influential factor on an individual’s behavior? |
|                    | *Community* – Does the model include communities as factor influencing an individual’s behavior? |
|                    | *Segment/Group* – Does the model include specific groups that influence an individual’s behavior? |
|                    | *Population* – Does the model include society as a whole as a factor that influences an individual’s behavior? |
| **Domain**         | *Psychological* – Does the model include psychological processes such as rational choices, individual’s motivation, or heuristics? |
|                    | *Bodily* – Does the model include individuals’ physical abilities as factor influencing an individual’s behavior? |
|                    | *Technological* – Does the model include the role of technology, or tangible objects for an individual’s behavior? |
|                    | *Institutional/Social* – Does the model include the role of intangible structures such as policies, laws, markets, other forms of social, cultural or economic organization? |
|                    | *Infrastructural/Environmental* – Does the model include the role of tangible structures such as infrastructure? |
| **Durability**     | *One-off* – Does the model focus on non-repetitive behavior that can be viewed in isolation? |
|                    | *Repeated* – Does the model focus on repeated behavior, such as habits? |
|                    | *Dependent* – Does the model consider the dependency of an individual’s behavior on other factors? |
|                    | *Enduring* – Does the model consider the long-term effects of an individual’s behavior? |
| **Scope**          | *Inter-related* – Does the model allow behavior being linked to other behaviors through the action itself, or the context or their meaning? |
|                    | *Bundled* – Does the model frame behavior as connected to other behaviors to form behavioral clusters? |
|                    | *Structuring* – Does the model frame behavior as an act that creates structure, which then has an effect on the original behavior? |
|                    | *Pervasive* – Does the model include the role of an individual’s life or lifestyle on an individual’s behavior? |

The task at hand. Table 3 features another column (‘Approach’ column) that should help researchers identify the theory, model, or concept that best suits the behavior under scrutiny. Table 3 can be used in conjunction with Table 4, which is an adaptation of the guiding questions provided by Chatterton and Wilson (2014). The original guiding questions aimed at supporting the characterization of a specific behavior. The adapted version helps to fill the ‘Approach’ column in Table 3, hence, to find a fitting theory, model, or concept. To illustrate how the ‘Approach’ column in the 4DBC framework is populated, Practice Theory is chosen as an example (see, Table 3).

In consulting literature, the column ‘Approach’ in Table 3 can be filled in. For example, Practice Theory does not focus on the individual (Reckwitz, 2002). Accordingly, the level ‘individual’ is left blank. Practice Theory uses the practice as analytical unit and understands the practice as structuring as well as taking place within structures (Heiskanen & Laakso, 2019). Thus, the societal level becomes more relevant in understanding a specific practice (Reckwitz, 2002). The social is not only relevant as different groups may have an effect on each other, it is also relevant as the social is the realm in which meaning is created (Kasper, 2009; Morrison, 2005; Spotswood et al., 2015). Since technology, environment, and the social domain are all parts that form structure, they are relevant for Practice Theory as well (Buck & Nurse, 2021; Reckwitz, 2002). Due to its connection to Structuration Theory, practices are understood to be structuring. On the individual level, one’s lifestyle is a relevant factor to understand
practices (Spaargaren, 2003). Based on this information, the column ‘Approach’ in Table 3 has been populated.

Different theories, models, or concepts can be checked in this manner. Once the most suitable approach has been chosen, the researcher may still decide to only use parts of this approach. Or the researcher may conclude that different approaches need to be combined. For example, McIlvenny (2015) uses the concept of interactional practices and adds the role of emotions into his analysis. Thus, the levels ‘psychologically’ and ‘individual’, which would usually be rather disregarded by Practice Theory, are added to the analysis. While these levels are added, other levels are disregarded by McIlvenny (2015). Hence, depending on the goal of an analysis, the analyst may choose specific levels to focus on.

Buck and Nurse (2021), also use Practice Theory to understand cycling behavior, but focus on the levels ‘bodily’, ‘infrastructure’, ‘technology’ as well as ‘group’. They discuss the skills (bodily) that could offset the lack of infrastructure (technology and infrastructure) as well as the conflict among different transportation modes. The latter focuses not only on the infrastructure, which reflects the competition between transportation modes, but also on groups of people using a specific transportation mode. The conflict between these groups then affects practices. Another way of looking at it would be to understand how different transportation modes compete for practitioners (Kurz et al., 2015). So, it is not only about people choosing one practice over another one, it is also about practices competing for practitioners. For the latter different aspects of a practice compete with each other, such as material (e.g. infrastructure) or meaning (e.g. lifestyle). Spotswood et al. (2015) also use Practice Theory to better understand people’s perception of cycling. Similarly, they focus on the levels ‘group’ (meaning), ‘bodily’ (competencies), ‘technology’, and ‘infrastructure’ (materials).

