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Inviting Sustainable Behavior Through the Power of Metaphors in Design

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Abstract Addressing sustainability challenges requires shifts in consumption patterns and lifestyles. Design for Sustainable Behavior (DfSB) aims to cultivate sustainable attitudes and behaviors through product-based interventions. However, there can be a disconnect between design strategy and its embodiment and sometimes conflicts between designers' intent and users' interpretation. This paper explores the role of metaphors in DfSB in terms of using metaphorical thinking during the design process and/or creating product metaphors in the final design. It begins by identifying barriers that prevent people from engaging in sustainable practices, such as human nature and ambiguity in design. It then examines the roles of metaphor in design and its key strengths in DfSB. Furthermore, the paper outlines three methods to generate metaphors in DfSB: (1) The source domain implies the target domain. (2) The source domain serves design goals and strategies. (3) Cross-domain mapping is based on embodied experience. In conclusion, the paper discusses potential issues surrounding its use in DfSB.

Keywords Metaphor · Metaphorical thinking · Product design · Design for sustainable behavior · Behavior change · Sustainability communication

1 Introduction

The intended usage of daily facilities and objects, like toilet flushers, water faucets, and recycling bins, is expected to be clear and straightforward. However, in the actual usage context, various misinterpretations and unexpected ways of use may occur, some of which go against the original design purpose. For example, behavioral traces such as incorrectly stuffed bottles in recycling bins demonstrate conflicts between

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the design intent and the user's interpretation. In addition to the use of the product, it is also necessary to consider the result of human-product interaction and the impact of this result on society and the environment.

Over the past decade, the research focus of Design for Sustainability has expanded from designing sustainable products to fostering sustainable behaviors during the product use phase, leading to the rise of Design for Sustainable Behavior (DfSB). Despite a growing body of knowledge on behavior change mechanisms and design strategies, little research has been dedicated to investigating how to generate new insights into a behavioral design context and incorporate behavioral change strategies into design ideation and conceptualization. In this paper, we explore the potential of metaphor in DfSB, explicitly focusing on how designers can use metaphor as a source to envision and shape designs to invite sustainable behaviors.

The structure of this paper is as follows. Section 2 examines the two main obstacles that hinder people from engaging in sustainable behaviors: human nature and the ambiguity in design. Section 3 provides an overview of the concept of metaphor and its role in the design process and expression. Section 4 illustrates the advantages of using metaphors in DfSB through three lenses. Based on findings reported in previous sections, Sect. 5 proposes three methods to incorporate metaphors into DfSB, each with a corresponding design example. We conclude the paper by reflecting on the potential issues underlying the use of metaphors in DfSB.

2 What Makes Sustainable Behavior Difficult?

Although a ten-minute shower can save significant water compared to a bath, the latter is often perceived as more relaxing and enjoyable (GRACE 2022). Finding a balance between comfortable living and responsible consumption can be difficult. In most cases, persuading people to choose a more sustainable option over a more enjoyable one is easier said than done. According to the *nudge theory*, designers are choice architects who can significantly influence what and how options are presented to users, ultimately affecting their decision-making and behaviors (Thaler and Sunstein 2009). This section explores the challenges that both human nature and design ambiguity present in promoting sustainable practices.

2.1 Human Nature

Human behavior is influenced by a combination of physiological, psychological, cultural, and social factors. One of the main obstacles to promoting sustainable practices is a lack of awareness and urgency among individuals. Despite concerns about environmental issues, people often fail to connect their consumption patterns with their corresponding ecological impacts, which creates a disconnect between intentions and actions. Therefore, people need clear and immediate feedback linking their

daily behaviors to environmental consequences. Besides, emotional and habitual factors often influence human behavior rather than rational decision-making (Baron 2000). Despite knowledge and awareness of the harmful consequences of some habits, such as smoking and excessive drinking, individuals who have become accustomed to these behaviors may find it difficult to change them (Aunger and Curtis 2016; Clayton et al. 2015). Under situations where quick decisions are required and many options are available, people tend to rely on instinct rather than logical thinking (Patton 2003).

