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Connecting consumers to production processes: A new pathway to sustainable behaviour

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ABSTRACT

A growing body of research shows that consumers feel increasingly distant from the production processes of everyday commodities, particularly fast-moving consumer goods. Literature on psychological distance suggests that when individuals feel distant from events, such as climate change, their engagement and pro-environmental behaviour decline. However, while psychological distance has been widely studied, its application to production-consumption patterns remains unexplored. Moreover, despite numerous behavioural interventions, none address "distance from the production process" as a means of fostering sustainable consumption. Across three studies, one online and two laboratory experiments, this research explores how implicit and explicit packaging design interventions can frame production processes as either closer to or more distant from the consumer, and how such framings affect sustainability perceptions and disposal behaviour. Results demonstrate that short-distance framings enhance perceived packaging sustainability and encourage environmentally responsible disposal, directly or by strengthening consumers' sense of connection to the production process. These findings highlight the role of design in connecting consumers to production processes as a novel and actionable pathway for sustainable behaviour.

1. Introduction

Promoting sustainable consumption remains a central challenge in mitigating global environmental issues such as resource depletion and climate change (Boström, 2020; Dauvergne, 2010; Ehrlich and Goulder, 2007; Krausmann et al., 2009). The food industry alone accounts for roughly one-third of global greenhouse gas emissions, about 18 Gt Co_2 equivalent annually, generated across the entire supply chain from agricultural production and land-use change to processing, transport, packaging, retail, and consumption (Crippa et al., 2021). Agriculture and land-use change account for about 71% of these emissions, while the remaining share originates from downstream supply-chain activities. Among these, packaging alone contributes approximately 5.4% of total food-system emissions, exceeding the emissions associated with food transportation (Crippa et al., 2021).

Despite its significant environmental footprint (Arfelli et al., 2024), the impacts of food-packaging production remain largely invisible to the end consumer, obscured by the complexity of modern supply chains (Krishnan, 2017). Research consistently shows that consumers possess limited understanding of pre- and post-consumption stages and the consequences of their own consumption decisions (Godfray et al., 2018; Kozar and Hiller Connell, 2013; Pierce et al., 2010). Strikingly, 22% of British consumers are unaware that bacon comes from pigs (Cacciottolo, 2007), and 41% of American children claim that bacon come from a plant (Hahn et al., 2021), underscoring a deep disconnection between products and their origins (e.g., British Nutrition Foundation, 2013; Brophy et al., 2003; Kruger, 2014; Ray and Nayak, 2023; U.S. Farmers and Ranchers Alliance, 2011; van Bussel et al., 2022; Wunderlich and Smoller, 2019). A recent survey to British meat eaters further reveal that consumers feel detached from all stages of the production process of animal meat products sold on supermarket shelves and possess little knowledge of how these products are made; nearly half have stated to have never visited a farm or only once in their life (Granato and Schifferstein, 2025). Similar patterns emerge beyond meat: 45% of British coffee drinkers barely recall that coffee is a natural product, growing on a tropical plant, with some even believing it is locally farmed (Nestlé, 2023).

The responsibilities of this phenomenon seem to lie both on the production as on the consumption side. On the one hand, companies' assumptions about consumers, often portrayed as unable to understand

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the complexity of production processes, may have contributed to limited communication about how products are made. Over time, this reduced transparency can result in consumers having only a partial understanding of the supply chain and its associated requirements and constraints (Duffy et al., 2005; Herbes et al., 2024; Granato et al., 2022b). On the other hand, the current consumption modus, which favours an "ultra-convenience" of purchases and fast decision-making processes might have made consumers increasingly more passive and oblivious to the production process, particularly in the context of fast-moving consumer goods (Ersche et al., 2017; Havranek et al., 2017; Jain, 2019). Consumers acknowledge that they never or rarely seek information about where their food was grown or how it was produced (Kirshenbaum, 2018), overburdened by the extreme repetition, speed and automaticity of their consumption actions. This is particularly common when information about the production process may raise feelings of disgust or discomfort, such as animal slathering in meat production (Cairns and Johnston, 2018; Hahn et al., 2021).

Regardless of whether this disconnection stems primarily from producers (e.g., limited transparency or communication) or from consumers (e.g., lack of information, involvement, or interest), existing evidence suggests that contemporary consumer culture has become increasingly distant and detached from the production processes behind everyday commodities (European Institute of Innovation and Technology, 2023).

Drawing on Psychological Distance Theory (Trope and Liberman, 2003; Trope and Liberman, 2010), this disconnection between the consumer and the food production process may help explain why consumers often remain insensitive to the environmental consequences embedded in production-consumption systems. Psychological distance refers to the perceived remoteness of an event or object from the self, across dimensions such as spatial, temporal, social, or hypothetical distance. When events are perceived as psychologically distant, they are processed more abstractly and experienced as less urgent or personally relevant, reducing individuals' motivation to engage with or respond to them. Conversely, research in the sustainability domain shows that reducing perceived distance, such as by framing environmental consequences as closer to the self, can increase perceived relevance and stimulate pro-environmental engagement and action (Griffioen et al., 2016; Maiella et al., 2020; Schill and Shaw, 2016). Applying this perspective to consumption contexts suggests that when production processes are perceived as distant from the consumer, the environmental impacts associated with those processes may also feel less immediate or personally significant. This reduced sense of relevance can weaken consumers' sensitivity to sustainability issues (Brosdahl and Carpenter, 2010; Mancini et al., 2017; Wunderlich and Smoller, 2019) and, ultimately, undermine pro-environmental engagement and sustainable behaviour (Bryant et al., 2023; Parfitt et al., 2010).

Building on this theoretical foundation, we conceptualize *distance from the production process* as the perceived psychological distance between the consumer and the sequence of events that transform raw materials into a final product. Similar to other events examined in psychological distance research, such as climate change, production processes can be perceived as closer to or farther from the self along spatial (where production occurs), temporal (how temporally distant the stages of production appear), and social dimensions (how connected consumers feel to the actors involved in the process). When these processes are perceived as distant, the environmental impacts embedded in them may appear less immediate or personally relevant, potentially weakening consumers' sensitivity to sustainability issues (Brosdahl and Carpenter, 2010; Mancini et al., 2017; Wunderlich and Smoller, 2019) and undermining pro-environmental engagement and behaviour (Bryant et al., 2023; James and Montgomery, 2016; Parfitt et al., 2010).

While prior research has extensively studied the effects of psychological distance on consumers' sustainability -related responses (e.g., Griffioen et al., 2016; Maiella et al., 2020; Schill and Shaw, 2016), it has largely overlooked the potential for distance-related interventions to actively foster such effects. In particular, no prior research has examined how interventions can actively shape consumer perceptions of distance from production processes. Yet, product and packaging design offer a promising opportunity to intervene in this regard. Visual elements, materials, and textual information can communicate aspects of a product's origin and transformation, thereby framing the production process as either closer to or more distant from the consumer.

By the way in which packaging communicates a product's origin or the production process, it can act as a "production process narrative" that fosters psychological closeness, encouraging consumers to reflect on sustainability and their role within it. Despite the central role of packaging as an interface between producers and consumers, and its recognized potential to promote sustainable consumption (Granato et al., 2022a; Granato et al., 2022b; Magnier and Schoormans, 2015; Nemat et al., 2022), no research has so far explored how packaging can communicate or manipulate distance from production process, and how shifts in distance framing may subsequently influence sustainable consumer behaviour.

This research addresses this knowledge gap by conceptualizing and testing two forms of intervention, an explicit and an implicit intervention, that frame the production process of a compostable food packaging as either short distance or long distance. By combining these two forms of interventions, this research contributes to answer the following research question: "*How do explicit and implicit distance framing interventions, designed to make consumers closer to or more distant from the production process, influence perceptions of packaging sustainability and disposal behaviour?*".

By examining the intricate relationship between design interventions, distance framing and consumers' sustainability-related responses, this research contributes to three main streams of literature. First, it extends research on psychological distance by introducing *distance to the production process* as a novel dimension of application. Second, it integrates insights from consumer behaviour, communication and sustainable design by showing how explicit and implicit design interventions can be created to effectively manipulate the concept of distance from production processes, thereby offering concrete implications on how to foster pro-environmental behaviours, beyond perceptions. Finally, it contributes to the literature on sustainable consumption by identifying feelings of connection to the production process as a potential psychological mechanism linking sustainable packaging design to pro-environmental behaviour. In this regard, while nature connectedness (i.e., sense of belonging to the natural world; Mayer and Frantz, 2004) has been previously associated with how consumers respond to packaging sustainability (Jaiswal and Bihari, 2020; Kautish et al., 2021; Nuojua et al., 2024), no research has so far applied this construct to the production process and how such feelings of connection may foster more environmentally responsible consumer actions. At a practical level, this paper offers insights to food-packaging producers, designers and policy makers into how packaging can be designed not only to inform consumers about the production-consumption system of our everyday commodities or changing their perceptions, but also to engage them more deeply moving them into actual sustainable actions.

2. Theoretical background and research hypotheses

2.1. The concept of distance from the production process

Psychological Distance Theory underpins our conceptualization of distance from the production process (Liberman and Trope, 1998; Trope and Liberman, 2003). Psychological distance refers to the perceived closeness or remoteness between any perceiver and generic events, objects, or experiences along spatial, temporal, social, or hypothetical dimensions (Mayer et al., 2009; Mir et al., 2016; Scannell and Gifford, 2010; White et al., 2011). Similar to other events such as climate change, the production process can be perceived as closer to or farther from the self across spatial, temporal, and social dimensions. For example, consumers may perceive production as temporally distant when it involves

processes occurring long before consumption, or spatially distant when raw materials and manufacturing stages are imagined occurring in remote locations, far from the consumer. As distance dimensions are interrelated with one another, changing perceptions on one dimension can lead individuals to infer distance along another dimension. For instance, if consumers perceive the production process as temporally distant, they may simultaneously infer spatial distance. Similarly, distance dimensions are interrelated with other constructs that may influence perceived distance (Coulter et al., 2019; Keller et al., 2022). For instance, familiarity with a location has been identified as a factor that can shape how psychologically close or distant individuals perceive it to be (Keller et al., 2022). Extending this reasoning, greater familiarity with the locations where production processes occur may reduce the perceived psychological distance from those processes. While these constructs can act as antecedents shaping distance perceptions, they remain conceptually distinct from psychological distance itself. With the exception of few conflicting findings (e.g., Brügger et al., 2015; Schuldt et al., 2018; Wang et al., 2019), the prevailing evidence indicates that a greater perceived distance between an individual and an event, is associated with lower perceived relevance of that event and decreased intention to take actions to mitigate its effects (e.g., Arnocky et al., 2014; Bashir et al., 2014; Jones et al., 2017; Kim and Ahn, 2019; Maiella et al., 2020; Scannell and Gifford, 2013; Schill and Shaw, 2016).

Prior research has examined psychological distance as broad and abstract constructs, in which the perceiver can be any individual and the object of the perception can be any event. Yet, no research has applied this construct to the concrete distance between consumers and the production process of a product, including the stages of transformation of raw materials into the final product. This omission is critical because production processes form the physical and moral link between consumption and environmental impact. They are the stages where natural resources are extracted and transformed, generating much of the ecological footprint of consumer goods, but also where ethical and sustainability issues become visible and connected to everyday choices. Understanding what it means for consumers to feel close to or distant from these production realities, and how these perceptions can be influenced, is essential for identifying the psychological factors that obscure or enhance awareness of environmental impact. Such insights are crucial for designing interventions that effectively reduce the distance between the consumer and production and, in turn strengthen pro-environmental engagement.