**Conclusion**

It can be a challenging task to select a suitable behavioral science theory, model, or concept that fits a specific research task. Human behavior is complex. Certain factors such as resource constraints or the availability of data may place some limitations on the suitability of some theories. However, even within such limitations, a selection might be daunting. Understanding the complexity of the behavior under scrutiny is the first step that helps make a choice. Accordingly, in this paper, the 4DB framework by Chatterton and Wilson (2014) has been used as a basis to understand the multifaceted character of a specific behavior. Furthermore, extending the 4DB framework helps to understand which behavioral science cluster covers the complexity of the respective behavior.

Behavioral science is a complex interdisciplinary field that offers many different vantage points to understand human behavior. The great number of different theories, models, and concepts can make it difficult to select one of these vantage points. Therefore, in this paper, four clusters of behavioral science approaches have been introduced. These four clusters help to make a pre-selection to guide further literature study to then find a suitable behavioral science approach. To this end, the 4DB framework has been extended to include the four clusters. The resulting 4DBC framework helps to systematically select an approach and, subsequently, a specific theory, model, or concept. Using the framework, the selection of a behavioral science approach is guided by
the behavior under scrutiny rather than by disciplinary limitations. Thus, the framework helps to transcend disciplinary boundaries. Filling in the framework helps to make a deliberate decision about which body of literature the analyst may want to consult first to find an approach that best suits the research task.

To further facilitate the selection of a suitable behavioral science approach, the framework column ‘Approach’ can be filled in with the help of Table 4. Even if no theory will be able to capture the full complexity of a specific behavior, the framework also provides insights into the aspects that are excluded from an analysis. This might be insightful, when drawing conclusions at the end of an analysis or when, for example, a specific model has shown to not (or not fully) explain the behavior under scrutiny.

Not only is behavioral science itself an interdisciplinary field, including behavioral insights is increasingly a requirement of other interdisciplinary research fields, such as sustainability science. The four clusters of behavioral science approaches and the 4DBC framework will hopefully contribute to helping researchers in interdisciplinary fields to include behavioral science within their research.

Notes

1. Economics, Education, Industrial Design, Psychology, Sociology, Architecture, Landscape Design, Urban Planning, Geography, Anthropology
2. A discussion about this can be found elsewhere. The paper by Gintis (2007) suggesting the unification of behavioural science is accompanied by 28 commentaries by other researchers and a response by Gintis to these commentaries. Kaufman et al. (2021) also argue for a ‘more pluralistic approach to behaviour change.’
3. A Wikipedia page list provides a more complete list: https://en.wikipedia.org/wiki/List_of_cognitive_biases
4. Without wanting to engage in an ontological discussion, depending on the discipline alternative terms are used such as (inter)action.
5. For an explanation of each level and an application to three different cases see Chatterton, T. and C. Wilson (2014). 'The “Four Dimensions of Behaviour” framework: a tool for characterising behaviours to help design better interventions.’ Transportation Planning and Technology 37(1): 38–61.

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References

Acheson, P., Dagli, C., & Kilicay-Ergin, N. (2013). Model based systems engineering for system of systems using agent-based modeling. Procedia Computer Science, 16, 11–19. https://doi.org/10.1016/j.procs.2013.01.002

Adams, M. (2014). Approaching nature, 'sustainability' and ecological crises from a critical social psychological perspective. Social and Personality Psychology Compass, 8(6), 251–262. https://doi.org/10.1111/sppc.12104

Agu, A. G., Kalu, O. O., Esi-Ubani, C. O., & Agu, P. C. (2021). Drivers of sustainable entrepreneurial intentions among university students: An integrated model from a developing world context. International Journal of Sustainability in Higher Education, 22(3), 659–680. https://doi.org/10.1108/IJSHE-07-2020-0277

Ajzen, I. (1991). The theory of planned behavior. Organizational Behavior and Human Decision Processes, 50(2), 179–211. https://doi.org/10.1016/0749-5978(91)90020-T

Akenji, L., Lettenmeier, M., Toivio, V., Nielsen, S., & Kamei, M. (2019). 1.5-degree lifestyles: Targets and options for reducing lifestyle carbon footprint. (pp. 49). Institute for Global Environmental Strategies Aalto University and D-mat ltd.

Armah, F. A. 2020. Systems thinking, approach. International encyclopedia of human geography (Second Edition). In A. Kobayashi, (Ed.), Oxford: Elsevier, 183–185. https://doi.org/10.1007/B978-0-08-102295-5.10434-2

Bandura, A. (1991). Social cognitive theory of self-regulation. Organizational Behavior and Human Decision Processes, 50(2), 248–287. https://doi.org/10.1016/0749-5978(91)90022-L

Barnett, V. 2021. Behavioral economics. Encyclopedia of evolutionary psychological science. T. K. Shackelford & V. A. Weekes-Shackelford. Springer International Publishing. 525–533.