The second obstacle to promoting sustainable practices is rooted in the way the human brain functions. According to the *dual-process theory*, there are two types of thinking—fast and slow—that play a significant role in shaping human behavior (Kahneman 2012). *Fast thinking* is based on intuition, which leads to automatic and implicit actions, while *slow thinking* involves logical reasoning and results in conscious and deliberate actions. In most scenarios, sustainable behavior like garbage sorting typically falls under the latter category, requiring reasoned actions. However, when attempting to use products to encourage sustainable consumption, the target behavior may often occur subconsciously or unconsciously, such as in the case of water usage during handwashing or energy consumption in taking lifts.

On the one hand, behavior change is difficult because most daily actions are conducted as habits that do not require deliberate thinking or require minimal cognitive effort to maintain (Linder et al. 2022). On the other hand, some behaviors that provide immediate satisfaction (e.g., ordering fast food or viewing short videos on social media) can be hard to alter because the recognition of the negative consequences can probably only appear after a long time (Jager 2003). Therefore, the tendency to prioritize immediate pleasure over long-term impact is further exacerbated when the consequences of our actions have a spatial or temporal gap (Halford et al. 2007; Stock 1998).

On a large scale, sustainable development is a public agenda. Therefore, the third obstacle touches on "a clash of concerns"—the gap between collective and individual interests (Tromp et al. 2011). Choosing to travel by train than by plane can have a positive impact on the environment, but it may require a trade-off for people in terms of time efficiency. Similarly, a vegetable-based diet can benefit the planet but may go against one's preference for meat. Despite these challenges, everyday products and services can aid in encouraging sustainable practices by offering prompt feedback, simplifying behavior options, or aligning personal goals with broader concerns.

2.2 Design Ambiguity

Ambiguity, as defined by the Cambridge dictionary, is "*something that has more than one possible meaning and thus can cause confusion.*" Think of a faucet that you have no idea how to turn on or change temperature, or a recycling bin that you are uncertain about what to dispose of; ambiguity in product attributes (e.g., color, size, icon, and materials) can interfere with the user's identification of the product

use and operation, giving rise to confusion in interaction. According to RTS (2021), ambiguity caused by different types of expiration labels (e.g., sell by, use by, and best before) on packaging leads to a significant amount of food waste in the United States, with estimates of more than 80% (Collart and Interis 2018). Thus, ambiguity in design can negatively impact the clarity and consistency of a product's message and may even work against the design's intended purpose. In general, the conflicting meanings conveyed by product semantics can be considered noise in communication, negatively impacting the effectiveness and precision of the designer-product-user conversation (Krippendorff and Butter 1984).

Despite its drawbacks, some researchers believe that ambiguity in design should be treated dialectically because it can also benefit the design process. Design, by its nature, is an inventive activity that relies on both creative and strategic thinking. A design process can begin with a general idea that is often not clearly defined. This initial idea, known as the fuzzy front end, is transformed into a design vision by identifying and conceiving a design situation. This vision typically includes practical (product use) and experiential (product experience) elements and is not limited to one specific solution. Therefore, ambiguity in the early stages of design thinking and reasoning allows for a wide range of possibilities in the conceptualization phase. That is one of the reasons that designers can create different design proposals even when faced with the same design situation. Linse (2017) highlighted the benefits of keeping ambiguity in the early stages of the design process. It allows designers to explore more design perspectives and expand the space for design innovation. Indeed, the ability to sustain ambiguity in the design process has been recognized as a valuable aspect for designers by scholars in various fields, including visual communication, product design, engineering design, environmental design, and architecture (Aoki and Woodruff 2005; Leifer and Steinert 2011; Rapoport and Kantor 2007; Toh and Miller 2016).