2.2. *Implicit and explicit design interventions and distance framing for sustainable behaviour*

Within consumer behaviour research, various design interventions have been investigated and tested to prompt more sustainable responses. These range from more implicit interventions, which predominantly rely on an associative inferential belief formation route (Fishbein and Ajzen, 1977; Lindh et al., 2016), to more explicit interventions, activating a more informational belief formation system (Fishbein and Ajzen, 1977; Steenkamp, 1990). Examples of implicit interventions include the manipulation of distinctive product properties, such as sounds, tactile elements, transparency/opacity level of a material (Pichierri and Pino, 2023; Granato et al., 2022a; Magnier and Schoormans, 2015; van Ooijen et al., 2017), imagery and graphics (Geiger, 2020; Steenis et al., 2017), or pictorial elements (Shen et al., 2020), with the aim to trigger certain associations and implicitly guide consumer perceptions, intentions or behaviours in a desired direction. On the other hand, explicit interventions encompass textual and verbal information provided on product and packaging, also referred as labelling strategies (Aagerup et al., 2019; Borgman, 2018; Schwartz et al., 2020; Siraj et al., 2022), educational campaigns (Grodzinska-Jurczak et al., 2006; Welfens et al., 2016) or message framing (Grazzini et al., 2018; White et al., 2011; Zhang et al., 2019; Ran et al., 2022). As explicit in nature, these interventions are purposely designed to increase consumer awareness and ability to take informed decisions in a desired direction.

Research has demonstrated the effectiveness of both implicit and explicit design interventions in promoting consumers' sustainability-related responses. In the context of food product-packaging, for example, implicit (e.g., colour, texture, sound) and explicit design cues (e.g., logos, labels and claims) have been proven useful to significantly enhance sustainability salience and perception (Granato et al., 2022a; Magnier and Schoormans, 2016; 2017; Majer et al., 2022), encourage eco-conscious purchase intentions (Krah et al., 2019; Magnier and Schoormans, 2015) and foster a more sustainable disposal behaviour of the packaging (e.g., Borgman, 2018; Geiger, 2020; Granato et al., 2022a). Extending beyond the context of product-packaging, implicit and explicit design interventions have effectively steered a wide range of eco-friendly intentions and behaviours, such as waste reduction (Jagau and Vyrastekova, 2017; Vermote et al., 2018; Zhang et al., 2025), energy conservation practices (Abrahamse et al., 2005; Staats et al., 2000), recycling (Grazzini et al., 2018; White et al., 2011) and even flying behaviour (Estrada-Mejia et al., 2025).

While effective, all of these design interventions have been conceptualized and tested to directly and specifically influence consumers' sustainability-related responses, without targeting the potential role of feelings of distance (or connection) from the production process as underlying process in shifting perceptions and behaviours. In addition, attempts to manipulate, rather than merely measure, the concept of distance through design interventions aimed at promoting sustainable behaviour remain relatively scarce. One notable effort in this direction is the research on "distance framing" (Bashir et al., 2014; Brügger et al., 2015; Spence and Pidgeon, 2010; Zhang et al., 2019). For example, prior studies have manipulated temporal distance related to the consequences of climate change through design interventions such as the visualization of timelines representing different future horizons (Bashir et al., 2014). Participants were asked to place a dot representing the year 2020 on a timeline extending from the "present" (i.e., 2010) to the year 2085 (i.e., short distance condition) or 2025 (i.e., long distance condition), making the year 2020 feel closer or more distant from the present (Bashir et al., 2014). It was observed that such a distance framing manipulation, aimed at reducing temporal distance, significantly fostered participants' pro-environmental motivation and behaviour during the week following the study. Similarly, in another study, distance was manipulated through a landscape photographs containing an arrow that was pointing to either a proximal or a distal point in the landscape (Bar-Anan et al., 2007). Each arrow contained a word denoting either psychological proximity (e.g., "tomorrow," "we," "sure") or psychological distance (e.g., "year," "others," "maybe"), in terms of temporal, social and hypothetical dimension. In a similar vein, participants who were primed with spatial distance (relative to proximity) by marking close (vs. distant) points on a Cartesian plan subsequently reported greater social distances between themselves and members of their family and their hometown (Williams and Bargh, 2008, Study 4).

Building upon these insights, we propose that packaging can frame the production process itself as either psychologically distant from or close to the consumer. For example, packaging cues may portray the production process as long-distance from the self by emphasizing stages that occur far away in time or space from the consumer, who stands at the end of the supply chain. Conversely, packaging may frame the process as short-distance from the self by highlighting aspects that appear closer to the consumer in terms of temporal distance (e.g., perceived time between production and consumption), spatial distance (e.g., perceived proximity of production stages), or social distance (e.g., perceived connection to the supply chain actors). While the traditional dimensions of psychological distance also include a hypothetical dimension, this aspect is likely less relevant in the context of production processes, where the creation of the final product represents a certain and completed event rather than a hypothetical one. Building on the concept of psychological distance and the potential of packaging to communicate a product's production narrative, this research

investigates how distance framing between consumers and the production process shapes sustainability perceptions and pro-environmental disposal behaviour by influencing the perceived connection to the product's production process.

2.3. Current research and studies overview

The present research has the two interrelated aims of 1) exploring whether and to what extent a short versus long distance framing enhance consumers' sustainability perceptions of the packaging and pro-environmental disposal behaviour and 2) of conceptualising and testing an explicit and implicit intervention to effectively manipulate the concept of distance between the consumer and the production process. While this second aim is primarily methodological, it contributes by providing validated approaches for studying production-process distance in future research and practical applications.

In achieving these objectives, this research adopts the production process of a compostable packaging for food as context of application and specifically formulates the following hypothesis and theoretical framework (Fig. 1).

H1: Short distance framing increases consumers' sustainability-related responses (i.e., sustainability perception of the packaging and pro-environmental disposal behaviour) compared to long distance framing.

H1a (explicit operationalization): The effect predicted in H1 occurs when distance framing is manipulated through an explicit intervention (packaging label and textual information).

H1b (implicit operationalization): The effect predicted in H1 occurs when distance framing is manipulated through an implicit intervention (overall packaging look).

H2: When an explicit short distance framing is already provided, combining it with an implicit short distance framing does not further strengthen consumers' sustainability-related responses, suggesting a saturation effect rather than additive influence.

This hypothesis (H2) is supported by prior studies examining the combined effect of an implicit and explicit intervention on sustainable responses (e.g., Granato et al., 2022a; Holenweger et al., 2023; Kanay et al., 2021; Estrada-Mejia et al., 2025) and is theoretically grounded in the Embedding Effect (Kahneman and Knetsch, 1992). This body of research provides evidence on a "more is not the merrier" pattern, in which the combination of implicit and explicit cues does not add any effect beyond the one already achieved by either cue alone.

H3: The effect of distance framing on consumers' sustainability-related responses is mediated by feelings of connection to the production process, that is, short distance framing should enhance perceived connectedness, which in turn promotes sustainability perceptions and behaviours.

This hypothesis (H3) is grounded in Psychological Distance Theory and supported by prior research on distance framing. Short distance framing interventions (e.g., visualizations of timelines) have been shown to make individuals feel psychologically closer to a targeted event (e.g., climate change; Bashir et al., 2014), thereby increasing engagement and perceived relevance. By analogy, we propose that design interventions aimed at shortening the distance between consumers and the production process will enhance their sense of connection, ultimately fostering more sustainable evaluations and behaviours toward the product.

Empirically, these hypotheses are tested across three complementary studies, one online and two lab experiments, focusing on the design of a compostable packaging for biscuits. Compostable packaging was chosen as the context for this research because it is widely used to reduce environmental impact but presents practical challenges. Consumers often struggle to understand proper disposal, and companies may hide material properties, such as opacity or texture, out of concern for acceptance. This context allows us to examine how distance-framing design interventions can influence sustainability perceptions and pro-environmental behaviours while highlighting the communicative role of packaging in connecting consumers to the production process.

Study 1 (lab experiment) manipulates distance framing through an explicit intervention with a packaging label to test the main effect predicted in H1a. Study 2 (online study) manipulates distance framing through explicit and implicit interventions, separately, to explore the inferences that consumes make from these different distance framing manipulations. Study 3 (a second lab experiment) replicates H1a, extends to the implicit intervention (H1b) and tests both interventions in combination (H2). In addition, it assesses the mediating role of feelings of connection to the production process (H3) (Fig. 1). All studies obtained ethical approval from Delft University of Technology and Study 3 was pre-registered (Open Science Framework- https://osf.io/b6fy3/files/jx8wf). Data collection took place between June 2023 and January 2024.

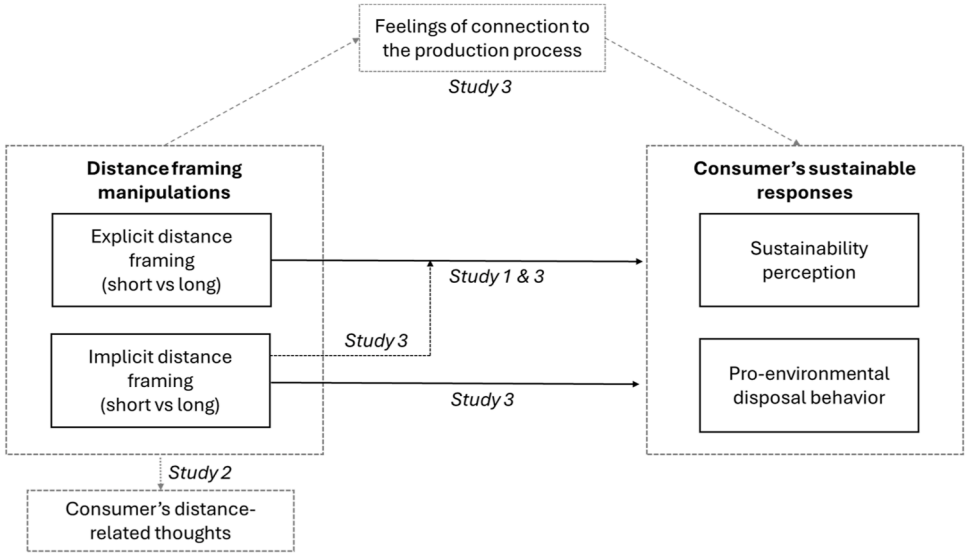


Fig. 1. Theoretical framework for studies 1, 2 and 3.

3. Study 1

3.1. Methods study 1

3.1.1. Participants and design

A 2 conditions between-subject design was conducted to test the effect of short vs long distance framing on sustainability perception and pro-environmental disposal behaviour of the packaging. To achieve a sufficient power ($\geq .80$) for detecting a medium effect size (d= .50) at a significance level of .05, a minimum sample size of 128 participants was calculated (two tailed t-test) (G*Power 3) (Faul et al., 2007). A total of 164 respondents were recruited in the lab. After excluding 10 participants who did not complete the experiment, and 11 participants who did not comply with the instruction to dispose of the packaging (but left it on the table), a final sample size of 143 participants (Mage = 22.53 years, SD = 4.59; 55.2% female, Dutch = 77.6%) was used for data analysis. As a cover story, participants were invited to take part in a biscuit-tasting session to evaluate a new biscuit product as well as its packaging. Upon completion of the experiment (10 minutes), participants were offered a chocolate bar as a thank-you gift.