Baum, C. M., & Gross, C. (2017). Sustainability policy as if people mattered: Developing a framework for environmentally significant behavioral change. Journal of Bioeconomics, 19(1), 53–95. https://doi.org/10.1007/s10818-016-9238-3

Bernard, M., & Terjesen, M. D. (2020). Rational emotive, cognitive behavioral approaches to the challenge of child and adolescent mental health. In M. Bernard & M. D. Terjesen (Eds.), Rational-emotive and cognitive-behavioral approaches to child and adolescent mental health: theory, practice, research, applications. (pp. 3–30). Springer International Publishing.

Bettencourt, L. M. A., & Kaur, J. (2011). Evolution and structure of sustainability science. Proceedings of the National Academy of Sciences, 108(49), 19540–19545. https://doi.org/10.1073/pnas.1102712108

Bickel, W. K., & Christensen, D. R. (2010). Behavioral Economics. In P. Stolerman & L. H. Price (Eds.), Encyclopedia of psychopharmacology (Vol. 1, pp. 1–7). Springer Berlin Heidelberg.

Biely, K. (2022). The behavioral perspective (pp. 133). Delft, Delft University of Technology.

Biernat, E., Buchholz, S., & Bartkiewicz, P. (2018). Motivations and barriers to bicycle commuting: Lessons from Poland. Transportation Research. Part F, Traffic Psychology and Behaviour, 55, 492–502. https://doi.org/10.1016/j.trf.2018.03.024

Bögel, P. M., & Upham, P. (2018). Role of psychology in sociotechnical transitions studies: Review in relation to consumption and technology acceptance. Environmental Innovation and Societal Transitions, 28, 122–136. https://doi.org/10.1016/j.eist.2018.01.002

Bolton, C. D. (1963). Is sociology a behavioral science? The Pacific Sociological Review, 6(1), 3–9. https://doi.org/10.2307/1388293

Bouman, T., & Steg, L. (2022). A spiral of (in)action: Empowering people to translate their values in climate action. One Earth, 5(9), 975–978. https://doi.org/10.1016/j.oneear.2022.08.009

Bouman, T., van der Werff, E., Perlaviciute, G., & Steg, L. (2021). Environmental values and identities at the personal and group level. Current Opinion in Behavioral Sciences, 42, 47–53. https://doi.org/10.1016/j.cobeha.2021.02.022

Bourdieu, P. (2010). Distinction: A social critique of the judgement of taste. Routledge.

Bowes, S. M., & Lilienfeld, S. O. (2020). Rationality. In V. Zeigler-Hill & T. K. Shackelford (Eds.), Encyclopedia of personality and individual differences (pp. 4294–4301). Springer International Publishing.
Brosch, T. (2021). Affect and emotions as drivers of climate change perception and action: A review. *Current Opinion in Behavioral Sciences*, 42, 15–21. https://doi.org/10.1016/j.cobeha.2021.02.001

Brosch, T., & Steg, L. (2021). Leveraging emotion for sustainable action. *One Earth*, 4(12), 1693–1703. https://doi.org/10.1016/j.oneear.2021.11.006

Buck, M., & Nurse, A. (2021). Cycling in an ‘ordinary city’: A practice theory approach to supporting a modal shift. *International Journal of Sustainable Transportation*, 1–12. https://doi.org/10.1080/15568318.2021.1983674

Bujold, P. M., Williamson, K., & Thulin, E. (2020). The Science of Changing Behavior for Environmental Outcomes: A Literature Review., Rare Center for Behavior & the Environment and the Scientific and Technical Advisory Panel to the Global Environment Facility.

Carlitz, A., & Rios, K. (2020). Beliefs. In V. Zeigler-Hill & T. K. Shackelford (Eds.), *Encyclopedia of personality and individual differences* (pp. 435–439). Springer International Publishing.

Chatterton, T., & Wilson, C. (2014). The ‘Four dimensions of behaviour’ framework: A tool for characterising behaviours to help design better interventions. *Transportation Planning and Technology*, 37(1), 38–61. https://doi.org/10.1080/03081060.2013.850257

Cialdini, R. B., & Jacobson, R. P. (2021). Influences of social norms on climate change-related behaviors. *Current Opinion in Behavioral Sciences*, 42, 1–8. https://doi.org/10.1016/j.cobeha.2021.01.005

Cieciuch, J., & Schwartz, S. H. (2020). Values. In V. Zeigler-Hill & T. K. Shackelford (Eds.), *Encyclopedia of personality and individual differences* (pp. 5704–5708). Springer International Publishing.

Cinner, J. (2018). How behavioral science can help conservation. *Science*, 362(6417), 889–890. https://doi.org/10.1126/science.aau6028

Collet, F. (2009). Does Habitus matter? A comparative review of Bourdieu’s Habitus and Simon’s bounded rationality with some implications for economic sociology. *Sociological Theory*, 27(4), 419–434. https://doi.org/10.1111/j.1467-9558.2009.01356.x

Connolly, J. (2016). Elias and habitus: Explaining bureaucratisation processes in the Gaelic Athletic Association. *Culture and Organization*, 22(5), 452–475. https://doi.org/10.1080/14759551.2014.1001394

Coskun, A., Zimmerman, J., & Erbug, C. (2015). Promoting sustainability through behavior change: A review. *Design Studies*, 41, 183–204. https://doi.org/10.1016/j.destud.2015.08.008

Darnton, A. (2008). Reference Report: An overview of behaviour change models and their uses, GSR Behaviour Change Knowledge Review.