In DfSB, it can be beneficial to bring out the merits of ambiguity during the design process (such as broadening the perspectives in analyzing design situations and creativity in design ideation) while balancing clarity and ambiguity in design expression to improve communication in user-product interaction. One possible solution is to use metaphors in design thinking, which allow for exploration and illustration while making abstract concepts concrete and understandable. The following section will further explore the notion of metaphor and its role in design.

3 The Power of Metaphors in Design

3.1 Foundations of Metaphor

Metaphor is one of the most common tools for expressing abstract ideas and thoughts in everyday language. For example, a difficult task can be described as "a tough nut to crack." A kind person can be referred to as "warm-hearted" or having "a

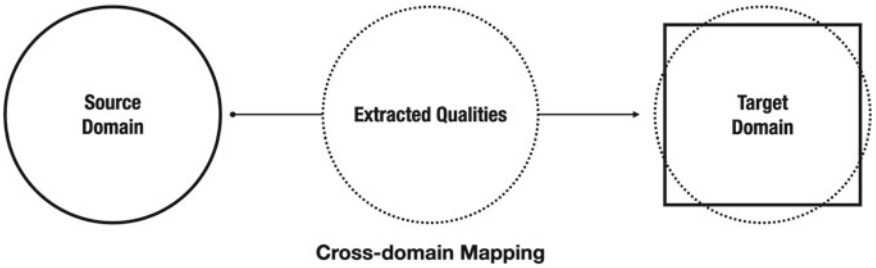

Fig. 1 Metaphor generation involves two domains (source and target) and the connection between them (cross-domain mapping)

heart of gold." According to Lakoff and Johnson (2008), metaphor is a way of "*understanding and experiencing one kind of thing through another.*" Therefore, metaphor involves transferring meaning to a new or abstract concept from a known or concrete idea. As illustrated in Fig. 1, metaphors can be created by establishing connections between two semantic domains by extracting relevant qualities from the source domain, referred to as "cross-domain mapping" or "metaphorical projection."

Cognitive linguistics argues that metaphor is not merely a figure of speech but also a representation of our embodied cognition, as conceptual understanding rooted in our bodily-based experiences (Steen and Gibbs 1999). Take the orientational metaphor as an example. Our understanding of happy/healthy as "up" and sad/sick as "down" derived mainly from our embodied interactions with the physical world. People tend to curl up or lie down when feeling sentimental or uneasy. In contrast, people are more inclined to stretch their bodies and jump up when feeling at ease or in a good mood. Because metaphorical thinking is prevalent in the human thinking system, implementing metaphors in design thinking can help designers resonate with users by relating their prior experiences with current interactions. Sometimes, it can also give rise to intuitive understanding and behavior. Below we elaborate on the role of metaphor in the design process and expression.

3.2 Metaphor in the Design Process: Metaphorical Thinking

The design process can be thought of as finding a balance between creativity and strategy, similar to finding equilibrium on a steelyard. Metaphors have long been a design thinking tool that can bridge imaginative and rational thinking (Liedtka 2015). According to Hey and Agogino (2007), engineering design students use metaphors spontaneously during product design, particularly in the initial concept generation stages. Likewise, Kim and Ryu (2014) observed that experienced designers frequently rely on intuition, emotional shortcuts, affect heuristics, or personal metaphors when defining design problems and creating new products.