3.1.2. Stimuli and manipulations

To manipulate short versus long distance framing from the production process, two compostable packaging prototypes made of corn starch were created including a packaging tray and a label for the short and long distance framing condition. The label explained the production process of the compostable packaging from the start to the end, either underlying the short distance between the consumer and the production process, or the long distance. This was achieved through the following design elements: 1) a line connecting the consumer with the raw material, at the start of the process. For the short distance condition, the line was shorter than in the long distance condition; 2) a number of arrows separating the consumer with the raw material, at the start of the process. For the short distance condition, the number of arrows were fewer (two arrows) than in the long distance condition (six arrows). Below each arrow, a step of the production process was explained (Fig. 2, panel a and b). These design elements are in line with previous manipulations of distance, where for example, temporal distance regarding the consequences of climate change was manipulated using a line depicting the time that separated the present with the future. In the short distance condition, the timeline was shorter, to make the future feel closer to the present, while in the long distance condition the line separating the future with the present was longer (Bashir et al., 2014). Because distance from the production process represents a novel form of distance that had not been experimentally manipulated before, a short explanatory text was included to support the manipulation. In the long (short) distance condition, participants read the following description: "*This is the relatively complex (simple), lengthy (rapid), and multiple-location (few-location) production process we follow to transform the raw material, the corn, into the highly processed biscuit packaging (biscuit packaging) you are holding. It shows no (still shows certain) resemblance to the corn*". The purpose of this text was to reinforce the intended perception of distance from the production process. Specifically, the wording highlighted aspects through which such distance may be inferred by consumers, such as the spatial separation between stages of production, the time required to transform the raw material into the final product, and the number of transformation steps involved. These elements were not manipulated as independent constructs but were included to make the perceived production-process distance more explicit and salient to participants.

To control for potential confounding effects related to knowledge and familiarity, both conditions provided the same textual information in terms of content and length. Only how the information was grouped differed: either in six stages in the long condition (i.e., corn harvesting, starch extraction, polymer creation, pellet formation, packaging shaping and final printing), or in two stages in the short condition (i.e., raw material processing, packaging formation). In addition, to ensure that disposal behaviour was influenced solely by the interventions, and not by prior knowledge or (un)familiarity with compostable packaging, all respondents received identical disposal instructions and the same definition of compostable packaging: "*A material is compostable if disposed of with organic waste. A compostable material decomposes in a composting facility and turns into compost*" (Granato et al., 2022a). A fictitious brand "*TreatTaste*," a few product details (volume, flavour) and the official European logo of compostable packaging were added on the packaging for a realistic look.

3.1.3. Procedure and measures

In Study 1, participants were recruited to evaluate a new biscuit product (with a tasting session included) and its packaging and directed to a computer room of the [blinded to reviewers] University. To limit social influence at the point of disposal, participants entered the room individually and commenced the study at their own pace, allowing for different completion times. Upon agreement to an informed consent, participants received the following instruction on their screens: "*Welcome! The company TreatTaste is launching a new biscuit in a new packaging. This is the overall product-packaging they developed. We will ask you to look carefully and evaluate 3 components of this new product-packaging: 1) the biscuit, 2) the packaging tray and 3) packaging information (see image below)*".

The tasting session served as a cover story to measure the spontaneous pro-environmental disposal behaviour of participants after their completion of the study. Participants were asked to carefully examine the packaging tray prototype on their desk. To maximise the engagement with the packaging and the effect of the interventions, participants were specifically instructed to hold the packaging tray in their hands. Next, they were instructed to read the label information on the screen carefully. Participants were asked to taste the biscuit and answer a series of questions measuring the overall appeal of the biscuit and packaging (e.g., its tastiness, naturalness, purchase intention) as filler questions. The main measurements included:

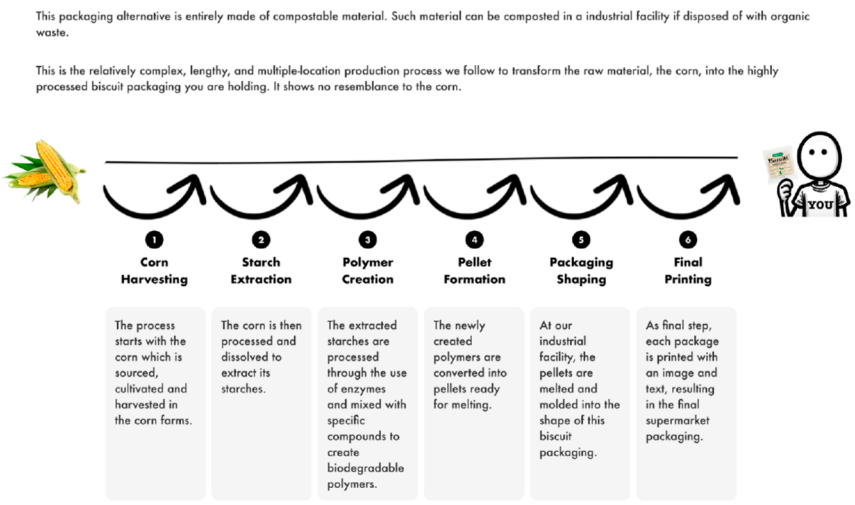
Sustainability perception of the packaging: Measured on a 7-point scale (1: very unsustainable; 7: very sustainable): "*To what extent is this packaging sustainable to you?*" (Granato et al., 2022a).

Actual disposal behaviour of the packaging: Prompted by the following instruction at the end of the study: "*To help us keep the room tidy and get it ready for the next participant, please empty your table and throw away any used materials on your way out. Thank you for your cooperation!*". A set of bin stations, comprising paper, organic, plastic, and general bin, was placed at the exit (Fig. A.1, Appendix A for the image of the study set-up). To guarantee maximum spontaneity, participants were not aware of this measurement.

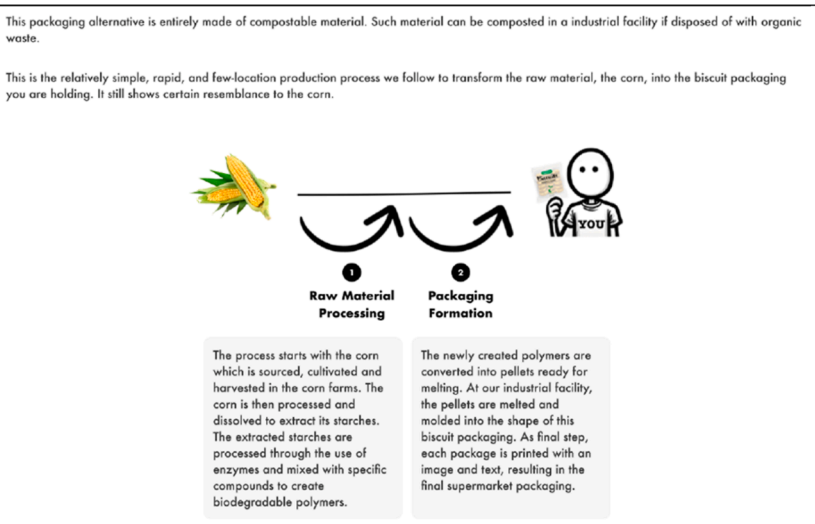
Other measures were recorded and reported below.

Manipulation check: A 5-items, 7-point bipolar scale was used to check whether the manipulation of the short versus long distance from the production process as depicted on the packaging was perceived as intended. "*To me the production process as explained on the packaging's wrapper seems… relatively complex/ relatively simple; to lead to a packaging with no resemblance to corn/ with certain resemblance to corn; lengthy/ rapid; performed at many locations/ few locations; far away from me/close to me*". An average of the five items was conducted to obtain a single manipulation check measure.

Individual traits and demographics: As individual differences in environmental concern have been shown to influence people's disposal behaviour, environmental concern was measured through a 7-points 3-items scale (1: completely agree, 7: completely disagree), adopted from the Ecologically Conscious Consumer Behaviour (ECCB) scale (Roberts and Bacon, 1997). This scale has also been adopted in previous research on design interventions for sustainable behaviour and has been used as potential covariate (e.g., Estrada-Mejia et al., 2025; Granato et al., 2022a; Granato and Mugge, 2025). The statements included *1) I normally make a conscious effort to limit my use of products that are made of*



Panel a: long distance condition



Panel b: short distance condition

Panel c: overall packaging design (packaging label and tray).

Fig. 2. The two packaging labels manipulating long vs short distance framing used in Study 1 (panel a and b) and the overall packaging design (panel c).The labels were presented to the respondents on a computer screen, in a large font and together with the overall packaging design (Fig. 2, panel c). The physical, square tray of the packaging was present on the desk of the respondents and included a six (vs two) arrows icon on its bottom as reminder for the long (vs short) distance condition. The tray contained one biscuit to taste as cover story and each packaging tray was labelled with a unique number, to allow for the analysis of the disposal behaviour.

scarce resources, 2) I have switched products for ecological reasons, 3) When I have a choice between two equal products, I always purchase the one that is less harmful to other people and the environment." To be able to describe the sample, demographic information, including age, gender, nationality, and city of residency was asked.

Attention check: an open-ended attention check question was added, by asking "Please recall the raw material of the packaging we have presented to you".

Confound checks: the information on the packaging was checked for clarity, credibility, transparency, involvement, packaging information appreciation, and processing fluency through a series of 7-point bipolar scales (e.g., *This packaging information is…* 1: difficult to process/understand/comprehend; 7: easy to process/ understand/comprehend; White et al., 2011).

3.1.4. Analysis plan

Reliability analyses were conducted for all the included scales (Cronbach's alpha) (Appendix B, Table B.1 for the values). Independent-samples t-tests were used to analyse the manipulation check, sustainability perception, and potential confounds. For sustainability perception and disposal behaviour, one-sided tests were conducted because our hypothesis (H1) predicted a specific direction of the effect, namely that short distance framing would lead to higher sustainability perception and more sustainable disposal behaviour than long distance framing. Accordingly, one-sided significance values were used (a one-sided t-test for sustainability perception and a one-sided Fisher's Exact Test within the Chi-square analysis for disposal behaviour), which are appropriate when directional hypotheses are specified a priori. Disposal behaviour of the packaging was analysed by examining the waste bins. The code "sustainable behaviour" (coded as 1) was assigned if participants had disposed of the packaging tray into the organic bin. Otherwise, the code "unsustainable disposal behaviour" (coded as 0) was attributed (Geiger, 2020; Granato et al., 2022a). Data were analysed with binary logistic regressions to test effects of short distance framing against the baseline "long distance framing" and a Chi-square test to test associations between distance framing and disposal behaviour. Environmental concern was included as a covariate to account for individual differences that may influence disposal behaviour, as previous research has shown that environmental concern can affect how individuals dispose of products.