Darnton, A., & Evans, D. (2013). Influencing Behaviors: A technical Guide to the ISM Tool The Scottish Government. The Scottish Government. https://digital.nls.uk/pubs/scotgov/2013/9781782565666.pdf

DeBacker, T. K., & Nelson, R. M. (1999). Variations on an expectancy-value model of motivation in science. *Contemporary Educational Psychology*, 24(2), 71–94. https://doi.org/10.1006/ceps.1998.0984

De Coninck, H., Revi, A., Babiker, M., Bertoldi, P., Buckeridge, M., Cartwright, A., Dong, W., Ford, J., Fuss, S., Hourcade, J.-C., Ley, D., Mechler, R., Newman, P., Revokatova, A., Schultz, S., Steg, L. & Sugiyama, T. (2018). Strengthening and implementing the global response. In P. Z. Masson- Delmonte & H.-O. Pörtner (Eds.), *Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty*. Cambridge, UK and New York, NY, USA: Cambridge University Press (pp. 131). https://doi.org/10.1017/9781009157940.006

de Leeuw, A., Valois, P., Ajzen, I., & Schmidt, P. (2015). Using the theory of planned behavior to identify key beliefs underlying pro-environmental behavior in high-school students: Implications for educational interventions. *Journal of Environmental Psychology*, 42, 128–138. https://doi.org/10.1016/j.jenvp.2015.03.005
Fahrenbach, F., & Kragulj, F. (2019). The ever-changing personality: Revisiting the concept of triple-loop learning. *The Learning Organization*. https://doi.org/10.1108/TLO-01-2019-0016

Farrow, K., Grolleau, G., & Ibanez, L. (2017). Social norms and pro-environmental behavior: A review of the evidence. *Ecological Economics, 140*, 1–13. https://doi.org/10.1016/j.ecolecon.2017.04.017

Fischer, J., Dyball, R., Fazey, I., Gross, C., Dovers, S., Ehrlich, P. R., Brulle, R. J., Christensen, C., & Borden, R. J. (2012). Human behavior and sustainability. *Frontiers in Ecology and the Environment, 10*(3), 153–160. https://doi.org/10.1890/110079

Fornara, F., Pattitoni, P., Mura, M., & Strazzer, E. (2016). Predicting intention to improve household energy efficiency: The role of value-belief-norm theory, normative and informational influence, and specific attitude. *Journal of Environmental Psychology, 45*, 1–10. https://doi.org/10.1016/j.jenvp.2015.11.001

Giddens, A. (1979). *Agency, structure. Central problems in social theory: Action, structure and contradiction in social analysis* (pp. 49–95). Macmillan Education UK.

Gilovich, T., & Griffin, D. (2002). Introduction – heuristics and biases: Then and now. In D. Griffin, D. Kahneman, & T. Gilovich (Eds.), *Heuristics and biases: The psychology of intuitive judgment* (pp. 1–18). Cambridge University Press.

Gintis, H. (2007). A framework for the unification of the behavioral sciences. *Behavioral and Brain Sciences, 30*(1), 1–16. https://doi.org/10.1017/S0140525X07000581

Greaves, M., Zibarras, L. D., & Stride, C. (2013). Using the theory of planned behavior to explore environmental behavioral intentions in the workplace. *Journal of Environmental Psychology, 34*, 109–120. https://doi.org/10.1016/j.jenvp.2013.02.003

Grills, S. (2014). *Emotions, sociology of encyclopedia of quality of life and well-being research*. A. C. Michalos. Springer Netherlands. 1876–1880.

Günther, H. (2009). The environmental psychology of research. *Journal of Environmental Psychology, 29*(3), 358–365. https://doi.org/10.1016/j.jenvp.2009.02.004

Guo, B. H. W., Yiu, T. W., & González, V. A. (2015). Identifying behaviour patterns of construction safety using system archetypes. *Accident Analysis & Prevention, 80*, 125–141. https://doi.org/10.1016/j.aap.2015.04.008

Guy, J.-S. (2018). ‘Niklas Luhmann before relational sociology: The cybernetics roots of systems theory’. *Systems Research and Behavioral Science, 35*(6), 856–868. https://doi.org/10.1002/sres.2523

Hampton, S., & Adams, R. (2018). Behavioural economics vs social practice theory: Perspectives from inside the United Kingdom government. *Energy Research & Social Science, 46*, 214–224. https://doi.org/10.1016/j.erss.2018.07.023

Han, H. (2021). Consumer behavior and environmental sustainability in tourism and hospitality: A review of theories, concepts, and latest research. *Journal of Sustainable Tourism, 29*(7), 1021–1042. https://doi.org/10.1080/09669582.2021.1903019