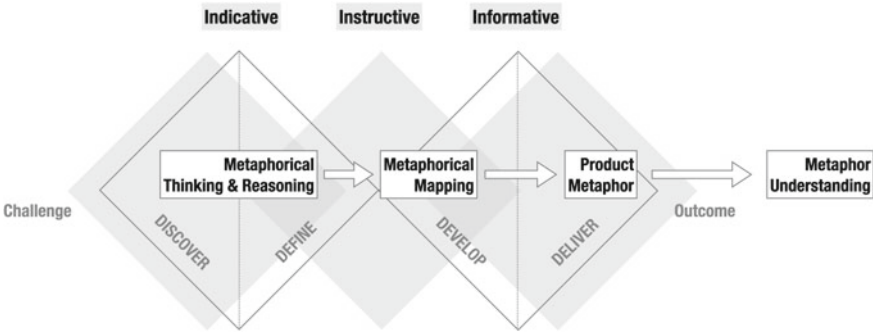

Fig. 2 The role of metaphors at different stages of the design process

The use of metaphors in the design process can be seen throughout the Double Diamond design model, which outlines the stages of discovering, defining, developing, and delivering. As shown in Fig. 2, in the first divergent-convergent phase, metaphor can aid in framing design issues and creating design visions (Liedtka 2015). In *generative metaphors*, Schön (1979) explored the potential of metaphors to address and solve complex and ill-defined problems. He coined "conceptual displacement" to describe how metaphors allow individuals to view situations from various perspectives, expanding the problem-solving space.

On the one hand, metaphor can bring new energy to conventional design topics. Casakin (2006) assessed the use of metaphors in urban design and found that it helped designers gain insights into a given design context. Building on these new viewpoints, designers can break away from existing designs and discover innovative and unique design opportunities. Metaphors, on the other hand, can provide designers access to new areas of design, particularly for those working closely with emerging technologies such as automated driving systems (Strömberg et al. 2020), human–robot interaction (Alves-Oliveira et al. 2021) and artificial intelligence (Murray-Rust et al. 2022). Previous research has proved that using metaphorical concepts (e.g., device, robot, and friend) could effectively aid designers in exploring and generating new interactive scenarios in intelligent environments (Kim and Maher 2020).

Next, in the transition between the two stages of the Double Diamond design model, metaphor can help connect the narrowing of focus in the Define stage with the expansion of ideas in the Develop stage. Using metaphors, designers can enhance their imagination and identify suitable sources for concept development (e.g., visualization and prototyping), eventually giving 'form' to the final design. Researchers have validated the capability of metaphors in distilling brand and product identity (Karjalainen 2001), such as creating shape-changing interfaces (Rasmussen et al. 2016) and creating multimodal-based artificial emotion displays (Löffler et al. 2018).

Finally, in the delivery stage, embedded metaphors in the final design can assist in communicating the design intent to users. However, the degree to which a metaphor is formulated in a design can vary, with designers able to either incorporate the

logical elements of a metaphor into the product interaction or deliberately make the metaphor a tangible aspect of the final product, referred to as "product metaphors" (Hekkert and Cila 2015).

3.3 Metaphor in Design Expression: Product Metaphors

According to Hekkert and Cila (2015), product metaphor means "*any kind of product whose design intentionally references the physical properties of another entity for specific, expressive purposes.*" The term "expressive purposes" can include both pragmatic and experiential aspects. In terms of pragmatic purposes, when designers use product metaphors to communicate the function of a design, product metaphors can provide behavioral cues that help users understand how to use and interact with the product. As shown in Fig. 3, the hourglass coffee maker uses design elements inspired by a sandglass, guiding the user to make coffee with simple steps: brewing, flipping, and enjoying.

Designers can employ product metaphors to convey not just the functional purpose of a design, but also to craft "aesthetic, emotional, and other meaningful experiences" for users (Desmet and Hekkert 2007; Schifferstein and Hekkert 2011). These metaphors are intended to communicate messages on an affective and ideological level and can evoke emotional and reflective thoughts beyond the context of the product. Figure 4 shows a desk lamp named "Balance," which has its head hanging downwards in its natural state. The user is asked to "trade" to use the light by placing their smartphone in a slot at one end. By referencing the properties of a balance