3.2. Results of study 1

3.2.1. Manipulation check

An independent samples t-test showed a significant main effect of distance framing on the average of the manipulation check measures. Participants perceived the production process of the packaging in the short distance framing as closer to them (M = 4.01, SE = .11) than the production process of the packaging in the long distance framing (M = 3.40, SE = .12; t (141) = -3.75, p < .001; Cohen's d= 0.98).

3.2.2. Effect of distance framing on sustainability perception and sustainable disposal behaviour

Sustainability perception: to test H1a for sustainability perception, an independent samples t-test showed that participants perceived the packaging in the short distance framing as more sustainable (Mshort = 5.42, SE = .11) than the packaging in the long distance framing (Mlong = 5.10, SE = .15; t (141) = -1.73, p = .04, Cohen's d= 1.10) (Fig. 3, panel a).

Disposal behaviour: to test H1a for disposal behaviour, a logistic regression showed that respondents disposed of the packaging more sustainably in the short distance framing condition, than in the long distance framing (B = 1.07; SE = 0.36; Wald= 8.88; Df = 1; p = .003). The effect of the environmental concern as covariate was not significant (p = .76). The chi-square test re-confirm these results, showing a significant association between distance framing and disposal behaviour, (χ^2 (1) = 9.48, p = .002). Participants in the short distance framing disposed of the packaging more sustainably (62.1 %) than participants in the long distance framing condition (37.9 %) (Fig. 3, panel b).

3.2.3. Excluding potential confounding effects

Independent samples t-tests showed no differences in terms of clarity (p = .74), processing fluency (p = .33), and credibility (p = .84) of the information in the short and long distance framing conditions. Regarding transparency of the packaging information, involvement, and packaging information appreciation, independent samples t-tests showed that participants perceived the information in the long distance framing as slightly more transparent (Mshort = 5.26, SE = .13; Mlong = 5.64, SE = .10; t (141) = 2.35, p = .020), more involving (Mshort = 3.62, SE = .17; Mlong = 4.19, SE = .16; t (141) = 2.42, p =.017); and as more appealing than the one in the short distance framing (Mshort = 4.73, SE = .17; Mlong = 5.28, SE = .17; t (141) = 2.20, p = .029). Despite the significance differences, the higher mean values were observed for the long distance framing and are thus unlikely to impact the results of the

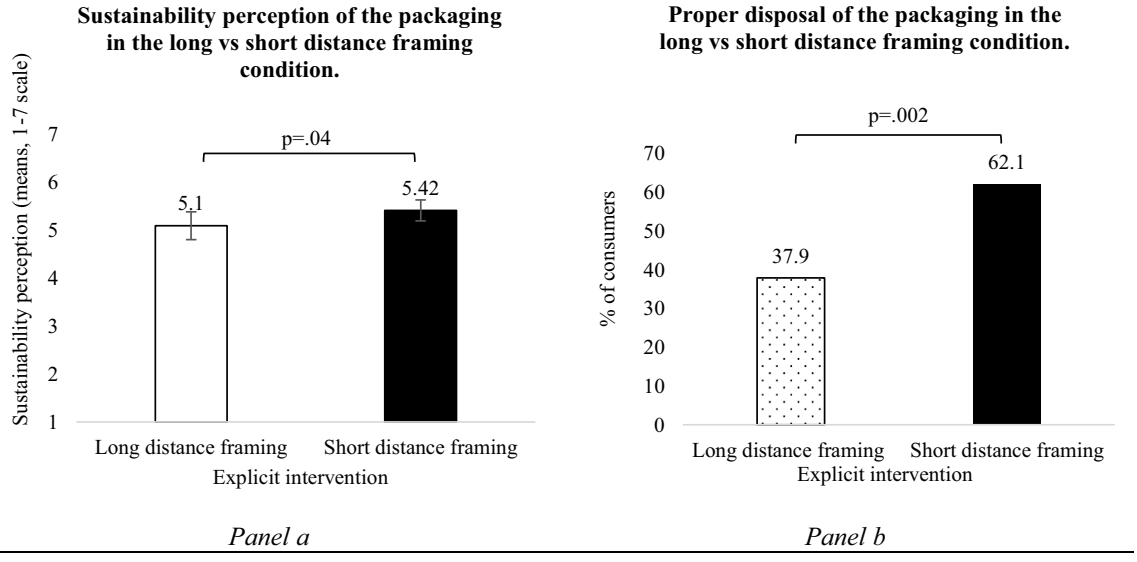


Fig. 3. Results of Study 1 on the effect of long vs short distance framing on sustainability perception of the packaging (panel a) and disposal behaviour (panel b).

hypothesized main effects.

3.3. Discussion of Study 1

The results of Study 1 confirmed H1a, showing that short distance framing increases consumers' sustainability-related responses, and specifically, sustainability perception of the packaging and pro-environmental disposal behaviour, compared to long distance framing. This was demonstrated through an explicit packaging label intervention, which effectively manipulated the distance that separates the consumer at the end of the production process from the steps in between and the raw material at the start of the process. The manipulation that shortened such a distance, making consumers closer to the production process, lead consumers to perceive the packaging as more sustainable and to disposed of it more sustainably.

Although the packaging label used in this study was effective in manipulating a shorter or longer distance, it had some limitations in regard to its ecological validity: it included a rather extensive text with detailed information about the production process. Some companies may be reluctant to adopt such interventions on the packaging of their supermarket products, which usually compress much information in a limited space, together with the ingredient list, the company brand, and other product details. A more compact label with a shorter text may be more realistic and may increase the ecological validity of this study-setup to test H1. In addition, a more compact label may increase the internal validity as well. In fact, although the explanatory text was included to make the manipulation clearer, the wording also referred to aspects such as duration, and number of production locations, which may have influenced participants' perceptions. Study 2 tackles this consideration by conceptualizing and testing a revised version of this explicit distance framing manipulation, with a shorter and more compact text, to increase its potential applicability and increase both internal and ecological validity of the research. In addition, as certain companies may be inclined to trigger short or long distance framings through an overall look of their packaging design (e.g., a colour, a texture etc.), rather than through explicit and detailed explanations of their production process, Study 2 develops and tests an implicit intervention as well. Through an exploratory focus, Study 2 aims to understand whether an implicit distance framing and a revised explicit distance framing can still activate distance related thoughts in the mind of consumers, even when these interventions do not explicitly relate to the concept of distance or do it less specifically. More broadly, Study 2 aims to explore the thoughts and associations consumers generate when interacting with distance framing interventions, thereby deepening understanding of the concept of distance from the production process. To achieve this, Study 2 was conducted online, transitioning from the controlled lab setting used in Study 1. Because its primary focus was on the qualitative exploration of consumer inferences and associations, rather than on measuring actual disposal behaviour, an online setting was both appropriate and sufficient for the research objectives.

4. Study 2

4.1. Methods study 2

4.1.1. Participants and design

To investigate consumers' thoughts and associations elicited by short or long distance framing interventions and increase the ecological validity of Study 1, a 4 between-subjects design was created, varying short versus long distance framing in an explicit and implicit intervention, separately. To achieve a sufficient power ($\geq$.80) for detecting a medium effect size (f = .25) at a significance level of .05, a minimum sample size of 176 participants was calculated (G*Power 3) (Faul et al., 2007). A total of 299 British participants were recruited through the platform Prolific. After excluding 12 participants who failed both embedded attention checks, four participants who provided incomplete questionnaire responses and one participant whose answers exhibited no variation, a total of 282 responses (Mage = 43.82, SD = 14.09; 64.9% female) were recorded for data analysis. Participants received the standard compensation set by the Prolific platform for an eight minutes' experiment (1.50 euros, converted from original pounds).

4.1.2. Stimuli and manipulations

For the implicit and explicit manipulations of distance framing four compostable packaging prototypes made of corn starch containing biscuits were created and presented to the respondents on the screen. While Study 1 included both physical prototypes in the lab and on-screen presentations, the online nature of Study 2 required that stimuli be shown solely as virtual images (see Table A.1, Appendix A, for similarities and differences across studies).

Explicit distance framing (short vs long): Based on Study 1, the revised manipulation included several improvements to increase internal and ecological validity. The text of the label for the long (vs short) distance framing contained one single sentence: "*These are the many (few) steps we follow to transform the raw material, the corn, into this final biscuit packaging*". This text was accompanied by the same image used in Study 1, where the production process was divided into six (vs two) steps for the long (vs short) distance framing manipulation. While the corn was depicted at the beginning of the production process, the final packaging was depicted at the end (differently from Study 1, where the consumer was at the end) (Fig. 4). The same definition of compostable material as in Study 1 was provided.

Implicit distance framing (short vs long): The manipulation of the implicit intervention consisted of two distinct packaging trays for the respective long vs short distance framing conditions (Fig. 4). The tray for the long distance condition had a transparent smooth look to implicitly communicate a longer distance separating the consumer with the origin of the packaging, the corn, which is not transparent. On the contrary, the tray for the short distance condition had an opaque non-smooth look to implicitly communicate a shorter distance between the consumer and the origin of the packaging, the corn, which has a very pale yellow colour when uncooked. Thus, in this context, opacity was used as a cue that makes the packaging material appear closer to its raw-material origins, and the consumer more connected to the transformation process that occur in the production of a compostable packaging for biscuits.

4.1.3. Procedure and measures

Participants were instructed to take time to carefully look at and evaluate the packaging tray (label), as done for Study 1. Since the aim of this study was to deepen understanding of the concept of distance from the production process, participants were prompted with the following message: *"We would like to receive your opinion on the distance that separates the final packaging, which is at the end of the production process, from its raw material, which is the corn at the start of the production process. Please answer these questions by moving the bar below"*. Three items were included*: (1) The distance between this packaging and its raw material, the corn, is…* (1 = very short, 7 = very long); *(2) The distance between the start and the end of the production process of this packaging is…* (1 = very short, 7 = very long); *(3) The production steps that separate the final packaging from its raw material, the corn, are…* (1 = very few, 7 = very many). *"Please explain here why you think the distance between the final packaging and its raw material is very short/very long. Please describe your reasons in as much detail as possible."* Three separate answer fields were made available to encourage participants to articulate their thoughts from various angles. We deliberately asked participants about the distance between the final packaging and the raw material, rather than between the consumer and the raw material. Because participants were directly exposed to the final packaging stimulus, this formulation was intended to reduce abstraction and ensure that respondents evaluated distance based on the elements presented in the stimulus. This also align with the notion that psychological distance judgments are often constructed