Heimlich, J. E., & Ardoin, N. M. (2008). Understanding behavior to understand behavior change: A literature review. *Environmental Education Research, 14*(3), 215–237. https://doi.org/10.1080/13504620802148881

Heiskanen, E., & Laakso, S. (2019). Editing out unsustainability from consumption: From information provision to nudging and social practice theory. In Mont, O. (Ed.), *A Research Agenda for Sustainable Consumption Governance*. Edward Elgar Publishing, (pp. 156–171). https://doi.org/10.4337/9781788117814.00020

Hogenson, G. B. (2009). Archetypes as action patterns1. *Journal of Analytical Psychology, 54*(3), 325–337. https://doi.org/10.1111/j.1468-5922.2009.01783.x

Jackson, T. (2002). Evolutionary psychology in ecological economics: Consilience, consumption and contentment. *Ecological Economics, 41*(2), 289–303. https://doi.org/10.1016/S0921-8009(02)00040-X

Jalali, S., & Wohlin, C. (2012). Systematic literature studies: Database searches vs. backward snowballing. *Proceedings of the 2012 ACM-IEEE International Symposium on Empirical Software Engineering and Measurement*. 
Javaid, A., Creutzig, F., & Bamberg, S. (2020). Determinants of low-carbon transport mode adoption: Systematic review of reviews. *Environmental Research Letters, 15*(10), 103002. https://doi.org/10.1088/1748-9326/aba032

Jones, M. R., & Karsten, H. (2008). Giddens’s structuration theory and information systems research. *MIS Quarterly, 32*(1), 127–157. https://doi.org/10.2307/25148831

Kahneman, D. (2003). Maps of bounded rationality: Psychology for behavioral economics. *The American Economic Review, 93*(5), 1449–1475. https://doi.org/10.1257/00028280322655392

Kahneman, D. (2011). *Schnelles Denken, Langsames Denken*. München, Penguin Verlag.

Kasper, D. (2009). Ecological habitus: Toward a better understanding of socioecological relations. *Organization & Environment, 22*(3), 311–326. https://doi.org/10.1177/1086026609343098

Kasper, D. (2016). Re-conceptualizing (environmental) sociology. *Environmental Sociology, 2*(4), 322–332. https://doi.org/10.1080/23251042.2016.1197474

Kaufman, S., Saeri, A., Raven, R., Malekpour, S., & Smith, L. (2021). Behaviour in sustainability transitions: A mixed methods literature review. *Environmental Innovation and Societal Transitions, 40*, 586–608. https://doi.org/10.1016/j.eist.2021.10.010

Klaniecki, K., Wuropulos, K., & Hager, C. P. (2018). Behaviour change for sustainable development. In *Encyclopedia of sustainability in higher education* (pp. 1–10). W. Leal Filho, Ed. Cham: Springer International Publishing.

Klotz, L., Weber, E., Johnson, E., Shealy, T., Hernandez, M., & Gordon, B. (2018). Beyond rationality in engineering design for sustainability. *Nature Sustainability, 1*(5), 225–233. https://doi.org/10.1038/s41893-018-0054-8

Kollmuss, A., & Agyeman, J. (2002). Mind the gap: Why do people act environmentally and what are the barriers to pro-environmental behavior? *Environmental Education Research, 8*(3), 239–260. https://doi.org/10.1080/13504620220145401

Kopnina, H. (2017). Working with human nature to achieve sustainability: Exploring constraints and opportunities. *Journal of Cleaner Production, 148*, 751–759. https://doi.org/10.1016/j.jclepro.2017.02.058

Kuhnhenn, K., Costa, L., Mahnke, E., Schneider, L., & Lange, S. (2021). A societal transformation scenario for staying below 1.5°C. Publication series economic ± social issues. *Heinrich Böll Stiftung, 23*. https://eu.boell.org/sites/default/files/2020-12/A%20Societal%20Transformation%20Scenario%20for%20Staying%20Below%201.5C.pdf

Kurz, T., Gardner, B., Verplanken, B., & Abraham, C. (2015). Habitual behaviors or patterns of practice? Explaining and changing repetitive climate-relevant actions. *WIREs Climate Change, 6*(1), 113–128. https://doi.org/10.1002/wcc.327

Kwon, H. R., & Silva, E. A. (2020). Mapping the landscape of behavioral theories: Systematic literature review. *Journal of Planning Literature, 35*(2), 161–179. https://doi.org/10.1177/088541219881135

LaCaille, L. 2013. *Theory of reasoned action. encyclopedia of behavioral medicine*. M. D. Gellman & J. R. Turner. Springer New York. 1964–1967.

Laland, K. N., & Brown, G. R. (2006). Niche construction, human behavior, and the adaptive-lag hypothesis. *Evolutionary Anthropology: Issues, News, and Reviews, 15*(3), 95–104. https://doi.org/10.1002/evan.20093

Lange, F. (2022). *Behavioral paradigms for studying pro-environmental behavior: A systematic review*. Behavior Research Methods.