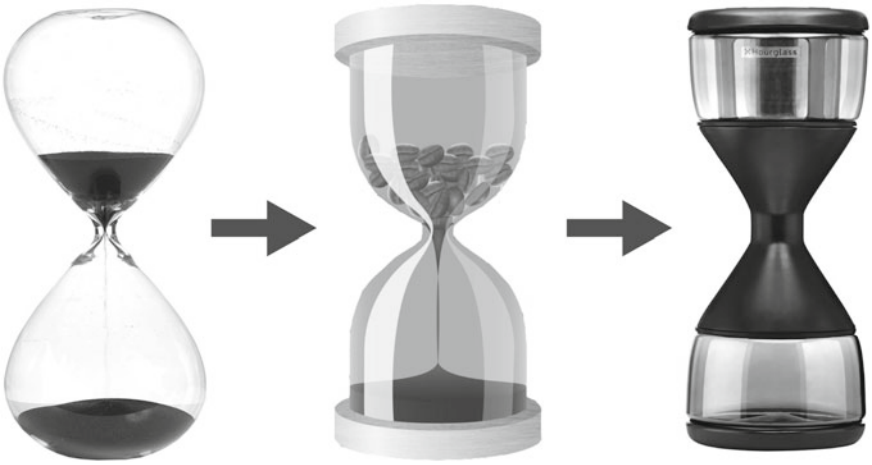

Fig. 3 The hourglass coffee maker references the salient qualities of a sandglass

Fig. 4 Balance Lamp by YUUE design studio. Photo by Xinyu Weng

scale, this product invites users to put down their smartphones intuitively while also prompting them to consider the balance between entertainment and work/study.

To summarize, metaphor can play a meaningful role in the design process and expression by helping define design issues (indicative), develop design ideas (instructive), and communicate design intent (informative). In DfSB, these three aspects can be used independently or in combination. This allows designers to employ metaphors to frame and articulate a design challenge, develop concepts, or shape product metaphors that steer user behavior. The following delves into the benefits of using metaphors in DfSB.

4 How Metaphors Help in DfSB

4.1 Bring Efficiency in Selecting Design Means

A design that relies heavily on written instructions and labels may indicate a lack of confidence in the design itself, as good design often tends to be self-explanatory. Metaphor has long been a powerful tool for artists, poets, and songwriters to express complex feelings and ideas in simple language. Similarly, metaphor in design can be used to achieve *Maximum Effects for Minimum Means* (MEMM), as Hekkert (2006) proposed. Humans naturally seek efficiency in perception, feeling, and action; in other words, everyone gravitates towards productive and energy-saving ways of functioning. In human-product interaction, this manifests as a drive to create designs that positively steer user experience and intended behavior while minimizing resources and information required—a principle that can be described as the economy of form. Colors can be linked to various meanings. Red, for instance, can represent anger and danger, while green can be associated with peace and vitality. By simple design means, we can see how colored traffic lights can effectively regulate road behavior or how green food packaging can appear healthier or more sustainable.

4.2 Eliminate Ambiguity in Design Understanding and Enrich Product Experience

Metaphors in verbal communication can create cognitive shortcuts that remove complexity and vagueness in conceptual understanding. Likewise, using metaphors in design can help remove ambiguity in interpretation and clarify the intended behavior for users. For example, compared with numerical information, implementing red and blue labeled icons in the faucet can easily guide users in setting the desired water temperature. The underlying reason for this color-heat association is that nature teaches us that fire/hot is red and water/cold is blue. In addition to the intended use, incorporating metaphors in DfSB can also enrich the product experience. An example of this point can be one of the classic designs of Alessi: Whistle Kettle. Richard Sapper, the acclaimed designer behind the work, drew inspiration from his nostalgic childhood memories. Through a creative transformation, he crafted an auditory metaphor by infusing the mellifluous siren of the Rhine River into the kettle's interactive dynamics. Technically, when the water approaches boiling, the ensuing steam emission engenders a rhythmic pattern due to fluctuating air pressure. This innovative design serves a dual purpose: it artfully informs the user when the water is ready while subtly instilling the idea of energy conservation and safety.