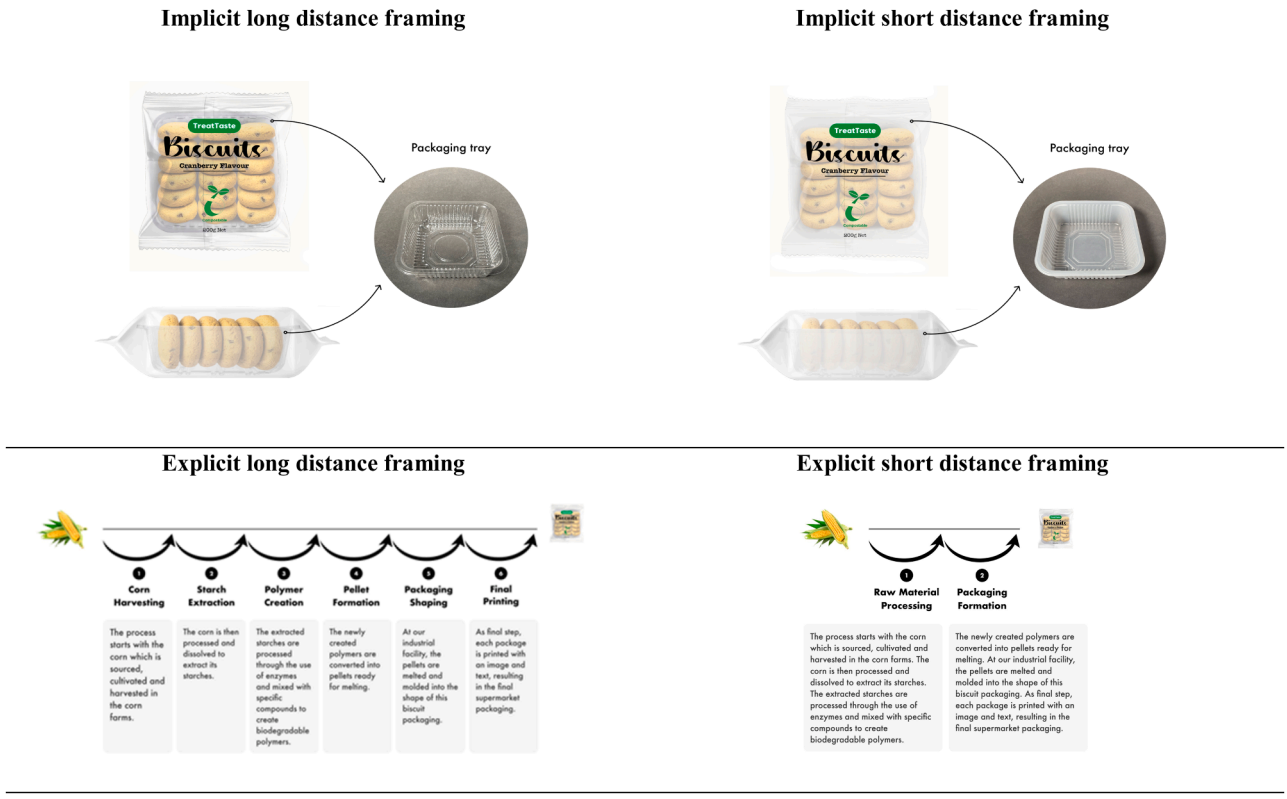


Fig. 4. The four separate conditions of Study 2, with the implicit tray (top: long vs short) and explicit label (bottom: long vs short) distance framing manipulations.

based on the cues that are most salient in the immediate context.

To further understand potential confounds resulting from the development and revisions of our distance manipulations from Study 1, respondents indicated levels of construal (*The packaging communicates…* 1: how it is made; 7: why it is made), processing fluency (*The way this packaging communicates the production process is…* 1: very difficult; 7: very easy to process/understand/comprehend; White et al., 2011) and level of abstraction (*The way this packaging communicates the production process is…* 1: very abstract/general/intangible, 7: very concrete/specific/tangible; Laroche et al., 2001).

4.1.4. Analysis of the qualitative data

The qualitative responses were analysed using an iterative coding process. In the first stage, responses were coded deductively based on the traditional dimensions of psychological distance, with indications of both temporal and spatial distance emerging. In the second stage, recurring patterns in participants' descriptions were identified and grouped inductively to further capture how distance from the production process was construed. This analysis yielded two broader themes. The first concerned the effort involved in the production process, including labour, resources, and functional transformations of materials, which appeared to shape participants' mental representations and evoke perceptions of shorter or longer psychological distance. The second theme related to aspects of the final product design, particularly the extent to which it visually signalled material transformations. This theme emerged most prominently in the implicit intervention condition, suggesting that visual design cues influenced how participants inferred the proximity of the production process. To enhance reliability, two researchers independently coded the responses and resolved discrepancies through discussion until agreement on the final coding scheme was reached.

Overall, the coding procedure identified four main themes. To assess whether these themes were present across all interventions (i.e., whether each intervention elicited all categories of distance-related thoughts), we summed the frequency of each code (see Fig. C.1, Appendix C). When respondents mentioned multiple thoughts corresponding to the same code, each instance was counted separately. In support of the robustness of our identified themes, both the implicit (packaging tray) and explicit (label) interventions triggered distance thoughts from all four themes (see Fig. C.1, Appendix C).

4.2. Results study 2

4.2.1. Distance thoughts triggered by the interventions

Following three probing questions about the explicit and implicit interventions manipulating short versus long distance, respondents elaborated on four categories of distance-related thoughts, as identified through the coding analysis: (1) temporal distance, (2) spatial distance, (3) resource-related distance, and (4) outcome-related distance (Table 1).

First, temporal distance referred to the perceived time between production and consumption. Respondents perceived the production process as more temporally distant when it appeared lengthy (e.g., "*it must have taken a long time to produce the packaging from its original state*") and as closer when it seemed relatively rapid (e.g., "*it looks a fairly rapid process*").

Second, spatial distance captured perceptions of the geographical separation between production and consumption. The process was seen as more distant when it involved multiple or far-removed locations (e.g., "*there are several locations required to produce the final product, from field to factory*") and as closer when production was perceived to occur in proximity (e.g., "*it can be made at the same place*").

Third, resource-related distance reflected the perceived intensity of resources involved in the production process. Greater distance was associated with complex, resource-intensive processes, including extensive use of machinery, energy, labour, and transformations of material functions (e.g., "*there are a lot of processes to get from the corn to the final packaging*"; "*it looks as if it requires a lot of different techniques and*

Table 1
Results from the coding analysis. four categories of distance thoughts (long vs short) triggered by the implicit and explicit interventions that manipulated distance from the production process.

Distance categories	Explanation and quotes from respondents
1. Temporal	Perceived time between production and consumption. Long distance in time: *"It must have taken a long time to produce from its original state", "It would take a long time to process the raw material to make a tray", "Timing of production would play a part in the long time", "Seems a long process when you take into consideration the added time to grow the corn and the harvesting storage required before the package is even made"* Short distance in time: *"The distance between the final packaging and its raw material seems shorter, as it takes less time to test/find packing materials", "ingredients sound fresh", "It looks a fairly rapid process", "Seems like a short amount of time"*
2. Spatial	Perceptions of the geographical separation between production and consumption. Long distance in space: *"This would probably require 1 or more processing facilities which may be a fair distance apart", "A factory producing packaging is unlikely to be in the vicinity of a corn field", "Too much distance between wheat harvesting and factory for production", "There are several locations required to produce the final product - from field to factory"* Short distance in space: *"I think it is short because it is made of the same material which means it can be made at the same place", "Not massive transport distance from source to sale location", "This could be done more locally to the biscuit factory saving transport cost", "From the sourcing to the processing of the packaging it wasn't greatly distanced"*
3. Resources	Perceived intensity of resources involved in the production process. Long distance in terms of resources used: *"I think there must be a lot of processing to get from the corn to the final packaging", "looks as if it would take many steps to change into its final form"* - Long material transformation in terms of functionality and durability: "*The initial thought of corn as food, which is what I associate it with, is at great distance from corn as a plastic substitute"* - High use of equipment and materials: *"looks as if it requires a lot of different techniques/machinery to change the product", "It seems that additional chemicals may be added to give it the texture"* - High use of energy: *"Corn harvested, requires energy and energy will be needed to transport the corn and to store it safely until it can be utilised"* - High use of labour and staff: "*The steps seem quite labour intensive", "Many different people are involved"* Short distance in terms of resources used: *"quick and easy to make packaging", "Doesn't seem to go through much process requirements", "converting from corn to starch should be relatively straightforward"* - Low use of materials: *"It is made of corn and little else", "Few materials needed in the process, it is made of corn and little else"* - Low use of labour and staff: "*Not many humans who help within the production line. Reduced staff needed and more automation means the process can be shortened and quickened", "Seems less labour intensive"*
4. Outcome	The extent to which the final product visually and functionally diverged from the raw material. Long distance signalled by outcome: *"It is nothing like corn", "It looks like plastic", "It is different from corn in composition (colour, texture, shape...)", "The packaging looks like plastic and has lost all natural colour and texture", "The appearance change from raw product to final product is huge - you wouldn't recognise the raw product in the end packaging, unbelievable", "The final packaging looks complicated and difficult to create", "it seems like it would take a while to break down further", "Composting takes quite some time"* Short distance signalled by outcome: *"It feels close to nature, giving the sense of a short distance", "The end product seems to be a natural form of packaging therefore not too far away from the raw material", "It seems less than artificial or plastic products might be", "The packaging was a simple design, meaning short and easy to make", "It seems as though the compostable material may need to degrade quicker than plastic", "The fact that the material can then be put into the compost and it will decompose easily also suggests it is not too far removed from its original raw material"*

machinery"). In contrast, processes perceived as simpler and less resource-intensive evoked a sense of proximity (e.g., "*few materials are needed in the process, it is made of corn and little else"*).

Fourth, outcome-related distance concerned the extent to which the final product visually and functionally diverged from the raw material. A high degree of transformation, such as a lack of resemblance to the original material or longer decomposition, elicited perceptions of greater distance (e.g., "*you would not recognize the raw product in the end packaging"; "it seems like it would take a while to break down*"). Conversely, designs that maintained a closer resemblance to the raw material and appeared simple to produce were associated with shorter perceived distance (e.g., "*it seems to be a natural form of packaging, not too far from the raw material*").

4.2.2. Excluding potential confounding effects

Independent samples t-tests showed that the short vs long distance manipulations in both the implicit and explicit interventions were perceived as comparable in terms of level of abstraction (implicit: $p = .61$; explicit: $p = .06$) and construal level (implicit: $p = .82$; explicit: $p = .15$). With respect to processing fluency, no differences were observed in the implicit intervention ($p = .45$). In the explicit intervention, however, participants perceived the packaging with the long distance framing as easier to process (Mlong=5.29) than the packaging with the short distance framing (Mshort= 4.77; $t(145) = 2.05$, $p = .04$, Cohen's $d = 0.34$). Importantly, the effect is in the opposite direction of the hypothesized pattern and is therefore unlikely to account for the observed results. In other words, it is unlikely that the slightly higher processing fluency in the long-distance framing would lead to less sustainable responses.

4.3. Discussion study 2

By uncovering the types of thoughts elicited by the distance-framing interventions, Study 2 deepens our understanding of how design interventions can be used to manipulate perceived distance from the production process. Four main categories of distance-related thoughts emerged, reflecting the underlying reasons why the production process was perceived as psychologically closer or more distant. These categories capture distinct dimensions of distance between the consumer and the production process: temporal ("when"), spatial ("where"), resource-related ("how"), and outcome-related ("what").

The first three dimensions, time, space, and resources, relate to characteristics of the production process itself and shape how distant the process appears from the consumer and the raw material. In contrast, the outcome dimension highlights how properties of the final packaging influence perceived distance. Notably, the resource and outcome dimensions can be conceptually integrated under a broader notion of *transformation*, whereby consumers perceive greater or lesser distance depending on the extent of functional (resource-related) or visual (outcome-related) transformations inferred.