Laszlo, E., & Laszlo, A. (1997). The contribution of the systems sciences to the humanities. *Systems Research and Behavioral Science, 14*(1), 5–19. https://doi.org/10.1002/(SICI)1099-1743(199701/02)14:1<5::AID-SRES150>3.0.CO;2-M

Lin, A., Ettekal, A., & Simpkins, S. D. (2018). Expectancy value models. In *Encyclopedia of adolescence*. R. J. R. Levesque, ed. (pp. 1264–1271). Springer International Publishing.

Lippke, S. 2020. *Self-efficacy theory. Encyclopedia of personality and individual differences*. V. Zeigler-Hill & T. K. Shackelford. Springer International Publishing. 4722–4727.

Lissack, M. 2021. *Cybernetics and control. Handbook of systems sciences*. In G. S. Metcalf, K. Kijima, & H. Deguchi. (Eds.), Springer: Singapore. (pp. 87–106). https://doi.org/10.1007/978-981-15-0720-5_2
Li, D., Zhao, L., Ma, S., Shao, S., & Zhang, L. (2019). What influences an individual’s pro-environmental behavior? A literature review. *Resources, Conservation and Recycling*, 146, 28–34. https://doi.org/10.1016/j.resconrec.2019.03.024

Loh, E. K. Y. (2019). What we know about expectancy-value theory, and how it helps to design a sustained motivating learning environment. *System*, 86, 102119. https://doi.org/10.1016/j.system.2019.102119

McIlvenny, P. (2015). The joy of biking together: Sharing everyday experiences of velomobility. *Mobilities*, 10(1), 55–82. https://doi.org/10.1080/17450101.2013.844950

Meadows, D. (1999). Leverage points: places to intervene in a system. *Hartland*. https://donella.meadows.org/wp-content/userfiles/Leverage_Points.pdf

Miller, A. G. (1995). Forty years of behavioral science. *Behavioral Science*, 40(1), 1–3. https://doi.org/10.1002/bs.3830400102

Miller, J. G. (1997). Statement from the founding editor of behavioral science: about the merger. *Systems Research and Behavioral Science*, 14(1), 3–4. https://doi.org/10.1002/(SICI)1099-1743(199701/02)14:1<3::AID-SRES153>3.0.CO;2-F

Mobus, G. E., & Kalton, M. C. (2015). *Principles of systems science*. Springer.

Morrison, K. (2005). Structuration theory, habitus and complexity theory: Elective affinities or old wine in new bottles? *British Journal of Sociology of Education*, 26(3), 311–326. https://doi.org/10.1080/0142569050128809

Moscarello, J. M., & Hartley, C. A. (2017). Agency and the calibration of motivated behavior. *Trends in Cognitive Sciences*, 21(10), 725–735. https://doi.org/10.1016/j.tics.2017.06.008

Neil, C., & Melissa, B. (2016). *Physiology of behavior, global edition*. Pearson Education.

Newell, P., Daley, F., & Twena, M. (2021). Changing our ways? Behaviour change and the climate crisis. The report of the Cambridge Sustainability Commission on Scaling Behaviour Change, The Cambridge Sustainability Commission.

Newell, P., Twena, M., & Daley, F. (2021). Scaling behaviour change for a 1.5 degree world: Challenges and opportunities. *Global Sustainability*, 1–25. https://doi.org/10.1017/sus.2021.23

Nielsen, K. S., Clayton, S., Stern, P. C., Dietz, T., Capstick, S., & Whitmarsh, L. (2021). How psychology can help limit climate change. *American Psychologist*, 76(1), 130–144. https://doi.org/10.1037/amp0000624

Nordfjærn, T., & Zavareh, M. F. (2017). Does the value-belief-norm theory predict acceptance of disincentives to driving and active mode choice preferences for children’s school travels among Chinese parents? *Journal of Environmental Psychology*, 53, 31–39. https://doi.org/10.1016/j.jenvp.2017.06.005

O’Rourke, D., & Lollo, N. (2015). Transforming consumption: From decoupling, to behavior change, to system changes for sustainable consumption. *Annual Review of Environment and Resources*, 40(1), 233–259. https://doi.org/10.1146/annurev-environ-102014-021224

Owens, S., & Driffill, L. (2008). How to change attitudes and behaviours in the context of energy. *Energy Policy*, 36(12), 4412–4418. https://doi.org/10.1016/j.enpol.2008.09.031

Pahl-Wostl, C. (2009). A conceptual framework for analysing adaptive capacity and multi-level learning processes in resource governance regimes. *Global Environmental Change*, 19(3), 354–365. https://doi.org/10.1016/j.gloenvcha.2009.06.001

Peschl, M. F. (2007). Triple-loop learning as foundation for profound change, individual cultivation, and radical innovation. *Construction Processes beyond Scientific and Rational Knowledge*, 2, 136–145. http://constructivist.info/2/2-3/136