4.3 Elicit Intuitive Interactions Through Embodied Metaphors

There are various metaphors in language, from embodied to cultural and learned metaphors. Among them, embodied metaphors can evoke intuitive thought and action because they are established through bodily-based experience (Casasanto and Gijssels 2015). For example, "*once bitten, twice shy*" describes a person previously scared by a snake and will continue to be wary and frightened when encountering something similar, like a hemp rope. This "rope snake" metaphor shows how a person projects past experiences into similar situations and how establishing this conceptual relationship leads to intuitive perceptions and responses. Likewise, embodied metaphors in design use physical experiences to create product expression (Diefenbach and Ullrich 2015), which can lead to intuitive interactions by activating bodily-based cognition (Cila 2013; Hurtienne and Israel 2007). For instance, the recycling bin metaphor in the user interface associates physical actions (discarding waste) with digital actions (deleting unwanted files). This type of design uses visual (icon) and auditory-based (sound of kneading paper balls) metaphors to allow users to interact with computing systems more intuitively (Carroll et al. 1988).

5 Three Methods to Generate Metaphors in DfSB

In DfSB, the methods to create metaphors are worth classifying. In this section, we propose three methods for generating metaphors in DfSB by considering the source and target domains and the strategies used to connect them. Figure 5 gives an overview of these three approaches, and we discuss each in detail below.

5.1 The Source Domain Points to a Design Target

The first method in DfSB involves identifying and using a potential source to link to a specific design goal. This approach often occurs when designers observe and look deeply into an existing situation, such as behavioral traces. Through this, they can make conceptual connections that provide them with a source for metaphorical mapping. This way of thinking and looking at an existing situation can be understood as metaphorical reasoning.

Description. This method usually occurs when a designer observes subtle yet significant environmental traces and feels inspired when reflecting on them. More specifically, when a designer regards behavioral traces in the environment, a potential design situation may arise in their mind. The designer can then extract the characteristics of the source and apply them to the target situation to create conditions for the intended effects. In DfSB, one of the default ideas is to change current behaviors to achieve sustainability. However, we can also bring people's current behavioral

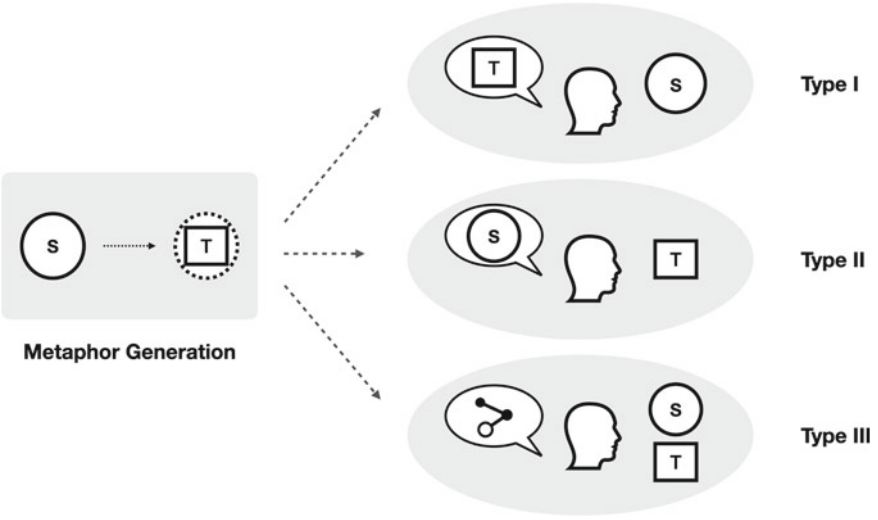

Fig. 5 Three methods to generate metaphors in DfSB

Fig. 6 The DropPit Ashtray Tiles improve efficiency in collecting cigarette butts. Photo by Siyuan Huang

patterns to a more appropriate context. In other words, designers can create conditions (referring to a source where desired behaviors often occur) that make it more likely to happen in the current situation. By making connections between cases, designers can identify potential sources through metaphorical thinking and create new associations.