In contrast, social ("who") and hypothetical ("if") distance, both core dimensions of Psychological Distance Theory (Trope and Liberman, 2003; 2010), did not emerge in participants' responses. This absence is consistent with the nature of our manipulations. The explicit intervention (a line with arrows) and the implicit intervention (variations in packaging opacity) did not provide cues about the people involved in the production process, thereby limiting the activation of social distance. Similarly, both interventions depicted or described completed production processes that resulted in a tangible outcome, which likely reduced the relevance of hypothetical distance.

A further key insight from Study 2 is that distance-related thoughts can be activated both implicitly, through the visual characteristics of the packaging, and explicitly, through concise textual information. Participants reported thoughts reflecting both shorter and longer distances across both types of interventions, suggesting that even subtle design cues can effectively trigger distance-related associations. This finding is particularly relevant for real-world applications, where packaging

constraints often limit the amount of information that can be communicated. Importantly, although the manipulations were intentionally minimal, such as varying the opacity of the material or the length of the line depicting the production process, the elicited responses were rich and varied. This indicates that relatively small design adjustments can shape consumers' perceptions across multiple dimensions of psychological distance. It is also important to distinguish between the intended manipulation and participants' inferences. Particularly in the implicit condition, respondents inferred attributes related with the compostability from visual cues (e.g., opacity). However, such inferences reflect consumers' interpretations of the manipulation rather than the construct being directly manipulated. Notably, the design did not incorporate explicit sustainability signals (e.g., green colouring or labels); instead, it relied on naturally occurring material properties, such as the opacity typical of compostable plastics (e.g., PLA-based materials).

Whereas Study 2 examined the implicit and explicit distance-framing manipulations separately to explore the associations they evoke, Study 3 investigates their combined effectiveness. Specifically, Study 3 tests H1a and H1b (the main effects of distance framing on sustainable responses, replicating and extending Study 1), H2 (the combined effect of implicit and explicit interventions), and H3 (a potential mediation mechanism).

5. Study 3

5.1. Materials and methods

5.1.1. Participants and design

A total of 275 participants, mainly students and of Dutch nationality, from [blinded to reviewers] University, were recruited and randomly assigned to one condition of a 2 (implicit intervention: long vs short distance framing) x 2 (explicit intervention: long vs short distance framing) between subject design. To achieve a sufficient power ($\geq .80$) for detecting a medium effect size ($f = .25$) at a significance level of .05, a minimum sample size of 179 participants was calculated (G*Power 3) (Faul et al., 2007). After excluding 23 participants who did not complete the experiment, and 8 participants who did not comply with the instruction to dispose of the packaging (but left it on the table), a final sample size of 244 participants (Mage = 22.39 years, SD = 3.17; 51.2% female, Dutch = 65.9%) was used for data analysis. The same cover story and thank you gift of Study 1 was used.

5.1.2. Stimuli

The stimuli were identical as for Study 2, the only differences were based on 1) the presentation mode, as Study 2 used virtual prototypes, while Study 3 presented participants with physical prototypes for hands-on interaction and 2) on the fact that the implicit and explicit interventions were tested in combination to test H2 (interaction effect). For similarities and differences across studies, see Table A.1, Appendix A. Each respondent was provided with 1) a physical prototype of the packaging tray containing a biscuit product for tasting and 2) an A4 format picture representing a zoom-in of the packaging label, which was attached to the participant's desk (Fig. A.2, Appendix A). The definition of compostable packaging and the disposal instructions were included as in Study 1. The overall stimulus (final packaging design with label and tray) was also presented on screen (Fig. A.2, Appendix A).

5.1.3. Procedure and measures

Study 3 was conducted in a computer room of the [blinded to reviewers] University and the same procedure of Study 1 applied. After the same filler questions of Study 1, sustainability perception and disposal behaviour of the packaging were measured and replicated from Study 1 to test H1ab and H2. In addition, to test H3, feelings of connection to the production process were measured using an adjusted version of the Connection to Nature Scale (Mayer and Frantz, 2004; Perrin and Benassi, 2009). The well-established connection-to-nature scale is one of the few validated instruments capturing perceived connectedness between the self and an external entity, such as the production process, in our research. The adapted items capture the perceived closeness or distance between the self, the consumer, and the production process, including the raw material at the beginning of the supply chain. The items were preceded by the following prompt: "*When I interact with this packaging, reading the information, looking at its design, holding the tray in my hand…*". Examples of the included items were: " *(1) I feel a sense of oneness with the packaging raw material, (2) I feel connected with this packaging, (3) I can imagine myself to be part of the overall production process of this product-packaging, (4) I feel close to the origin of this packaging*". While such items directly measure a degree of connection between the consumer and the overall process, others measure the reversed effect, namely a degree of distance that consumers may perceive from the process, along the spatial and temporal dimensions. Examples included: " *(7) I feel distant from the start of this supply chain, (8) I feel that there is a lot of time between me and the raw material, (9) I feel that I am far away in space from the raw material*" (see Table B.2, Appendix B for the original items and the adapted ones). After the environmental concern measurement and the demographic questions (same as in Study 1), respondents were asked to leave a tidy table and dispose of any materials, as in Study 1.

5.1.4. Analysis plan

Disposal behaviour of the packaging was analysed using logistic regression and a Chi-square test (Fisher's Exact Test, one-sided), as we had a clear directional hypothesis regarding which of the two distance-framing conditions would lead to more sustainable disposal behaviour (H1). This approach was consistent with the analysis of disposal behaviour conducted in Study 1. The logistic regression tested the effect of short distance framing in the implicit and explicit intervention and of their interaction on disposal behaviour, compared to the "long distance framing" condition as baseline. Environmental concern was inserted as covariate, as in Study 1. To test the mediation effect of H3, a series of four mediation analyses was conducted using Hayes' PROCESS macro (Model 4) in SPSS (Hayes, 2012) with distance framing in the implicit and explicit intervention as independent variables, sustainability perception and disposal behaviour as dependent variables and feelings of connection to the production process as mediator.

5.2. Results

5.2.1. Effect of distance framing interventions on sustainability perception and disposal behaviour

Sustainability perception: To test H1a/b and H2 on sustainability perception, a two-way independent ANOVA was conducted. Regarding H1a, no significant main effect of the distance framing in the explicit intervention was observed ($F(1,248) = .42$; $p = .52$), thus rejecting H1a. Regarding H1b, results showed a significant main effect of distance framing in the implicit intervention on sustainability perception of the packaging ($F(1,248) = 6.51$, $p = .01$, part. $\eta^2 = .03$). Participants perceived the packaging in the short distance framing as more sustainable ($M = 5.21$, $SE = 0.11$) than the packaging in the long distance framing ($M = 4.80$, $SE = 0.11$), thus supporting H1b. Regarding H2, results of the interaction effect ($F(1,248) = .05$; $p = .83$) and of the post-hoc pairwise comparisons provide support for H2. Specifically, when the explicit intervention already conveyed a short-distance framing, adding the implicit short-distance framing did not further enhance sustainability perceptions ($p = .13$), confirming what predicted in H2 regarding a saturation effect rather than an additive one. Instead, when the explicit intervention conveyed long-distance framing, the addition of an implicit short distance framing provided an additive effect: participants evaluated the implicit short-distance framing as significantly more sustainable ($M=5.31$; $SE=0.16$) than the implicit long-distance framing ($M=4.86$; $SE=0.16$; $p = .04$) (Fig. 5, panel a).

Disposal behaviour: Regarding H1a, the logistic regression and the Chi-square results showed that consumers tended to dispose of the

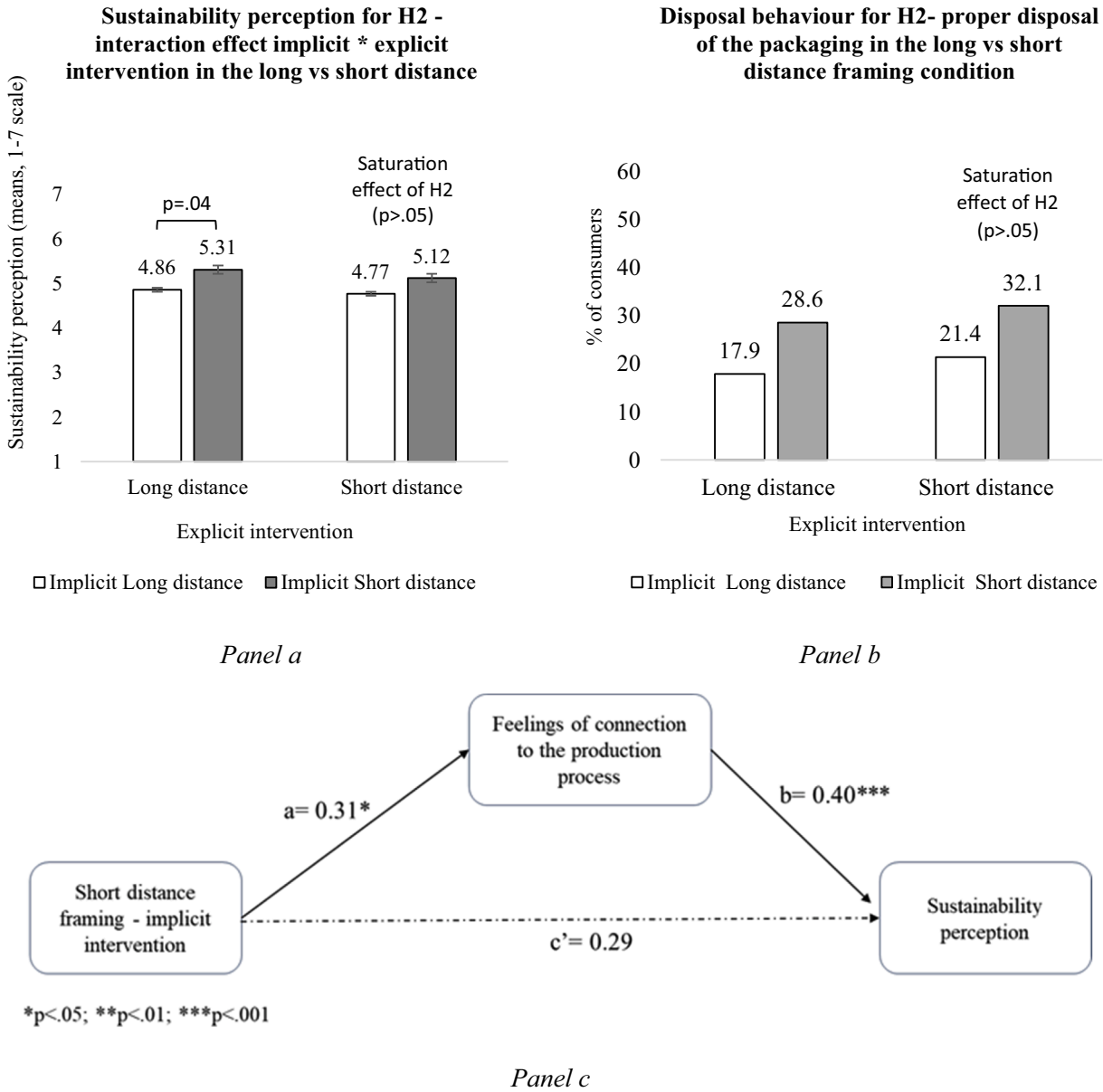


Fig. 5. Results for H2 on the combined effect of implicit and explicit intervention in long vs short distance framing on sustainability perception (panel a) and disposal behaviour (panel b) and results for H3 for mediation analysis (panel c). Error bars indicate 95% confidence interval.

packaging more sustainably in the explicit short distance framing condition (53.6 %), than in the explicit long distance framing condition (46.4 %). However, this difference was only marginally significant, showing a rather weak pattern ($\chi 2$ (1) = 3.02, p = .054; p value in the logistic regression=.066). Regarding H1b, the results showed that consumers in the implicit short distance framing condition disposed of the packaging significantly more sustainably (60.7 %) compared to consumers in the implicit long distance framing (39.3 %) (χ^2 (1) = 11.02, p < .001; B=0.87; SE=0.26; Wald= 10.85; Df=1; p<.001). This supports H1b. Consistent with study 1, the effect of environmental concern was not significant (p = .656).