Pezzey, J. (1992). Sustainability: An interdisciplinary guide. *Environmental Values*, 1(4), 321–362. https://doi.org/10.3197/09632719276680034

Pichert, D., & Katsikopoulos, K. V. (2008). Green defaults: Information presentation and pro-environmental behaviour. *Journal of Environmental Psychology*, 28(1), 63–73. https://doi.org/10.1016/j.jenvp.2007.09.004

Quackenbush, S. (2004). The rationality of rational choice theory. *International Interactions*, 30(2), 87–107. https://doi.org/10.1080/03050620490462595

Reckwitz, A. (2002). Toward a theory of social practices: A development in culturalist theorizing. *European Journal of Social Theory*, 5(2), 243–263. https://doi.org/10.1177/1368431022225432
Rehbein, B., & Saalmann, G. 2014. Habitus (habitus). Bourdieu-Handbuch: Leben — Werk — Wirkung. G. Fröhlich & B. Rehbein. Metzler. 110–118.

Richardson, K., Tortoriello, G. K., & Hart, W. (2020). Attitudes. In V. Zeigler-Hill & T. K. Shackelford (Eds.), Encyclopedia of personality and individual differences (pp. 310–312). Springer International Publishing.

Rubaltelli, E. (2020). Heuristics. In The Palgrave encyclopedia of the possible. Cham: Palgrave Macmillan. https://doi.org/10.1007/978-3-319-98390-5_1-1

Salonen, A., & Helne, T. (2012). Vegetarian diets: A way towards a sustainable society. Journal of Sustainable Development, 5(6). https://doi.org/10.15539/jsd.v5n6p10

Sarigil, Z. (2015). Showing the path to path dependence: The habitual path. European Political Science Review, 7(2), 221–242. https://doi.org/10.1017/S1755773914000198

Schaffernicht, M. (2019). Unrecognized interdependencies in mental models—The case for taking feedback loops into account. Systems Research and Behavioral Science, 36(4), 580–603. https://doi.org/10.1002/sres.2572

Schill, C., Anderies, J. M., Lindahl, T., Folke, C., Polasky, S., Cárdenas, J. C., Crépin, A.-S., Janssen, M. A., Norberg, J., & Schlüter, M. (2019). A more dynamic understanding of human behaviour for the Anthropocene. Nature Sustainability, 2(12), 1075–1082. https://doi.org/10.1038/s41893-019-0419-7

Schwartz, S. H., Cieciuch, J., Vecchione, M., Davidov, E., Fischer, R., Beierlein, C., Ramos, A., Verkasalo, M., Lönnqvist, J.-E., Demirutku, K., Dirilen-Gumus, O., & Konty, M. (2012). Refining the theory of basic individual values. Journal of Personality and Social Psychology, 103(4), 663–688. https://doi.org/10.1037/a0029393

Secchi, D., & Bui, H. T. M. (2018). Group effects on individual attitudes toward social responsibility. Journal of Business Ethics, 149(3), 725–746. https://doi.org/10.1007/s10551-016-3106-x

See, Y. H. M. (2020). Cognitive-affective processing system. In V. Zeigler-Hill & T. K. Shackelford (Eds.), Encyclopedia of personality and individual differences (pp. 733–739). Springer International Publishing.

Shahadu, H. (2016). Towards an umbrella science of sustainability. Sustainability Science, 11(5), 777–788. https://doi.org/10.1007/s11625-016-0375-3

Shipley, N. J., & van Riper, C. J. (2022). Pride and guilt predict pro-environmental behavior: A meta-analysis of correlational and experimental evidence. Journal of Environmental Psychology, 79, 101753. https://doi.org/10.1016/j.jenvp.2021.101753

Silva, R. D. A., & Braga, R. T. V. (2020). Simulating systems-of-systems with agent-based modeling: A systematic literature review. IEEE Systems Journal, 14(3), 3609–3617. https://doi.org/10.1109/JYST.2020.2980896

Simis, M. J., Madden, H., Cacciatore, M. A., & Yeo, S. K. (2016). The lure of rationality: Why does the deficit model persist in science communication? Public Understanding of Science, 25(4), 400–414. https://doi.org/10.1177/0963662516629749

Spaargaren, G. (2003). Sustainable consumption: A theoretical and environmental policy perspective. Society & Natural Resources, 16(8), 687–701. https://doi.org/10.1080/08941920309192

Spalding, A. K., Biedenweg, K., Hettinger, A., & Nelson, M. P. (2017). Demystifying the human dimension of ecological research. Frontiers in Ecology and the Environment, 15(3), 119. https://doi.org/10.1002/fee.1476

Spotswood, F., Chatterton, T., Tapp, A., & Williams, D. (2015). Analysing cycling as a social practice: An empirical grounding for behaviour change. Transportation Research. Part F, Traffic Psychology and Behaviour, 29, 22–33. https://doi.org/10.1016/j.trf.2014.12.001