Design Example. Sewer slides or utility holes are often misused as trash receptacles due to their convenience as a place to discard or hide litter in public spaces. However, this can lead to blocked pipes and other issues. Modifying the behavior of smokers who throw cigarette butts in these holes can be challenging. A design case named the DropPit Ashtray (see Fig. 6) addressed this issue by extracting the sewer slide's salient qualities into the design of an ashtray. This product is not meant to alter the habit of smokers throwing cigarette butts on the ground. It is designed to remind them of the characteristics of sewer grates to encourage them to continue doing so. Compared with products in the same category, this ashtray is designed to be easy to understand and convenient for smokers to use as they pass by, redirecting smokers' behavior toward a more beneficial outcome by reframing the problem.

5.2 The Source Domain Serves Design Goals and Strategies

The second method involves using metaphors to inspire the development of concrete design proposals when the design target and strategy are already known. Design thinking always begins with setting a specific goal. To achieve this goal, a designer will typically consider different strategies and choose the most appropriate means to communicate their intent to the user. Using metaphors can offer designers tangible concepts and ideas to guide the design process and shape the outcome.

Description. This approach is usually used after defining the design goal and behavioral design strategy. In DfSB, the objective of design is frequently connected to either hindering an undesirable behavior or fostering a desirable behavior. Design strategies that support the goal of promoting physical exercise can be to make exercise-related activities more enjoyable (increase people's motivation) or reduce the effort required to participate in sports (provide behavioral shortcuts). However,

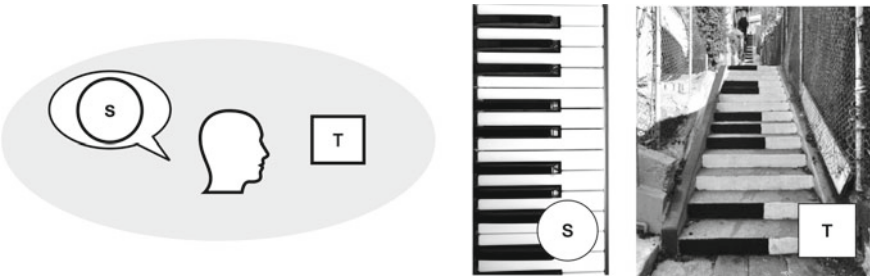

Fig. 7 Piano stairs make the target behavior fun, interactive, and engaging. Photo by Zara Marie

these design strategies are usually abstract, leaving a gap between the technique and the actual design. For this reason, a metaphoric source can help designers locate more specific design paths to give 'form' to the final design.

Design Example. Think of a design vision like "encouraging people to exercise more by making the behavioral choice of taking the stairs more appealing." A possible design strategy to achieve this vision might be to make stair-climbing more fun and motivating. However, it is still vague to sketch a concrete design concept. In other words, how can we make the activity fun and motivating? In this case, metaphors can help bridge this strategy-conceptualization gap by providing conceptual sources for the final design. A typical example of this method could be the Piano Stair, as depicted in Fig. 7. Instead of playing the piano with one's fingers, one can play it with their feet while walking and climbing. This turns the simple act of stepping into a playful and enjoyable experience, akin to creating melodies with every step.

5.3 Cross-Domain Mapping Is Based on Embodied Experience

The third method concerns creating conditions for embodied interaction, which refers to situations where the source and target are connected through physical, bodily-based experiences. Unlike the first two methods, this emphasizes generating embodied metaphors in design to promote intuitive interaction.

Description. For this approach, designers often identify similarities between the two domains and then map salient qualities associated with existing behaviors in the source domain onto the design target. Metaphors created in this way allow users to interact with the product in terms of familiar physical experiences, making it simple and easy to understand. The success of this type of metaphor generation relies heavily on the designer's ability to identify similarities and extract meaningful features for conceptualization. In the context of DfSB, similarities refer to comparable existing behaviors in the current interaction and the target behavior in the envisioned interaction. Meaningful features refer to the bodily-based qualities from the source domain that the designer maps onto the design target to create embodied product metaphors.

Fig. 8 This eye-catching trash bin is a cost-effective design solution to reduce littering in public spaces. Photo by Silver Spoon

The key lies in whether the designer emphasizes behavioral design strategies or a particular bodily-based behavior mechanism.