Regarding H2, results on the interaction effect (p = .115) and of the Chi-square test provide support for H2. Specifically, when the explicit intervention already conveyed short-distance framing, adding implicit short-distance framing did not further enhance sustainable behaviour (e.g., significant pair-wise differences were observed between *explicit short + implicit long* and *explicit short + implicit short*; all p's >. 05), confirming what predicted in H2 regarding a saturation effect rather than an additive influence. The only significant differences were obtained between the *explicit short + implicit short* and the *explicit long + implicit long* conditions (χ^2 (3) = 14.429, p = .002) (Fig. 5, panel b).

5.2.2. The mediating role of feelings of connection to the production process

To test H3, a mediation analysis was conducted examining the role of feelings of connection to the production process. The results provided evidence for mediation only in the implicit intervention and only with respect to sustainability perception. Specifically, the short distance framing of the implicit intervention increased feelings of connection to the production process (a = 0.31, SE = 0.13, t = 2.36, p = .03), which in turn positively influenced the sustainability perception of the packaging (b = 0.40, SE = 0.07, t = 5.44, p < .001). Results suggested a partial mediation, as the direct effect of distance framing on sustainability perception remained marginal significant (c' = 0.29, SE = 0.15, t = 1.90, p = .06) (Fig. 5, panel c). In contrast, distance framing in the

explicit intervention did not significantly influence feelings of connection to the production process ($p = .52$). Furthermore, no mediating effect of connection to the production process was observed for disposal behaviour, neither in the implicit intervention ($p = .91$) nor in the explicit intervention ($p = .47$). Taken together, these findings provide only partial support for H3.

5.3. Discussion Study 3

Study 3 confirmed and extended the results of Study 1, showing that design interventions that shorten the distance between the consumer and the production process positively affect consumers' sustainability-related responses, such as the sustainability perception of the final product-packaging and sustainable disposal behaviour of it. This phenomenon was partly explained by feelings of connection to the production process that consumers experience when exposed to such interventions. Specifically, an intervention that implicitly reminds consumers of the origin and raw material of the final product makes consumers feel more connected to the production process, leading to perceive the product as more sustainable. Feelings of connection to the production process can thus foster a higher sustainability perception of the packaging, as predicted in H3.

In addition, Study 3 revealed that both the implicit and explicit distance framing manipulations positively influenced consumer sustainable disposal behaviour of the packaging, confirming H1a and H1b (for an overview of hypothesis and results, see Table C.1, Appendix C). In this regard, a short distance framing, aiming at connecting the final product with the previous steps of the supply chain (either with visual/tactile elements or with information on a packaging label) led consumers to behave more sustainably in disposing the packaging rather than a long distance framing. This effect was stronger for the implicit intervention (full significance) and lighter for the explicit intervention (only marginal significance). This can be explained by the fact that the explicit intervention was not present at the moment of disposal, as the packaging label with the manipulation of distance framing remained attached on the respondents' desk. Nevertheless, the explicit short distance framing managed to leave a lasting impression in consumer memory, thus functioning as a good reminder for correct behaviour, regardless of a direct or continuous exposure to it.

Moreover, the tested interventions directly influenced sustainable disposal behaviour, without affecting possible mediating factors, as feelings of connection to the production process (for both the implicit and explicit intervention). Such direct effect may suggest the activation of an unconscious, automatic and intuitive process where distance framing nudges certain behavioural tendencies without engaging an underlying psychological mechanism. In addition, the explicit intervention affected sustainable disposal behaviour without altering the sustainability perception of the packaging. Challenging traditional assumptions in the sustainability literature, which primarily emphasizes the need to change perceptions and attitudes in order to influence behaviour (Ajaps and McLellan, 2015; Liu et al., 2020; White et al., 2019), these results underscore the potential of contextual cues as automatic prompts and meaningful reminders on sustainability.

Last, the results of the interaction effect between the implicit and explicit intervention confirm prior studies on the "more is not the merrier" pattern (Granato et al. 2022a; Estrada-Mejia et al., 2025), theoretically grounded in the Embedding Effect (Kahneman and Knetsch, 1992). In this regard, the results showed that when the explicit intervention already conveyed a short-distance framing, adding the implicit short-distance framing did not further enhance sustainability perceptions and sustainable disposal behaviour, in line with H2.

6. General discussion and implications

6.1. Theoretical implications

Our findings advance research in sustainable consumption, sustainability communication and sustainable product design by addressing the relationship between design interventions, distance from the production process and consumers' sustainability-related responses. To our knowledge, this is the first research that conceptualises the notion of "distance from the production process", and systematically examines how distance framing interventions, designed to connect consumers to the production process, can positively affect a different range of consumer responses, such as sustainability perception of a food packaging, feelings of connection to the production process and actual pro-environmental disposal behaviour.

Building upon and contributing to the literature on psychological distance (Bashir et al., 2014; Brügger et al., 2015; Liberman and Trope, 1998; Spence and Pidgeon, 2010; Zhang et al, 2019), this research introduced an innovative and previously unexamined dimension of distance, which specifically targets the production process. Such distance captures the separation between the consumer and the sequence of events that transform raw materials into a final product. By exploring this construct, this paper adds clarity and specificity to a theoretically broad and multidimensional concept, thereby making it more actionable and relevant for design practice, communication strategies and policy interventions aimed at fostering sustainable production and consumption systems.

Furthermore, by examining how design interventions both influence perceived distance or connection to the production process and sustainable behaviour, our study bridges to two research streams that have typically evolved in parallel: eco-design and environmental psychology. Prior work has predominantly examined either design features to foster sustainable behaviour (Magnier and Schoormans, 2015) or psychological processes such as connectedness in isolation (Mayer and Frantz, 2004; Schill and Shaw, 2016). Our results show how design interventions can effectively manipulate the concept of distance from the production process either implicitly through more inferential, perception-based cues, or explicitly through more informational cues. Importantly, we demonstrate that a short-distance framing intervention, that better connects the final product with its origin or the consumer with the overall process, can positively enhance sustainable responses, including actual disposal actions. These insights extend theories of psychological distance, suggesting that increasing connection between a perceiver and an event (or object) increases sensitivity towards that event and lead to higher environmental engagement (Bashir et al., 2014; Scannell and Gifford, 2013). In doing so, our work contributes not only conceptually but also practically, highlighting how subtle yet strategically designed interventions can support more sustainable consumption and production patterns.

6.2. Practical implications

Our findings offer practical implications for food and packaging producers, designers and for policy makers seeking to promote consumer awareness of the production-consumption system of our everyday commodities, including their impacts on the environment. Despite social movements that encourage consumers to ask questions about the processes underlying products' production, reflected in popular entertainment formats, such as the TV show "How It's Made" or "Inside the Factory", scientific research on how to support a greater connection to the production process through design has remained limited. This research fills this gap by providing empirically grounded insights into how design interventions can be strategically leveraged to connect consumers to the production process, fostering greater consumer engagement with sustainability. While our empirical context centres on a compostable food packaging, the implications are far broader.

Companies across diverse industries, including fashion, electronics, automative, agriculture, are adopting more sustainable practices such as regenerative sourcing, circular production systems, or fair-trade labour. Our findings provide concrete guidance on how these sustainability efforts can be made visible and meaningful to consumers. By carefully crafting distance-framing interventions, companies can communicate production practices more effectively and foster more sustainable patterns of engagement, from consumption to disposal. Design elements that shorten the distance between the consumer and the overall production process, through visual cues, material choices, or concise descriptions of production steps, can encourage responsible actions, such as correctly disposing of compostable packaging. These insights underscore how design can bridge sustainable production and sustainable consumption by helping consumers feel closer to the processes behind the products they use. Our results have particularly relevant implications for the bioplastics sector. Perceptual cues, such as higher opacity or other sensory properties, can be leveraged to enhance consumers' sense of connection to the production process. While such features are often hidden due to concerns about consumer acceptance, emphasizing them responsibly can strengthen perceived sustainability and valorise bioplastic materials. However, this approach must be applied with caution: modifications that make packaging appear eco-friendly, such as coatings or visual alterations, can unintentionally reduce recyclability or increase environmental impact. Transparent and responsible use of distance-based cues is therefore essential to avoid greenwashing.

Importantly, we also show that environmentally responsible disposal behaviours can be triggered even without direct and immediate exposure to distance-framing cues. This suggests that such interventions can have delayed or memory-driven effects. Producers and policymakers can therefore extend distance-framing strategies beyond packaging design itself, incorporating them into advertising, educational initiatives, and public communication campaigns to reinforce consumers' mental connection to the production process over time.

Last, our findings are particularly relevant in the context of the European Green Deal and the new Circular Economy Action Plan, which aim to ensure re-usability and recyclability of materials in the future food-packaging production (Salini and Burkhardt, 2023). Achieving these goals requires not only technological innovation but also consumer participation. Designers, producers and policymakers thus need communication strategies to signal both the novelty and the improved environmental efficiency of emerging production practices. The concept of distance from the production process and its manipulation through design may open a window of opportunities in this direction, as a promising new avenue for encouraging more circular and environmentally responsible consumer behaviour.

6.3. Limitations and further research

The current research presents some limitations that should be acknowledged. First, this research was limited to the creation and testing of one implicit and one explicit intervention aimed at conveying a shorter or longer distance between the final packaging and its raw material. Future research could build upon the present studies by investigating alternative approaches to manipulate the concept of distance from the production process and effectively integrate distance framing into different design interventions, beyond food packaging. For example, future studies could develop and test distance framing interventions in the context of fast fashion, by reducing or enhancing the distance between consumers and the origin of a fashion garment (e.g., the cotton) and measure whether a shift in distance framing leads consumers to engage in more sustainable fashion practices (e.g., repairing and extending the product lifetime, instead of prematurely discarding it).

Second, the interventions in this research were limited to manipulating the objective distance between the consumer (at the end of the production process) and the product's origin (at its beginning). Although these manipulations build on prior work (Bashir et al., 2014; Brügger et al., 2015; Spence and Pidgeon, 2010; Zhang et al., 2019), for example, by operationalizing temporal distance through timeline visualizations, changes in objective distance did not consistently translate into perceived psychological distance or a stronger sense of connection, as evidenced in Study 3. Future research is therefore needed to further examine how design interventions can meaningfully shape perceived distance between consumers and the production process across different dimensions, including temporal, spatial, and social distance, as well as more context-specific dimensions such as resource-related and outcome-related distance identified in this research (Study 2).