Steg, L., Lindenber, S., & Keizer, K. (2016). Intrinsic motivation, norms and environmental behaviour: The dynamics of overarching goals. International Review of Environmental and Resource Economics, 9(1–2), 179–207. https://doi.org/10.1561/100.0000077

Steg, L., & Vlek, C. (2009). Encouraging pro-environmental behaviour: An integrative review and research agenda. Journal of Environmental Psychology, 29(3), 309–317. https://doi.org/10.1016/j.jenvp.2008.10.004

Stern, P. C., Dietz, T., Abel, T., Guagnano, G. A., & Kalof, L. (1999). A value-belief-norm theory of support for social movements: The case of environmentalism. Human Ecology Review, 6(2), 81–97. http://www.jstor.org/stable/24707060
Stern, P. C., Dietz, T., & Kalof, L. (1993). Value orientations, gender, and environmental concern. Environment and Behavior, 25(5), 322–348. https://doi.org/10.1177/0013916593255002

Stern, P. C., Kalof, L., Dietz, T., & Guagnano, G. A. (1995). Values, beliefs, and proenvironmental action: Attitude formation toward emergent attitude objects. Journal of Applied Social Psychology, 25(18), 1611–1636. https://doi.org/10.1111/j.1559-1816.1995.tb02636.x

Thaler, R. H. (2021). Nudge: The final edition. Penguin Books.

Thoits, P. A. (1995). Social psychology: The interplay between sociology and psychology*. Social Forces, 73(4), 1231–1243. https://doi.org/10.2307/2580444

Tian, H., & Liu, X. (2022). Pro-environmental behavior research: Theoretical progress and future directions. International Journal of Environmental Research and Public Health, 19(11), 6721. https://doi.org/10.3390/ijerph19116721

Triandis, H. C. (1977). Cross-cultural social and personality psychology. Personality & Social Psychology Bulletin, 3(2), 143–158. https://doi.org/10.1177/014616727700300202

Triandis, H. C. (1979). Values, attitudes, and interpersonal behavior. Nebraska Symposium on Motivation, 27, 195–259.

Van Egeren, L. F. (2009). A cybernetic model of global personality traits. Personality and Social Psychology Review, 13(2), 92–108. https://doi.org/10.1177/1088868309334860

Verplanken, B., & Whitmarsh, L. (2021). Habit and climate change. Current Opinion in Behavioral Sciences, 42, 42–46. https://doi.org/10.1016/j.cobeha.2021.02.020

Vest, A. E., & Simpkins, S. D. (2011). Expectancy value models. In R. Levesque (Ed.), Encyclopedia of adolescence (pp. 895–900). Springer New York.

Wagner, N.-F. (2021). Habits and narrative agency. Topoi, 40(3), 677–686. https://doi.org/10.1007/s11245-020-09695-1

Wallnoefer, L. M., & Riefler, P. (2021). Concepts describing and assessing individuals’ environmental sustainability: An integrative review and taxonomy. Frontiers in Psychology, 12.

Wee, B. V., & Banister, D. (2016). How to write a literature review paper? Transport Reviews, 36(2), 278–288. https://doi.org/10.1080/01441647.2015.1065456

Wendel, S. (2020). Designing for behavior change: Applying psychology and behavioral economics. O’Reilly UK Ltd.

Wilkinson, T. M. (2013). Nudging and manipulation. Political Studies, 61(2), 341–355. https://doi.org/10.1111/j.1467-9248.2012.00974.x

Williamson, K., Bujold, P. M., & Thulin, E. (2020). Behavior Change. Interventions in Practice: A synthesis of criteria, approaches, case studies & indicators. Rare Center for Behavior & the Environment and the Scientific and Technical Advisory Panel to the Global Environment Facility. https://behavior.rare.org/wp-content/uploads/2021/02/Behavior-Change-Interventions-in-Practice-final.pdf

Williamson, K., Satre-Meloy, A., Velasco, K., & Green, K. (2018). Climate change needs behavior change: Making the case for behavioral solutions to reduce global warming. RARE.

Winters, M., Davidson, G., Kao, D., & Teschke, K. (2011). Motivators and deterrents of bicycling: Comparing influences on decisions to ride. Transportation, 38(1), 153–168. https://doi.org/10.1007/s11116-010-9284-y

Woiwode, C., Schäpke, N., Bina, O., Veciana, S., Kunze, I., Parodi, O., Schweizer-Ries, P., & Wamsler, C. (2021). Inner transformation to sustainability as a deep leverage point: Fostering new avenues for change through dialogue and reflection. Sustainability Science, 16(3), 841–858. https://doi.org/10.1007/s11625-020-00882-y

Worldbank. (2015). World Development Report 2015: Mind, Society, and Behavior.

Yamin, P., Fei, M., Lahlou, S., & Levy, S. (2019). Using social norms to change behavior and increase sustainability in the real world: A systematic review of the literature. Sustainability, 11 (20), 5847. https://doi.org/10.3390/su11205847