Note that while the methods implemented in Sects. 5.2 and 5.3 share a common ground, they have different characteristics. The approach in Sect. 5.2 uses metaphors to achieve the effect of predefined behavioral mechanisms. In contrast, the approach in Sect. 5.3 downplays the use of behavioral mechanisms and instead focuses on concrete embodied experiences to trigger intuitive interactions.

Design Example. The right side of Fig. 8 shows an unconventional trash bin, which is not placed vertically on the ground but is positioned at an angle and height. This eye-catching trash can draw people's attention and, more importantly, invites people moving on the road to dispose of their waste without having to pull over. Its form and interactive features (target domain) reference the physical properties and meanings of fly traps and basketball nets (source domains). This cross-domain mapping creates new meanings for waste disposal behavior in the target domain by leveraging the embodied experience of catching flying insects with a trap and throwing a basketball into a net.

6 Conclusion

Linguistic metaphors can improve environmental awareness by reframing the relationship between humans and nature (Larson 2011). In 2019, the Oxford Dictionary's annual report revealed a significant increase in the use of "climate emergency." Compared with "climate change," this phrase emphasizes the urgent need for action, as "emergency" is often used in critical situations. This paper proposes that similar impacts could be achieved by using metaphors in the design process and creating product metaphors as a final design outcome. In general, using metaphorical thinking and reasoning in the design process can help designers reframe design situations, identify innovation opportunities, and connect behavior change strategies with design conceptualization and embodiment. In addition, product metaphors in the final design can help clarify and smooth the designer-product-user communication process by providing behavioral cues to help users understand how to use

and interact with the product. Notably, we emphasize that in the context of DfSB, metaphors can (1) bring efficiency in selecting design means, (2) eliminate ambiguity in design understanding and enrich product experience, and (3) elicit intuitive interactions through embodied metaphors.

Since metaphorical thinking and reasoning can also occur unconsciously or unintentionally, designers often benefit from metaphors without being fully aware of or deliberately using them. This paper intends to articulate and explicitly bring the merits of metaphor more to the surface to enrich the design space. For instance, designers can explore alternative ways to encourage sustainable actions rather than focusing solely on changing current behavior. The DropPit Ashtray example discussed above reflects the idea of transferring existing habitual behavior to a proper context to achieve a sustainable outcome. In this case, users are not forced to change their current behaviors but can still achieve desired results.

However, potential issues underlying the use of metaphors in DfSB need to be noted and treated with care. One of these is that individuals may interpret and understand conceptual metaphors differently. Designers can create meanings through a design, whereas the users' interpretations of the design complicate this process. To ensure that the design intent can be communicated to users as accurately as possible, designers should anticipate possible variations in interpretation and be prone to adopt embodied metaphors to achieve simplicity and clarity in interactions (Crilly et al. 2008). Second, when choosing the metaphoric source, we suggest designers leverage innate and embodied ones as those can be universally accepted and appreciated. This is because cultural or novel metaphors are context-dependent and only applicable to the corresponding audience that can comprehend the meaning of the metaphor. For example, the color red entails very different meanings in Western and Eastern cultures. Third, some designers would naturally be inclined to use visual elements when transferring features from a metaphorical source to a design target. This can sometimes result in dull or arbitrary rather than intriguing results in view of product experience. Regarding such challenges in the conceptualization process, designers can adopt those design tools intended to translate and shape abstract ideas into tangible design qualities. For instance, the experience map Camere et al. (2018) developed can support the navigation of different sensory modalities and stimulate the rich materialization of design ideas.

In conclusion, incorporating metaphors in design to invite sustainable behavior is a powerful and practical approach to addressing complex sustainability issues. The key is how effectively and thoroughly the designer can generate and utilize metaphors to achieve the desired behavioral goal. Since metaphor generation and embodiment quality depend on the designer's intuition, creativity, and other professional skills, more relevant guidance could be incorporated into the existing design education system. We believe this research topic has much potential for further exploration and investigation.

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