Third, to measure feelings of connection between the consumer and the production process (i.e., the proposed mediator), this research adapted the validated Connection to Nature scale. Although this scale has been previously applied in related contexts to capture perceived distance or connectedness (e.g., Dong et al., 2020; Mayer et al., 2009), further investigation is needed to assess its suitability for the specific context of production processes. In the present study, despite being adapted to this context, the scale did not fully explain why short-distance framing had a positive and significant effect on sustainable responses. Future research could therefore explore alternative measures of perceived distance between consumers and the production process, such as through an Implicit Association Test. Recent research (Geng et al., 2015) which measured feelings of connection both implicitly and explicitly, seems to support this argument, suggesting that while explicit connection (to nature) was positively correlated with deliberate self-reported environmental behaviours, implicit connection (to nature) was positively correlated with spontaneous environmental behaviours. Besides feelings of connection to the production process, other psychological processes could explain the effect of short distance framing on sustainable behaviour and, thus, should be explored. Future research could for example, examine the role of processing fluency that was only preliminary measured in this research, as confound checks. The results of Study 1 and 2 showed that in the explicit intervention, participants perceived the packaging in the short distance condition as more difficult to process than the packaging in the long distance condition. As a result of this inferior fluency, a shorter distance framing might linger longer in consumer memory, being more effective in steering correct disposal practices (placing the compostable packaging in the organic bin). Processing disfluency could play a role in the activation of a "stop and re-think" process in consumers' minds, by disrupting automatic behaviours and prompting to re-think imminent disposal actions.

7. Conclusions

Modern production-consumption systems have progressively distanced consumers from the production process of the goods that they buy and consume. Such distance between consumers and the production process is particularly evident in fast moving consumer goods, where the ultra-convenience of the offer and automatic decision making tend to obscure the stages "before and after" consumption. Although numerous interventions aim to educate or nudge consumers, none of them has so far addressed and leveraged the concept of distance from the production process as a way to sensitise consumers and foster more sustainable behaviour. By drawing inspiration from the theoretical concepts of psychological distance and applying it to the context of the production process, this research investigates whether and to what extent reducing the distance between consumers and the production process of a product fosters more sustainable behaviours toward that product. Across three studies, one online and two laboratory experiments, this research conceptualised and tested an implicit and explicit intervention, in the context of food packaging, that effectively manipulate the concept of distance from the production process, framed as either short or long distance. Short-distance framings consistently enhanced sustainability perceptions and encouraged more sustainable disposal behaviours,

either directly, or by increasing consumers' perceived connection to the production process. Together, these findings identify the concept of distance from the production process as a meaningful and previously under investigated lever for promoting sustainable consumer behaviour, offering a novel direction for both research and practice in behavioural interventions for sustainability, pivotal for addressing the ecological challenges of our time.

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Declaration of generative AI and AI-assisted technologies in the manuscript preparation process

During the preparation of this work the authors used ChatGPT (OpenAI) in order to improve the readability of certain sections of the manuscript (language polishing). After using this tool/service, the authors reviewed and edited the content as needed and take full responsibility for the content of the published article.

CRediT authorship contribution statement

Giulia Granato: Writing – review & editing, Writing – original draft, Visualization, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Ellis van den Hende:** Writing – review & editing, Project administration, Data curation, Conceptualization.

Declaration of competing interest

None.

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Appendix A: set-up of the studies and differences and similarities across them

Fig. A.1, Fig. A.2, Table A.1

Fig. A.1. Study set-up for Studies 1 and 3.

Fig. A.2. Stimuli set-up for Study 3: packaging label attached on the desk and packaging tray containing biscuits.

Table A.1
Differences and similarities across studies 1, 2 and 3.

	Study 1 (lab study)	Study 2 (online study)	Study 3 (lab study)
Objective	Test the effect of distance framing manipulations (short vs long) on consumers' sustainability-related responses (H1a)	Explore consumers' thoughts and associations from distance framing manipulations	Replicate and extend the effect of distance framing manipulations on consumers' sustainability-related responses and explore the role a potential mediating mechanism (H1a, H1b, H2, H3)
Study design	2 (explicit intervention: long vs short distance framing) between subject design	1 × 4 (implicit intervention long vs short vs explicit intervention long vs short distance framing) between subject design	2 (implicit intervention: long vs short distance framing) x 2 (explicit intervention: long vs short distance framing) between subject design
Manipulation of distance framing	Explicit: two packaging labels (text and image) for short and long distance framing on a packaging tray made of compostable plastic (corn starch)	Explicit: two packaging labels (revised text and image from Study 1) for short and long distance framing Implicit: two packaging trays for short and long distance framing	Explicit and implicit (combined): same packaging labels as Study 2 on packaging trays
Stimuli	Physical prototypes for hands-on interaction	Virtual prototypes for online setting	Physical prototypes for hands-on interaction
Main dependent variables	Sustainability perception Disposal behaviour	Distance-related thoughts triggered by the interventions	Sustainability perception Disposal behaviour Potential mediating variable: feelings of connection to the production process

Appendix B: Scales used in Studies 1, 2 and 3

Table B.1, Table B.2

Table B.1
Reliability analysis (Cronbach's alpha values) of the used scales for studies 1, 2 and 3. not applicable (NA) is in case of a single item.

	No of items	Study 1	Study 2	Study 3
Manipulation check measures	5	0.64	Not used	Not used
Environmental concern (covariate)	3	0.75	0.89	0.76
Distance promting questions	3	Not used	0.87	Not used
Processing fluency	3	0.85	0.96	Not used
Clarity of the information	2	0.69	Not used	Not used
Credibility of the information	1	NA	Not used	Not used
Packaging information appreciation	1	NA	Not used	Not used
Transparency of the information	2	0.80	Not used	Not used
Level of involvement with the information	3	0.87	Not used	Not used
Level of abstraction of the information	3	Not used	0.86	Not used
Construal level	1	Not used	NA	Not used
Feelings of connection to the production process (mediator)	9	Not used	Not used	0.82

Table B.2
Original connection to nature scale and the adjusted one for study 3 (connection to the production process).

Connectedness to nature (Mayer and Frantz, 2004)	Connection to the production process
1. I often feel a sense of oneness with the *natural world around me.*	1. I feel a sense of oneness with the *packaging raw material.*
2. I think of the natural world as a community to which I belong.	2. I feel *connected with this packaging.*
3. I recognize and appreciate the intelligence of other living organisms.	3. I can imagine myself to be part of the *overall production process of this product-packaging.*
4. I often feel *disconnected from nature.*	*4.* I feel *close to the origin of this packaging.*
5. When I think of my life, I imagine myself to be part of a *larger cyclical process of living.*	5. I feel that all the materials, processes, and me in the supply chain share *a common purpose.*
6. I often feel a *kinship with animals and plants.*	6. I feel like I am playing a significant role in this supply chain.
7. I feel as though I belong to the Earth as equally as it belongs to me.	7. I feel distant from the start of this supply chain.
8. I have a deep understanding of how my actions affect the natural world.	8. I feel that there is a lot of time between me and the raw material.
9. I often feel part of the web of life.	9. I feel that I am far away in space from the raw material.
10. I feel that all inhabitants of Earth, human, and nonhuman, share a common *'life force'.*	
11. Like a tree can be part of a forest, I feel embedded within the broader natural world.	
12. When I think of my place on Earth, I consider myself to be a top member of a hierarchy that exists in nature.	
13. I often feel like I am only a small part of the natural world around me, and that I am no more important than the grass on the ground or the birds in the trees.	
14. My personal welfare is independent of the welfare of the natural world.	

Appendix C: Additional Results

Fig. C.1, Table C.1

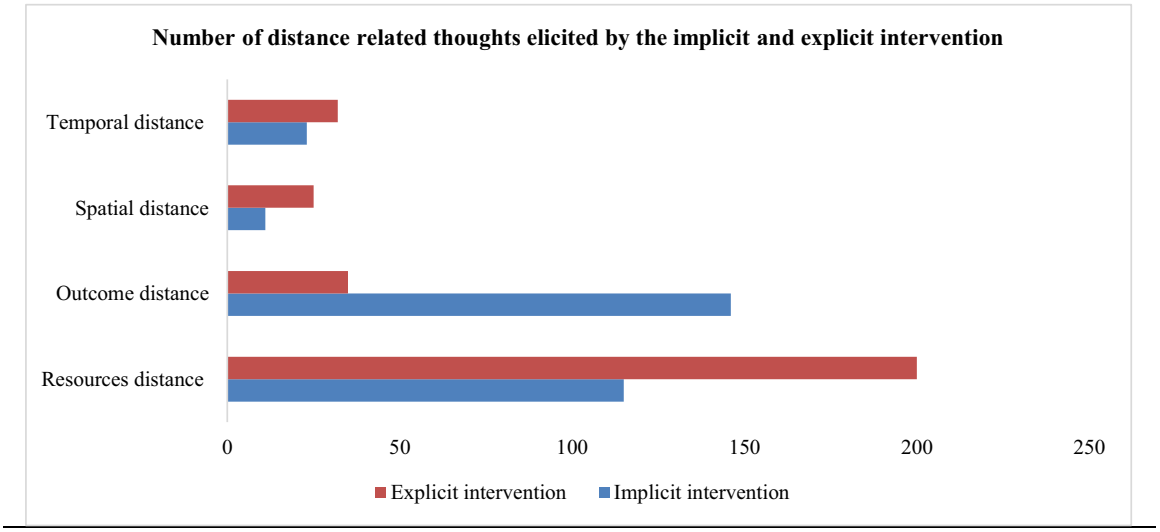

Fig. C.1. Results of Study 2: Number of distance related thoughts elicited by the explicit (label) and implicit packaging tray) interventions. The type of distance relate to the inferences consumers made and were coded as temporal distance, spatial distance, distance in terms of resources and distance in terms of outcome.

Table C.1
Overview of the hypothesis and results across studies confirming or rejecting the hypothesis. not applicable (NA) is when the hypothesis has not been tested in that study.

Hypothesis	Study 1	Study 2	Study 3
H1: Short distance framing increases consumers' sustainability-related responses (i.e., sustainability perception of the packaging and pro-environmental disposal behavior) compared to long distance framing. H1a (explicit operationalization): The effect predicted in H1 occurs when distance framing is manipulated through an explicit intervention (packaging label and text).	Confirmed for perception and behaviour	NA	Rejected for perception and marginally supported for behaviour
H1b (implicit operationalization):The effect predicted in H1 occurs when distance framing is manipulated through an implicit intervention (overall packaging look).	Confirmed for perception and behaviour	NA	Confirmed for perception and behaviour
H2: When an explicit short distance framing is already provided, combining it with an implicit short distance framing does not further strengthen consumers' sustainability-related responses, suggesting a saturation effect rather than additive influence.	NA	NA	Confirmed for perception and behaviour
H3: The effect of distance framing on consumers' sustainability-related responses is mediated by feelings of connection to the production process, that is, short distance framing should enhance perceived connectedness, which in turn promotes sustainability perceptions and behaviours.	NA	NA	Confirmed only for implicit intervention and perception

Data availability

Data will be made available on request.

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